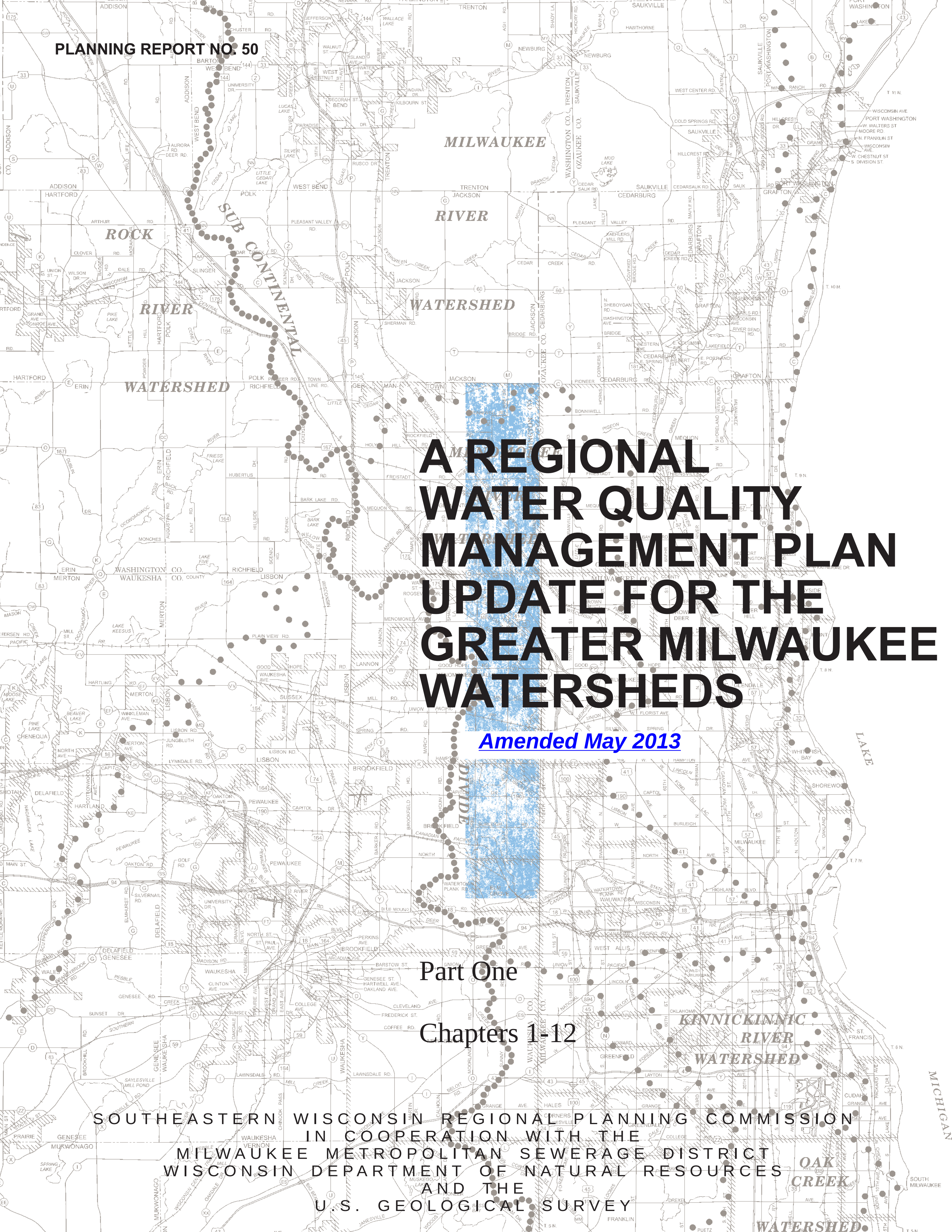
PLANNING REPORT NO. 50

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Amended May 2013

Part One

Chapters 1-12



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
IN COOPERATION WITH THE
MILWAUKEE METROPOLITAN SEWERAGE DISTRICT
WISCONSIN DEPARTMENT OF NATURAL RESOURCES
AND THE
U.S. GEOLOGICAL SURVEY

Special acknowledgement is due Mr. Martin A. Aquino, Environmental Manager, City of Milwaukee Department of Public Works; Mr. Mark Baran, former Interim District Conservationist for Ozaukee County; Ms. Marsha B. Burzynski, Program and Planning Analyst, Wisconsin Department of Natural Resources; Mr. David E. Carpenter, retired Director of Planning and Development for Dodge County; Ms. Diane M. Georgetta, former Coordinator, Town and Country Resource Conservation and Development, Inc.; Ms. Elizabeth L. Gillen, Acting District Conservationist for Ozaukee County; Ms. Shannon K. Haydin, former Director, Sheboygan County Department of Planning and Resources; Ms. Judy Jooss, Representative, Town and Country Resource Conservation and Development, Inc.; Mr. Charles J. Krohn, former Regional Water Leader for the Wisconsin Department of Natural Resources; Mr. David Lynch, retired Ozaukee County Conservationist; Mr. Gary A. Mick, retired Director Milwaukee County Environmental Services; Mr. Stephen Poloncsik, Senior Staff Engineer, U.S. Environmental Protection Agency; and Ms. Gretchen Sawtelle, Executive Director, USDA Farm Services Agency, all of whom served on the Committee during much of the planning process.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

W239 N1812 ROCKWOOD DRIVE • PO BOX 1607 • WAUKESHA, WI 53187-1607• TELEPHONE (262) 547-6721
FAX (262) 547-1103

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WALWORTH
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WAUKESHA

December 5, 2007

SUBJECT: Certification of the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds

TO: The Legislative Bodies of All the Local Units of Government within the Greater Milwaukee River Watersheds Study Area in the Southeastern Wisconsin Region, and in Dodge, Fond du Lac, and Sheboygan Counties, and All Concerned State and Federal Agencies

This is to certify that at a meeting of the Southeastern Wisconsin Regional Planning Commission held at the Milwaukee Intermodal Station, Milwaukee, Wisconsin, on the 5th day of December 2007, the Commission, by a vote of all Commissioners present, being 15 ayes and 0 nays, and by appropriate resolution, a copy of which is made a part hereof and is incorporated by reference to the same force and effect as if it had been specifically set forth herein in detail, did adopt the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, as part of the master plan for the physical development of the Region. Said plan is documented in SEWRPC Planning Report No. 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds*, published in December 2007, which is attached hereto and made a part hereof. Such action taken by the Commission is hereby recorded on and is part of said plan, which is hereby transmitted for implementation to all concerned levels and agencies of government in the Southeastern Wisconsin Region, the State of Wisconsin, and the United States.

IN TESTIMONY WHEREOF, I have hereunto set my hand and seal and cause the Seal of the Southeastern Wisconsin Regional Planning Commission to be hereto affixed.

Dated at the City of Pewaukee, Wisconsin, this 5th day of December 2007.

Thomas H. Buestrin, Chairman
Southeastern Wisconsin
Regional Planning Commission

Attest:

Philip C. Evenson

Philip C. Evenson, Deputy Secretary

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RESOLUTION NO. 2007-21

RESOLUTION OF THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION ADOPTING THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS, THE PLAN BEING AN AMENDMENT TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN FOR THE REGION CONSISTING OF THE COUNTIES OF KENOSHA, MILWAUKEE, OZAUKEE, RACINE, WALWORTH, WASHINGTON, AND WAUKESHA IN THE STATE OF WISCONSIN

WHEREAS, the Southeastern Wisconsin Regional Planning Commission, which was duly created by the Governor of the State of Wisconsin in accordance with Section 66.0309(2) of the *Wisconsin Statutes* on the 8th day of August 1960, upon petition of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha, has the function and duty of making and adopting a master plan for the physical development of the Region; and

WHEREAS, the Governor of the State of Wisconsin has designated the seven-county Southeastern Wisconsin Region as an areawide water quality management planning area and the Southeastern Wisconsin Regional Planning Commission as the official water quality management planning agency for that area, all in accordance with the procedural requirements set forth in Section 208 of the Federal Water Pollution Control Act as amended; and

WHEREAS, the Southeastern Wisconsin Regional Planning Commission on July 12, 1979, adopted a regional water quality management plan, which constitutes an integral part of the master plan for the Region, and which is set forth in the report entitled, SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin – 2000*; and

WHEREAS, the Milwaukee Metropolitan Sewerage District executed an agreement with the Regional Planning Commission on September 30, 2003, for the development of an update to the regional water quality management plan, leading to recommendations for land use development and regulation; environmental corridor land preservation; abatement of point and nonpoint sources of water pollution; and groundwater quality management in the Greater Milwaukee Watersheds study area; and

WHEREAS, the Southeastern Wisconsin Regional Planning Commission, pursuant to its function and duty as a regional planning agency and its designation as a water quality management planning agency, has prepared an update to the regional water quality management plan set forth in a report entitled, SEWRPC Planning Report No. 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* published in December 2007; and

WHEREAS, the Technical Advisory Committee for the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, an advisory committee to the Commission duly constituted pursuant to Section 66.0309(7) of the *Wisconsin Statutes*, held public hearings on the plan update on October 15, 16, and 23, 2007, and unanimously approved the regional water quality management plan update after considering the testimony provided at the hearings, all as presented in the aforenoted report, at its meeting held on October 31, 2007; and

WHEREAS, such plan contains recommendations for land use development and regulation; environmental corridor land preservation; abatement of point and nonpoint sources of water pollution; and groundwater quality management, including studies, data, maps, figures, charts, and tables, and, being a water quality management plan for the Greater Milwaukee Watersheds, is intended by the Southeastern Wisconsin Regional Planning Commission to constitute an amendment to the regional water quality management plan; and

WHEREAS, Section 66.0309(9) of the *Wisconsin Statutes* authorizes and empowers the Regional Planning Commission, as the work of making the whole master plan progresses, to amend, extend, or add to the master plan or carry any part or subject thereof into greater detail;

NOW THEREFORE, BE IT HEREBY RESOLVED:

FIRST: That the regional water quality management plan update, being an amendment to the regional water quality management plan and comprised of SEWRPC Planning Report No. 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds*, published in December 2007, shall be and the same hereby is in all respects, ratified, approved, and officially adopted.

SECOND: That the said SEWRPC Planning Report No. 50, together with all maps, plats, charts, programs, and descriptive and explanatory matter contained therein, are hereby made a matter of public record, and the originals and true copies thereof shall be kept at all times at the offices of the Southeastern Wisconsin Regional Planning Commission, presently located in the City of Pewaukee, Waukesha County, and State of Wisconsin, or at any subsequent office that the Commission may occupy, for examination and study by whomsoever may desire to examine same.

THIRD: That a true, correct, and exact copy of this resolution, together with a complete and exact copy of the aforereferenced planning report, shall be forthwith distributed to each of the local legislative bodies of the governmental units within the Region entitled thereto and to such other bodies, agencies, or individuals as the law may require, or as the Commission or its Executive Committee or its Executive Director in their discretion shall determine and direct.

The foregoing resolution upon motion duly made and seconded was regularly adopted at the meeting of the Southeastern Wisconsin Regional Planning Commission held on the 5th day of December 2007, the vote being: Ayes 15, Nays 0.

Thomas H. Buestrin, Chairman

ATTEST:

Philip C. Evenson

Philip C. Evenson, Deputy Secretary

PLANNING REPORT NUMBER 50

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Part One of Two Parts
Chapters 1-12

Prepared by the

Southeastern Wisconsin Regional Planning Commission
In Cooperation with the
Milwaukee Metropolitan Sewerage District,
Wisconsin Department of Natural Resources,
and the
U.S. Geological Survey

The preparation of this report was financed in part by the Milwaukee Metropolitan Sewerage District and by the Wisconsin Department of Natural Resources and the U.S. Environmental Protection Agency under the continuing water quality management planning program conducted cooperatively by the Department and the Regional Planning Commission.

December 2007

Amended May, 2013

$20.00

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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December 3, 2007

STATEMENT OF THE CHAIRMAN

Pursuant to the provisions of Section 208 of the Federal Water Pollution Control Act, the Southeastern Wisconsin Regional Planning Commission undertook preparation of an update to the regional water quality management plan from 2003 through 2007. The plan was prepared as part of the Water Quality Initiative, which is a collaborative program involving the Milwaukee Metropolitan Sewerage District (MMSD), the Wisconsin Department of Natural Resources (WDNR), and the Regional Planning Commission, each of which provided funding for the planning effort. Under the Water Quality Initiative, the regional water quality management plan update was closely coordinated with the MMSD 2020 facilities plan, which is largely incorporated in the regional plan. The study was guided by a Technical Advisory Committee, consisting of representatives of county and municipal government, special-purpose units of government, MMSD, WDNR, the U.S. Geological Survey, the U.S. Environmental Protection Agency, academic institutions, and environmental and conservation organizations. The findings and recommendations of the planning program are presented in a planning report which has been produced in two parts.

The plan was developed for the geographic area consisting of the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds, the Oak Creek watershed, the Milwaukee Harbor estuary, and the Lake Michigan Direct Drainage Area (collectively designated the "Greater Milwaukee Watersheds"). That area includes all or part of Kenosha, Milwaukee, Ozaukee, Racine, Washington, and Waukesha Counties within the Region and parts of Dodge, Fond du Lac, and Sheboygan Counties outside the Region. The study area includes all or part of 88 cities, towns, and villages.

The objectives of this plan update were: to determine the current state of stream and lake water quality conditions within the Greater Milwaukee Watersheds, to compare these conditions against established water use objectives and supporting water quality standards, to explore alternative means of meeting those objectives and standards through the abatement of both point and nonpoint sources of water pollution, and to recommend the most cost-effective means of improving water quality over time.

While the work of the Regional Planning Commission is advisory to its constituent units and agencies of government, State and Federal regulations can be expected to operate in such a manner as to promote plan implementation in the following three ways:

- State and Federal grants may be conditioned upon conformance of water quality projects with the recommended plan,
- The issuance of permits under the Wisconsin Pollutant Discharge Elimination System program by law must not conflict with plan recommendations, and
- Sanitary sewer service areas associated with specific sewer service extensions must conform by State regulation to the areas recommended in the plan as those areas may be amended from time-to-time.

Review and study of the entire report by all responsible public officials and by interested citizens is urged, for the findings and recommendations of the plan may be expected to have a far-reaching impact on the cost of providing certain municipal facilities and services, as well as on the overall quality of life within the study area and the Region.

The Commission recommends this plan to all of the designated implementing agencies as a sound point of departure for making water quality management and related land use development decisions within the study area. In its continuing role of acting as a center for cooperative, areawide planning within southeastern Wisconsin, the Commission stands ready to provide assistance to the various units of government and agencies involved in implementation of the plan.

Respectfully submitted,

Thomas H. Buestrin,
Chairman

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Chapter I

INTRODUCTION AND BACKGROUND

INTRODUCTION

This report documents an update to the regional water quality management plan for the "greater Milwaukee watersheds,"[1] as well as the process used to arrive at that plan. The plan update is for the design year 2020 and represents a major amendment to the regional water quality management plan for southeastern Wisconsin.[2]

During 2002, the Milwaukee Metropolitan Sewerage District (MMSD) initiated work on a third-generation sewerage facilities planning effort. This effort is responsive to a court-ordered stipulation requiring the facilities plan to be completed by June 30, 2007, and is consistent with Section 201 of the Federal Clean Water Act. As the facilities planning program was conceptualized, the MMSD proposed to utilize the watershed approach to plan development consistent with the evolving U.S. Environmental Protection Agency (USEPA) policies. That approach was further defined to be conducted cooperatively with a coordinated and integrated comprehensive regional water quality management planning effort. Such an approach builds consensus among stakeholders and is sound public planning practice, as well as being consistent with the requirements of Section 208 of the Federal Clean Water Act.

The approach to cooperatively carrying out the MMSD facilities planning program and the regional water quality management plan updating program was developed cooperatively by the Wisconsin Department of Natural Resources (WDNR), the MMSD (including its facilities plan consultant team), and the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and was conceptually formalized under a February 19, 2003, WDNR/MMSD/SEWRPC Memorandum of Understanding. Two separate, but coordinated and cooperative planning programs were conducted. These planning efforts, when taken together, represent an integrated watershed water quality planning approach incorporating facilities planning. One planning effort was the preparation of an update to the regional water quality management plan for the entirety of watersheds in the greater Milwaukee area and one was a facilities planning program for the MMSD sewerage system. Because of

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[1]*The term "greater Milwaukee watersheds" is defined for purposes of this report as all of five watersheds which lie entirely or partially in the greater Milwaukee area, the Lake Michigan direct drainage area, as well as the Milwaukee Harbor estuary and a portion of nearshore Lake Michigan. The watersheds involved are those of the Kinnickinnic River, Oak Creek, Menomonee River, Milwaukee River, and Root River.*

[2]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin–2000, *Volume One*, Inventory Findings, *September 1978; Volume Two*, Alternative Plans, *February 1979; and Volume Three*, Recommended Plan, *June 1979.*

the interrelationships between these two planning programs, it was necessary to carefully coordinate and integrate the planning activities.

This report documents the regional water quality management plan update effort that was integrated with the MMSD facilities planning effort to form an integrated watershed water quality management plan. The regional water quality management plan update was designed to possibly complement future efforts in developing watershed-based, total maximum daily pollution loading, and water quality standard use attainability analyses and reports consistent with the evolving policies of the WDNR and USEPA.

STUDY AREA

The study area for the regional water quality management plan update consists of all of five watersheds which lie entirely or partially in the greater Milwaukee area, the Lake Michigan direct drainage area, the Milwaukee Harbor estuary, and a portion of nearshore Lake Michigan, as shown on Map 1. The watersheds involved are those of the Kinnickinnic River, Oak Creek, Menomonee River, Milwaukee River, and Root River.

With regard to the Milwaukee Harbor estuary and nearshore Lake Michigan portion of the study area, it is important to make a physical distinction between the boundaries of the Milwaukee Harbor and the boundaries of the estuary itself. The Milwaukee Harbor includes the outer harbor area—from the breakwater to the shoreline, excluding the anchorage area protected by the offshore breakwater south of E. Lincoln Avenue extended—and the inner harbor area—which includes those lower reaches of the Kinnickinnic, Menomonee, and Milwaukee Rivers that are maintained to depths which will accommodate navigation by deep draft commercial vessels. The inner harbor is approximately bounded by the Becher Street bridge on the Kinnickinnic River, S. 25th Street on the Menomonee River, and Buffalo Street extended on the Milwaukee River. The Milwaukee Harbor estuary itself includes the 3.1-mile reach of the Milwaukee River below the site of the former North Avenue dam, the 2.2-mile reach of the Menomonee River below the Falk Corporation dam, and the 2.4-mile reach of the Kinnickinnic River below the Chase Avenue bridge along with the outer harbor to the breakwater structure. Thus, defined, the Milwaukee Harbor estuary has a total length of stream of about 9.1 miles, and a total surface water area of approximately 1,630 acres, or about 2.55 square miles. A break wall shelters the Milwaukee Harbor area and is aligned from approximately one mile north of the Milwaukee River to south of the Jones Island wastewater treatment plant. Lake Michigan water level conditions affect discharges from each river in the Milwaukee Harbor estuary. The nearshore Lake Michigan area protected by the South Shore breakwater immediately south of the Milwaukee Outer Harbor is an important part of the study area forming an extension of the Milwaukee Harbor extending about 12,500 feet south along the Lake Michigan shoreline and partially protecting the South Shore Yacht Club, South Shore Park, and Bay View Park.

The Lake Michigan direct drainage area consists of a number of drainage swales and storm sewers draining a limited area directly tributary to Lake Michigan. The largest example is Fish Creek located on the border of Milwaukee and Ozaukee Counties. The portion of the nearshore area of Lake Michigan included in the study area extends from the Village of Fox Point in Milwaukee County, to a point approximated by Three Mile Road extended in Racine County. The land area draining directly to the Lake in this reach is included in the study area.

PURPOSE AND OBJECTIVES

The primary purpose of the update of the regional water quality management plan is to develop a sound and workable plan for the abatement of water pollution within the greater Milwaukee watersheds so as to meet the plan objectives as described in Chapter VII of this report. More specifically, the planning program is intended to set forth a framework plan for the management of surface water for the greater Milwaukee watersheds incorporating measures to abate existing pollution problems and elements intended to prevent future pollution problems. It should be recognized that plan implementation will be dependent upon local actions, including, but not limited to: refinement and detailing of sanitary sewer service areas; the development of stormwater management plans and sewerage system facilities plans; and the integration of the plan recommendations into County land and water resource planning as a means for implementing the rural land management recommendations.

Map 1

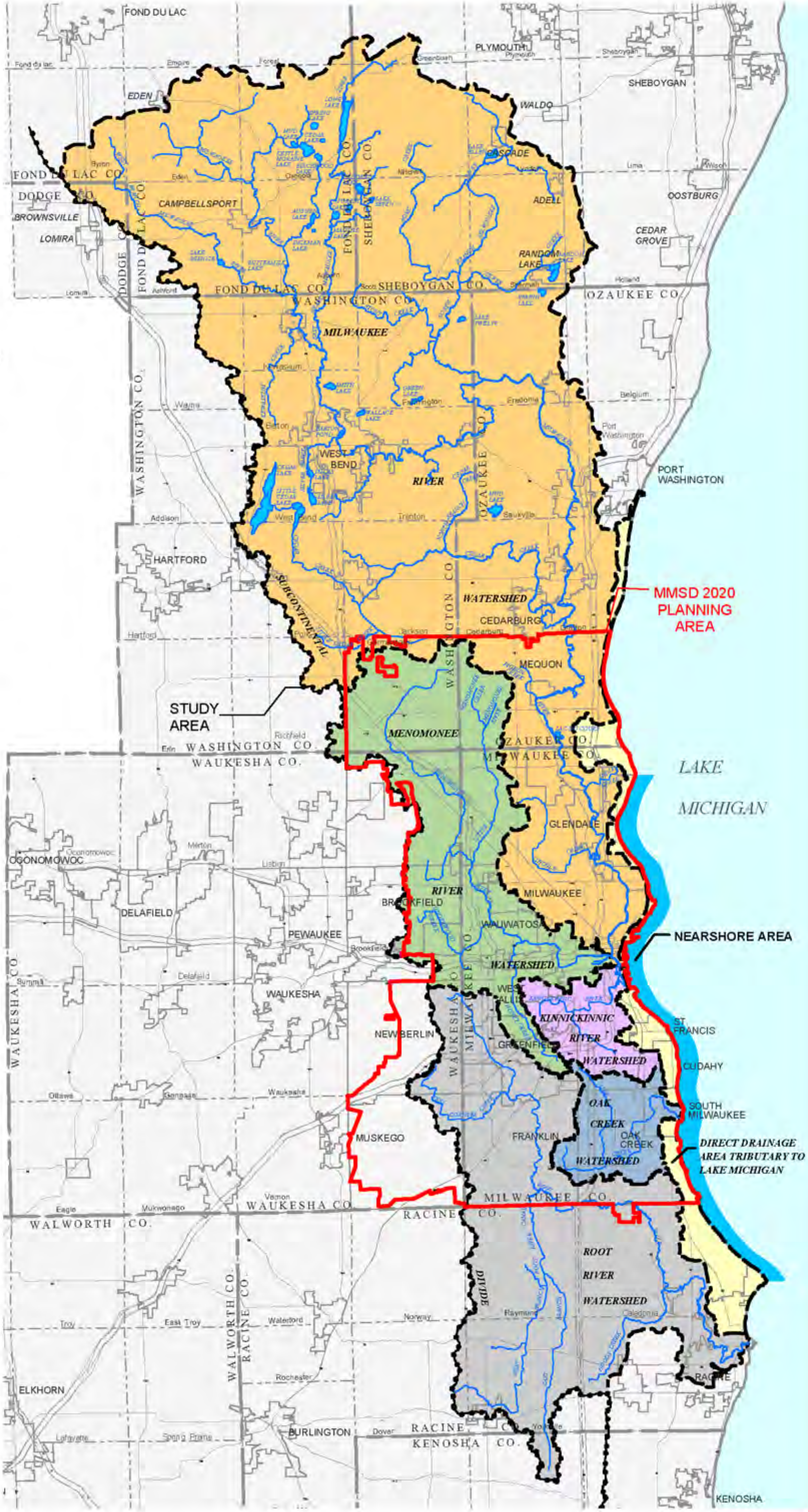
REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

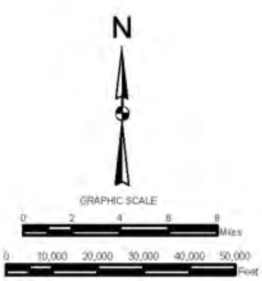
Watershed	Area (square miles)
Kinnickinnic River	24.7
Menomonee River	135.8
Milwaukee River	700.0
Oak Creek	28.2
Root River	197.6
Lake Michigan Direct Drainage Area	40.7
Total	1,127.0

Number of Counties	9
Number of Local Municipalities	88

MMSD PLANNING AREA

Number of Counties	5
Number of Local Municipalities	29
Total Area (square miles)	411





Source: SEWRPC.

REGIONAL WATER QUALITY MANAGEMENT PLAN

The Southeastern Wisconsin Regional Planning Commission is, pursuant to State legislation, the official planning agency for the seven-county Southeastern Wisconsin Region. The Commission is charged by law with the duty of preparing and adopting a comprehensive plan for the development of the Region. The Commission is also the State-designated and federally recognized areawide water quality management planning agency for southeastern Wisconsin.

Pursuant to the provisions of Section 208 of the Federal Clean Water Act, the Commission prepared and adopted an areawide water quality management plan for the Southeastern Wisconsin Region in 1979. That plan was subsequently adopted by the Wisconsin Natural Resources Board and approved by the USEPA. That plan provided the necessary framework for the preparation and adoption of the 1980 MMSD facilities plan. Although certain elements of the areawide plan have been updated since 1979, and although many key recommendations of that plan have been implemented, it was appropriate that the plan be updated to provide a needed framework for the preparation of the new MMSD facilities plan.

The previously cited initial regional water quality management plan was designed, in part, to meet the Congressional mandate that the waters of the United States be made to the extent practicable "fishable and swimmable." In accordance with the requirements of Section 208 of the Federal Clean Water Act, the plan provides recommendations for the control of water pollution from such point sources as wastewater treatment plants, points of separate and combined sewer overflow, and industrial waste outfalls and from such nonpoint sources as urban and rural stormwater runoff.

An important amendment to the regional water quality management plan, adopted in 1987, addressed water quality issues in the Milwaukee Harbor estuary. The estuary plan set forth recommendations to abate water pollution from combined sewer overflows, including a determination of the level of protection to be provided by such abatement, and from other point and nonpoint sources of pollution in the tributary watersheds, including recommendations for instream measures, that might be needed to achieve established water use objectives.

Since completion of the initial regional water quality management plan, SEWRPC and the WDNR have cooperatively conducted a continuing water quality management planning effort. That effort has been severely limited by fiscal constraints, however, with work confined largely to sanitary sewer service area planning, groundwater inventories and analyses, and selected plan implementation activities.

In 1995, SEWRPC completed a report documenting the implementation status of the regional water quality management plan as amended over the approximately first 15 years since the initial adoption of the plan. This report, SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995, provides a comprehensive restatement of the regional water quality management plan as amended. The plan status report reflects implementation actions taken and plan amendments adopted since the initial plan was completed. The status report also documents, as available data permitted, the extent of progress which had been made toward meeting the water use objectives and supporting water quality standards set forth in the regional water quality management plan.

All of the regional water quality management planning efforts were conducted using the watershed as the primary planning unit. In addition to providing clear and concise recommendations for the control of water pollution, the adopted areawide plan provides the basis for the continued eligibility of local units of government for Federal and State grants and loans in partial support of sewerage system development and redevelopment, for the issuance of waste discharge permits by the WDNR, for the review and approval of public sanitary sewer extensions by that Department, and for the review and approval of private sanitary sewer extensions and large onsite sewage disposal systems and holding tanks by the Wisconsin Department of Commerce. The WDNR also permits large farm animal operations. However, these permits are not directly related to the regional water quality plan recommendations.

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT FACILITIES PLANNING

The Milwaukee Metropolitan Sewerage District is a special-purpose unit of government directed by an appointed Commission. The MMSD includes all of Milwaukee County, except the City of South Milwaukee and portions of the City of Franklin. In addition, sewage conveyance and treatment services are provided to portions of Ozaukee, Racine, Washington, and Waukesha Counties. The District, which exists pursuant to the provisions of Section 200.23 of the *Wisconsin Statutes*, has a number of important responsibilities in the area of water resources management, including the provision of floodland management programs for most of the major streams within the District and the collection, transmission, and treatment of domestic, industrial, and other sanitary sewage generated in the District and its contract service areas.

The MMSD has defined a series of interrelated projects which were designed to carry out its sewage management responsibilities, and which are collectively referred to as the Milwaukee water pollution abatement program. These projects were developed through facilities planning programs which were subregional in nature, the latest of which was completed in 1998 and had a design year of 2010. The recently completed MMSD facilities planning program amended its sewerage facilities plan and extended it to a design year of 2020. A court-ordered stipulation required that the MMSD submit the final plan by June 30, 2007. The MMSD's 2020 facilities planning project encompassed a number of interrelated activities contracted through various consultant contracts that were directed and supported by substantial commitments from the MMSD.

APPROACH TO UPDATING THE REGIONAL WATER QUALITY MANAGEMENT PLAN FOR THE GREATER MILWAUKEE WATERSHEDS

The regional water quality management plan for the greater Milwaukee watersheds portion of southeastern Wisconsin was updated, revised, and extended to a new design year 2020. The contemplated work effort resulted in the reevaluation and, as necessary, revision of the three major elements comprising the original plan—the land use element; the point source pollution abatement element; and the nonpoint source pollution abatement element. In addition, a groundwater element was added largely based upon recently completed and ongoing programs.

The plan was completed in a time frame which was consistent with the MMSD commitments for the completion of a new facilities plan, using currently available data. This allowed the plan update to be largely completed during the first half of 2007, with selected elements being completed earlier as was required by the MMSD facilities planning effort schedule. Some of the plan documentation, public involvement, and continuing support for the MMSD facilities planning was carried out during the last half of 2007.

The regional water quality management plan updating employed a seven-step planning process through which the principal functional relationships existing within the planning area related to water quality management were accurately described, and the effect of different courses of action with respect to land use and facility development tested and evaluated. The seven steps involved in this planning process were: 1) study organization; 2) formulation of objectives and standards; 3) inventory; 4) analysis and forecast; 5) preparation, test, and evaluation of alternative plans; 6) plan selection; and 7) plan implementation. Report preparation and public involvement are additional steps which were integrated throughout the process. The principal steps in the process are described in the following sections and are summarized in Figure 1. This figure also shows the two reports that were prepared to document the planning program.

The regional water quality management planning and the MMSD facilities planning were conducted in separate, but coordinated and cooperative, work efforts. As noted above, the two planning efforts were interfaced and coordinated for many of the work elements and selected work elements were jointly carried out. That interfacing is generally illustrated in Figure 1. However, because of the important interrelationships between the two planning programs, a seamless approach to the planning program was needed, and very close coordination and integration

Map 1

REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Watershed	Area (square miles)
Kinnickinnic River	24.7
Menomonee River	135.8
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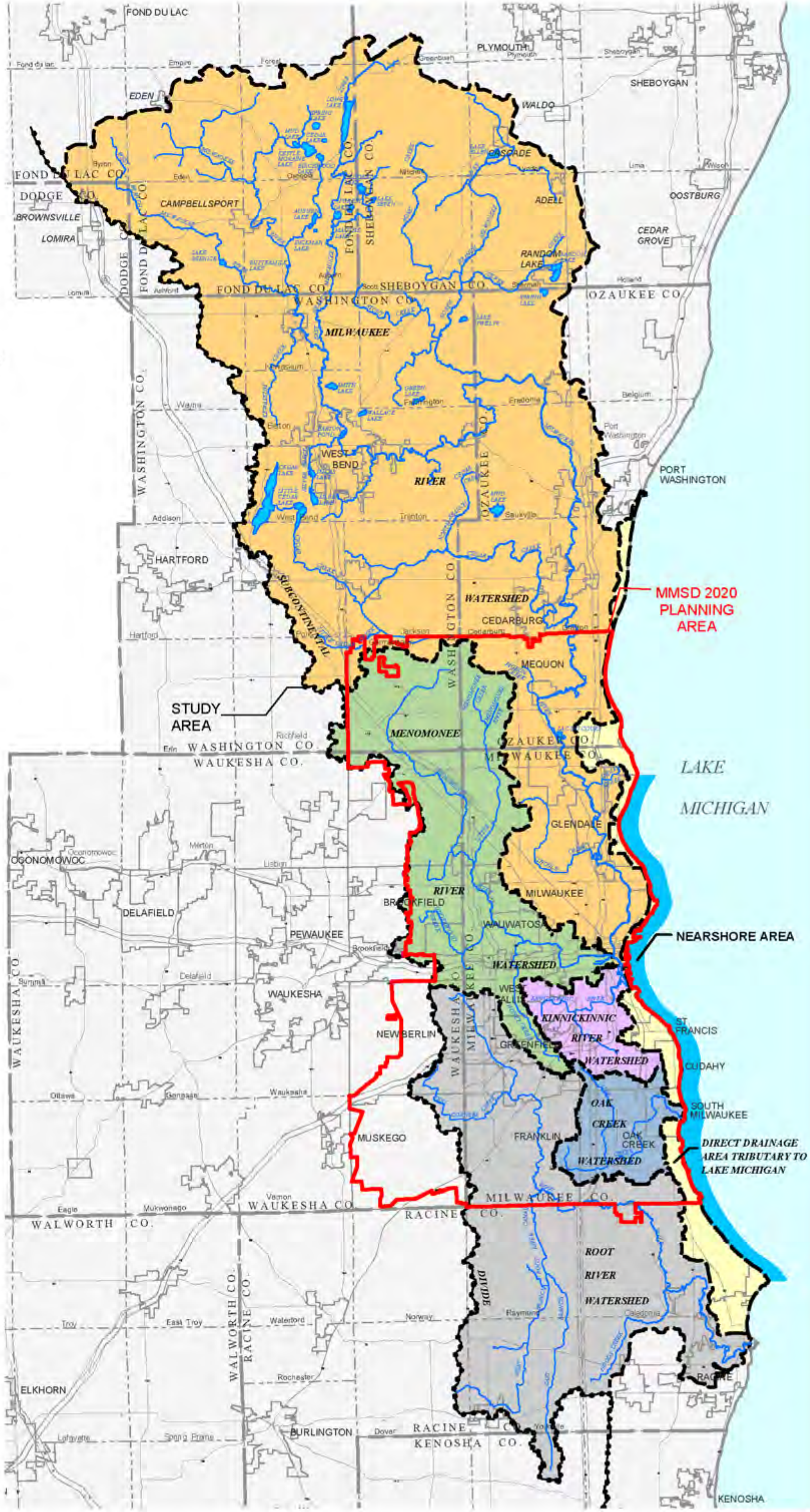

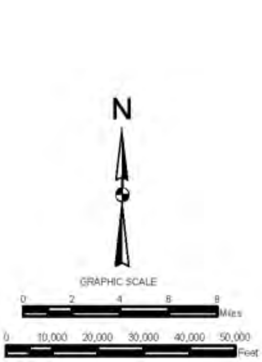

Source: SEWRPC.

of the two programs were essential. Thus, the details of the interfacing could only be specifically identified as the work proceeded.

RELATIONSHIP TO OTHER PLANNING PROGRAMS

In addition to the regional water quality management plan and the MMSD facilities planning programs, the current regional water quality management plan update is related to a number of past or ongoing planning programs. These include, among others, the County land and water resource management plans; the ongoing and anticipated future comprehensive or "smart growth" plans being prepared at the regional, county, and local units of government level; and the basin planning being carried out by the WDNR. Also, the extensive water resources data base recently collected and collated by the MMSD in conjunction with the U.S. Geological Survey (USGS), in cooperation with the WDNR and others, is directly related and will be used as the basic water quality data source. In addition to the planning programs specifically noted above, there are other local planning programs which are relevant to the regional water quality management plan update which have been considered, as appropriate, during the planning process. These plans include local sewerage system facilities plans, local stormwater management plans, local land use plans, and water resource management plans which have been prepared for selected areas.[3]

County Land and Water Resource Management Plans

Each of the counties within the study area has prepared a land and water resource management plan pursuant to Wisconsin Act 27. Those plans are typically updated every five to seven years. These plans provide information on the natural resources in each county, the limitations of those resources, and include a strategy that addresses the natural resource issues and problems. The plans also provide a means to inform the public about these issues and problems and include them in the steps necessary to protect the natural resource base. As such, these plans were all carefully reviewed during the plan alternative development and evaluation steps in this current planning effort. In addition, certain of the plan recommendations and implementation strategies include specific plan elements which depend upon integration into the county land and water resource management plans for purposes of local refinement and implementation.

Comprehensive Planning

By January 1, 2010, counties, cities, villages, and towns need to adopt comprehensive ("smart growth") plans compliant with recent State requirements. These plans need to address nine specific plan elements, three of which are directly related to the regional water quality management plan updating. These elements include:

- **Land-Use Element:** A compilation of objectives, policies, goals, maps and programs to guide the future development and redevelopment of public and private property. . .. The element shall also includes a series of maps that show current land uses and future land uses that indicate productive agricultural soils, natural limitations for building site development, floodplains, wetlands and other environmentally sensitive lands, the boundaries of areas to which services of public utilities and community facilities. . .will be provided in the future. . ..

- **Utilities and Community Facilities Element:** A compilation of objectives, policies, goals, maps and programs to guide the future development of utilities and community facilities in the local governmental unit such as sanitary sewer service, stormwater management, water supply. . . The element shall describe the location, use and capacity of existing public utilities and community facilities that serve the local governmental unit, shall include an approximate timetable that forecasts the need in the local governmental unit to expand or rehabilitate existing utilities and facilities or to create new utilities and facilities and shall assess future needs for government services in the local governmental unit that are related to such utilities and facilities.

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[3]*Quaas Creek (Washington County) Watershed Protection Plan prepared by Washington County Land Conservation Department and the Ulao Creek (Ozaukee County) Management Plan.*

- **Agricultural, Natural and Cultural Resources Element:** A compilation of objectives, policies, goals, maps and programs for the conservation, and promotion of the effective management, of natural resources such as groundwater, forests, productive agricultural areas, environmentally sensitive areas, surface water, floodplains, wetlands. . .

Given the related work elements noted, the regional water quality management plan update has been coordinated to the extent practical with the ongoing comprehensive planning. In addition, the plan implementation strategies includes specific integration and local refinement of selected plan elements into the comprehensive planning programs.

Wisconsin Department of Natural Resources Basin Planning

The Wisconsin Department of Natural Resources carries out program management and planning for the Milwaukee River basin, comprised of the Kinnickinnic, Menomonee, and Milwaukee River watersheds and Root-Pike basin, which includes the Root River and Oak Creek watersheds. The Department has prepared state-of-the-basin plans[4] for each basin. These plans include resource management recommendations related to the WDNR programmatic activities, including surface water quality objectives (classifications), sewerage system management, and related water resources programs. The regional water quality management plan updating program included review and coordination with the basin planning and has included a specific plan implementation strategy for integrating the current regional planning with the WDNR basin planning.

ORGANIZATIONAL STRUCTURE FOR THE PLAN UPDATE

The study organization, coordination, and staffing required to prepare the regional water quality management plan update for the watershed areas involved were an extension of the ongoing water quality management planning program currently being conducted cooperatively by SEWRPC and the WDNR. The MMSD was directly involved as a participant in the preparation of the study design and selected components of the planning program and largely supported the program as an important cooperative effort to its facilities planning program. The MMSD also conducted its sewerage system facilities planning program in a parallel coordinated manner. The relationship of MMSD facilities planning and the regional plan updating is summarized generally in Figure 1.

For selected work activities, as appropriate, the work on the regional water quality management planning program and the MMSD facilities plan was carried out under a single, coordinated work effort using shared staff. These activities included three specific areas: 1) watercourse modeling, 2) Milwaukee Harbor estuary and nearshore Lake Michigan water quality modeling, and 3) state-of-the-art evaluation and report on pollution abatement practices. These three work elements were conducted under a cooperative effort involving SEWRPC, the MMSD, and the MMSD 2020 facilities planning consultant team. The MMSD 2020 consultant team conducted the technical work, with oversight being provided by SEWRPC and MMSD staffs. The work was developed in an integrated manner to meet all of the needs of both the regional plan update and the MMSD facilities plan. The consultant staffing to carry out the work for these three activities was provided by and through the MMSD facilities planning program and related programs.

In addition to the MMSD consultant work elements for modeling and state-of-the-art reports noted above, SEWRPC, with assistance from the WDNR and USEPA, contracted with the USGS to conduct water quality monitoring and analyses in the upper portion of the Milwaukee River watershed and lower portion of the Root River watershed.

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[4]*Wisconsin Department of Natural Resources,* The State of the Milwaukee River Basin, *August 2001; and Wisconsin Department of Natural Resources*, The State of the Root-Pike River Basin, *May 2002.*

PUBLIC INVOLVEMENT FOR THE PLAN UPDATE

Public involvement activities were an important component of the plan preparation. The public involvement activities were focused through the use of advisory committees, cooperative actions with other related ongoing public involvement activities, and other public involvement and watershed education programming. An important consideration was to carefully coordinate and integrate the public involvement activities for the regional water quality management plan with such activities being carried out particularly as part of the MMSD 2020 facilities planning program, and also the WDNR basin partnership ongoing programs. In this regard, it should be noted that the MMSD and SEWRPC developed and initiated a joint public involvement program for a number of key purposes, including joint activity planning and public events, several shared committees, and deferring to one another as appropriate in the preparation of informational and educational materials that both programs can utilize.

Advisory committees form a most fundamental type of public involvement, with strong prospects for the planning program contributions to be of a broad and representative nature. Three types of advisory bodies guided the regional water quality management plan update, one of a technical nature, one provided intergovernmental coordination and policy advice and assistance, and one was citizen based. In addition, continued participation in the oversight committee for the coordinated regional water quality management planning program and the MMSD facilities planning program—involving the WDNR, MMSD, SEWRPC, and the MMSD consultant project manager—was considered an important adjunct to public involvement activity. The details of the advisory committee structure and other public involvement activities are documented in a public involvement program summary included in this report as Appendix A.

SCHEME OF PRESENTATION

The findings and recommendations of the year 2020 regional water quality management plan update for the greater Milwaukee watersheds are documented in this report. Following this introductory chapter, Chapter II presents updated information regarding the demographic and economic base, the natural environment, and land use and other aspects of the man-made environment of the watersheds, including information that is essential to the planning process. Chapters III and IV present a summary of a technical report prepared as part of the planning program which includes more detail relating to existing and historic water quality and pollution sources in the watersheds involved. Chapter V describes the water quality simulation models and other important analytic methods employed in the planning process. Chapter VI summarizes the legal structures or regulations affecting the study area. Chapter VII presents the planning objectives and standards adopted for use in the planning program. Chapter VIII presents land use and related population levels anticipated for the study in the year 2020. Chapter IX presents a description and evaluation of alternative water quality management plans. Chapter X presents a recommended water quality management plan designed to accommodate the year 2020 conditions. Chapter XI describes the actions which should be taken by the concerned units and agencies of government to facilitate implementation of the recommended plan. Chapter XII provides an overall summary of the major findings and recommendations of the planning study.

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Chapter II

DESCRIPTION OF THE STUDY AREA

INTRODUCTION

The water-resource and water-resource-related problems of a watershed, as well as the ultimate solutions to those problems, are a function of the human activities within the watershed and of the ability of the underlying natural resource base to sustain those activities. Regional water quality management planning seeks to rationally direct the future course of human actions within the watershed so as to promote the conservation and wise use of the natural resource base. Accordingly, the purpose of this chapter is to describe the natural resource base and the man-made features of the greater Milwaukee watersheds, thereby establishing a factual base upon which the regional water quality management planning process may proceed. This description of the study area is presented in two major sections: the first describes the man-made features; the second describes the natural resource base of the watersheds.

REGIONAL AND WATERSHED SETTING OF THE PLANNING AREA

The planning area encompasses the greater Milwaukee watersheds within Southeastern Wisconsin, which, as shown on Map 1 in Chapter I of this report, cover approximately 1,127 square miles. About 861 square miles of these watersheds are located within the seven-county Southeastern Wisconsin Region, representing about 32 percent of the Region. Within the region, these watersheds include all of the Kinnickinnic River, Menomonee River, Oak Creek, and Root River watersheds, portions of the Milwaukee River watershed, and lands directly tributary to Lake Michigan. In addition, approximately 266 square miles of the greater Milwaukee watersheds, or about 23.6 percent of the study area, are located outside of the Region. This portion of the study area consists of the upper reaches of the Milwaukee River watershed, located in Dodge, Fond du Lac, and Sheboygan Counties. The greater Milwaukee watersheds are drained by approximately 1,010 miles of streams, including the Kinnickinnic River and its tributaries, the Menomonee River and its tributaries, the Milwaukee River and its tributaries, Oak Creek and its tributaries, and the Root River and its tributaries, as well as several smaller streams draining directly to Lake Michigan. Importantly, the study area also includes the Milwaukee Harbor Estuary and the nearshore Lake Michigan area.

MAN-MADE FEATURES OF THE STUDY AREA

The man-made features of the study area include its political boundaries, land use pattern, including park and open spaces and historic sites, public utility network, and transportation system. Together with the population residing and the economic activities taking place within the study area, these features may be thought of as the socioeconomic base. A description of this socioeconomic base is an important aspect of watershed-based water quality management planning. Any attempt to protect or improve the socioeconomic environment must be founded in an understanding, not only of the various demands for land, public facilities, and resources generated by the demographic and economic activities of an area, but also the ability of the existing land use pattern and public facility systems to meet those demands.

In order to facilitate such understanding, a description of the socioeconomic base of the greater Milwaukee watersheds is presented in four sections. The first section places these watersheds in perspective as a rational planning unit within a regional setting by delineating their internal political and governmental boundaries and relating these boundaries to the Region as a whole. The second section describes the demographic and economic base of the area in terms of population size, distribution, and composition and in terms of employment levels and distribution. The third section describes the pattern of land use in the watershed in terms of both historical development and existing (2000) conditions. The fourth section describes the public and private utility systems within the study area. These elements comprise the man-made features of the study area which are most directly related to water quality management planning.

UNITS OF GOVERNMENT

Civil Divisions

Superimposed on the irregular study area boundary as defined by watershed boundaries is a pattern of local political boundaries. As shown on Map 2, the watersheds lie primarily within Fond du Lac, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha Counties with small portions in northern Kenosha and northeastern Dodge Counties. Eighty-eight civil divisions lie in part or entirely within the greater Milwaukee watersheds, as also shown on Map 2 and in Table 1. Geographic boundaries of the civil divisions are an important factor which must be considered in any watershed-based planning effort like the regional water quality management plan update program, since the civil divisions form the basic foundation of the public decision-making framework within which intergovernmental, environmental, and developmental problems must be addressed.

Special-Purpose Units of Government

Special-purpose units of government are of particular interest to the water quality management update planning program. Among these are the Milwaukee Metropolitan Sewerage District (MMSD); the legally established, active town sanitary and utility districts created to provide various urban-related services, such as sanitary sewerage, water supply, and solid waste collection and disposal, to designated portions of rural towns with urban service needs; and inland lake protection and rehabilitation districts.

Milwaukee Metropolitan Sewerage District

The Milwaukee Metropolitan Sewerage District is directed by an appointed Commission. The MMSD includes all of Milwaukee County, except the City of South Milwaukee and portions of the City of Franklin. In addition, sewage conveyance and treatment services are provided to portions of Ozaukee, Racine, Washington, and Waukesha Counties. The District, which exists pursuant to the provisions of Section 200.23 of the *Wisconsin Statutes*, has a number of important responsibilities in the area of water resources management, including the provision of floodland management programs for most of the major streams within the District and the collection, transmission, and treatment of domestic, industrial, and other sanitary sewage generated in the District and its contract service areas.

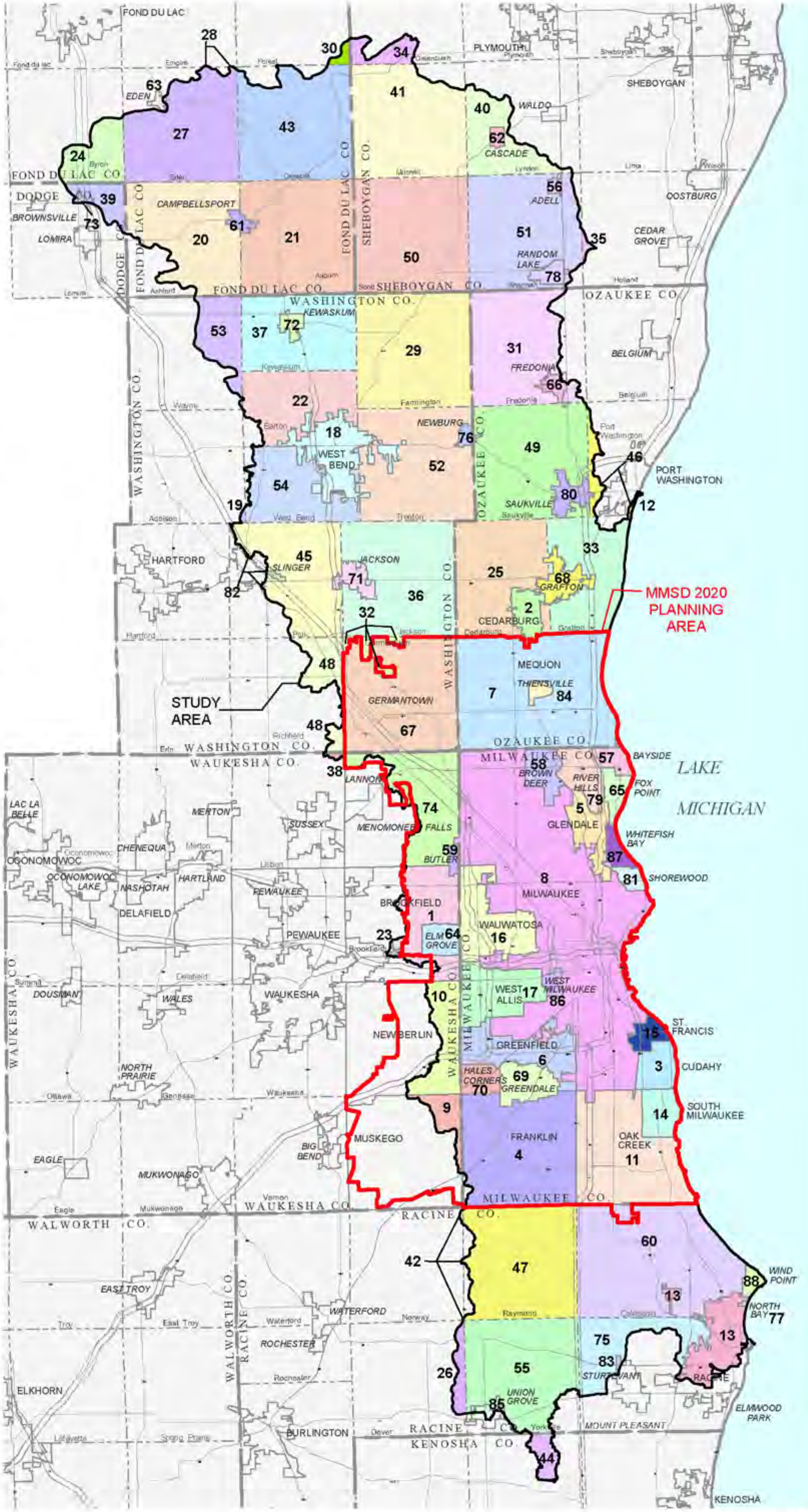
The MMSD has defined a series of interrelated projects which were designed to carry out its sewage management responsibilities, and which are collectively referred to as the Milwaukee water pollution abatement program. These projects were developed through facilities planning programs which were subregional in nature, the latest of which was completed in 1998 and had a design year of 2010. The present MMSD initiative, which is being conducted in coordination with the regional water quality management plan update, seeks to amend and extend its sewerage facilities plan to a design year of 2020.

Town Sanitary and Utility Districts

There are nine active town sanitary and utility districts within the study area: the Caledonia East and West Utility Districts in the Villages of Caledonia, North Bay, and Wind Point; the Lake Ellen Sanitary District in the Town of Lyndon; the Mount Pleasant Sewer Utility District No. 1 in the Village of Mt. Pleasant; the Silver Lake

Map 2

CIVIL DIVISIONS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000



1 City of Brookfield
2 City of Cedarburg
3 City of Cudahy
4 City of Franklin
5 City of Glendale
6 City of Greenfield
7 City of Mequon
8 City of Milwaukee
9 City of Muskego
10 City of New Berlin
11 City of Oak Creek
12 City of Port Washington
13 City of Racine
14 City of South Milwaukee
15 City of St. Francis
16 City of Wauwatosa
17 City of West Allis
18 City of West Bend
19 Town of Addison
20 Town of Ashford
21 Town of Auburn
22 Town of Barton
23 Town of Brookfield
24 Town of Byron
25 Town of Cedarburg
26 Town of Dover
27 Town of Eden
28 Town of Empire
29 Town of Farmington
30 Town of Forest
31 Town of Fredonia
32 Town of Germantown
33 Town of Grafton
34 Town of Greenbush
35 Town of Holland
36 Town of Jackson
37 Town of Kewaskum
38 Town of Lisbon
39 Town of Lomira
40 Town of Lyndon
41 Town of Mitchell
42 Town of Norway
43 Town of Osceola
44 Town of Paris
45 Town of Polk
46 Town of Port Washington
47 Town of Raymond
48 Town of Richfield
49 Town of Saukville
50 Town of Scott
51 Town of Sherman
52 Town of Trenton
53 Town of Wayne
54 Town of West Bend
55 Town of Yorkville
56 Village of Adell
57 Village of Bayside
58 Village of Brown Deer
59 Village of Butler
60 Village of Caledonia
61 Village of Campbellsport
62 Village of Cascade
63 Village of Eden
64 Village of Elm Grove
65 Village of Fox Point
66 Village of Fredonia
67 Village of Germantown
68 Village of Grafton
69 Village of Greendale
70 Village of Hales Corners
71 Village of Jackson
72 Village of Kewaskum
73 Village of Lomira
74 Village of Menomonee Falls
75 Village of Mt. Pleasant
76 Village of Newburg
77 Village of North Bay
78 Village of Random Lake
79 Village of River Hills
80 Village of Saukville
81 Village of Shorewood
82 Village of Slinger
83 Village of Sturtevant
84 Village of Thiensville
85 Village of Union Grove
86 Village of West Milwaukee
87 Village of Whitefish Bay
88 Village of Wind Point

NOTE: MAP REFLECTS YEAR 2000 CORPORATE LIMITS. THE TOWNS OF CALEDONIA AND MOUNT PLEASANT INCORPORATED TO VILLAGES IN THE YEAR 2005 AND 2003, RESPECTIVELY.

Source: SEWRPC.

Table 1

AREAL EXTENT OF COUNTIES, CITIES, VILLAGES, AND TOWNS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000

Civil Division	Area (square miles)	Percent of Total
Dodge County		
Village of Lomira	0.2	0.02
Town of Lomira	4.4	0.39
Subtotal	4.6	0.41
Fond du Lac County		
Village of Campbellsport	1.1	0.10
Village of Eden	0.1	0.01
Town of Ashford	28.9	2.56
Town of Auburn	35.8	3.18
Town of Byron	8.9	0.79
Town of Eden	29.7	2.63
Town of Empire	<0.1	<0.01
Town of Forest	0.8	0.07
Town of Osceola	33.5	2.97
Subtotal	138.8	12.31
Kenosha County		
Town of Paris	2.8	0.25
Subtotal	2.8	0.25
Milwaukee County		
City of Cudahy	4.8	0.43
City of Franklin	34.2	3.04
City of Glendale	6.0	0.53
City of Greenfield	11.5	1.02
City of Milwaukee	96.7	8.58
City of Oak Creek	28.5	2.53
City of South Milwaukee	4.9	0.44
City of St. Francis	2.6	0.23
City of Wauwatosa	13.2	1.17
City of West Allis	11.4	1.01
Village of Bayside	2.3	0.20
Village of Brown Deer	4.4	0.39
Village of Fox Point	2.9	0.26
Village of Greendale	5.6	0.50
Village of Hales Corners	3.2	0.28
Village of River Hills	5.3	0.42
Village of Shorewood	1.6	0.14
Village of West Milwaukee	1.1	0.10
Village of Whitefish Bay	2.1	0.19
Subtotal	242.3	21.46
Ozaukee County		
City of Cedarburg	3.7	0.33
City of Mequon	47.0	4.17
City of Port Washington	0.1	0.01
Village of Bayside	0.1	0.01
Village of Fredonia	1.3	0.12
Village of Grafton	4.1	0.36
Village of Newburg	0.1	0.01
Village of Saukville	2.9	0.26
Village of Thiensville	1.1	0.10

Table 1 (continued)

Civil Division	Area (square miles)	Percent of Total
Ozaukee County (continued)		
Town of Cedarburg	26.0	2.31
Town of Fredonia	28.1	2.49
Town of Grafton	19.5	1.73
Town of Port Washington	2.6	0.23
Town of Saukville	33.4	2.96
Subtotal	170.0	15.09
Racine County		
City of Racine	10.6	0.94
Village of Caledonia	45.6	4.05
Village of Mt. Pleasant	13.5	1.20
Village of North Bay	0.1	0.01
Village of Sturtevant	0.2	0.02
Village of Union Grove	0.7	0.06
Village of Wind Point	1.3	0.12
Town of Dover	2.6	0.23
Town of Norway	0.1	0.01
Town of Raymond	34.0	3.02
Town of Yorkville	29.9	2.65
Subtotal	138.6	12.31
Sheboygan County		
Village of Adell	0.6	0.05
Village of Cascade	0.8	0.07
Village of Random Lake	1.7	0.15
Town of Greenbush	3.7	0.33
Town of Holland	0.5	0.04
Town of Lyndon	12.6	1.12
Town of Mitchell	33.5	2.97
Town of Scott	36.5	3.24
Town of Sherman	32.6	2.90
Subtotal	122.5	10.87
Washington County		
City of Milwaukee	>0.1	>0.01
City of West Bend	12.6	1.12
Village of Germantown	34.4	3.05
Village of Jackson	2.5	0.22
Village of Kewaskum	1.4	0.12
Village of Newburg	0.8	0.07
Village of Slinger	0.3	0.03
Town of Addison	0.2	0.02
Town of Barton	18.0	1.60
Town of Farmington	36.8	3.26
Town of Germantown	1.8	0.16
Town of Jackson	34.2	3.03
Town of Kewaskum	22.9	2.03
Town of Polk	24.2	2.15
Town of Richfield	7.2	0.64
Town of Trenton	33.5	2.97
Town of Wayne	9.1	0.81
Town of West Bend	17.2	1.53
Subtotal	257.1	22.81

Table 1 (continued)

Civil Division	Area (square miles)	Percent of Total
Waukesha County		
City of Brookfield	13.5	1.20
City of Milwaukee	0.1	0.01
City of Muskego	3.9	0.35
City of New Berlin	9.9	0.88
Village of Butler	0.8	0.07
Village of Elm Grove	3.3	0.29
Village of Menomonee Falls	18.5	1.64
Town of Brookfield	0.2	0.02
Town of Lisbon	0.3	0.03
Subtotal	50.5	4.49
Total	1,127.2	100.00

NOTE: The Town of Mt. Pleasant incorporated to a Village in the year 2003. The Town of Caledonia incorporated to a Village in the year 2005.

Source: SEWRPC.

Sanitary District in the Town of West Bend; the Town of Scott Sanitary District; the Wallace Lake Sanitary District in the Towns of Barton and Trenton; the Waubeka Area Sanitary District in the Town of Fredonia; and the Yorkville Sewer Utility District No. 1 in the Town of Yorkville

Inland Lake Protection and Rehabilitation Districts

Inland lake protection and rehabilitation districts are special-purpose units of government created pursuant to Chapter 33 of the *Wisconsin Statutes*. There are three such districts in the watershed: the Big Cedar Lake Protection and Rehabilitation District, the Little Cedar Lake Protection and Rehabilitation District, and the Silver Lake Protection and Rehabilitation District. Lake protection and rehabilitation district powers include 1) study of existing water-quality conditions to determine the causes of existing or expected future water-quality problems, 2) control of aquatic macrophytes and algae, 3) implementation of lake rehabilitation techniques, including aeration, diversion, nutrient removal or inactivation, dredging, sediment covering, and drawdown, 4) construction and operation of water-level-control structures, 5) control of nonpoint source pollution, and 6) creation, operation, and maintenance of a water safety patrol unit.

Other Agencies with Resource-Management Responsibilities Related to Water Quality

Superimposed upon these local and special-purpose units of government are those State and Federal agencies with important responsibilities for water quality management and resource conservation and management. These include the Wisconsin Department of Natural Resources (WDNR); the University of Wisconsin-Extension; the State Board of Soil and Water Conservation Districts; the U.S. Department of the Interior, U.S. Geological Survey; the U.S. Environmental Protection Agency; the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS); and the U.S. Army Corps of Engineers.

DEMOGRAPHIC AND ECONOMIC BASE

An understanding of the size, characteristics, and spatial distribution of the resident population is basic to any watershed-based planning effort because of the direct relationships which exist between population levels and the demand for land, water, and other important elements of the natural resource base, as well as the demand for various kinds of transportation, utility, and community facilities and services. The size and other characteristics of the population of an area are greatly influenced by growth and other changes in economic activity. Population characteristics and economic activity must, therefore, be considered together.

Demographic Base

For planning purposes, a demographic inventory should include consideration of population size, distribution, and composition.

Population Size

Table 2 shows the number of persons, the number of households, and the average household size for the regional water quality management plan study area in the year 2000 broken down by civil division. In 2000, the study area had a population of 1,281,444 persons and contained 506,164 households. Mean household size in the study area was about 2.5 persons per household. This quantity varied among the civil divisions, ranging between a low of 2.04 persons per household in the Village of Butler to a high of 3.11 persons per household in the Town of Germantown.

Table 3 shows the number of persons residing in the study area in 1970, 1980, 1990, and 2000. Between 1970 and 2000, the number of persons living in the study area declined from about 1,323,000 to about 1,281,000. A decline took place during the 1970s; since 1980 the population of the study area has increased. As shown in Figure 2, this overall result for the study area reflects different patterns of population change in the constituent watersheds. Population in the Kinnickinnic River watershed declined from 1970 to 1980 and has remained stable since then. A similar pattern was seen in the Menomonee River watershed. During the 1970s, population in this watershed exhibited declines. Since 1980, the total population within the watershed has remained relatively stable. Population change in the Milwaukee River watershed followed a slightly different pattern. Like the Kinnickinnic River and Menomonee River watersheds, the Milwaukee River watershed experienced a decline in population during the 1970s. This was followed, however, by a slight increase in population during the 1980s. Decline of population resumed during the 1990s. Population trends in the Oak Creek and Root River watersheds are characterized by a different pattern. In both of these watersheds, population has increased continuously since 1970. Finally, the Lake Michigan direct tributary drainage area has experienced continuous population decreases since 1970.

Table 4 shows the number of households in the study area in 1970, 1980, 1990, and 2000. Between 1970 and 2000, the number of households in the study area increased from about 412,300 to about 506,100, an increase of almost 23 percent. While the number of households increased in all six watersheds of the study area over the same period, the magnitude of growth in this quantity varied among the watersheds. The Kinnickinnic River watershed experienced the smallest increase, 3,158 households, representing an increase of 5.6 percent. By contrast, the Oak Creek watershed experienced a high increase in the number of households, 10,495, representing an increase of over 100 percent. Similarly, during this period, 25,709 households were added to the Root River watershed, representing a 65.5 percent increase in the number of households. While both the Menomonee River and Milwaukee River watersheds experienced increases in number of households in excess of 22,000, the increases in these watersheds represent a smaller percentage of growth.

These increases in the number of households, coupled with the changes in population sizes discussed above, reflect a trend toward decreasing household size in the study area. Table 5 shows mean household size for the study area and each of the constituent watersheds for the period 1970 to 2000. Overall, the mean household size in the study area declined by about 21 percent, from 3.21 persons per household in 1970 to 2.53 persons per household in 2000. The greatest change in household size occurred in the Oak Creek watershed where mean household size decreased from 3.65 persons per household in 1970 to 2.44 persons per household in 2000, a 33 percent decline. Slower decreases occurred in the Kinnickinnic River and Milwaukee River watersheds. Mean household size in these watersheds declined by about 17 percent over the same period resulting in values of 2.56 persons per household and 2.57 persons per household respectively in 2000. The other watersheds in the study area experienced intermediated percentage declines.

Table 2

POPULATION AND HOUSEHOLDS BY CIVIL DIVISION WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000[a]

Civil Division	Total Population	Total Households	Average Household Size
Dodge County			
Village of Lomira	155	71	2.18
Town of Lomira	132	43	3.07
Subtotal	287	114	2.52[b]
Fond du Lac County			
Village of Campbellsport	1,913	710	2.53
Town of Ashford	1,773	641	2.77
Town of Auburn	2,075	732	2.83
Town of Byron	375	136	2.76
Town of Eden	778	264	2.95
Town of Oseola	1,779	694	2.56
Subtotal	8,693	3,177	2.70[b]
Kenosha County			
Town of Paris	56	19	2.95
Subtotal	56	19	2.95[b]
Milwaukee County			
City of Cudahy	18,423	7,884	2.32
City of Franklin	30,254	10,958	2.57
City of Glendale	11,721	4,938	2.20
City of Greenfield	34,839	15,447	2.20
City of Milwaukee	596,663	231,776	2.50
City of Oak Creek	28,836	11,393	2.52
City of St. Francis	8,898	4,129	2.14
City of South Milwaukee	21,189	8,669	2.40
City of Wauwatosa	47,065	20,594	2.24
City of West Allis	60,922	27,399	2.18
Village of Bayside	4,200	1,637	2.47
Village of Brown Deer	12,190	5,138	2.28
Village of Fox Point	7,418	3,061	2.41
Village of Greendale	14,364	5,985	2.38
Village of Hales Corners	7,156	2,980	2.37
Village of River Hills	1,481	546	2.71
Village of Shorewood	13,609	6,419	2.09
Village of West Milwaukee	4,467	2,044	2.17
Village of Whitefish Bay	16,467	6,731	2.44
Subtotal	940,162	377,728	2.42[b]
Ozaukee County			
City of Cedarburg	10,906	4,397	2.47
City of Mequon	22,694	7,920	2.74
Village of Fredonia	1,863	679	2.74
Village of Grafton	11,090	4,364	2.53
Village of Saukville	4,088	1,584	2.58
Village of Thiensville	3,277	1,462	2.20
Town of Cedarburg	5,703	1,909	2.89
Town of Fredonia	1,955	681	2.87
Town of Grafton	3,421	1,285	2.66
Town of Port Washington	414	138	3.00
Town of Saukville	1,852	669	2.77
Subtotal	67,263	25,088	2.63[b]

Table 2 (continued)

Civil Division	Total Population	Total Households	Average Household Size
Racine County			
City of Racine	55,696	21,488	2.55
Village of Caledonia	24,194	8,820	2.69
Village of Mt. Pleasant	5,925	2,310	2.55
Village of North Bay[c]	- -	- -	- -
Village of Union Grove	2,528	916	2.66
Village of Wind Point	1,941	706	2.75
Town of Dover	552	35	2.83
Town of Raymond	3,348	1,194	2.80
Town of Yorkville	2,834	1,023	2.74
Subtotal	97,018	36,492	2.60[b]
Sheboygan County			
Village of Adell	517	207	2.50
Village of Cascade	666	255	2.61
Village of Random Lake	1,551	613	2.53
Town of Greenbush	1,389	448	3.10
Town of Lyndon	939	362	2.59
Town of Mitchell	1,098	405	2.71
Town of Scott	1,804	658	2.74
Town of Sherman	1,459	513	2.84
Subtotal	9,423	3,461	2.72[b]
Washington County			
City of West Bend	27,652	11,176	2.44
Village of Germantown	18,333	6,927	2.63
Village of Jackson	4,944	1,957	2.52
Village of Kewaskum	3,185	1,179	2.64
Village of Newburg	1,046	362	2.88
Town of Barton	2,543	897	2.84
Town of Farmington	3,239	1,116	2.90
Town of Germantown	205	66	3.11
Town of Jackson	3,541	1,206	2.94
Town of Kewaskum	1,211	428	2.83
Town of Polk	3,088	1,065	2.88
Town of Richfield	1,893	679	2.79
Town of Trenton	4,591	1,572	2.91
Town of Wayne	438	143	3.06
Town of West Bend	4,459	1,530	2.64
Subtotal	80,368	30,303	2.61[b]
Waukesha County			
City of Brookfield	18,455	6,767	2.72
City of Muskego	5,054	1,683	3.00
City of New Berlin	19,332	7,225	2.67
Village of Butler	1,835	896	2.04
Village of Elm Grove	6,247	2,446	2.55
Village of Menomonee Falls	26,960	10,605	2.54
Town of Brookfield	278	105	2.64
Town of Lisbon	13	5	2.60
Subtotal	78,174	29,732	2.54[b]
Total	1,281,444	506,114	2.47[d]

[a] *Civil division and watershed boundaries approximated by whole U.S. Public Land Survey one-quarter sections.*

[b] *This number represents the mean household size for those portions of the County in the study area.*

[c] *Because the Village of North Bay covers a relatively small land area, that does not lend itself to quantification on an U.S. Public Land Survey one-quarter section basis, the Village population is not specified separately in this table, but it is included in the population estimates for the City of Racine.*

[d] *This number represents the mean household size for the study area.*

Source: U.S. Bureau of the Census and SEWRPC.

Table 3

POPULATION BY WATERSHED WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1970-2000

Watershed	Population 1970	1980	1990	2000	Change 1970-2000 Persons	Percent
Kinnickinnic River.................	172,453	151,135	149,186	152,137	-20,316	-11.8
Menomonee River................	346,412	322,432	322,443	321,999	-24,413	-7.0
Milwaukee River...................	511,010	488,374	490,757	485,115	-25,895	-5.1
Oak Creek............................	38,162	41,365	43,301	51,033	12,871	33.7
Root River............................	142,268	149,688	155,090	169,420	27,152	19.1
Lake Michigan Direct Tributary Drainage	112,829	104,995	103,479	101,740	-11,089	-9.8
Total	1,323,134	1,257,989	1,264,256	1,281,444	-41,690	-3.2

Source: U.S. Bureau of the Census and SEWRPC.

Economic Base

Employment[1]

Information regarding the number and type of employment opportunities, or jobs, in an area is an important measure of the size and structure of the area's economy. Employment data presented in this section pertain to both wage and salary employment and the self-employed, and include both full-time and part-time jobs.

As shown in Table 6, total employment in the regional water quality management plan update study area stood at 828,793 jobs in 2000, compared to 776,155 jobs in 1990. Table 7 shows that, in relative terms, employment in the study area grew at a somewhat slower rate than the Southeastern Wisconsin Region, the State, and the Nation during the 1990s. As a result, the study area's share of total State employment decreased from about 28 percent to about 24 percent, with the study area's share of national employment also showing a slight decrease.

Information on current employment levels is presented by watershed in the study area in Table 6. With the exception of the Lake Michigan direct drainage area, each watershed in the study area experienced an increase in employment between 1990 and 2000. With an increase of almost 25,500 jobs, the Menomonee River watershed accounted for almost half of the total net increase in employment in the study area during the 1990s. Significant increases also occurred in the Root River and Milwaukee River watersheds. By comparison, the number of jobs in the Kinnickinnic River watershed remained stable during this period.

LAND USE

An important concept underlying the watershed planning effort is that land use development should be planned considering the ability of the underlying natural resource base to sustain such development. The type, intensity, and spatial distribution of land uses determine, to a large extent, the resource demands within a watershed. Water-resource demands can be correlated directly with the quantity and type of land use, as can water quality conditions. The existing land use pattern can best be understood within the context of its historical development. Thus, attention is focused here on both historical and existing land use development.

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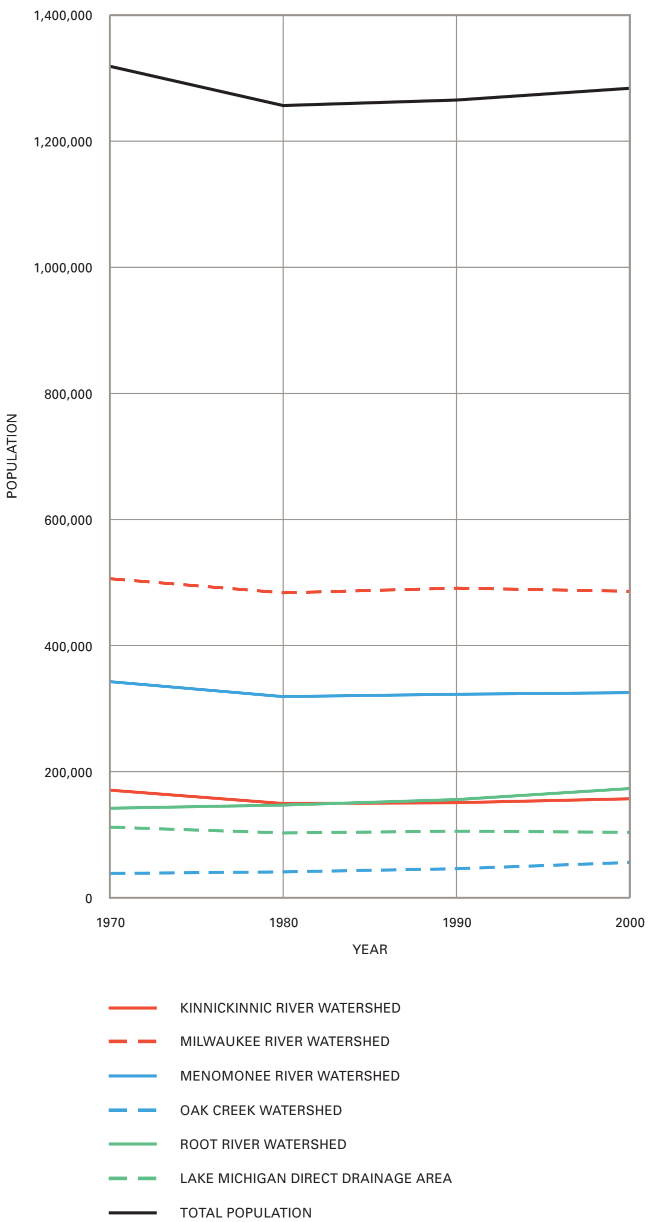
[1]*The Regional Planning Commission conducted a detailed inventory and analysis of the regional economy in 2004. The findings are presented in detail in SEWRPC Technical Report No. 10 (4th Edition),* The Economy of Southeastern Wisconsin, *dated July 2004.*

Figure 2

POPULATION TRENDS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1970-2000



Source: U.S. Bureau of the Census and SEWRPC.

Historic Growth Patterns

The movement of European settlers into the Southeastern Wisconsin Region began around 1830. Completion of the U.S. Public Land Survey in 1836 and the subsequent sale of public lands in Wisconsin brought an influx of settlers into the area. In 1850, the urban portion of the regional water quality management plan update study area was located at what is now the Cities of Cedarburg, Milwaukee, Racine, and West Bend and the Village of Grafton, along with many smaller settlements throughout the study area. Over the 100-year period from 1850 to 1950, urban development in the study area occurred in a pattern resembling concentric rings around existing urban centers, resulting in a relatively compact settlement pattern. After 1950, there was a significant change in the pattern and rate of urban development in the study area. While substantial amounts of development continued to occur adjacent to established urban centers, considerable development also occurred in isolated enclaves in outlying areas of the study area. Map 3 indicates a continuation of this trend during the 1990s within the northern and southern portions of the watersheds that are within the Southeastern Wisconsin Region, with significant development occurring adjacent to existing urban centers, and with considerable development continuing to occur in scattered fashion in outlying areas. In Milwaukee and Waukesha Counties in the central portion of the study area new urban development consists primarily of in-fill and redevelopment.

Table 8 summarizes the historic urban growth pattern in the study area for the period 1850 to 2000. The rate at which urban growth occurred in the study area increased gradually until 1940. After 1940, the rate of urban growth increased substantially, reaching a maximum average rate of approximately 4,500 acres converted to urban uses per year during the period 1950 to 1963. Since 1963, the average rate of urban growth in the study area has declined from this peak.

Existing Land Use

The existing land use pattern within the greater Milwaukee watersheds is shown on Map 4, and the existing land uses are quantified by watershed in Table 9.

As indicated in Table 9, about 486,000 acres of the watersheds, or about 67 percent of the total area of the watersheds, was still in rural uses in 2000, with agriculture and related open uses occupying about 304,000 acres, or about 42 percent of the total study area. In 2000, urban land uses occupied about 235,000 acres, or about 33 percent of the total area of the watersheds. Residential land use accounted for over 113,000 acres, or about 16 percent of the total study area.

Table 4

HOUSEHOLDS BY WATERSHED IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1970-2000

Watershed	Households 1970	1980	1990	2000	Change 1970-2000 Households	Percent
Kinnickinnic River	56,233	58,560	59,415	59,391	3,158	5.6
Menomonee River	107,155	119,766	125,231	129,736	22,581	21.0
Milwaukee River	165,099	178,271	183,251	188,947	23,848	14.4
Oak Creek	10,456	14,032	16,526	20,951	10,495	100.4
Root River	39,278	49,959	56,517	64,987	25,709	65.5
Lake Michigan Direct Tributary Drainage	34,046	38,708	40,606	42,102	8,056	23.7
Total	412,267	459,296	481,546	506,114	93,847	22.8

Source: U.S. Bureau of the Census and SEWRPC.

Table 5

HOUSEHOLD SIZE BY WATERSHED WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1970-2000

Watershed	Persons per Household 1970	1980	1990	2000	Change 1970-2000 Percent
Kinnickinnic River	3.03	2.55	2.49	2.54	-16.2
Menomonee River	3.03	2.67	2.60	2.49	-17.8
Milwaukee River	3.12	2.61	2.50	2.43	-22.1
Oak Creek	3.64	2.92	2.60	2.41	-33.8
Root River	3.56	2.94	2.69	2.53	-28.9
Lake Michigan Direct Tributary Drainage	3.26	2.68	2.51	2.39	-26.7
Total	3.14	2.68	2.56	2.47	-21.3

Source: U.S. Bureau of the Census and SEWRPC.

Table 6

TOTAL EMPLOYMENT WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1990-2000

Watershed	Employment 1990	2000	Change 1990-2000 Jobs	Percent
Kinnickinnic River	77,313	77,720	407	0.5
Menomonee River	242,086	267,578	25,492	10.5
Milwaukee River	325,662	337,876	12,214	3.8
Oak Creek	29,467	32,928	3,461	11.7
Root River	65,459	78,911	13,452	20.6
Lake Michigan Direct Tributary Drainage	36,168	33,780	-2,388	-6.6
Total	776,155	828,793	52,638	6.8

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Table 7

EMPLOYMENT IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA, THE REGION, WISCONSIN, AND THE UNITED STATES: 1990-2000[a]

Year	Regional Water Quality Management Plan Update Study Area			Southeastern Wisconsin Region			Wisconsin			United States			Regional Water Quality Management Plan Update Study Area As a Percent of:	
	Jobs	Change from Preceding Year		Jobs	Change from Preceding Year		Jobs	Change from Preceding Year		Jobs	Change from Preceding Year		Wisconsin	United States
		Number	Percent		Number	Percent		Number	Percent		Number	Percent		
1990	776,155	- -	- -	1,062,600	- -	- -	2,810,400	- -	- -	136,708,900	- -	- -	27.6	0.57
2000	828,793	52,638	6.8	1,222,800	160,200	15.1	3,421,800	611,400	21.8	165,209,800	28,500,900	20.8	24.2	0.50

[a]*Excludes military employment.*

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Table 10 shows land use for those portions of the study area within the Southeastern Wisconsin Region for the years 1970, 1990, and 2000. Historical land use data were unavailable for the portions of the study area outside of the Region. During the period from 1970 to 2000, the amount of land in the portion of the study area in the Region devoted to agricultural and related uses declined from about 420 square miles to about 317 square miles. Much of this decrease resulted from the conversion of land from agricultural and related uses to urban uses. Over the same time period, the amount of land in urban land uses increased from about 259 square miles to about 347 square miles. In addition, the area represented by surface water increased from 10.1 square miles in 1970 to 11.5 square miles in 2000. This change represents the net effect of a number of changes, including changes in watershed boundaries, changes in the water levels in inland lakes and ponds, and the construction of stormwater detention and infiltration basins. Over the same time period, the area represented by wetlands increased from 73.6 square miles to 78.2 square miles. This change represents the net effect of a number of changes, including conversion of prior-converted agricultural lands back to wetland, the creation or restoration of some wetlands, and the delineation of previously unidentified wetlands. The total area of the portion of the study area in the Region increased slightly by 0.5 square mile from 1970 to 2000. This increase represents the combined effects of refinements of watershed boundaries and the net effect of erosion and aggradation of land along the shore of Lake Michigan.

Park and Open Space

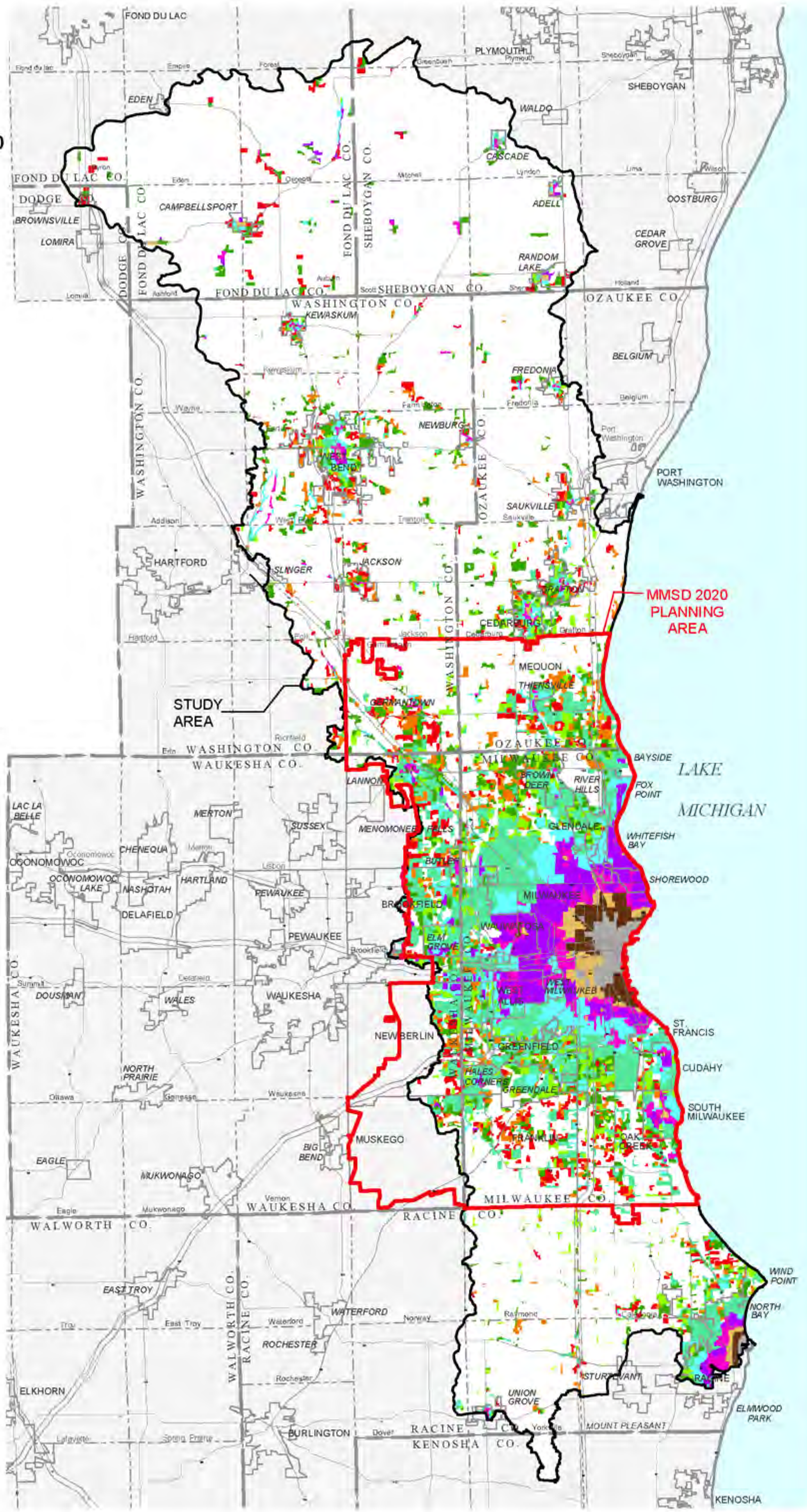
Comprehensive and areawide inventories of publicly owned park and open space sites have been conducted throughout the regional water quality management plan update study area. Park and open space sites owned by public agencies, including State, county, or local units of government and school districts, are identified in the inventories, as are lands held in conservation easements by organizations, such as the Wisconsin Department of Natural Resources. In addition, the inventories include privately owned resource-oriented outdoor recreation sites, such as golf courses, campgrounds, ski hills, boating access sites, swimming beaches, hunting clubs, retreat centers, open space areas, and group camps, such as Scout or YMCA camps, and special-use outdoor recreation sites of regional significance. Other resources of recreational significance, such as existing trails and bicycle ways and historic sites listed on the National Register of Historic Places, were identified.

Park and Open Space Sites Owned By County Governments

Park and open space sites owned by the seven counties that comprise the study area are shown on Map 5 and listed in Table 11. As of 2004, the counties owned 189 sites, comprising 18,400 acres of park land and open space or approximately 2.6 percent of the total acreage within the study area. Within the study area, Milwaukee County owns and manages the greatest amount of county-owned park land, over 15,000 acres, and has the three largest

Map 3

HISTORIC URBAN GROWTH WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1850-2000



	1850
	1880
	1900
	1920
	1940
	1950
	1963
	1970
	1980
	1990
	2000

NOTE: DATA NOT AVAILABLE FOR 1990 URBAN GROWTH ANALYSIS FOR DODGE, FOND DU LAC, AND SHEBOYGAN COUNTIES.

Source: SEWRPC.

Table 8

EXTENT OF URBAN GROWTH WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1850-2000

Year	Extent of New Urban Development Occurring Since Previous Year (acres)[a]	Cumulative Extent of Urban Development (acres)[a]	Cumulative Extent of Urban Development (percent)[a]
1850	4,617	4,617	0.6
1880	5,063	9,680	1.3
1900	4,479	14,159	2.0
1920	11,101	25,260	3.5
1940	18,331	43,591	6.0
1950	21,651	65,242	9.0
1963	57,944	123,186	17.1
1970	18,966	142,152	19.7
1980	15,360	168,494	23.4
2000	10,177	202,632	28.1

[a]Urban development, as defined for the purposes of this discussion, includes those areas within which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses. Scattered residential developments were not considered in this analysis.

Source: U.S. Bureau of the Census and SEWRPC.

contiguous areas of county-owned park land; the Oak Creek Parkway, the Root River Parkway, and the Little Menomonee River and Menomonee River Parkways.

Park and Open Space Sites Owned By the State of Wisconsin

Park and open space sites owned by the State of Wisconsin within the counties that comprise the study area are shown on Map 5 and listed in Table 11. The State of Wisconsin owns and manages 42 sites, with a total of approximately 30,150 acres or almost 4.2 percent of all land within the study area. Of the total State-owned acreage, one site, a portion of the Kettle Moraine State Forest-Northern Unit, comprises over two-thirds of the State-owned park land within the study area, over 23,460 acres located in Fond Du Lac and Washington Counties. Various State agencies maintain control over State owned park lands, notably the Department of Natural Resources, the Wisconsin Department of Transportation, and the University of Wisconsin.

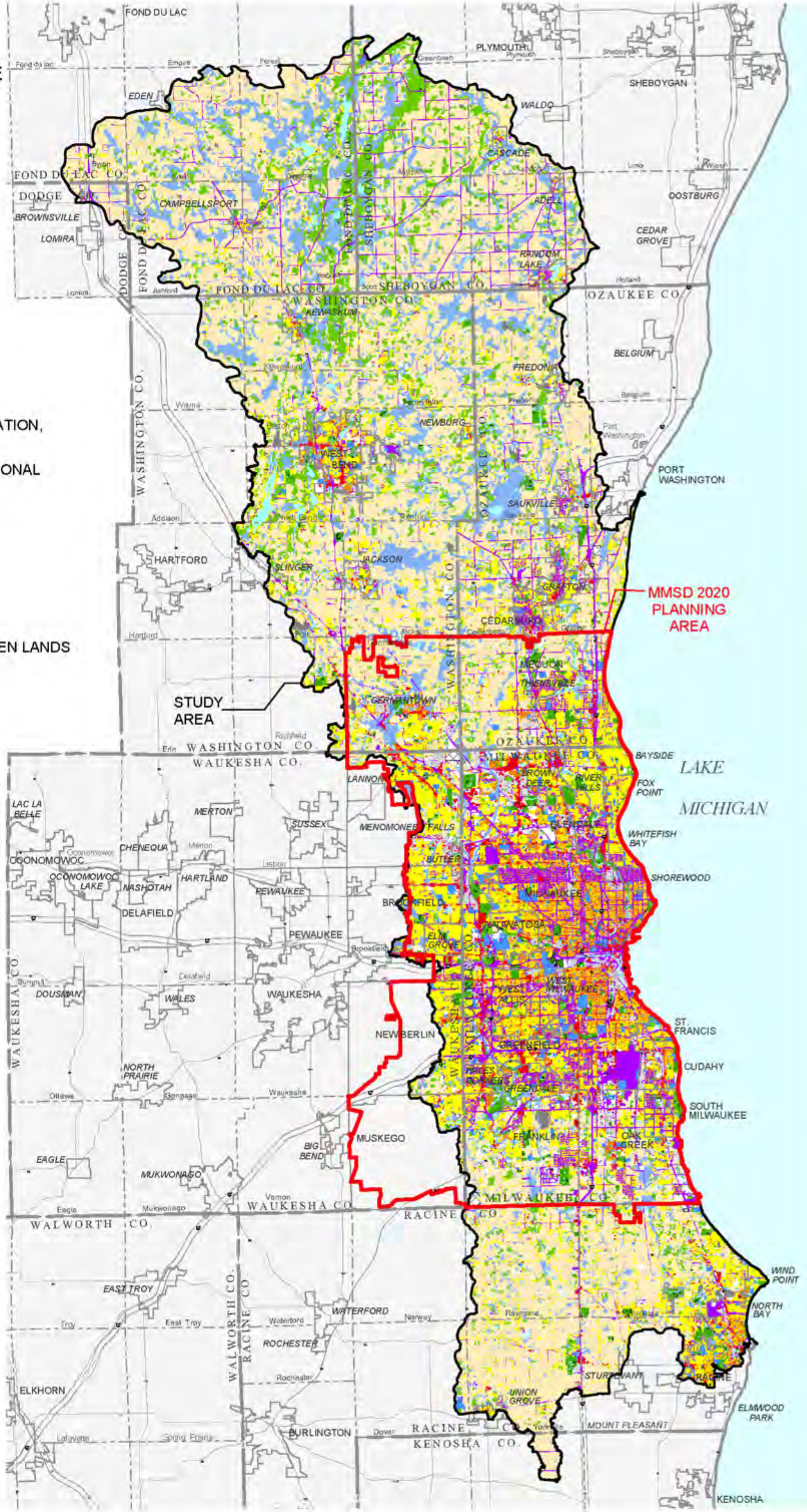
Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) has acquired large areas of park and open space lands throughout Wisconsin and within the study area for a variety of resource protection and recreational purposes. Park and open space sites owned by the Department of Natural Resources within the study area are listed in Table 11. Major sites acquired for resource preservation and limited recreational purposes include the Kettle Moraine State Forest-Northern Unit, the Cedarburg Bog Scientific Area, the Jackson Marsh Wildlife area, and Nichols Creek State Wildlife area. Aside from several major parks, the WDNR also maintains 18 sites comprised of nearly 500 acres throughout the study area.

In addition to the recreation and open space sites listed in Table 11, the Wisconsin Department of Natural Resources has defined the North Branch Milwaukee River Wildlife and Farming Heritage Project Area. Within this area, the Department does not intend to rely as heavily on fee simple acquisition as it does in the other project areas in the study area. Rather, the Department anticipates implementing a long-term plan of preserving both natural resource and agricultural lands within the project area through a combination of public ownership, conservation easements, and purchase of development rights. The project area encompasses a 19,500-acre area entirely within the Milwaukee River watershed, as shown on Map 5.

Map 4

EXISTING LAND USE WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000



SINGLE-FAMILY RESIDENTIAL
MULTI-FAMILY RESIDENTIAL
COMMERCIAL
INDUSTRIAL
TRANSPORTATION, COMMUNICATION, AND UTILITIES
GOVERNMENTAL AND INSTITUTIONAL
RECREATIONAL
SURFACE WATER
WOODLANDS
WETLANDS
AGRICULTURAL AND OTHER OPEN LANDS
EXTRACTIVE
LANDFILL

N

GRAPHIC SCALE
0 2 4 6 8 Miles
0 10,000 20,000 30,000 40,000 50,000 Feet

Source: SEWRPC.

Table 9

LAND USE IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000[a,b]

	Watershed												Total	
	Lake Michigan Direct Drainage		Kinnickinnic River		Menomonee River		Milwaukee River		Oak Creek		Root River			
Category	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban														
Residential	9,322	35.6	5,741	34.7	25,928	29.8	45,848	10.2	4,599	25.5	22,215	17.6	113,384	15.7
Commercial	520	2.0	913	5.8	3,510	4.0	4,045	0.9	638	3.5	1,812	1.4	11,438	1.6
Industrial	844	3.2	1,154	7.3	4,417	5.1	5,688	1.3	865	4.8	1,639	1.3	14,608	2.0
Transportation, Communication, and Utilities[c]	4,519	17.3	5,175	32.8	14,546	16.8	28,504	6.4	3,516	19.5	10,645	8.4	66,904	9.3
Governmental and Institutional	971	3.7	1,201	7.6	3,647	4.2	4,415	0.9	652	3.6	1,956	1.5	12,841	1.8
Recreational	1,200	4.6	646	4.1	3,409	3.9	6,593	1.5	555	3.1	3,361	2.7	15,763	2.2
Subtotal	17,376	66.4	14,560	92.3	55,457	63.8	95,093	21.2	10,825	60.0	41,628	32.9	234,938	32.6
Rural														
Agricultural and Related	2,801	10.7	70	0.4	14,978	17.3	219,168	48.9	2,919	16.2	64,012	50.6	303,948	42.1
Water	127	0.5	153	1.0	542	0.6	7,715	1.7	28	0.2	1,017	0.8	9,583	1.3
Wetlands	415	1.6	57	0.3	6,741	7.8	67,110	15.0	920	5.1	6,793	5.4	82,036	11.4
Woodlands	1,464	5.6	92	0.6	2,110	2.4	39,836	8.9	760	4.2	4,936	3.9	49,199	6.8
Landfill, Extractive, Unused, and Other Open Land	3,983	15.2	847	5.4	7,062	8.1	19,080	4.3	2,587	14.3	8,104	6.4	41,662	5.8
Subtotal	8,790	33.6	1,219	7.7	31,433	36.2	352,909	78.8	7,214	40.0	84,862	67.1	486,428	67.4
Total	26,166	100.0	15,779	100.0	86,890	100.0	444,802	100.0	18,039	100.0	126,490	100.0	721,366	100.0

[a]*As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b]*As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more usable to public agencies and private interests throughout the Region. As a result of this change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the watershed and study area level, the most significant effect of the change is the increase to transportation, communication, and utilities categories, as a result of the use of narrower estimated right-of-ways in prior inventories. The treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories.*

[c]*Off-street parking of more than 10 spaces is included with the associated land use.*

Source: SEWRPC.

Table 10

LAND USE IN THE SOUTHEASTERN WISCONSIN PORTION OF THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1970-2000[a,b,c]

Category	1970		1990		2000[b]		Change 1970-2000	
	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent of Total
Urban								
Residential	123.5	14.4	152.4	17.7	169.0	19.7	45.5	36.8
Commercial	9.7	1.1	15.2	1.8	17.6	2.0	7.9	81.4
Industrial	14.7	1.7	18.5	2.1	21.6	2.5	6.9	46.9
Transportation, Communication, and Utilities[d]	77.1	9.0	84.8	9.9	96.0	11.2	18.9	24.5
Governmental and Institutional	17.1	2.0	18.7	2.2	19.4	2.2	2.3	13.5
Recreational	17.3	2.0	20.7	2.4	23.7	2.8	6.4	37.0
Subtotal	259.4	30.2	310.3	36.1	347.3	40.4	87.9	33.9
Rural								
Agricultural and Related	419.8	48.8	362.2	42.1	317.2	36.9	-102.6	-24.4
Water	10.1	1.2	11.2	1.3	11.5	1.3	1.4	13.9
Wetlands	73.6	8.6	75.6	8.8	78.2	9.1	4.6	6.2
Woodlands	42.2	4.9	43.4	5.1	43.6	5.1	1.4	3.3
Unused and Other Open Lands	54.4	6.3	57.0	6.6	62.2	7.2	7.8	14.3
Subtotal	600.1	69.8	549.4	63.9	512.7	59.6	-87.4	-14.6
Total	859.5	100.0	859.7	100.0	860.0	100.0	0.5	- -

[a] *As approximated by whole U.S. Public Land Survey one-quarter sections.*

[b] *As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more usable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is the increase to transportation, communication, and utilities category, as a result of the use of narrower estimated right-of-ways in prior inventories. The treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories.*

[c] *Because data are unavailable for Dodge, Fond du Lac, and Sheboygan Counties for 1970 and 1990, these data include only those portions of the study area that are within the Southeastern Wisconsin Region.*

[d] *Off-street parking of more than 10 spaces is included with the associated land use.*

Source: SEWRPC.

Wisconsin Department of Transportation

The Wisconsin Department of Transportation manages five sites within the study area. Three of these sites are waysides, and the other two are mitigation sites. Each wayside is approximately two acres, while the combined acreage of the two mitigation sites is 138 acres. Park and open space sites owned by the Wisconsin Department of Transportation that are located within the study area are listed in Table 11.

University of Wisconsin

The University of Wisconsin owns and manages three sites with about 356 acres within the study area, and jointly owns the 1,568 acre Cedarburg Bog Scientific Area with the Department of Natural Resources. Park and open space sites owned by the University of Wisconsin that are located within the study area are listed in Table 11.

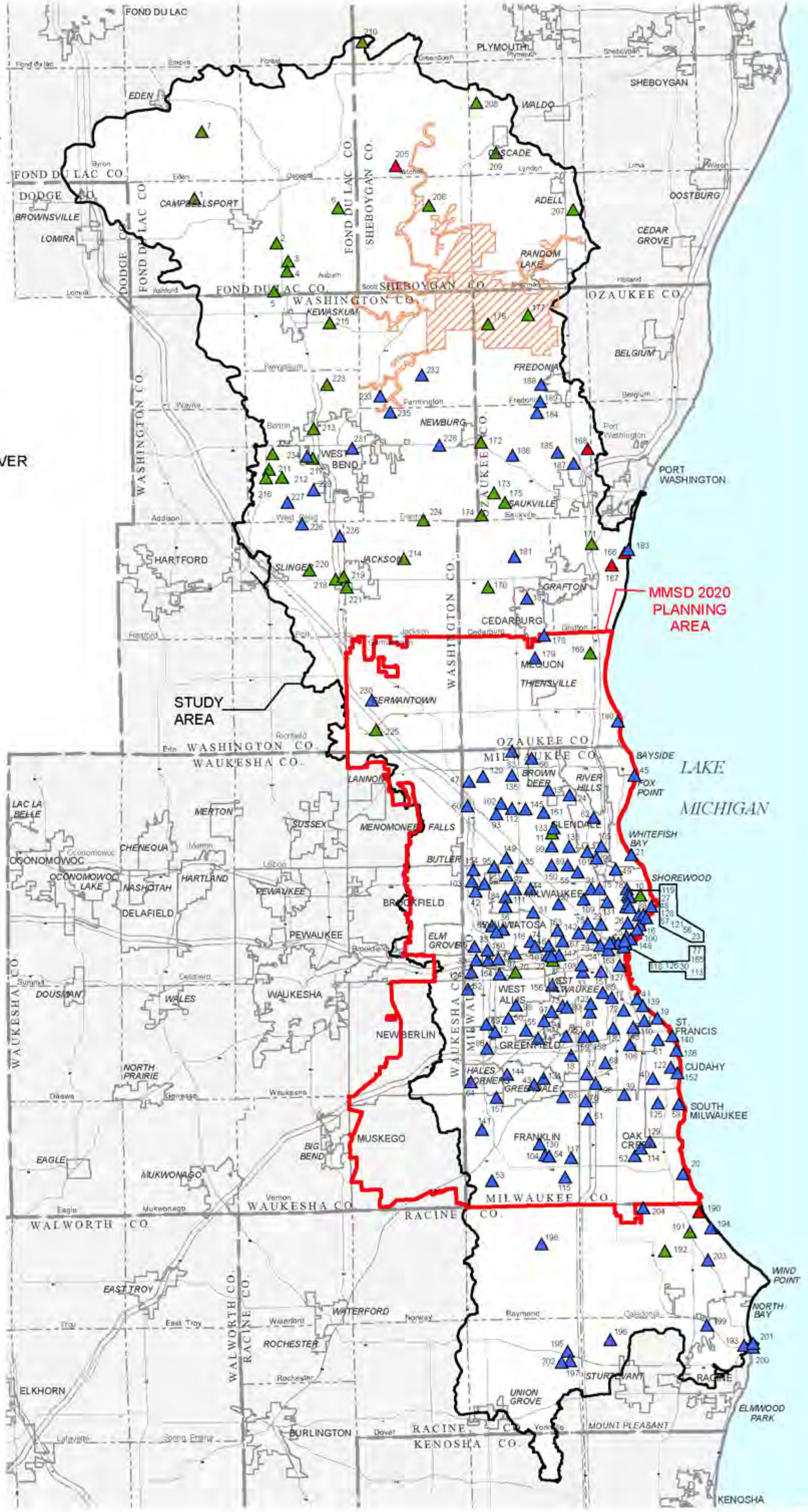
Park and Open Space Sites Owned By the United States Federal Government

The United States Federal Government maintains five sites within the study area. The United States Fish and Wildlife Service maintains four sites, three in Ozaukee County and one in Sheboygan County. The fifth Federal site is the Racine County Line Rifle Club Range. In total, these sites comprise about 514 acres and are listed in Table 11.

Map 5

FEDERAL, STATE, AND COUNTY RECREATION AND OPEN SPACE LANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- FEDERAL SITE
- STATE SITE
- COUNTY SITE
- 15 IDENTIFICATION NUMBER (SEE TABLE 11)
- NORTH BRANCH MILWAUKEE RIVER WILDLIFE AND FARMING HERITAGE PROJECT AREA



Source: SEWRPC.

Table 11

FEDERAL, STATE, AND COUNTY RECREATION AND OPEN SPACE LANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Number on Map 5	Site Name	Location[a]	Size (acres)
	Fond du Lac County		
	State Sites		
1	WDNR Site	T13N, R18E, Section 3	10
2	WDNR Site	T13N, R19E, Section 20	19
3	WDNR Site	T13N, R19E, Section 28	9
4	WDNR Site	T13N, R19E, Section 28	3
5	WDNR Site	T13N, R19E, Section 32	6
6	Kettle Moraine State Forest-Northern Unit	T13N, R19E, Sections 1, 2, 3, 10, 11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 25, 26, 35, 36 T13N, R20E, Sections 5, 7, 18, 19 T14N, R19E, Sections 1, 12, 13, 22, 23, 24, 25, 26, 34, 35, 36 T14N, R20E, Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 21, 29, 30, 31, 32 T15N, R20E, Sections 27, 28, 32, 33, 34	20,638[b]
7	WDNR Site	T14N, R18E, Section 22	16
	Milwaukee County		
	State Sites		
8	Miller Park[c]	T7N, R21E, Section 26	98
9	State Fairgrounds	T7N, R21E, Section 33	214
10	University of Wisconsin-Milwaukee	T7N, R22E, Section 10	25
11	Havenwoods State Forest	T8N, R21E, Section 26	237
	County Sites		
12	Alcott Park	T6N, R21E, Section 17	17
13	Algonquin Park	T8N, R21E, Section 14	9
14	Armour Park	T6N, R21E, Section 22	16
15	Atkinson Triangle	T7N, R22E, Section 08	1
16	Back Bay	T7N, R22E, Section 22	7
17	Baran Park	T6N, R22E, Section 8	24
18	Barnard Park	T6N, R21E, Section 25	10
19	Bay View Park	T6N, R22E, Section 14	38
20	Bender Park	T5N, R22E, Section 25	304
21	Big Bay Park	T8N, R22E, Section 33	7
22	Bluff Park	T7N, R21E, Section 26	7
23	Bradford Beach	T7N, R22E, Section 15	27
24	Brown Deer Park	T8N, R21E, Section 13	363
25	Burns Commons	T7N, R22E, Section 21	2
26	Caesar's Park	T7N, R22E, Section 21	3
27	Cambridge Woods	T7N, R22E, Section 9	21
28	Cannon Park	T7N, R21E, Section 29	8
29	Carver Park	T7N, R22E, Section 20	28
30	Cathedral Square	T7N, R22E, Section 28	2
31	Center Street Park	T7N, R21E, Section 15	5
32	Chippewa Park	T7N, R21E, Section 30	11
33	Clarke Square	T7N, R22E, Section 31	2
34	Clas Park	T7N, R22E, Section 29	1
35	Columbus Park	T7N, R21E, Section 3	10
36	Cooper Park	T7N, R21E, Section 16	8
37	Copernicus Park	T6N, R22E, Section 31	20
38	County Grounds	T7N, R21E, Section 20	231
39	Cudahy Nature Preserve	T5N, R22E, Section 4	72
40	Cudahy Park	T6N, R22E, Section 34	18
41	Cupertino Park	T6N, R22E, Section 10	7
42	Currie Park	T7N, R21E, Section 7	196
43	Dale Creek Parkway	T6N, R21E, Section 34	45
44	Dineen Park	T7N, R21E, Section 10	64
45	Doctors Park	T8N, R22E, Section 10	51

Table 11 (continued)

Number on Map 5	Site Name	Location[a]	Size (acres)
	Milwaukee County (continued)		
	County Sites (continued)		
46	Doyne Park	T7N, R21E, Section 26	35
47	Dretzka Park	T8N ,R21E, Section 7	326
48	Eastside Bike Trail	T7N, R22E, Section 5	61
49	Estabrook Park	T7N, R22E, Section 4	126
50	Euclid Park	T6N, R21E, Section 16	9
51	Falk Park	T5N, R22E, Section 7	215
52	Former North Shore R.O.W	T5N, R22E, Section 9	71
53	Franklin Park	T5N, R21E, Section 29	165
54	Froemming Park	T5N, R21E, Section 23	17
55	Garden Homes Square	T7N, R22E, Section 6	2
56	Gilman Triangle	T7N, R22E, Section 15	1
57	Gordon Park	T7N, R22E, Section 16	25
58	Grant Park	T5N, R22E, Section 1	375
59	Grantosa Parkway	T7N, R21E, Section 8	11
60	Granville Dog Park	T8N, R21E, Section 18	25
61	Greene Park	T6N, R22E, Section 23	36
62	Greenfield Park	T6N, R21E, Section 6	282
63	Grobschmidt Park	T5N, R21E, Section 1	152
64	Hales Corners Park	T6N, R21E, Section 31	33
65	Hansen Park	T7N, R21E, Section 20	54
66	Hanson A.C. Park	T8N, R21E, Section 3	14
67	Highland Park	T7N, R21E, Section 25	3
68	Holler Park	T6N, R22E, Section 29	15
69	Holt Park	T6N, R21E, Section 17	21
70	Honey Creek Parkway	T7N, R21E, Section 28	108
71	Hoyt Park	T7N, R21E, Section 21	20
72	Humboldt Park	T6N, R22E, Section 9	70
73	Jackson Park	T6N, R21E, Section 12	113
74	Jacobus Park	T7N, R21E, Section 27	26
75	Johnsons Park	T7N, R22E, Section 19	13
76	Johnstone Park	T5N, R22E, Section 6	13
77	Juneau Park	T7N, R22E, Section 28	15
78	Kern Park	T7N, R22E, Section 9	3
79	King Park	T7N, R22E, Section 19	21
80	Kinnickinnic River Parkway	T6N, R21E, Section 11	194
81	KK Sports Center	T6N, R22E, Section 7	20
82	Kletzsch Park	T8N, R22E, Section 19	130
83	Kohl Park	T8N, R21E, Section 3	205
84	Kops Park	T7N, R21E, Section 9	8
85	Kosciuszko Park	T6N, R22E, Section 5	34
86	Kulwicki Park	T6N, R21E, Section 19	48
87	La Follette Park	T7N, R21E, Section 32	18
88	Lake Park	T7N, R22E, Section 15	129
89	Lincoln Creek Parkway	T8N, R22E, Section 31	126
90	Lincoln Park	T8N, R22E, Section 31	312
91	Lingbergh Park	T7N, R22E, Section 7	3
92	Lindsay Park	T7N, R21E, Section 4	13
93	Little Menomonee River Parkway	T8N, R21E, Section 31	863
94	Lyons Park	T6N, R21E, Section 14	12
95	Madison Park	T7N, R21E, Section 5	59
96	Maitland Park	T6N, R22E, Section 31	27
97	Manitoba Park	T6N, R21E, Section 11	4
98	McCarty Park	T6N, R21E, Section 9	52
99	McGovern Park	T8N, R21E, Section 35	61
100	McKinley Park[d]	T7N, R22E, Section 22	101
101	Meaux Park	T8N, R22E, Section 31	26
102	Melody View Preserve	T8N, R21E, Section 16	14
103	Menomonee River Parkway	T7N, R21E, Section 6	597
104	Milwaukee County Sports Complex	T5N, R21E, Section 23	119
105	Milwaukee River Parkway	T8N, R22E, Section 19	106

Table 11 (continued)

Number on Map 5	Site Name	Location[a]	Size (acres)
	Milwaukee County (continued)		
	County Sites (continued)		
106	Mitchell Airport Park	T6N, R22E, Section 21	19
107	Mitchell Boulevard	T7N, R21E, Section 26	15
108	Mitchell Park	T7N, R22E, Section 31	61
109	Moody Park	T7N, R22E, Section 7	4
110	Morgan Triangle	T6N, R22E, Section 15	1
111	Nash Park	T7N, R21E, Section 9	9
112	Noyes Park	T8N, R21E, Section 21	72
113	O'Donnell Park	T7N, R22E, Section 28	7
114	Oak Creek Parkway	T5N, R22E, Section 10	1,051
115	Oakwood Park	T5N, R21E, Section 25	277
116	Park Maintenance	T7N, R21E, Section 27	4
117	Park Site 59 (Southwood Glen)	T5N, R21E, Section 24	9
118	Pere Marquette Park	T7N, R22E, Section 29	2
119	Pleasant Valley Park	T7N, R22E, Section 9	23
120	Popuch Park	T8N, R21E, Section 8	12
121	Prospect Triangle	T7N, R22E, Section 15	1
122	Pulaski Park (Cudahy)	T6N, R22E, Section 26	16
123	Pulaski Park (Milwaukee)	T6N, R22E, Section 7	26
124	Rainbow Park	T7N, R21E, Section 31	26
125	Rawson Park	T5N, R22E, Section 2	30
126	Red Arrow Park	T7N, R22E, Section 29	1
127	Riverfront Launch Site	T7N, R22E, Section 33	1
128	Riverside Park	T7N, R22E, Section 16	26
129	Riverton Meadows	T5N, R22E, Section 15	8
130	Root River Parkway	T6N, R21E, Section 7	3776
131	Rose Park	T7N, R22E, Section 17	10
132	Saveland Park	T6N, R22E, Section 17	3
133	Schoenecker Park	T8N, R21E, Section 26	17
134	Scout Lake Park	T6N, R21E, Section 35	64
135	Servite Park Preserve	T8N, R21E, Section 9	20
136	Sheridan Park	T6N, R22E, Section 25	107
137	Sherman Park	T7N, R21E, Section 13	21
138	Smith Park	T8N, R21E, Section 36	19
139	South Shore Park[e]	T6N, R22E, Section 10	35
140	St. Francis Property	T6N, R22E, Section 23	24
141	St. Martin’s Park	T5N, R21E, Section 7	19
142	Tiefenthaler Park	T7N, R22E, Section 19	11
143	Tippecanoe Park	T6N, R22E, Section 16	17
144	Trimborn Farm	T6N, R21E, Section 33	7
145	Uihlein Soccer Park	T8N, R21E, Section 22	51
146	Underwood Creek Parkway	T7N, R21E, Section 20	173
147	Valley Park	T7N, R21E, Section 25	1
148	Veteran’s Park	T7N, R22E, Section 28	101
149	Vogel Park	T8N, R21E, Section 33	12
150	Wahl Park	T7N, R21E, Section 2	12
151	Walker Square	T7N, R22E, Section 32	2
152	Warnimont Park	T6N, R22E, Section 36	249
153	Washington Park	T7N, R21E, Section 23	129
154	Webster Park	T7N, R21E, Section 6	5
155	Wedgewood Park	T6N, R21E, Section 15	6
156	West Milwaukee Park	T6N, R21E, Section 2	22
157	Whitnall Park	T5N, R21E, Section 5	625
158	Wilson Park	T6N, R22E, Section 19	77
159	Wilson Recreation Center	T6N, R22E, Section 19	51
160	Wisconsin Avenue Park	T7N, R21E, Section 29	18
161	Wyrick Park	T8N, R21E, Section 23	18
162	Zablocki Park	T6N, R21E, Section 24	45
163	Zeidler Union Square	T7N, R22E, Section 29	1
164	Milwaukee County Zoo	T7N, R21E, Section 29	170
165	War Memorial and Art Center	T7N, R22E, Section 28	14

Table 11 (continued)

Number on Map 5	Site Name	Location[a]	Size (acres)
	Ozaukee County		
	Federal Sites		
166	U.S. Fish and Wildlife Service	T10N, R22E, Section 9	40
167	U.S. Fish and Wildlife Service	T10N, R22E, Section 16	55
168	U.S. Fish and Wildlife Service	T11N, R21E, Section 13	40
	State Sites		
169	WDNR Site	T9N, R22E, Section 7	30
170	Cedarburg Habitat Preservation	T10N, R21E, Section 20	21
171	WDNR Site	T10N, R22E, Section 8	28
172	Wayside	T11N, R21E, Section 7	2
173	UW Cedarburg Bog Arboretum	T11N, R21E, Sections 29, 30	295
174	WDNR Site	T11N, R21E, Section 31	80
175	Cedarburg Bog Scientific Area	T11N, R21E, Sections 20, 21, 28, 29, 31, 32	1,568
176	Scattered Wetland	T12N, R21E, Section 7	80
177	WDNR Site	T12N, R21E, Section 9	73
	County Sites		
178	Carlson Park/Ozaukee Ice Center	T9N, R21E, Section 2	12
179	Mee-Kwon County Park	T9N, R21E, Sections 10, 11	239
180	Virmond Park	T9N, R22E, Section 28	66
181	Covered Bridge Park	T10N, R21E, Section 10	12
182	Ozaukee County Fairgrounds	T10N, R21E, Sections 22, 27	18
183	Lion’s Den Gorge Nature Preserve	T10N, R22E, Section 10	79
184	Hawthorne Hills County Park	T11N, R21E, Sections 3, 4	290
185	Tendick Nature Park	T11N, R21E, Section 14	123
186	Guenther Farmstead	T11N, R21E, Section 17	213
187	Ehlers County Park	T11N, R21E, Sections 13, 14, 23, 24	11
188	Waubedonia Park	T12N, R21E, Sections 27, 34	42
189	Magritz Property	T12N, R21E, Section 34	60
	Racine County		
	Federal Sites		
190	Racine County Line Rifle Club Range	T4N, R23E, Section 6	80
	State Sites		
191	32nd Division Memorial Marker and Wayside	T4N, R22E, Section 12	2
192	Renak-Polak Maple Beech Woods	T4N, R22E, Section 14	107
	County Sites		
193	Belle Harbor Marina	T3N, R23E, Section 9	5
194	Cliffside Park	T4N, R23E, Sections 7, 8	233
195	Evans Park	T3N, R21E, Section 12	66
196	Haban Park	T3N, R22E, Section 8	37
197	Ives Grove Golf Links	T3N, R21E, Section 13	291
198	Koerber Property	T4N, R21E, Section 15	11
199	Quarry Lake Park	T3N, R23E, Section 6	40
200	Racine Harbor Park	T3N, R23E, Section 9	17
201	Reef Point Marina	T3N, R23E, Section 9	40
202	Skewes Memorial Park	T3N, R21E, Section 14	4
203	Tabor Sokol Memorial Park	T4N, R23E, Section 19	1
204	Root River Parkway	T3N, R23E, Section 6 T4N, R21E, Section 1 T4N, R22E, Sections 3, 4, 5, 10, 11, 14, 23, 25 T4N, R23E, Sections 19, 30, 31	651
	Sheboygan County		
	Federal Sites		
205	U.S. Fish and Wildlife Service	T14N, R20E, Sections 32, 33	299
	State Sites		
206	Kettle Moraine Springs Fish Hatchery	T13N, R20E, Sections 10, 11	313
207	Adell Wildlife Area	T13N, R21E, Sections 12, 13	139
208	Nichols Creek State Wildlife Area	T14N, R20E, Section 12 T14N, R21E, Sections 7, 18	659
209	WDNR Site	T14N, R21E, Section 29	40
210	WDNR Site	T15N, R20E, Section 30	84

Table 11 (continued)

Number on Map 5	Site Name	Location[a]	Size (acres)
	Washington County		
	State Sites		
211	Gilbert Lake Open Space Site	T11N, R19E, Section 20	35
212	Hacker Road Bog Natural Area	T11N, R19E, Section 20	28
213	Ice Age Trail Corridor	T11N, R19E, Section 10	8
214	Jackson Marsh Wildlife Area	T10N, R20E, Sections 8-11, 14-17	2,196
215	Kettle Moraine State Forest-Northern Unit	T12N, R19E, Section 1, 2, 10-15, 22-24	2,828[f]
216	Public Access-Big Cedar Lake	T11N, R19E, Section 19	2
217	University of Wisconsin Center-Washington County	T11N, R19E, Section 15	36[g]
218	WDNR Site	T10N, R19E, Section 13	2
219	WDNR Site	T10N, R19E, Section 13	3
220	WDNR Site	T10N, R19E, Section 14	17
221	WDNR Site	T10N, R20E, Section 19	23
222	WDNR Site	T11N, R19E, Section 17	20
223	WDNR Site	T12N, R19E, Section 26	15
224	WisDOT Mitigation Site	T11N, R20E, Section 34	21
225	WisDOT Mitigation Site	T9N, R20E, Section 29	117
	County Sites		
226	Ackerman's Grove County Park	T10N, R19E, Section 3	78
227	Cedar Lake Wayside	T11N, R19E, Section 28	3
228	Goeden Park	T11N, R20E, Section 14	4
229	Henschke Hillside Lake Access	T11N, R19E, Section 27	9
230	Homestead Hollow Park	T9N, R20E, Section 20	105
231	Hughes Burckhardt Field[h]	T11N, R19E, Section 13	12
232	Leonard J. Yahr Park	T12N, R20E, Section 27	38
233	Lizard Mound Park	T12N, R20E, Sections 31, 32	31
234	Ridge Run Park	T11N, R19E, Section 15	148
235	Sandy Knoll Park	T11N, R20E, Section 5	257
236	Washington County Fair Park	T10N, R19E, Section 1	129

[a]*Indicates location given in U.S. Public Land Survey Township, Range, and Section.*

[b]*Only includes those lands within the Milwaukee River Watershed that are outside the Southeastern Wisconsin Region-Fond du Lac and Sheboygan County.*

[c]*Owned by the Southeast Wisconsin Professional Baseball Park District, a special purpose district established by the State.*

[d]*Includes Milwaukee Yacht Club, which is privately owned.*

[e]*Includes South Shore Yacht Club, which is privately owned.*

[f]*Only includes those lands located in Washington County.*

[g]*The University of Wisconsin Center-Washington County is located on lands managed by the University, but owned jointly by Washington County and the City of West Bend. The entire site encompasses 60 acres, of which 36 acres are in recreational or open space use.*

[h]*Hughes Burckhardt Field is on County-owned land leased by the County to the West Bend Little League.*

Source: SEWRPC.

Historic Sites

Historic sites within the study area often have important recreational, educational, and cultural value. A number of inventories and surveys of potentially significant historic sites have been conducted by various units and agencies of government within the study area. The results of these inventories and surveys are on file at agencies, such as the Wisconsin Historical Society, as well as county and local agencies.

Certain sites of known historic significance are listed on the National Register of Historic Places. In 2004, there were 237 individual sites and 48 historic districts within the study area listed on the National Register. The locations of these sites and districts are presented in Tables 12 through 14 and Map 6, respectively.

Table 12

HISTORIC SITES AND DISTRICTS ON THE NATIONAL REGISTER OF HISTORIC PLACES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA, EXCEPTING THE CITIES OF MILWAUKEE AND RACINE: 2004

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
		Fond du Lac County		
3	Saint John Evangelical Lutheran Church	131926	Town of Auburn	1986
4	St. Matthias Mission	131924	Town of Auburn	1988
		Milwaukee County		
1	Benjamin Church House	072204	Village of Shorewood	1972
2	Lowell Damon House	072121	City of Wauwatosa	1972
4	Frederick C. Bogk House	072215	City of Milwaukee	1972
5	Jeremiah Curtin House	062133	Village of Greendale	1972
9	St. Josephat Basilica	062208	City of Milwaukee	1973
16	Milwaukee -Downer "Quad"	072210	City of Milwaukee	1974
17	Henni Hall	062215	City of St. Francis	1974
19	Annunciation Greek Orthodox Church	072105	City of Wauwatosa	1974
29	Frederick Pabst House	072230	City of Milwaukee	1975
31	Joseph Schlitz Brewing Company Saloon	062209	City of Milwaukee	1977
32	Robert Machek House	072219	City of Milwaukee	1977
33	Painesville Chapel	052124	City of Franklin	1977
36	Joseph W. Kalvelage House	072230	City of Milwaukee	1978
37	South Milwaukee Passenger Station	052211	City of South Milwaukee	1978
41	Charles Quarles House	072215	City of Milwaukee	1979
44	Spring Grove Site	082219	City of Glendale	1979
47	Sunnyhill Home	072121	City of Wauwatosa	1980
48	Trimborn Farm	062128	Village of Greendale	1980
49	Forest Home Cemetery and Chapel	062207	City of Milwaukee	1980
50	Elderwood	082220	City of Glendale	1980
51	Milwaukee Fire Department-High Pressure Pumping Station	062205	City of Milwaukee	1981
52	Bay View Historic District	062210	City of Milwaukee	1982
59	Herman Uihlien House	082233	Village of Whitefish Bay	1983
61	Ward Memorial Hall	072135	City of Milwaukee	1984
66	Shorewood Village Hall	072210	Village of Shorewood	1984
72	N. 1st Street Historic District	072217	City of Milwaukee	1984
77	North Point Light House	072215	City of Milwaukee	1984
79	Milwaukee County Dispensary and Emergency Hospital	072230	City of Milwaukee	1985
80	Concordia Historic District	072125	City of Milwaukee	1985
81	Highland Boulevard Historic District	072125	City of Milwaukee	1985
82	McKinley Boulevard Historic District	072124	City of Milwaukee	1985
83	Starke Meyer House	082216	Village of Fox Point	1985
84	Otto F. Fiebing House	072126	City of Milwaukee	1985
85	Alfred M. Hoelz House	072203	City of Milwaukee	1985
86	Thomas Bossert House	072210	Village of Shorewood	1985
87	Erwin Cords House	072203	Village of Shorewood	1985
88	Seneca W. and Bertha Hatch House	072210	Village of Shorewood	1985
89	Henry A. Meyer House	072210	Village of Shorewood	1985
90	George E. Morgan House	072203	Village of Shorewood	1985
91	H. R. Davis House	072127	City of Wauwatosa	1985
92	J. H. Fiebing House	072121	City of Wauwatosa	1985
93	Warren B. George House	072127	City of Wauwatosa	1985
94	Willis Hopkins House	072128	City of Wauwatosa	1985
95	Pearl C. Norton House	072121	City of Wauwatosa	1985
96	Rufus Arndt House	072203	Village of Whitefish Bay	1985
97	Barfield-Staples House	082233	Village of Whitefish Bay	1985
98	George Gabel House	072203	Village of Whitefish Bay	1985
99	Paul S. Grant House	082233	Village of Whitefish Bay	1985
100	Harrison Hardie House	072203	Village of Whitefish Bay	1985
101	Horace W. Hatch House	082228	Village of Whitefish Bay	1985
102	Halbert D. Jenkins House	082233	Village of Whitefish Bay	1985
103	John F. McEwens House	082233	Village of Whitefish Bay	1985
104	Frederick Sperling House	082233	Village of Whitefish Bay	1985
105	William Van Altena House	072204	Village of Whitefish Bay	1985
106	Frank J. Williams House	082233	Village of Whitefish Bay	1985
107	G. B. Van Devan House	072203	Village of Whitefish Bay	1985
108	American System Built Homes (Burnham Street District)	062101	City of Milwaukee	1985
109	Thomas B. Hart House	072121	City of Wauwatosa	1985
110	Charles Abresch House	072230	City of Milwaukee	1986

Table 12 (continued)

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
		Milwaukee County (continued)		
112	Michael Carpenter House	072125	City of Milwaukee	1986
114	Thomas Cook House	072230	City of Milwaukee	1986
115	Abraham H. Esbenshade House	072125	City of Milwaukee	1986
117	Grand Avenue Congregational Church	072230	City of Milwaukee	1986
118	Highland Avenue Methodist Church	072230	City of Milwaukee	1986
119	David W. Howie House	072125	City of Milwaukee	1986
122	Milwaukee Normal School (Mil. Girls' Trade and Tech. H.S.)	072230	City of Milwaukee	1986
123	Pabst Brewery Saloon	072219	City of Milwaukee	1986
124	George Schuster House and Carriage Shed	072125	City of Milwaukee	1986
125	Second Church of Christ Scientist	072125	City of Milwaukee	1986
126	Fred Sivyer House	072230	City of Milwaukee	1986
127	Street George Melkite Catholic Church	072230	City of Milwaukee	1986
128	Tripoli Temple	072125	City of Milwaukee	1986
129	Harry B. Walker House	072125	City of Milwaukee	1986
132	Town of Milwaukee Town Hall	082230	City of Glendale	1986
133	Victor Schlitz House	072230	City of Milwaukee	1986
134	Edward J. Dahinden House	072125	City of Milwaukee	1986
135	Eagles' Club	072230	City of Milwaukee	1986
136	Kilbourn Avenue Row House Historic District	072230	City of Milwaukee	1986
139	Fred W. Ullius Jr. House	082229	Village of Whitefish Bay	1987
141	Christ Evangelical Lutheran Church	062206	City of Milwaukee	1987
142	St. Martini Evangelical Lutheran Church	062206	City of Milwaukee	1987
144	St. Vincent's Infant Asylum	062205	City of Milwaukee	1987
149	New Coeln House	062232	City of Milwaukee	1988
150	Pythian Castle Lodge	072231	City of Milwaukee	1988
154	Chief Lippert Fire Station	072117	City of Milwaukee	1988
156	Kneeland-Walker House	072122	City of Wauwatosa	1989
159	Church Street Historic District	072121	City of Wauwatosa	1989
160	Washington Highlands Historic District	072122	City of Milwaukee	1989
168	Garden Homes Historic District	072206	City of Milwaukee	1990
172	St. Peter and Paul Roman Catholic Church Complex	072215	City of Milwaukee	1991
174	Congregation Beth Israel Synagogue	072218	City of Milwaukee	1992
176	Lake Park	072215	City of Milwaukee	1993
177	Newberry Boulevard Historic District	072215	City of Milwaukee	1994
178	Brown Deer School	082102	Village of Brown Deer	1993
179	Washington & Hi-Mount Blvds. Historic District	072123	City of Milwaukee	1994
181	Harley-Davidson Motorcycle Factory Building	072125	City of Milwaukee	1994
182	North Grant Boulevard Historic District	072113	City of Milwaukee	1995
185	South Layton Historic District	062101	City of Milwaukee	1996
187	Wauwatosa Arcade Building	072115	City of Wauwatosa	1997
188	Wauwatosa Woman's Club	072121	City of Wauwatosa	1998
190	Mil. Cty School of Ag. & Domestic Economy Historic District	072120	City of Wauwatosa	1998
191	Mil. Cty Home for Dependent Children School	072120	City of Wauwatosa	1998
192	Mil. Cty Home for Dependent Children Administration Bldg.	072120	City of Wauwatosa	1999
195	North Point North Historic District	072215	City of Milwaukee	2000
199	Lawson Airplane Company/Continental Faience & Tile Co.	052211	City of South Milwaukee	2001
200	Kenwood Park-Prospect Hill Historic District	072210	City of Milwaukee	2002
202	Whitefish Bay National Guard Armory	082233	Village of Whitefish Bay	2002
205	North Sherman Boulevard Historic District	072113	City of Milwaukee	2004
206	The Goodwill Industries Building	072231	City of Milwaukee	2004
207	Wadhams Gas Station	062104	City of West Allis	2004
		Ozaukee County		
1	Covered Bridge	102110	Town of Cedarburg	1973
2	Concordia Mill	102135	Town of Cedarburg	1974
3	Cedarburg Mill	102127	City of Cedarburg	1974
5	Hamilton Historic District	102135	Town of Cedarburg	1976
6	Stony Hill School	122128	Town of Fredonia	1976
9	Hilgen and Wittenberg Woolen Mill	102127	City of Cedarburg	1978
10	Jonathan Clark House	092103	City of Mequon	1982
11	John Reichert Farmhouse	092104	City of Mequon	1982
13	Grafton Flour Mill	102124	Village of Grafton	1983
14	Cedarburg Woolen Company Worsted Mill	102124	Village of Grafton	1983
16	Wayside House	102134	City of Cedarburg	1986
17	Washington Avenue Historic District	102127	City of Cedarburg	1986
18	Payne Hotel	112125	Village of Saukville	1991
19	Columbia Historic District	102126	City of Cedarburg	1992
20	Edwin J. Neiman Sr. House	092110	City of Mequon	1996

Table 12 (continued)

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
	Ozaukee County (continued)			
23	Mequon Town Hall and Fire Department	092110	City of Mequon	2000
24	Bigelow School	092101	City of Mequon	2000
25	William F. Jahn Farmstead	092115	City of Mequon	2000
27	Jacob Voigt House	092121	City of Mequon	2000
28	O'Brien-Peushel Farmstead	092116	City of Mequon	2000
29	Isham Day House (Yankee Settler's Cottage)	092110	City of Mequon	2000
30	Green Bay Road Historic District	092123	Village of Thiensville	2004
31	Main Street Historic District	092123	Village of Thiensville	2004
	Racine County			
4	John Collins House	042215	Village of Caledonia	1974
8	Herbert F. Johnson House (Wingspread)	042327	Village of Wind Point	1975
9	Racine Harbor Lighthouse and Life Saving Station	032309	City of Racine	1975
18	Hansen House	032309	City of Racine	1979
20	No. 4 Engine House	032309	City of Racine	1979
21	St. Patrick's Roman Catholic Church	032309	City of Racine	1979
30	Wind Point Light Station	042327	Village of Wind Point	1984
38	Karel Jonas House	032309	City of Racine	1982
47	Southern Wisconsin Home Historic District	032025	Town of Dover	1991
48	Northside Historic District of Cream Brick Workers' Cottages	032304	City of Racine	1994
	Sheboygan County			
1	St. Patrick's Roman Catholic Church	132101	Town of Sherman	1983
2	Gooseville Mill/Grist Mill	132117	Town of Sherman	1984
	Washington County			
1	Lizard Mound County Park[c]	*122032*	Town of Farmington	*1970*
2	Gadow's Mill	111901	City of West Bend	1974
3	St. John of God Roman Catholic Church, Convent, and School	121910	Village of Kewaskum	1979
5	Washington County Courthouse and Jail	111914	City of West Bend	1982
6	St. Peter's Church	122034	Town of Farmington	1983
7	Christ Evangelical Church	092009	Village of Germantown	1983
8	Jacob Schunk Farmhouse	092026	Village of Germantown	1983
9	Leander F. Frisby House	111914	City of West Bend	1985
16	St. Augustine Catholic Church and Cemetery	112025	Town of Trenton	1990
17	Barton Historic District	111911	City of West Bend	1992
19	Washington County "Island" Effigy Mound District	122031	Town of Farmington	1996
	Waukesha County			
5	Miller Davidson House	082003	Village of Menomonee Falls	1973
18	Dousman Inn	072027	City of Brookfield	1979
30	Garwin Mace Lime Kilns	082010	Village of Menomonee Falls	1982
95	Albert R. Baer House	082003	Village of Menomonee Falls	1988
96	Andrew Barnes House	082003	Village of Menomonee Falls	1988
101	LeRoy H. Henze House	082003	Village of Menomonee Falls	1988
102	Herbert Hoeltz House	082010	Village of Menomonee Falls	1988
103	Elizabeth Hoos House	082003	Village of Menomonee Falls	1988
104	Rowell Hoos House	082003	Village of Menomonee Falls	1988
105	Frank Koehler House and Office	082003	Village of Menomonee Falls	1988
106	Garwin A. Mace House	082003	Village of Menomonee Falls	1988
107	Main Street Historic District	082003	Village of Menomonee Falls	1988
108	Menomonee Falls City Hall	082003	Village of Menomonee Falls	1988
109	Menomonee Golf Club	082013	Village of Menomonee Falls	1988
110	John A. Pratt House	082003	Village of Menomonee Falls	1988
111	Third Street Bridge	082003	Village of Menomonee Falls	1988
112	Village Park Bandstand	082010	Village of Menomonee Falls	1988
113	Michael Wick Farmhouse and Barn	082013	Village of Menomonee Falls	1988
114	Johann Zimmer Farmhouse	082002	Village of Menomonee Falls	1988
129	George Lawrence Clarke House	082036	Village of Butler	1995
149	Enoch Gardener and Mary Caroline Koch Needham House	062001	City of New Berlin	2000

[a]Numbering of sites is not in sequence in cases where portions of counties lie outside the study area. The numbering used is the same as in countywide listings in order to maintain consistency with local county plans.

[b]Indicates location given in U.S. Public Land Survey Township, Range, and Section.

[c]In 2005, this site was listed as "Lizard Mound State Park" on the National Register of Historic Places. However, the site was acquired by Washington County in 1986.

Source: The Wisconsin Historical Society and SEWRPC.

Table 13

HISTORIC SITES AND DISTRICTS ON THE NATIONAL REGISTER OF HISTORIC PLACES IN THE CITY OF MILWAUKEE: 2004

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
3	Pabst Theater	072229	City of Milwaukee	1972
6	Holy Trinity Roman Catholic Church (Our Lady of Guadlupe)	072232	City of Milwaukee	1972
7	North Point Water Tower	072222	City of Milwaukee	1973
8	Old St. Mary's Church	072228	City of Milwaukee	1973
10	Milwaukee City Hall	072229	City of Milwaukee	1973
11	Milwaukee County Historical Center	072229	City of Milwaukee	1973
12	Federal Building	072228	City of Milwaukee	1973
13	Northwestern Mutual Life Insurance Company, Home Office	072228	City of Milwaukee	1973
14	Mitchell Building	072229	City of Milwaukee	1973
15	Mackie Building	072229	City of Milwaukee	1973
18	St. Patrick's Roman Catholic Church	072232	City of Milwaukee	1974
20	Immanuel Presbyterian Church	072228	City of Milwaukee	1974
21	Iron Block	072229	City of Milwaukee	1974
22	All Saints' Episcopal Cathedral Complex	072221	City of Milwaukee	1974
23	St. Paul's Episcopal Church	072221	City of Milwaukee	1974
24	First Unitarian Church	072221	City of Milwaukee	1974
25	Central Library	072229	City of Milwaukee	1974
26	Lloyd R. Smith House	072222	City of Milwaukee	1974
27	St. John's Roman Catholic Cathedral	072228	City of Milwaukee	1974
28	Charles Allis House	072221	City of Milwaukee	1975
30	German-English Academy	072228	City of Milwaukee	1977
34	Turner Hall	072229	City of Milwaukee	1977
35	First Ward Triangle Historic District	072221	City of Milwaukee	1987
38	Walker's Point Historic District	072232	City of Milwaukee	1978
39	Trinity Evangelical Lutheran Church	072229	City of Milwaukee	1979
40	St. James Episcopal Church	072229	City of Milwaukee	1979
42	Graham Row	072221	City of Milwaukee	1979
43	North Point South Historic District	072222	City of Milwaukee	1979
45	Sixth Church of Christ Scientist	072228	City of Milwaukee	1980
46	Knapp-Astor House	072221	City of Milwaukee	1980
53	Milwaukee County Courthouse	072229	City of Milwaukee	1982
54	Women's Club of Wisconsin	072228	City of Milwaukee	1982
55	Milwaukee News Building and Mil. Abstract Assoc. Building	072228	City of Milwaukee	1982
56	Germania Building	072229	City of Milwaukee	1983
57	Valentin Blatz Brewing Company Office Building	072229	City of Milwaukee	1983
58	Baumbach Building	072228	City of Milwaukee	1983
60	Abbott Row	072221	City of Milwaukee	1983
62	Historic Third Ward District	072228	City of Milwaukee	1984
63	The State Bank of Wisconsin/Bank of Milwaukee Block	072228	City of Milwaukee	1984
64	William Steinmeyer House	072220	City of Milwaukee	1984
65	Shorecrest Hotel	072222	City of Milwaukee	1984
67	Baasen House-German YMCA	072220	City of Milwaukee	1984
68	Golda Meir School (4th Street School)	072220	City of Milwaukee	1984
69	Gallun Tannery Historic District	072221	City of Milwaukee	1984
70	Frederick Ketter Warehouse	072220	City of Milwaukee	1984
71	F. Mayer Boot and Shoe Co., Building	072220	City of Milwaukee	1984
73	N. 3rd Street Historic District	072220	City of Milwaukee	1984
74	Public School No. 27	072220	City of Milwaukee	1984
75	Oneida Street Station	072229	City of Milwaukee	1984
76	Vine/Reservoir Historic District	072220	City of Milwaukee	1984
78	Astor on the Lake	072228	City of Milwaukee	1984
111	Calvary Presbyterian Church	072229	City of Milwaukee	1986
116	Gesu Church	072229	City of Milwaukee	1986
120	Johnston Hall	072229	City of Milwaukee	1986
121	Kilbourn Masonic Temple	072229	City of Milwaukee	1986
130	Blatz Brewery Complex	072229	City of Milwaukee	1986
131	East Side Commercial Historic District	072228	City of Milwaukee	1986
137	Cass-Wells Street Historic District	072228	City of Milwaukee	1986
138	Plankinton-Wells-Water Street Historic District	072229	City of Milwaukee	1986

Table 13 (continued)

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
140	Old World 3rd Street Historic District	072229	City of Milwaukee	1987
143	St. Peter's Evangelical Lutheran Church	072232	City of Milwaukee	1987
145	Salem Evangelical Church	072232	City of Milwaukee	1987
146	South First & Second Street Historic District	072232	City of Milwaukee	1987
147	J. L. Burnham Block	072232	City of Milwaukee	1988
148	South Branch Library	072232	City of Milwaukee	1988
151	Lohman Funeral Home and Livery Stable	072232	City of Milwaukee	1988
152	Foth Christian House	072232	City of Milwaukee	1988
153	Knickerbocker Hotel	072221	City of Milwaukee	1988
155	Cass-Juneau Street Historic District	072228	City of Milwaukee	1988
157	First Church of Christ Scientist	072221	City of Milwaukee	1989
158	Old Coast Guard Station	072222	City of Milwaukee	1989
161	Herman W. Buemming House	072221	City of Milwaukee	1990
162	Elias R. Calkins Double House	072221	City of Milwaukee	1990
163	Joseph B. Oliver House	072221	City of Milwaukee	1990
164	Desmond-Farmham-Hustis House	072221	City of Milwaukee	1990
165	Brady Street Historic District	072221	City of Milwaukee	1990
166	Prospect Avenue Mansions Historic District	072221	City of Milwaukee	1990
167	Prospect Avenue Apartment Buildings Historic District	072222	City of Milwaukee	1990
169	Emanuel D. Alder House	072221	City of Milwaukee	1991
170	Sanford R. Kane House	072221	City of Milwaukee	1991
173	Milwaukee Western Fuel and Oil Company	072222	City of Milwaukee	1992
175	St. John's Evangelical Lutheran Church Complex	072220	City of Milwaukee	1992
180	Wisconsin Consistory Building	072228	City of Milwaukee	1994
183	Brewers Hill Historic District	072220	City of Milwaukee	1995
184	Friedman Row	072221	City of Milwaukee	1996
186	Exton Apartments Building	072221	City of Milwaukee	1997
189	Public Service Building	072229	City of Milwaukee	1998
193	Commerce Street Power Plant	072220	City of Milwaukee	1999
194	Joseph Schlitz Brewing Company Brewery Complex	072220	City of Milwaukee	1999
196	McIntosh-Goodrich Mansion	072221	City of Milwaukee	2000
197	West Side Commercial Historic District	072228	City of Milwaukee	2000
198	Gimbels Parking Pavilion	072228	City of Milwaukee	2001
201	Lindsay-Bostrom Building	072232	City of Milwaukee	2002
203	Pabst Brewing Company Complex	072229	City of Milwaukee	2003
204	East Village Historic District	072221	City of Milwaukee	2004
- -	Total: 95 sites	- -	- -	- -

[a]*Numbering of sites is not in sequence in cases where portions of counties lie outside the study area. The numbering used is the same as in countywide listings in order to maintain consistency with local county plans.*

[b]*Indicates location given in U.S. Public Land Survey Township, Range, and Section.*

Source: The Wisconsin Historical Society and SEWRPC.

PUBLIC UTILITY BASE

Utility systems are among the most important and permanent elements of urban growth and development, as urban development is highly dependent upon such systems. Sanitary sewerage, water supply, stormwater management, and solid waste disposal systems are particularly important to sound water resource planning because their location should influence the location and density of urban development and these systems can have direct and indirect impacts on surface water and groundwater quality and quantity. Proper land use planning can serve to discourage development to prevent the need to serve some areas, while encouraging development to make serving other areas more feasible, in both cases minimizing environmental impacts and public expenditures.

The majority of sewerage and water supply utilities in the regional water quality management plan update study area are organized as sewer and water departments of incorporated municipalities or as municipal utility enterprises, and serve largely those areas within the respective political boundaries of the municipalities. A general pattern of sewer and water service areas following political boundaries rather than natural topographic boundaries, such as watershed boundaries, exists within the study area.

Table 14

HISTORIC SITES AND DISTRICTS ON THE NATIONAL REGISTER OF HISTORIC PLACES IN THE CITY OF RACINE WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2004

Number on Map 6[a]	Site Name	Location[b]	Civil Division	Year Listed
3	McClurg Building	032309	City of Racine	1977
13	Shoop Building	032309	City of Racine	1978
31	United Laymen Bible Student Tabernacle	032316	City of Racine	1983
35	Racine Depot (Chicago & Northwestern)	032308	City of Racine	1980
40	Uptown (Majestic Theater)	032317	City of Racine	1982
43	Peter Johnson House	032308	City of Racine	1986
45	Old Main Street Historic District	032309	City of Racine	1987
46	Historic 6th Street Business District	032309	City of Racine	1988
49	Lincoln School	032308	City of Racine	1994
50	Wilmanor Apartments	032317	City of Racine	1994
52	The Thomas Driver and Sons Manufacturing Company	032309	City of Racine	2004
- -	Total: 11 sites	- -	- -	- -

[a]*Numbering of sites is not in sequence in cases where portions of counties lie outside the study area. The numbering used is the same as in countywide listings in order to maintain consistency with local county plans.*

[b]*Indicates location given in U.S. Public Land Survey Township, Range, and Section.*

Source: The Wisconsin Historical Society and SEWRPC.

Sanitary Sewer Service

Table 15 lists the sanitary sewerage facilities in the regional water quality management plan update study area. As shown on Map 7, areas served by sanitary sewers in the portion of the regional water quality management plan study area within the Southeastern Wisconsin Region in 2000 encompassed about 303 square miles, or about 27 percent of the total area of the study area. In 2004, there were 17 public sewage treatment plants located in the study area. In addition, while the City of Racine's sewage treatment plant is not located in the study area and discharges to Lake Michigan at a location south of the study area, much of its service area is located within the study area. Urban development outside of areas served by sanitary sewers encompassed approximately 33 square miles, or about 3 percent of the study area. An estimated 1,216,000 persons, or about 95 percent of the population of the watersheds, were served by public sanitary sewers in 2000. Planned or anticipated future sanitary sewer service areas in the study area in 2000 encompassed approximately 429 square miles, or approximately 38 percent of the study area. Planned sewer service areas are shown on Map 8.

In addition to the publicly owned sewage treatment facilities, the following three private sewage treatment plants were in existence in 2000 in the regional water quality management plan update study area. These plants served the following uses: Long Lake Recreational Area in Fond du Lac County, Fonks Mobile Home Park in Racine County, and Kettle Moraine Correctional Institution in Sheboygan County.

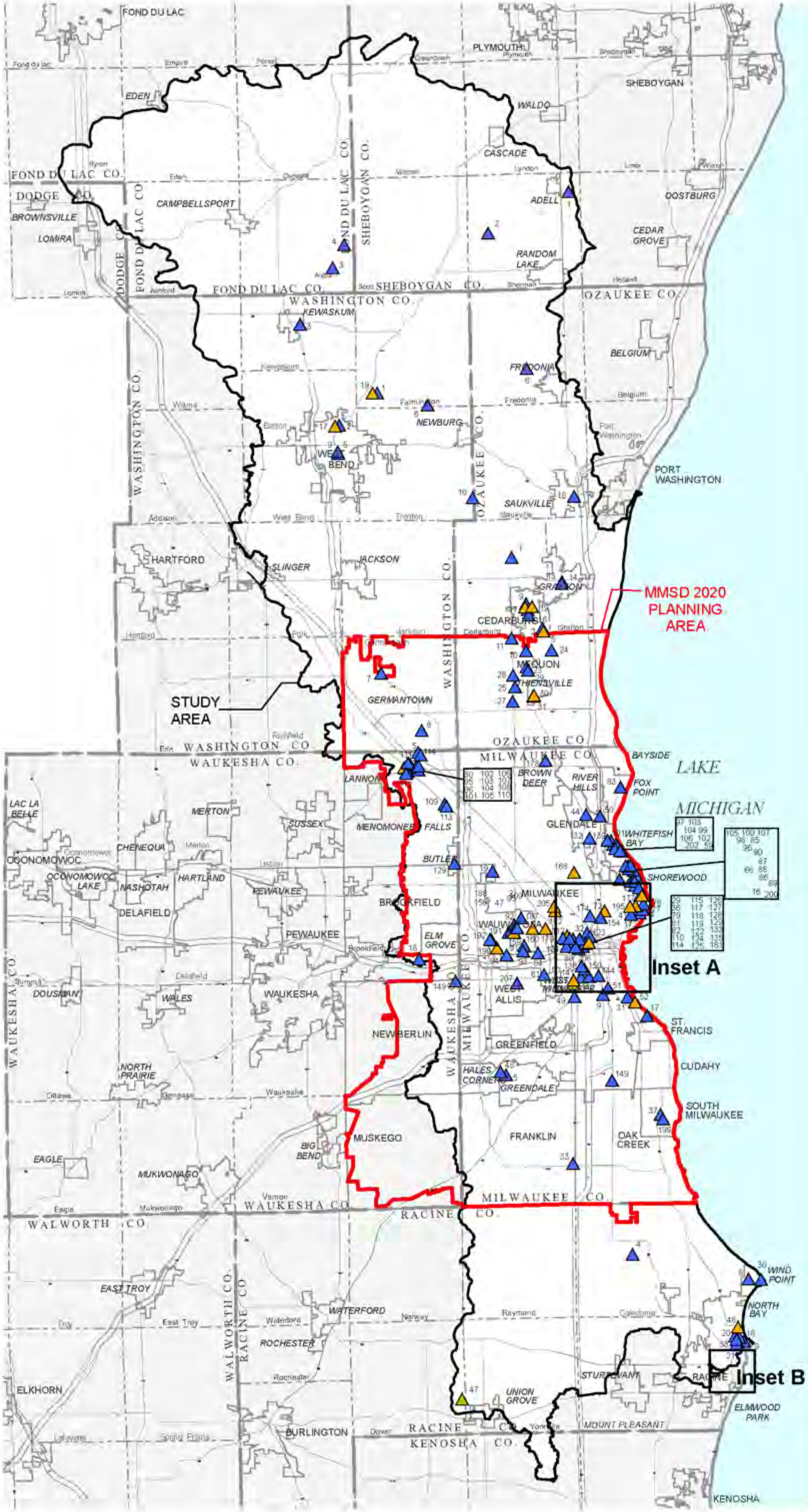
Water Supply Service

As shown on Map 9, areas served by public water utilities in 2000 encompassed about 256 square miles, or about 23 percent of the total area of the regional water quality management plan study area. An estimated 1,155,683 persons, or about 90 percent of the population of the study area, were served by public water utilities in 2000. In addition, urban areas not served by public water supplies constitute about 61 square miles, or about 5 percent of the study area. Municipal water supply facilities in the study area are listed in Table 16.

In addition to publicly owned water utilities, there are numerous privately or cooperatively owned water systems operating in the study area. These water supply systems typically serve residential subdivisions, apartment or condominium developments, mobile home parks, and institutions. The areas served by such systems are shown on Map 9. This map distinguishes those municipal water supply systems which currently utilize Lake Michigan as a

Map 6

HISTORIC SITES AND DISTRICTS ON THE NATIONAL REGISTER OF HISTORIC PLACES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



HISTORIC SITES

HISTORIC DISTRICTS

15 IDENTIFICATION NUMBER (SEE TABLE 12)

N

GRAPHIC SCALE

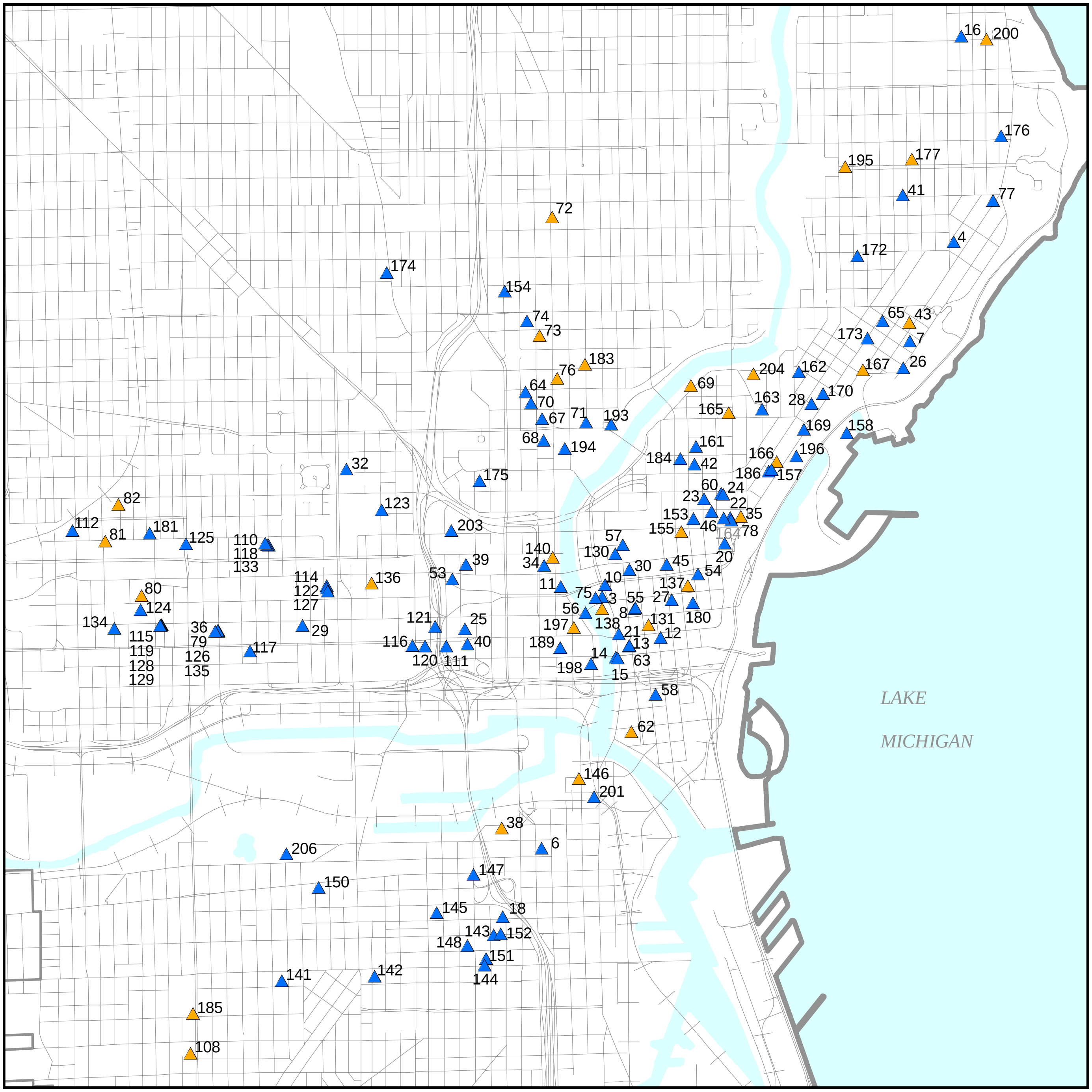
0 2 4 6 8 Miles

0 10,000 20,000 30,000 40,000 50,000 Feet

Source: SEWRPC.

INSET A TO Map 6

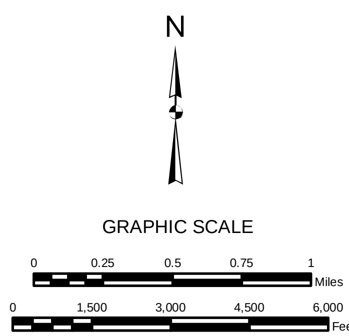
CITY OF MILWAUKEE



HISTORIC SITE

HISTORIC DISTRICT

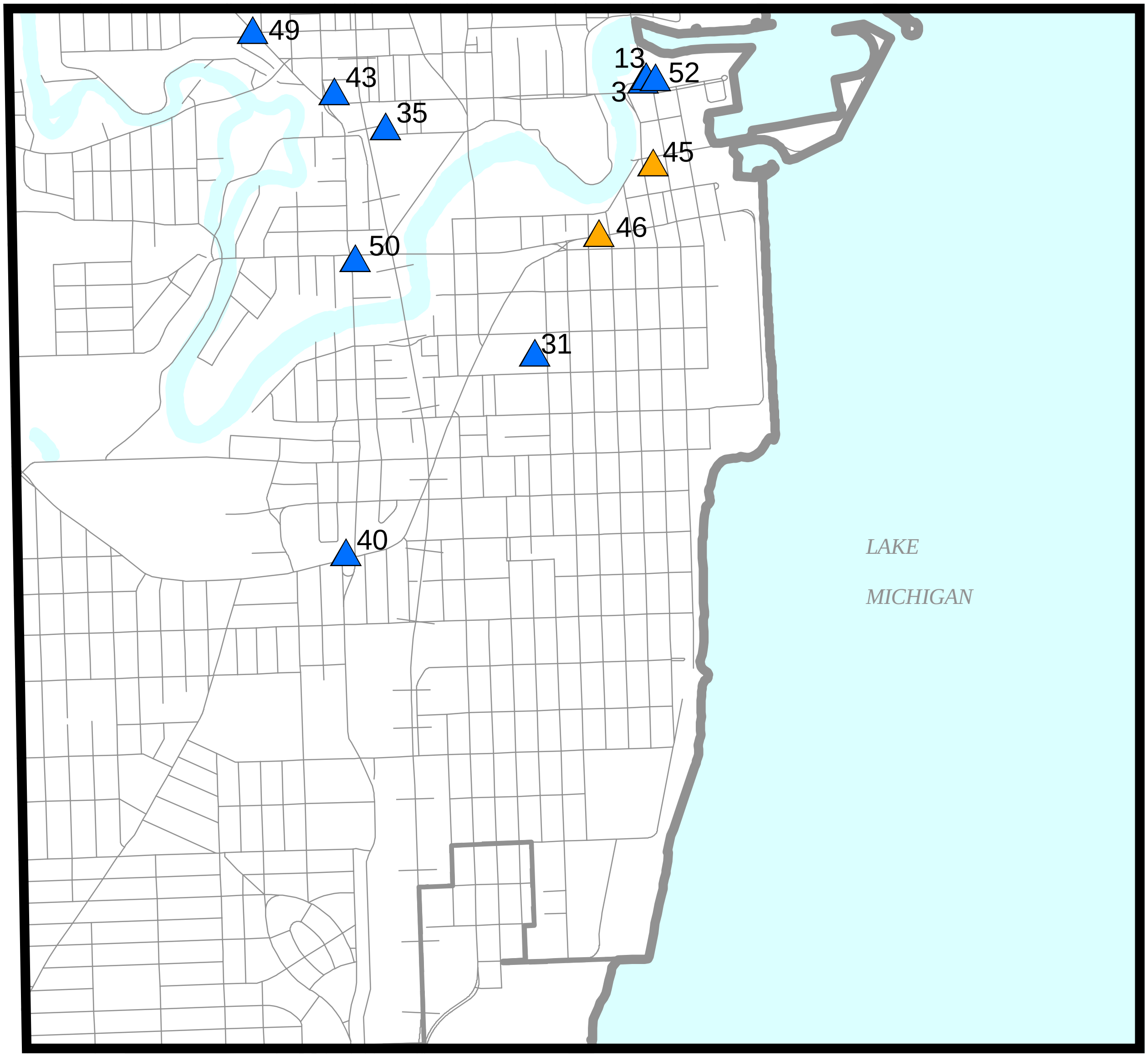
10 NUMBER ON TABLE 13



Source: SEWRPC

INSET B TO Map 6

CITY OF RACINE



HISTORIC SITE

HISTORIC DISTRICT

10 NUMBER ON TABLE 14

N

GRAPHIC SCALE

0 0.1 0.2 0.3 0.4 Miles

0 1,000 2,000 3,000 4,000 Feet

Source: SEWRPC

Table 15

PUBLIC AND PRIVATE SEWERAGE FACILITIES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Sewage Treatment Facility or Collection System		Watershed within Which System Lies						Sewerage Facilities Type		
Name	Location	Lake Michigan Direct Drainage	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Public Sewage Treatment Plant	Private Sewage Treatment Plant	Public Sewer Collection/ Conveyance System
Dodge County										
Village of Lomira	Village of Lomira	- -	- -	- -	X	- -	- -	- -[a]	- -	X
Fond du Lac County										
Village of Campbellsport	Village of Campbellsport	- -	- -	- -	X	- -	- -	X	- -	X
Village of Eden	Village of Eden	- -	- -	- -	X	- -	- -	- -	- -	X
Long Lake Recreation Area	Town of Osceola	- -	- -	- -	X	- -	- -	- -	X	- -
Milwaukee County										
City of Cudahy	City of Cudahy	X	X	- -	- -	X	- -	- -	- -	X
City of Franklin	City of Franklin	- -	- -	- -	- -	X	X	- -	- -	X
City of Glendale	City of Glendale	- -	- -	- -	X	- -	- -	- -	- -	X
City of Greenfield	City of Greenfield	- -	X	X	- -	X	X	- -	- -	X
City of Milwaukee	City of Milwaukee	X	X	X	X	X	X	- -	- -	X
City of Oak Creek	City of Oak Creek	X	- -	- -		X	X	- -	- -	X
City of St. Francis	City of St. Francis	X	- -	- -	- -	- -	- -	- -	- -	X
City of South Milwaukee	City of South Milwaukee	X	- -	- -	- -	X	- -	X	- -	X
City of Wauwatosa	City of Wauwatosa	- -	- -	X	- -	- -	- -	- -	- -	X
City of West Allis	City of West Allis	- -	X	X	- -	- -	X	- -	- -	X
Village of Bayside	Village of Bayside	X	- -	- -	- -	- -	- -	- -	- -	X
Village of Brown Deer	Village of Brown Deer	- -	- -	- -	X	- -	- -	- -	- -	X
Village of Fox Point	Village of Fox Point	X	- -	- -	X	- -	- -	- -	- -	X
Village of Greendale	Village of Greendale	- -	- -	X	- -	- -	X	- -	- -	X
Village of Hales Corners	Village of Hales Corners	- -	- -	- -	- -	- -	X	- -	- -	X
Village of River Hills	Village of River Hills	X	- -	- -	X	- -	- -	- -	- -	X
Village of Shorewood	Village of Shorewood	X	- -	- -	X	- -	- -	- -	- -	X
Village of West Milwaukee	Village of West Milwaukee	- -	X	X	- -	- -	- -	- -	- -	X
Village of Whitefish Bay	Village of Whitefish Bay	X	- -	- -	X	- -	- -	- -	- -	X
Milwaukee Metropolitan Sewerage District[b]	Milwaukee County	X	X	X	X	X	X	X	- -	- -
Ozaukee County										
City of Cedarburg	City of Cedarburg	- -	- -	- -	X	- -	- -	X	- -	X
City of Mequon	City of Mequon	X	- -	X	X	- -	- -		- -	X
Village of Fredonia	Village of Fredonia	- -	- -	- -	X	- -	- -	X	- -	X
Village of Grafton	Village of Grafton	- -	- -	- -	X	- -	- -	X	- -	X
Village of Newburg	Village of Newburg	- -	- -	- -	X	- -	- -	X	- -	X
Village of Saukville	Village of Saukville	- -	- -	- -	X	- -	- -	X	- -	X
Village of Thiensville	Village of Thiensville	- -	- -	- -	X	- -	- -	- -	- -	X
Waubeka Area Sanitary District	Town of Fredonia	- -	- -	- -	X	- -	- -	- -	- -	X
Racine County										
City of Racine[c]	City of Racine	X	- -	- -	- -	- -	X	X	- -	X
Caledonia West Utility District	Village of Caledonia	- -	- -	- -	- -	- -	X	- -	- -	X
Caledonia East Utility District	Villages of Caledonia	X	- -	- -	- -	- -	X	- -	- -	X
Mt. Pleasant Sewer Utility District No. 1	Village of Mt. Pleasant	X	- -	- -	- -	- -	X	- -	- -	X
Village of North Bay	Village of North Bay	X	- -	- -	- -	- -	- -	- -	- -	X
Village of Union Grove	Village of Union Grove	- -	- -	- -	- -	- -	X	X	- -	X
Village of Wind Point	Village of Wind Point	X	- -	- -	- -	- -	- -	- -	- -	X
Fonks Mobile Home Park	Town of Yorkville	- -	- -	- -	- -	- -	X	- -	X	- -
Yorkville Sewer Utility District No. 1	Town of Yorkville	- -	- -	- -	- -	- -	X	X	- -	X

Table 15 (continued)

Sewage Treatment Facility or Collection System		Watershed within Which System Lies						Sewerage Facilities Type		
Name	Location	Lake Michigan Direct Drainage	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Public Sewage Treatment Plant	Private Sewage Treatment Plant	Public Sewer Collection/ Conveyance System
Sheboygan County										
Scott Sanitary District No. 1	Town of Scott	- -	- -	- -	X	- -	- -	X	- -	X
Lake Ellen Sanitary District	Town of Lyndon	- -	- -	- -	X	- -	- -	- -	- -	x
Village of Adell	Village of Adell	- -	- -	- -	X	- -	- -	- -[d]	- -	X
Village of Cascade	Village of Cascade	- -	- -	- -	X	- -	- -	X	- -	X
Village of Random Lake	Village of Random Lake	- -	- -	- -	X	- -	- -	X	- -	X
Kettle Moraine Correctional Institute	Town of Greenbush	- -	- -	- -	X	- -	- -	- -	X	- -
Washington County[e]										
City of West Bend	City of West Bend	- -	- -	- -	X	- -	- -	X	- -	X
Village of Germantown	Village of Germantown	- -	- -	X	X	- -	- -	- -	- -	X
Village of Jackson	Village of Jackson	- -	- -	- -	X	- -	- -	X	- -	X
Village of Kewaskum	Village of Kewaskum	- -	- -	- -	X	- -	- -	X	- -	X
Wallace Lake Sanitary District	Towns of Barton and Trenton	- -	- -	- -	X	- -	- -	- -	- -	X
Silver Lake Sanitary District	Town of West Bend	- -	- -	- -	X	- -	- -	- -	- -	X
Waukesha County										
City of Brookfield[f]	City of Brookfield	- -	- -	X	- -	- -	- -	- -	- -	X
City of Muskego	City of Muskego	- -	- -	- -	- -	- -	X	- -	- -	X
City of New Berlin[g]	City of New Berlin	- -	- -	X	- -	- -	X	- -	- -	X
Village of Butler	Village of Butler	- -	- -	X	- -	- -	- -	- -	- -	X
Village of Elm Grove	Village of Elm Grove	- -	- -	X	- -	- -	- -	- -	- -	X
Village of Menomonee Falls	Village of Menomonee Falls	- -	- -	X	- -	- -	- -	- -	- -	X

[a]*Village of Lomira operates a sewage treatment plant which discharges into the Rock River watershed.*

[b]*Operates two sewage treatment plants discharging to Lake Michigan and trunk/interceptor sewer system.*

[c]*City of Racine operates a sewage treatment plant discharging directly to Lake Michigan.*

[d]*Village of Adell operates a sewage conveyance system which discharges into a regional sewage treatment plant that discharges into the Onion River Watershed.*

[e]*The Sand Drive Sanitary District in the Town of Trenton does not provide sanitary sewer service.*

[f]*City of Brookfield operates a sewage treatment plant tributary to the Fox River and a sewage collection system serving portions of the Fox River and Menomonee River watershed, with the Menomonee River watershed being tributary to the Milwaukee Metropolitan Sewerage District sewerage system.*

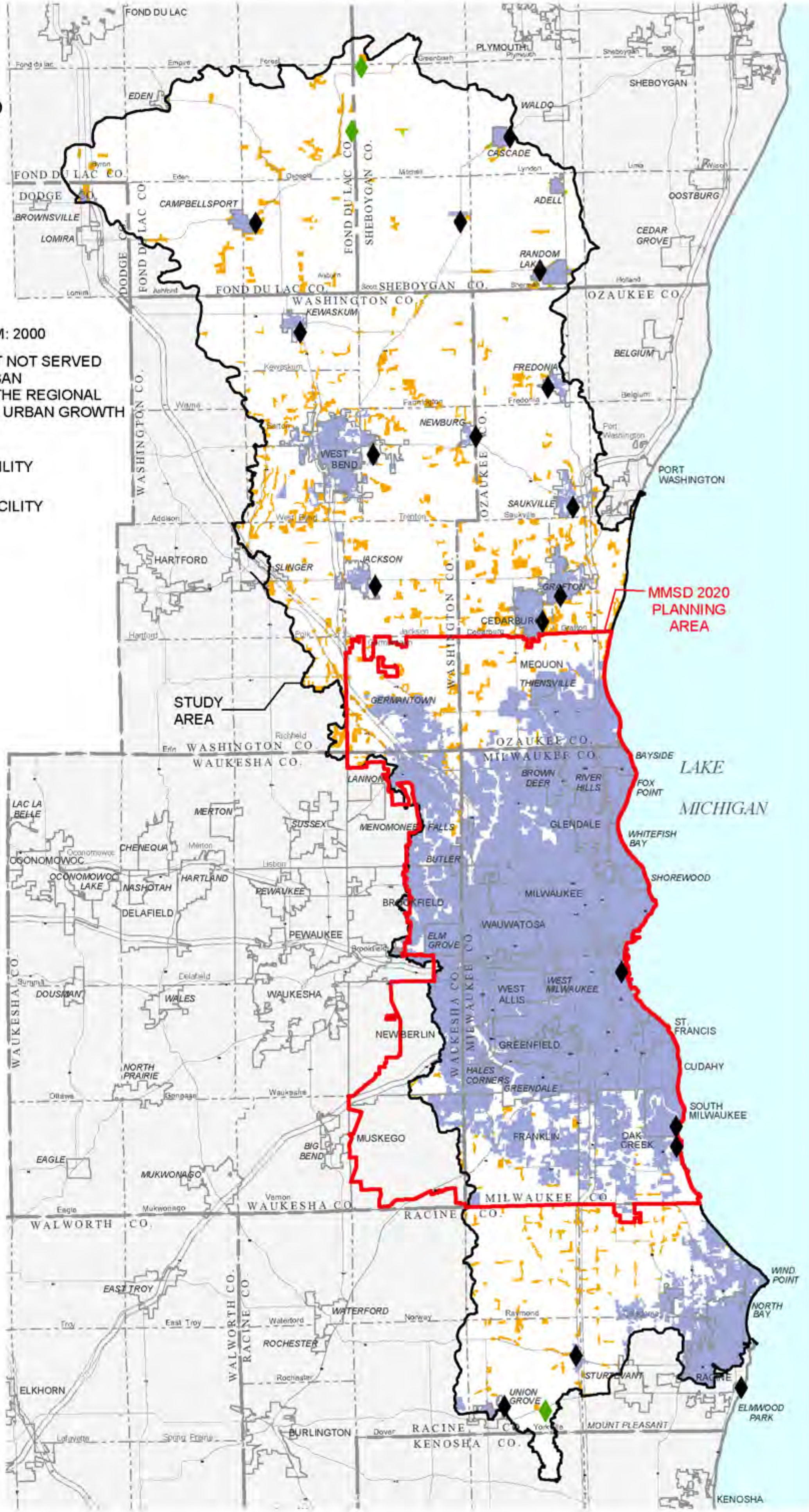
[g]*Small portion of collection system in the Menomonee River watershed.*

Source: SEWRPC.

Map 7

AREAS SERVED BY CENTRALIZED SANITARY SEWERAGE SYSTEMS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- AREA SERVED BY CENTRALIZED SEWERAGE SYSTEM: 2000
- EXTENT OF URBAN DEVELOPMENT NOT SERVED BY PUBLIC SEWER: INCLUDES URBAN DEVELOPMENT AS IDENTIFIED IN THE REGIONAL PLANNING COMMISSION HISTORIC URBAN GROWTH RING ANALYSIS
- PUBLIC SEWAGE TREATMENT FACILITY
- PRIVATE SEWAGE TREATMENT FACILITY

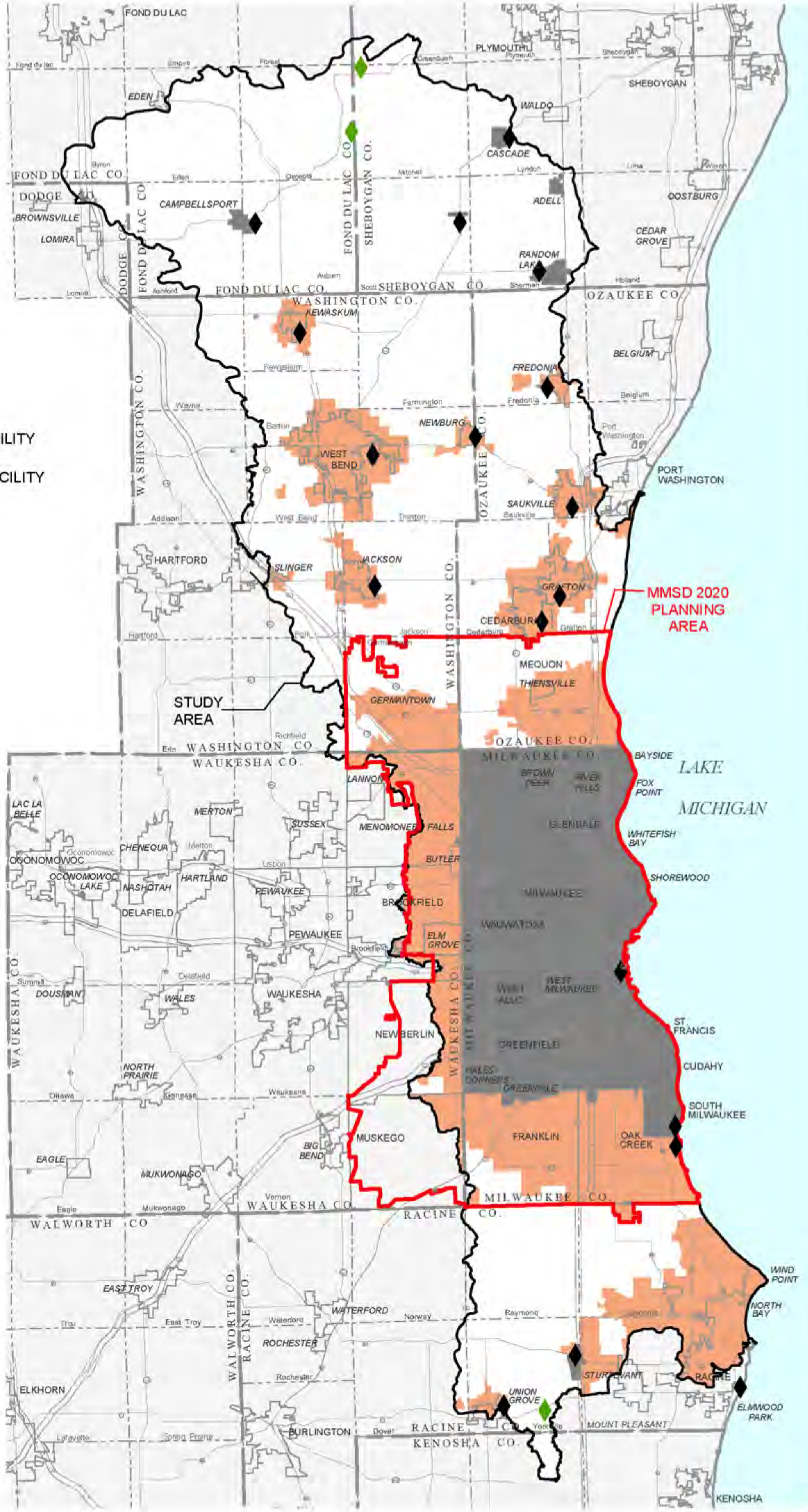


Source: SEWRPC.

Map 8

PLANNED SEWER SERVICE AREAS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- UNREFINED SANITARY SEWER SERVICE AREA: DECEMBER 31, 2006
- REFINED SANITARY SEWER SERVICE AREA: DECEMBER 31, 2006
- PUBLIC SEWAGE TREATMENT FACILITY
- PRIVATE SEWAGE TREATMENT FACILITY



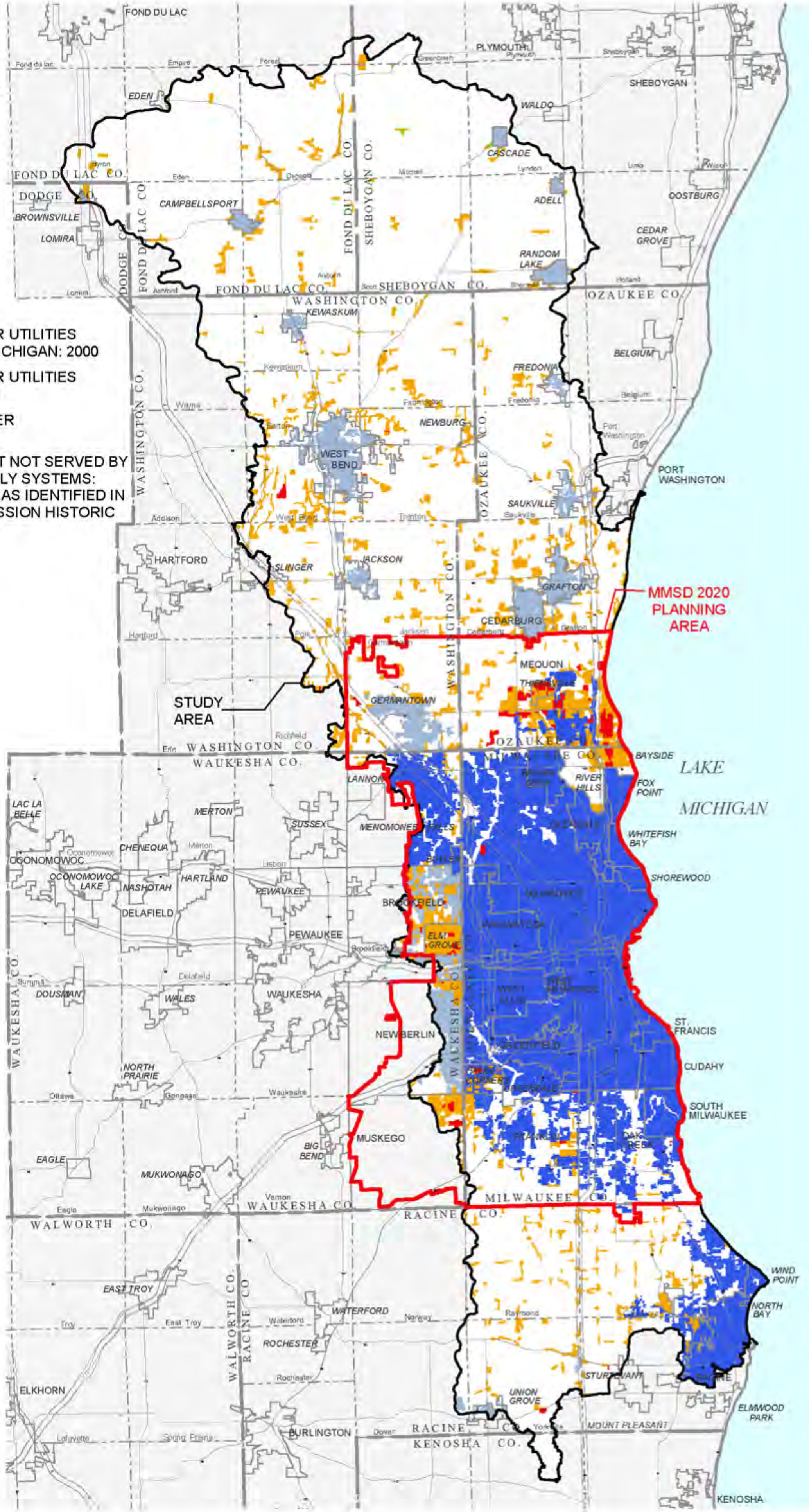
Source: SEWRPC.

Map 9

AREAS SERVED BY PUBLIC AND PRIVATE WATER UTILITIES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- AREAS SERVED BY PUBLIC WATER UTILITIES PROVIDING WATER FROM LAKE MICHIGAN: 2000
- AREAS SERVED BY PUBLIC WATER UTILITIES PROVIDING GROUNDWATER: 2000
- AREAS SERVED BY PRIVATE WATER UTILITIES: 2000
- EXTENT OF URBAN DEVELOPMENT NOT SERVED BY PUBLIC OR PRIVATE WATER SUPPLY SYSTEMS: INCLUDES URBAN DEVELOPMENT AS IDENTIFIED IN THE REGIONAL PLANNING COMMISSION HISTORIC URBAN GROWTH RING ANALYSIS

NOTE: PORTIONS OF THE CITY OF MEQUON SYSTEM WERE CONVERTED TO A PUBLIC SYSTEM OVER THE PERIOD 1998 THROUGH 2002.



Source: SEWRPC.

Table 16

MUNICIPAL WATER UTILITY FACILITIES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Water Utility Facility		Watershed						Water Supply Source		
								Local Municipal		
Name	Class[a]	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Groundwater	Lake Michigan	Other
Dodge County										
Village of Lomira Municipal Water Utility	D	- -	- -	X	- -	- -	- -	X	- -	- -
Fond du Lac County										
Campbellsport Municipal Water Utility	D	- -	- -	X	- -	- -	- -	X	- -	- -
Milwaukee County										
Village of Brown Deer Public Water Utility	AB	- -	- -	X	- -	- -	- -	- -	- -	X[b]
City of Cudahy Water Utility	AB	X	- -	- -	X	- -	X	- -	X	- -
City of Franklin Water Utility	C	- -	- -	- -	X	X	- -	- -	- -	X[c]
Village of Fox Point Water Utility	C	- -	- -	X	- -	- -	- -	- -	- -	X[d]
City of Glendale Water Utility	AB	- -	- -	X	- -	- -	- -	- -	- -	X[d]
Village of Greendale Water Utility	AB	- -	X	- -	- -	X	- -	- -	- -	X[b]
City of Milwaukee Water Works[e]	AB	X	X	X	X	X	X	- -	X	- -
City of Oak Creek Water and Sewer Utility	AB	- -	- -	- -	X	X	X	- -	X	- -
Village of Shorewood Municipal Water Utility	C	- -	- -	X	- -	- -	X	- -	- -	X[b]
Village of Bayside (We Energies Water Services)[f]	N/A	- -	- -	- -	- -	- -	X	- -	- -	X[d]
City of South Milwaukee Water Utility	AB	- -	- -	- -	X	- -	X	- -	X	- -
City of Wauwatosa Water Utility	AB	- -	X	- -	- -	- -	- -	- -	- -	X[b]
City of West Allis Water Utility	AB	X	- -	X	- -	X	- -	- -	- -	X[b]
Village of West Milwaukee	N/A	X	X	- -	- -	- -	- -	- -	- -	X[b]
Village of Whitefish Bay Water Utility	AB	- -	- -	X	- -	- -	X	- -	- -	X[d]
Ozaukee County										
City of Cedarburg Light & Water Commission	AB	- -	- -	X	- -	- -	- -	X	- -	- -
Village of Fredonia Municipal Water Utility	D	- -	- -	X	- -	- -	- -	X	- -	- -
Village of Grafton Water and Wastewater Commission	C	- -	- -	X	- -	- -	- -	X	- -	- -
City of Mequon Water Utility (We Energies Water Services)[f]	D	- -	- -	X	- -	- -	X	- -	- -	X[b]
Village of Saukville Municipal Water Utility	C	- -	- -	X	- -	- -	- -	X	- -	- -
Racine County										
Town of Caledonia Water Utility District No. 1[g]	C	- -	- -	- -	- -	X	X	- -	- -	X[h]
City of Racine Water and Wastewater Utility	AB	- -	- -	- -	- -	X	X	- -	X	- -
Village of Union Grove Municipal Water Utility	C	- -	- -	- -	- -	X	- -	X	- -	- -
Village of Wind Point Municipal Water Utility	D	- -	- -	- -	- -	- -	X	- -	- -	X[h]
Town of Yorkville Water Utility District No. 1	D	- -	- -	- -	- -	X	- -	X	- -	- -
Caddy Vista Sanitary District[g]	D	- -	- -	- -	- -	X	- -	- -	- -	X[i]
Crestview Sanitary District[j]	D	- -	- -	- -	- -	- -	X	- -	- -	X[i]
North Park Sanitary District No. 1[j]	C	- -	- -	- -	- -	X	X	- -	- -	X[h,i]

Table 16 (continued)

Water Utility Facility		Watershed						Water Supply Source		
								Local Municipal		
Name	Class[a]	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Groundwater	Lake Michigan	Other
Sheboygan County										
Village of Adell Water and Sewer Utility	D	- -	- -	X	- -	- -	- -	X	- -	- -
Village of Cascade Water Utility	D	- -	- -	X	- -	- -	- -	X	- -	- -
Village of Random Lake Municipal Water Department	D	- -	- -	X	- -	- -	- -	X	- -	- -
Washington County										
Village of Germantown Water Utility	AB	- -	X	- -	- -	- -	- -	X	- -	- -
Village of Jackson Water Utility	C	- -	- -	X	- -	- -	- -	X	- -	- -
Village of Kewaskum Municipal Water Utility	C	- -	- -	X	- -	- -	- -	X	- -	- -
City of West Bend Water Utility	AB	- -	- -	X	- -	- -	- -	X	- -	- -
Waukesha County										
City of Brookfield Municipal Water Utility	AB	- -	X	- -	- -	- -	- -	X	- -	- -
Village of Butler Public Water Utility	C	- -	X	- -	- -	- -	- -	- -	- -	X[b]
Village of Menomonee Falls Water Utility	AB	- -	X	- -	- -	- -	- -	- -	- -	X[b]
City of Muskego Public Water Utility	C	- -	- -	- -	- -	X	- -	X	- -	- -
City of New Berlin Water Utility	AB	- -	X	- -	- -	X	- -	X	- -	X[b]

[a]*The municipal water and combined water and sewer utilities are based upon the number of customers as follows: Class AB – four thousand or more customers; Class C – From one thousand to less than four thousand customers; and Class D – Less than one thousand customers.*

[b]*City of Milwaukee Water Works.*

[c]*City of Milwaukee Water Works and City of Oak Creek Water and Sewer Utility.*

[d]*North Shore Water Utility.*

[e]*Provides retail water supply services to the Cities of Greenfield and Saint Francis, a portion of the City of Franklin and Village of Hales Corners.*

[f]*The We Energies Water Services, a private water utility, provides water supply service to portions of the Village of Bayside and the City of Mequon.*

[g]*The Caledonia West Utility District, incorporating the Town of Caledonia Water Utility District No. 1 and the Caddy Vista Sanitary District, was formed in 2007.*

[h]*City of Racine Water and Wastewater Utility.*

[i]*City of Oak Creek Water and Sewer Utility.*

[j]*The Caledonia East Utility District, incorporating the Crestview Sanitary District and the North Park Sanitary District No. 1, was formed in 2007.*

Source: Public Service Commission of Wisconsin and SEWRPC.

source of supply and those systems which utilize groundwater as a source of supply. In addition, all of the study area private water supply systems utilize groundwater as a source of supply.

The entire study area is located within the Great Lakes-St. Lawrence drainage basin. Thus, the use of Lake Michigan as a source of water supply is not a limitation from regulatory and policy considerations. However, given the distance from Lake Michigan and the availability of groundwater resources, much of the study area is expected to continue to rely upon groundwater as a source of supply. Tables 17 and 18 illustrate the water uses and sources of supply for the nine counties within, or partially within, the study area. As can be seen by review of Table 17, the highest use of water within the counties located within, or partially within, the study area is for electric power generation, comprising about 87 percent of the usage. Most of the water used for electric power generation is returned to Lake Michigan following use. As shown in Table 18, about 77 and 96 percent of the public water supplies and total water supplies, respectively, within the counties involved, is obtained from Lake Michigan and 23 and 4 percent of the public water supplies and total water supplies, respectively, is obtained from groundwater.

Municipal Stormwater Management Systems

Municipal stormwater management systems are comprised of facilities that function to provide stormwater drainage and control of nonpoint source pollution. The facilities that perform those two functions generally work as part of an integrated system which incorporates the streams, lakes, ponds, and wetlands of the study area. Components of a stormwater management system may include subsurface pipes and appurtenant inlets and outlets, streams and engineered open channels, detention basins, retention basins, pumping facilities, infiltration facilities, constructed wetlands for treatment of runoff, and proprietary treatment devices based on settling processes and control of oil and grease.

Within the study area, the urban portions of the communities indicated on Map 10 are served by engineered stormwater management systems.

In Wisconsin, the U.S. Environmental Protection Agency (USEPA) has designated the WDNR as the administering authority for the program to regulate stormwater discharges as required under the Federal Clean Water Act. In that respect, the WDNR administers the Wisconsin Pollutant Discharge Elimination System (WPDES) for permitting of stormwater discharges. Under that program discharge permits have been issued to the units of government listed in Table 19.

In order to establish a reliable funding source to meet the requirements of their stormwater discharge permits, several communities in the study area have established stormwater utilities. Those communities are indicated on Map 10. In addition, each of the communities within the MMSD service area, with the exception of the Village of West Milwaukee,[2] and all of the communities with WPDES stormwater discharge permits have a stormwater management ordinance and/or plan and a construction erosion control ordinance. Those communities and several additional ones with ordinances and/or plans are indicated on Map 10.

Solid Waste Disposal Facilities

Landfilling and recycling are the primary methods of managing solid wastes generated in the regional water quality management plan update study area. As shown in Table 20, as of 2005, there were six active, licensed, privately owned and operated solid waste landfills within or adjacent to the study area. Four of these, the Kestrel Hawk Park Landfill within the City of Racine, the Metro Landfill and Development within the City of Franklin, the Onyx Emerald Park within the City of Muskego, and the WMWI Orchard Ridge Landfill within the Village of Menomonee Falls accept municipal wastes. These four facilities also accept a variety of other types of solid

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[2]*The Village of West Milwaukee does have a construction erosion control ordinance. It is anticipated that the Village will adopt a stormwater management ordinance to fulfill the conditions of their stormwater discharge permit.*

Table 17

ESTIMATED USE OF WATER WITHIN THE COUNTIES LOCATED WITHIN, OR PARTIALLY WITHIN, THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA (IN MILLION GALLONS PER DAY)[a]

County	Domestic	Agricultural	Irrigation	Industrial	Commercial	Thermoelectric	Public Use and Losses	Total
Dodge	4.03	2.90	0.16	4.06	1.34	0.00	1.76	14.25
Fond du Lac	6.06	2.11	0.15	4.82	2.56	22.33	3.37	41.39
Kenosha	7.02	0.18	0.25	4.44	2.95	15.21	3.89	33.94
Milwaukee	54.06	0.01	0.81	57.92	33.14	1,867.56	43.60	2,057.10
Ozaukee	4.11	0.32	0.51	1.88	1.08	118.78	1.42	128.09
Racine	13.00	1.80	2.16	10.82	5.22	0.00	6.87	39.86
Sheboygan	8.12	2.02	0.40	6.21	3.75	487.55	4.94	512.99
Washington	5.64	0.62	0.31	2.55	1.84	2.89	2.42	16.26
Waukesha	14.12	0.27	2.68	9.10	5.07	0.00	6.67	37.90
Total	116.16	10.23	7.43	101.80	56.95	2,514.32	74.94	2,881.78
Percent of Total	4.03	0.35	0.26	3.53	1.98	87.25	2.60	100.00

[a]*Includes all water use for the entire counties, including those only partially within the study area.*

Source: B.R. Ellefson, G.D. Mueller, and C.A. Buchwald, U.S. Geological Survey, "Water Use in Wisconsin, 2000."

Table 18

ESTIMATED SOURCE OF WATER SUPPLY WITHIN THE COUNTIES LOCATED IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA (IN MILLION GALLONS PER DAY)[a]

	Public Water Supply Use[b]			Total Water Use		
County	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
Dodge	0.00	7.04	7.04	0.30	13.95	14.25
Fond du Lac	0.00	13.47	13.47	22.52	18.87	41.39
Kenosha	15.47	0.08	15.55	31.25	2.69	33.94
Milwaukee	173.65	0.75	174.40	2,050.78	6.32	2,057.10
Ozaukee	1.43	4.24	5.67	120.29	7.80	128.09
Racine	23.72	3.75	27.47	26.23	13.63	39.86
Sheboygan	15.50	4.26	19.76	503.56	9.43	512.99
Washington	0.00	9.67	9.67	2.96	13.30	16.26
Waukesha	0.00	26.67	26.67	0.34	37.56	37.90
Total	229.77	69.93	299.70	2,758.23	123.55	2,881.78
Percent of Total	76.70	23.30	100.00	95.71	4.29	100.00

[a]*Includes all water use for the entire counties, including those only partially within the study area.*

[b]*Includes water delivered to residents, industry, and commerce within the served area.*

Source: B.R. Ellefson, G.D. Mueller, and C.A. Buchwald, U.S. Geological Survey, "Water Use in Wisconsin, 2000."

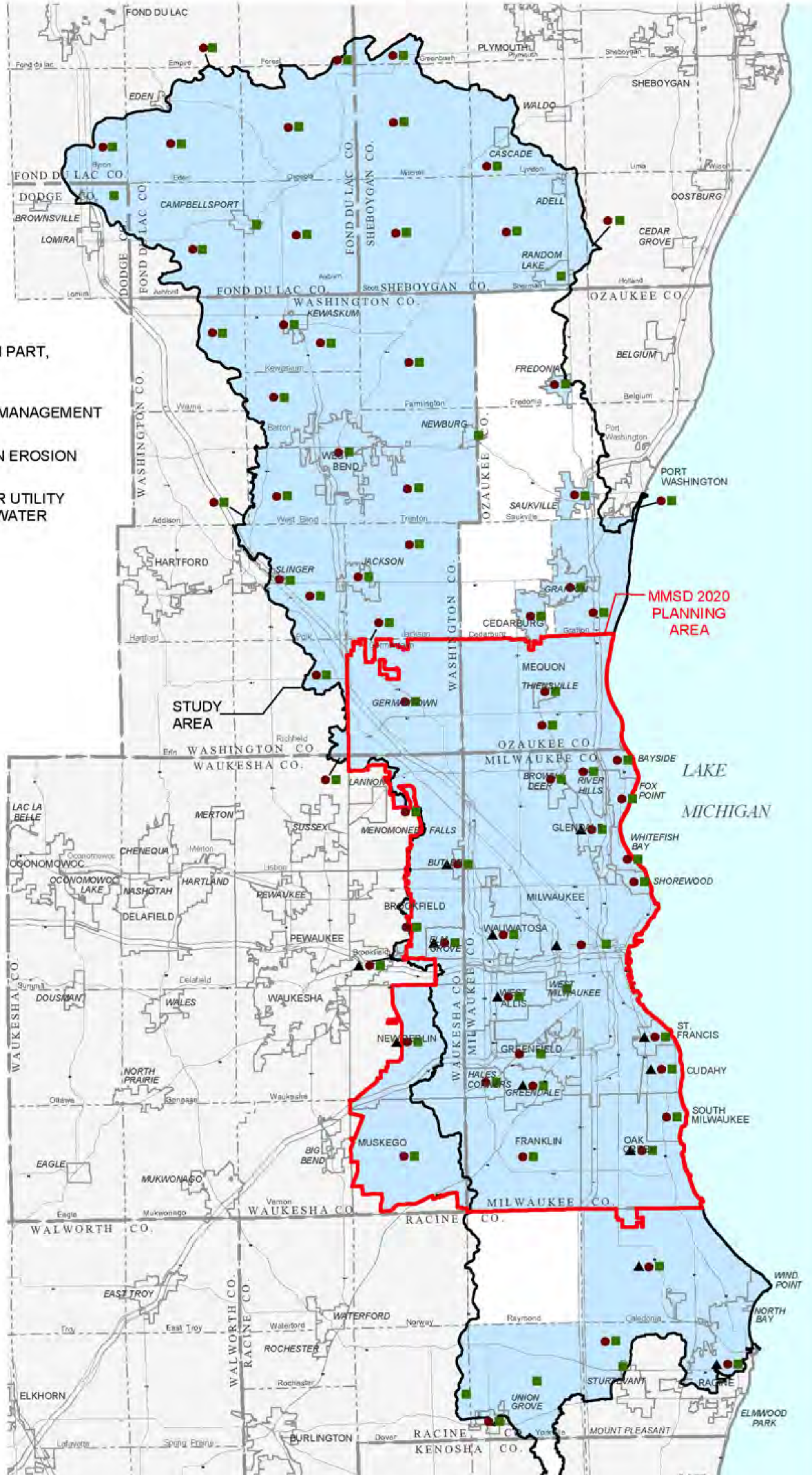
wastes as indicated in Table 20. As of January 2004, these four sites had slightly over 16 million cubic yards of capacity remaining. The estimated remaining lives of these sites range from two to seven years. In addition to these facilities, one active landfill within the Village of Caledonia is licensed to accept fly ash and another active landfill within the City of South Milwaukee is licensed to accept foundry wastes. The locations of the solid waste disposal sites within and near the study area are shown on Map 11. An inventory of all of the landfills in the study area, including both active and inactive sites, is included in a technical report which supplements this planning report. That information is summarized in Chapter IV of this report.

NATURAL RESOURCES AND ENVIRONMENTAL FEATURES OF THE STUDY AREA

The natural resource base is an important determinant of the development potential of a watershed-based water resources planning area and of its ability to provide a pleasant and habitable environment for all forms of life. The

Map 10

SELECTED INFORMATION REGARDING STORMWATER MANAGEMENT SYSTEMS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



- COMMUNITY SERVED, AT LEAST IN PART, BY ENGINEERED STORMWATER MANAGEMENT SYSTEMS
- ● COMMUNITY WITH STORMWATER MANAGEMENT ORDINANCE AND/OR PLAN
- ■ COMMUNITY WITH CONSTRUCTION EROSION CONTROL ORDINANCE
- ▲ COMMUNITY WITH A STORMWATER UTILITY AND/OR AN ESTABLISHED STORMWATER FEE PROGRAM

GRAPHIC SCALE: 0–8 Miles; 0–50,000 Feet

Source: SEWRPC.

Table 19

COMMUNITIES IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA THAT HAVE STATE OF WISCONSIN WPDES STORMWATER DISCHARGE PERMITS

Grafton Group
Village of Grafton
Town of Grafton
Menomonee River Watershed Group
City of Brookfield
City of Greenfield
City of Wauwatosa
Village of Butler
Village of Elm Grove
Village of Germantown
Village of Menomonee Falls
Village of West Milwaukee
Mequon/Thiensville Group
City of Mequon
Village of Thiensville
North Shore Group
City of Glendale
Village of Bayside
Village of Brown Deer
Village of Fox Point
Village of River Hills
Village of Shorewood
Village of Whitefish Bay
Root River Watershed Group
City of Franklin
City of New Berlin
City of Racine
Village of Caledonia
Village of Greendale
Village of Hales Corners
Village of Mt. Pleasant
Upper Fox River Watershed Group[a]
Town of Brookfield
Town of Lisbon
Communities and Districts that Applied Individually
City of Cedarburg
City of Cudahy
City of Milwaukee
City of Oak Creek
City of St. Francis
City of South Milwaukee
City of West Allis
Southeast Wisconsin Professional Baseball District

[a]*Most of the land area of these communities is in the Upper Fox River watershed, but a part is in the Menomonee River watershed in the regional water quality management plan update study area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

principal elements of the natural resource base which are important considerations in the regional water quality management plan update planning program are climate, physiography, air quality, soils, vegetation, water resources, fish and wildlife resources, and environmentally sensitive areas. Without a proper understanding and recognition of the elements comprising the natural resource base and their interrelationships, human use and alteration of the natural environment proceed at the risk of excessive costs in terms of both monetary expenditures and destruction of nonrenewable or slowly renewable resources. Given the location of the regional water quality management plan update study area in a rapidly urbanizing region, it is especially important that the natural resource base be a significant consideration in the water quality management planning effort, since the areawide diffusion of urban land uses makes the underlying and sustaining resource base highly vulnerable to misuse and destruction.

Accordingly, the spatial distribution, extent, and quality of the natural resources of the study area pertinent to the planning effort are described in this report. While the most pertinent components of the natural resource base are described in this chapter, some are considered in more detail in later chapters of this report or in the accompanying technical report.[3] For example, this chapter provides an overview of the surface water resources of the watershed, while the findings of a more detailed evaluation of the surface water quality conditions and sources of pollution are described in Chapters III and IV of this report and in the accompanying technical report.[4]

Climate

General Climatic Conditions

The mid-continental location of the regional water quality management plan update study area, far removed from the moderating effect of the oceans, gives the study area a typical continental climate, characterized primarily by a continuous progression of markedly different seasons and a large range in annual temperature. Low temperatures during winter are intensified by prevailing frigid northwesterly winds, while summer high temperatures are reinforced by the warm southwesterly winds common during that season.

[3]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

[4]Ibid.

Table 20

SOLID WASTE LANDFILLS LICENSED FOR YEAR 2005[a] WITHIN AND ADJACENT TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Number on Map 11	Facility Name	WDNR License Number	Civil Division	Capacity As of January 2004 (cubic yards)	Estimated Site Life (years)	Categories of Waste Accepted[b]
1	Falk Corporation Landfill	1882	City of South Milwaukee	95,557	7	4
2	Kestrel Hawk Landfill	572	City of Racine	4,077,890	6	1, 6, 21, 22, 23
3	Metro Landfill and Development	1099	City of Franklin	3,629,000	4	1, 4, 5, 6, 19, 21, 23
4	Onyx Emerald Park Landfill	3290	City of Muskego	7,319,503	7	1, 6, 19, 21, 22, 23
5	WMWI Orchard Ridge Recycling and Disposal	3360	Village of Menomonee Falls	1,220,794[c]	2[c]	1, 3, 4, 5, 6, 21, 23
6	WEPCo Caledonia Landfill	3232	Village of Caledonia	2,627,084	66	2

[a]*The license period runs from October 1, 2004 to September 30, 2005.*

[b]*The waste categories are as follows:*

1-Municipal Waste
2-Utility Ash and Sludge
3-Pulp and Paper Mill Manufacturing Wastes
4-Foundry Wastes
5-Publicly Owned Treatment Works Sludge
6-All Other Solid Waste, Excluding Hazardous Wastes
19-Fee Exempt Waste Used for Dikes, Berms, etc.
20-Energy Recovery Incinerator Ash
21-High-Volume Industrial Waste Used for Daily Cover
22-Shredder Fluff Used for Daily Cover
23-Treated Contaminated Soil Used for Daily Cover

[c]*During 2004, an expansion to the Orchard Ridge Recycling and Disposal facility was approved. The expansion provides for an additional capacity of 10,900,000 cubic yards and extends the site life by approximately 10.5 years. This facility is located immediately in the vicinity of three inactive landfills: the Omega Hills North landfill in the Village of Germantown and the Boundary Road and Parkview landfills in the Village of Menomonee Falls.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The study area is positioned astride cyclonic storm tracks along which low-pressure centers move from the west and southwest and also lies in the path of high-pressure centers moving in a generally southeasterly direction. This location at the confluence of major migratory air masses results in the watersheds generally being influenced by a continuously changing pattern of different air masses, which results in frequent weather changes being superimposed on the large annual range in weather characteristics, particularly in winter and spring, when distinct weather changes normally occur every three to five days. These temporal weather changes consist of marked variations in temperature, type and amount of precipitation, relative humidity, wind speed and direction, and cloud cover.

In addition to these distinct temporal variations in weather, the study area exhibits spatial variations in weather due primarily to its proximity to Lake Michigan, particularly during the spring, summer, and autumn seasons, when the temperature differential between the lake water and the land air masses tends to be the greatest. During these periods, the presence of the Lake tends to moderate the climate of the eastern portion of the study area.

Map 12 shows the location of several meteorological stations located in or near the study area, as well as the availability of temperature and other meteorological data. These stations were used to construct a Thiessen polygon network, which was used to associate land areas with specific meteorological data as input into the water quality modeling. Table 21 provides data for meteorological stations for which records were used to characterize the climatological and meteorological conditions in the study area as presented in the following paragraphs.

Climate Change

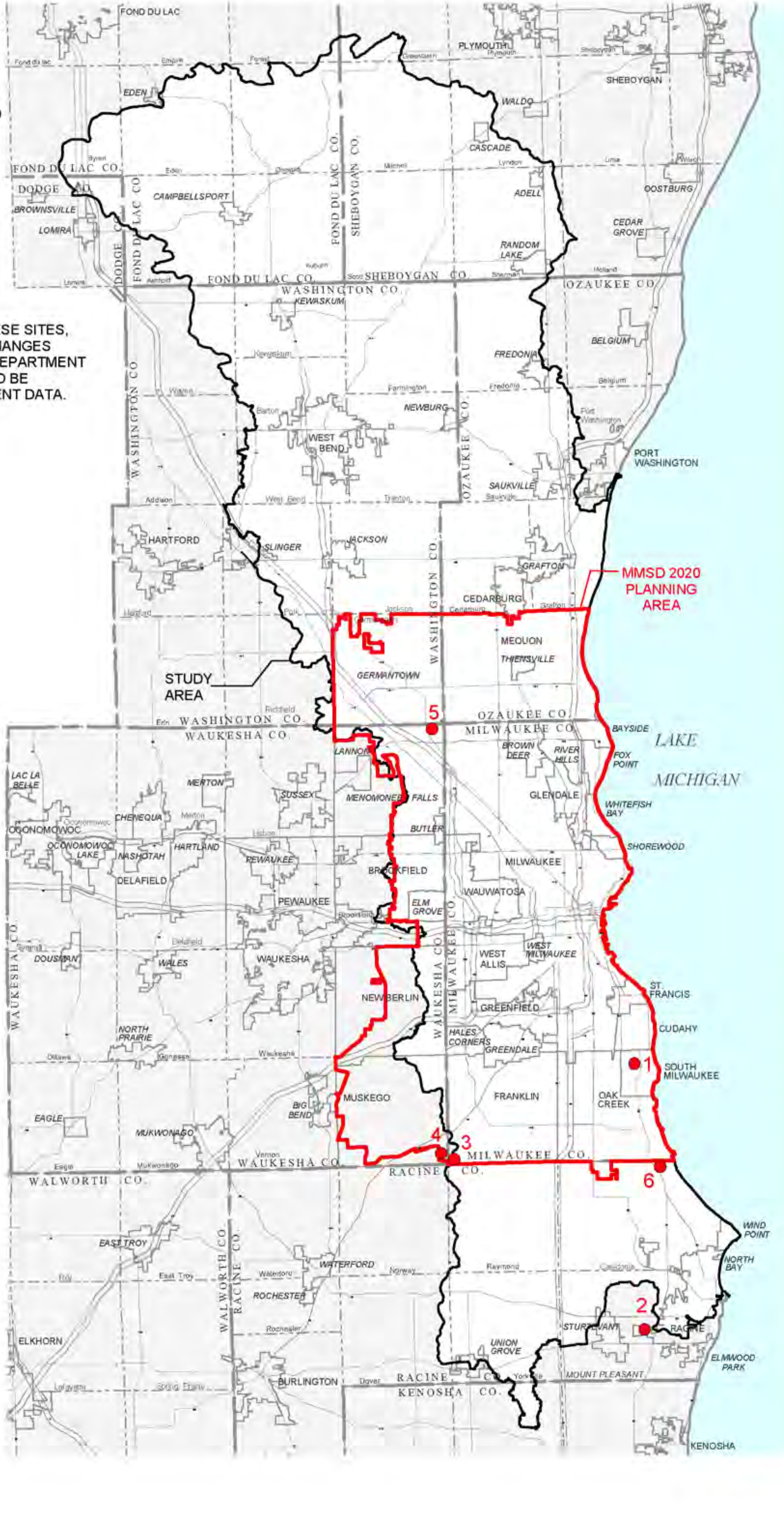
Changes in climate over the last century, attributed to both natural and anthropogenic influences, have been extensively studied in recent years. The most significant indicator of climate change presented in the scientific

Map 11

ACTIVE SOLID WASTE DISPOSAL SITES WITHIN AND ADJACENT TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2005

● ACTIVE LANDFILL SITES

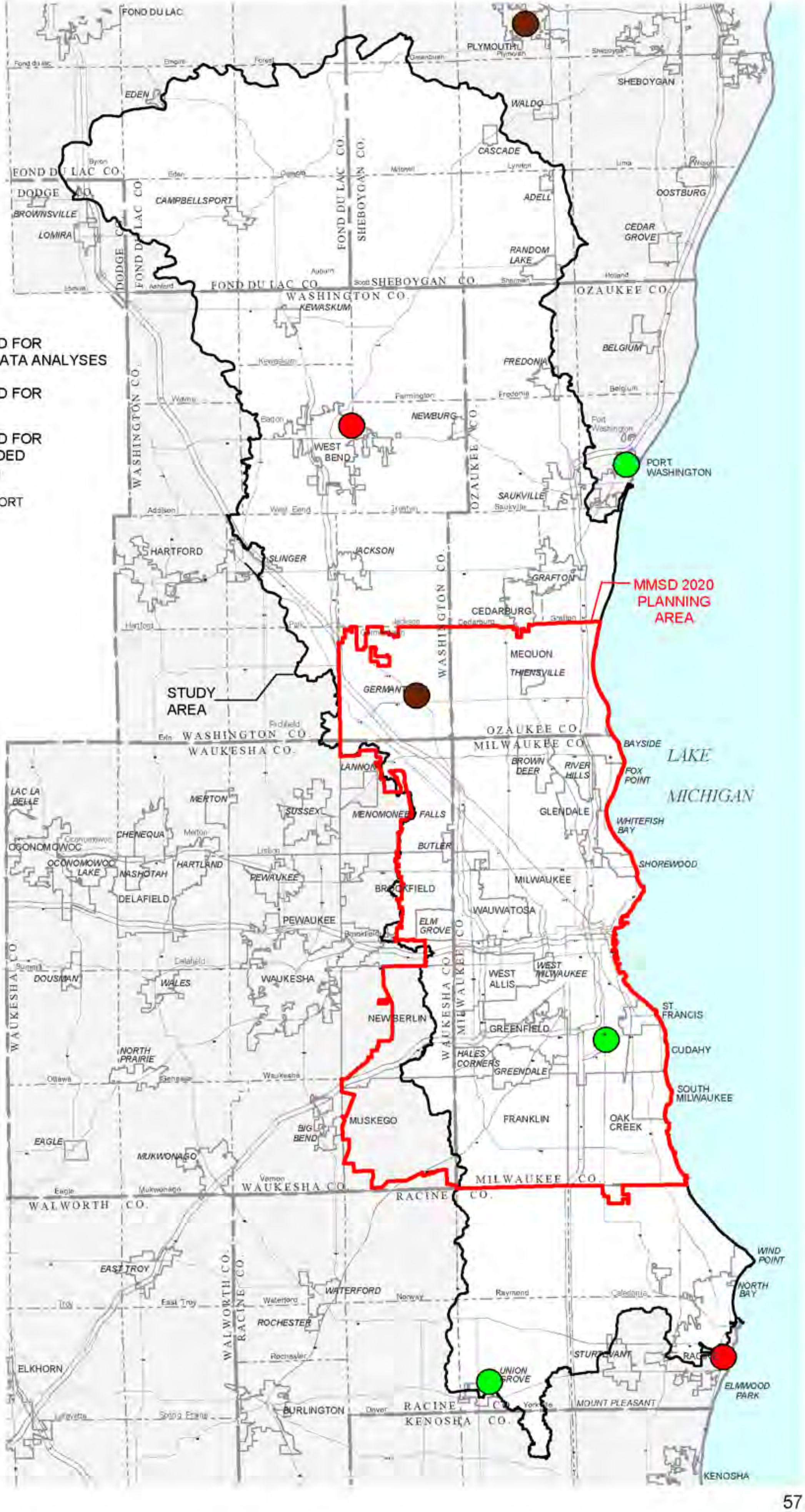
NOTE: BECAUSE OF THE NATURE OF THESE SITES, THE INVENTORY INFORMATION CHANGES PERIODICALLY. THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES SHOULD BE CONTACTED FOR THE MOST RECENT DATA.



Source: SEWRPC.

Map 12

METEOROLOGICAL STATIONS WITHIN AND NEAR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



- METEOROLOGICAL STATIONS USED FOR WATER QUALITY MODELING AND DATA ANALYSES
- METEOROLOGICAL STATIONS USED FOR WATER QUALITY MODELING ONLY
- METEOROLOGICAL STATIONS USED FOR DATA ANALYSIS ONLY (NOT INCLUDED IN THIESSEN POLYGON NETWORK)

NOTE: SEE MAP 43 IN CHAPTER V OF THIS REPORT FOR THE LOCATIONS OF ALL OF THE METEOROLOGICAL STATIONS USED IN THE MODELING EFFORT.

GRAPHIC SCALE

Source: SEWRPC.

Table 21

SELECTED NATIONAL WEATHER SERVICE METEOROLOGICAL STATIONS WITHIN AND NEAR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Station		Location				
Name	National Weather Service Number	County	Civil Division	Current Location	Year Operation Began	Data Recorded
Germantown[a]	3058	Washington	Germantown	Waterworks Plant	1942 (NCDC-climate data)	Daily precipitation, daily temperature
Milwaukee[b]	5479	Milwaukee	Milwaukee	General Mitchell International Airport	1925 (NCDC-climate data)	Daily precipitation, daily temperature
Plymouth[a]	6678	Sheboygan	Plymouth	Sewage treatment plant	1908 (NCDC-climate data)	Daily precipitation, daily temperature
Port Washington[b]	6764	Ozaukee	Port Washington	City of Port Washington	1928 (NCDC-climate data)	Daily precipitation, daily temperature
Racine[c]	6922	Racine	Racine	Sewage treatment plant	1948 (NCDC-climate data)	Daily precipitation, daily temperature
Union Grove[b]	8723	Racine	Union Grove	Sewage treatment plant	1939 (NCDC-climate data)	Daily precipitation, daily temperature
West Bend[c]	9050, 9053[d]	Washington	West Bend	West Bend fire station	1948 (NCDC-climate data)	Daily precipitation, daily temperature[e]

[a]*Station used for data analysis.*

[b]*Station used for water quality modeling calibration and data analysis.*

[c]*Station used for water quality modeling calibration.*

[d]*For the period from January 1948 through November 2003, data was obtained from station 9050 (private citizen observer). Data from December 2003 to the present was obtained from station 9053 (West Bend fire station).*

[e]*Daily temperature observations ceased in December 2004.*

Source: National Weather Service; National Climatic Data Center; and SEWRPC.

literature is an increase in mean annual air temperature over the last century.[5] That change has influenced other climatological parameters, hydrology, water quality, and natural ecosystems. Considerable effort has also been directed toward applying computer models to predict future climate change based on different assumptions regarding natural and anthropogenic influences on climate. Such climate change modeling is generally accomplished at a global scale, and it is not directly applicable to more-localized areas such as the regional water quality management plan study area.

The calibration and validation of the continuous simulation water quality model that was developed for the regional water quality management plan update were based on simulation of hydrologic conditions using meteorological data for the time period from 1994 through 2001 and the alternative plans were developed based on simulation of the period from 1988 through 1997, during which rainfall characteristics were consistent with the long-term mean. Those simulations were made to develop streamflow, nonpoint source pollutant loads, and instream concentrations of pollutants from both point and nonpoint sources.

Streamflow is a major, climate-related influence on washoff of nonpoint source pollutants and a determinant of instream concentrations. A recent study of streamflow trends in the United States, prepared by the U.S. Geological Survey (USGS) under its National Streamflow Information Program and summarized in a USGS fact

[5]*Great Lakes Water Quality Board of the International Joint Commission,* Climate Change and Water Quality in the Great Lakes Basin," *August 2003, www.ijc.org/php/publications/html/climate/.*

sheet[6] indicates increasing trends in annual minimum, annual median, and annual maximum streamflows at 435 stream gages that are part of the USGS national Hydroclimatic Data Network (HCDN). The gages of the HCDN have been identified as gages where the main influence on streamflows is climatic variations, thus, they are suitable for the study of long-term climate change. The USGS study fact sheet states that "the observed trends … appear to have occurred around 1970 as an abrupt rather than gradual change." The simulation periods applied for the regional water quality management plan update are both after 1970, indicating that they should adequately reflect the climate conditions subsequent to the abrupt change in streamflows identified by the USGS.

The effects of climate change over the planning period, which extends to the year 2020, cannot be explicitly evaluated in the context of the water quality model. However, model input parameters approximate the current state of the climate and they are considered to adequately represent the anticipated climate regime over the relatively short planning period.

Temperature

Temperatures, which exhibit a large annual range, are relevant to watershed-based water resource planning. Seasonal temperatures determine the kinds and intensities of the recreational uses for which surface waters and adjacent riverine lands may be used and, consequently, the periods over which the highest levels of water quality should be maintained. More importantly, aerobic and anaerobic biochemical processes fundamental to the self-purification of streams are temperature-dependent, since reaction rates approximately double with each rise of 20 degrees Fahrenheit (°F) in temperature within the temperature range normally encountered in nature. The supply of oxygen available for such processes is a function of oxygen solubility in water or the maximum concentration of oxygen that can be retained in solution, which is also highly dependent on temperature. For example, a stream at or near freezing temperatures can hold about 15 milligrams per liter (mg/l) of dissolved oxygen, but the capacity is reduced by almost one-half at 80°F. The summer period is therefore critical and limiting in both natural and artificially induced aerobic processes, since oxygen demands are at their annual maximum because of accelerated reaction rates while the oxygen supply is at its annual minimum because of solubility limitations associated with high temperatures.

Data for selected air temperature observation stations in and near the study area are presented in Table 22. The air temperature and precipitation data used to develop the related tables and figures presented in this and subsequent sections of this chapter are for periods encompassing the 54 years from 1950 to 2003. The temperature data illustrate how air temperatures in the study area lag approximately one month behind the summer and winter solstices during the annual cycle, with the result that July is the warmest month in the study area and January the coldest. In addition, the effects of Lake Michigan are seen when comparisons are made between inland and lakeshore observations stations that have the same latitude.[7]

Summer air temperatures throughout the study area as reflected by monthly means at these five stations for July and August, range from 68.3°F to 70.9°F. Average daily maximum temperatures within the study area for these two months range from 73.5°F to 76.6°F, average daily minimum temperatures vary from 60.3°F to 66.2°F. With respect to minimum daily temperatures, the meteorological network is not sufficiently dense to reflect the effects of topography. During nighttime hours, cold air, because of its greater density, flows into low-lying areas. Because of this phenomenon, the average daily minimum temperatures in these topographically low areas will be lower than those recorded by the meteorological stations, particularly during the summer months.

Winter temperatures in the study area, as measured by monthly means for January and February at the five selected meteorological stations, range from 17.6°F to 24.4°F. Average daily maximum temperatures within the study area for these two months vary from 27.8°F to 35.0°F, whereas average daily minimum temperatures range from 3.1°F to 14.9°F.

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[6]*U.S. Geological Survey,* "Streamflow Trends in the United States," Fact Sheet 2005-3017, *March 2005.*

[7]*SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002.*

Table 22

AIR TEMPERATURE CHARACTERISTICS AT SELECTED LOCATIONS WITHIN AND NEAR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1950-2003

	Observation Station								
	Plymouth			Port Washington			Germantown		
Month	Average Daily Maximum	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]
January	29.4	5.9	17.9	30.1	6.3	19.5	27.8	3.1	17.6
February	31.5	13.6	22.0	33.4	14.1	23.5	32.7	11.6	22.4
March	40.1	22.3	31.3	39.1	23.3	31.9	40.6	21.7	31.7
April	50.4	37.2	44.2	51.4	37.9	43.0	50.1	37.9	44.4
May	62.7	48.7	55.3	59.4	47.1	53.2	61.8	48.5	55.1
June	71.0	58.7	65.2	69.2	58.0	62.9	69.8	58.9	64.7
July	74.9	64.2	70.1	75.2	64.9	69.0	74.5	63.9	69.4
August	74.0	63.3	68.5	73.5	62.9	68.3	74.1	60.3	67.9
September	65.2	55.0	60.4	65.9	56.4	60.7	64.5	51.6	59.9
October	58.2	44.1	49.3	57.9	44.1	49.8	58.0	42.2	48.9
November	44.2	26.9	35.8	45.8	25.8	36.8	45.6	27.3	35.7
December	31.7	12.4	23.5	32.6	13.6	24.9	31.3	10.8	23.5
Year	52.8	37.7	45.3	52.8	37.9	44.8	52.6	36.5	45.1

	Observation Station						Study Area Summary		
	Milwaukee[c]			Union Grove					
Month	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]	Average Daily Maximum[a]	Average Daily Minimum[a]	Mean[b]
January	30.8	7.9	20.2	28.9	5.9	19.6	29.4	5.8	19.0
February	34.3	14.9	24.4	35.0	14.8	24.0	33.4	13.8	23.2
March	41.5	21.3	33.1	41.6	24.9	33.6	40.6	22.7	32.3
April	50.4	37.5	44.6	52.1	37.0	45.5	50.9	37.5	44.3
May	62.8	49.1	54.9	63.9	50.6	56.2	62.1	48.8	54.9
June	71.8	58.5	65.3	69.9	60.4	66.1	70.3	58.9	64.8
July	76.3	66.2	70.9	76.7	65.9	71.2	75.5	65.0	70.1
August	75.8	65.2	69.7	76.4	62.9	69.4	74.8	62.9	68.8
September	67.2	57.5	61.9	69.2	55.5	61.8	66.4	55.2	61.0
October	58.1	39.4	50.5	60.5	44.0	50.6	58.5	42.7	49.8
November	47.2	29.0	36.9	45.2	28.9	37.2	45.6	27.6	36.5
December	34.1	12.8	25.3	33.6	13.3	25.2	32.7	12.6	24.5
Year	54.2	38.3	46.6	54.4	38.7	46.7	53.3	37.8	45.7

[a]*The monthly average daily maximum temperature and the monthly average daily minimum temperature are obtained by using daily measurements to compile an average for each month.*

[b]*The mean monthly temperature is the average of the average daily maximum temperatures and average daily minimum temperatures for each month.*

[c]*General Mitchell International Airport.*

Source: National Climate Data Center; Wisconsin State Climatologist; and SEWRPC.

Extreme high and low temperatures for the watershed, based on 40 years of data recorded at Milwaukee General Mitchell International Airport, located within the study area, range from a high of 105°F to a low of -26°F. The growing season, which is defined as the number of days between the last 32°F frost in spring and the first freeze in autumn, normally begins in late April and ends in late October.

Precipitation

Precipitation within the watershed takes the form of rain, sleet, hail, and snow, ranging from gentle showers of trace quantities to destructive thunderstorms and major rainfall-snowmelt events, which may cause property damage, the inundation of poorly drained areas, and stream flooding. Rainfall events may also cause sanitary sewerage systems to surcharge and back up into basements and overflow into surface watercourses. Surcharging of sanitary sewerage systems is caused by the entry of excessive quantities of rain, snowmelt, and groundwater into sanitary sewers via manholes, building sewers, building downspouts, and foundation drain connections and by infiltration through faulty sewer pipe joints, manhole structures, and cracked pipes.

Total precipitation data for the Germantown, Milwaukee, Plymouth, Port Washington, and Union Grove, observation stations are presented in Table 23. Monthly total precipitation observations are presented graphically in Figure 3. The table and figure illustrate the amount of precipitation that normally occurs within and near the study area.

The average annual total precipitation in the study area and immediate surroundings, based on data from the five stations, is 32.20 inches, expressed as water equivalent. Average total monthly precipitation for the study area, based on data for the three weather stations, ranges from a low of 1.22 inches in February to a high of 3.77 inches in August.

During the 54-year period examined, annual precipitation within the study area and the immediate surroundings has varied from a low of approximately 21 inches, or about 65 percent of the area average, to a high of approximately 41 inches, or about 27 percent above the average. The maximum monthly precipitation recorded at the five stations is 18.33 inches, recorded at Port Washington in June 1996.

Snow Cover

The likelihood of snow cover and the depth of snow on the ground are important factors influencing the planning, design, construction, and maintenance of public utilities. Snow cover, particularly early in the winter season, significantly influences the depth and duration of frozen ground, which, in turn, affects engineered works involving excavation and underground construction. Accumulated snow depth at a particular time and place is primarily dependent on antecedent snowfall, rainfall, and temperature characteristics and the amount of solar radiation. Rainfall is relatively unimportant as a melting agent but, because of compaction effects, can significantly affect the depth of snow cover on the ground.

Table 24 indicates the snow cover probabilities at Milwaukee as measured during the 94-year period from 1900 through 1993. It should be emphasized that the tabulated data pertain to snow depth on the ground as measured at the place and time of observation, but are not a direct measure of average snowfall. Recognizing that snowfall and temperatures, and therefore snow accumulation on the ground, vary spatially within the study area, the data presented in Table 24 should be considered only as an approximation of conditions throughout the study area. As indicated by the data, snow cover is most likely during the months of December, January, and February, when there is at least a 0.39 probability of having one inch or more of snow cover in Milwaukee. Furthermore, during January and early February, there is at least a 0.31 probability of having five or more inches of snow on the ground. During early March, the time during which severe spring snowmelt-rainfall flood events are most likely to occur, there is at least a 0.31 probability of having one inch or more of snow on the ground.

By using Table 24, the probability that a given snow cover will exist or be exceeded at any given time can be estimated; thus, the data in the table can be useful in planning winter outdoor work and construction activities and in estimating runoff for hydrologic purposes. There is, for example, only a 0.18 probability of having one inch or more of snow cover on November 30 of any year, whereas there is a much higher probability, 0.63, of having that much snow cover on January 15.

Frost Depth

The terms “ground frost” or “frozen ground” refer to that condition in which the ground contains variable amounts of water in the form of ice. Frost influences hydrologic processes, particularly the proportion of rainfall or snowmelt that will run off the land directly to sewerage or stormwater systems and to surface watercourses in contrast to that which will enter and be temporarily detained in the soil. Anticipated frost conditions influence the design of engineered works in that structures and facilities are designed either to prevent the accumulation of water and, therefore, the formation of damaging frost, as in the case of pavements and retaining walls, or to be partially or completely located below the frost-susceptible zone in the soil, as in the case of foundations and water mains. For example, in order to avoid or minimize the danger of structural damage, foundation footings must be placed at a depth sufficient in the ground to be below that zone in which the soil may be expected to contract, expand, or shift as a result of frost actions. The design and construction of sanitary sewers are based on similar considerations.

Table 23

AVERAGE MONTHLY PRECIPITATION FROM SELECTED METEOROLOGICAL STATIONS WITHIN AND NEAR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1950-2003

Month	Average Monthly Precipitation (inches)					
	Plymouth	Port Washington	Germantown	Milwaukee[a]	Union Grove	Average[b]
January	1.35	1.45	1.26	1.70	1.36	1.42
February	1.27	1.15	1.09	1.47	1.15	1.22
March	2.16	1.86	1.81	2.38	2.01	2.04
April	3.37	3.18	3.11	3.45	3.46	3.31
May	3.46	2.99	3.01	2.93	3.19	3.12
June	3.68	3.49	3.66	3.57	3.91	3.66
July	3.75	3.63	3.79	3.61	3.78	3.71
August	3.92	3.62	3.79	3.56	3.99	3.77
September	3.76	3.37	3.39	3.03	3.21	3.35
October	2.77	2.34	2.43	2.39	2.41	2.47
November	2.64	2.17	2.27	2.37	2.38	2.36
December	1.84	1.69	1.52	1.99	1.70	1.75
Annual Total	33.97	30.93	31.12	32.45	32.54	32.20

[a]*General Mitchell International Airport.*

[b]*This represents the mean based on data from these five observation stations.*

Source: National Climatic Data Center; Wisconsin State Climatologist; and SEWRPC.

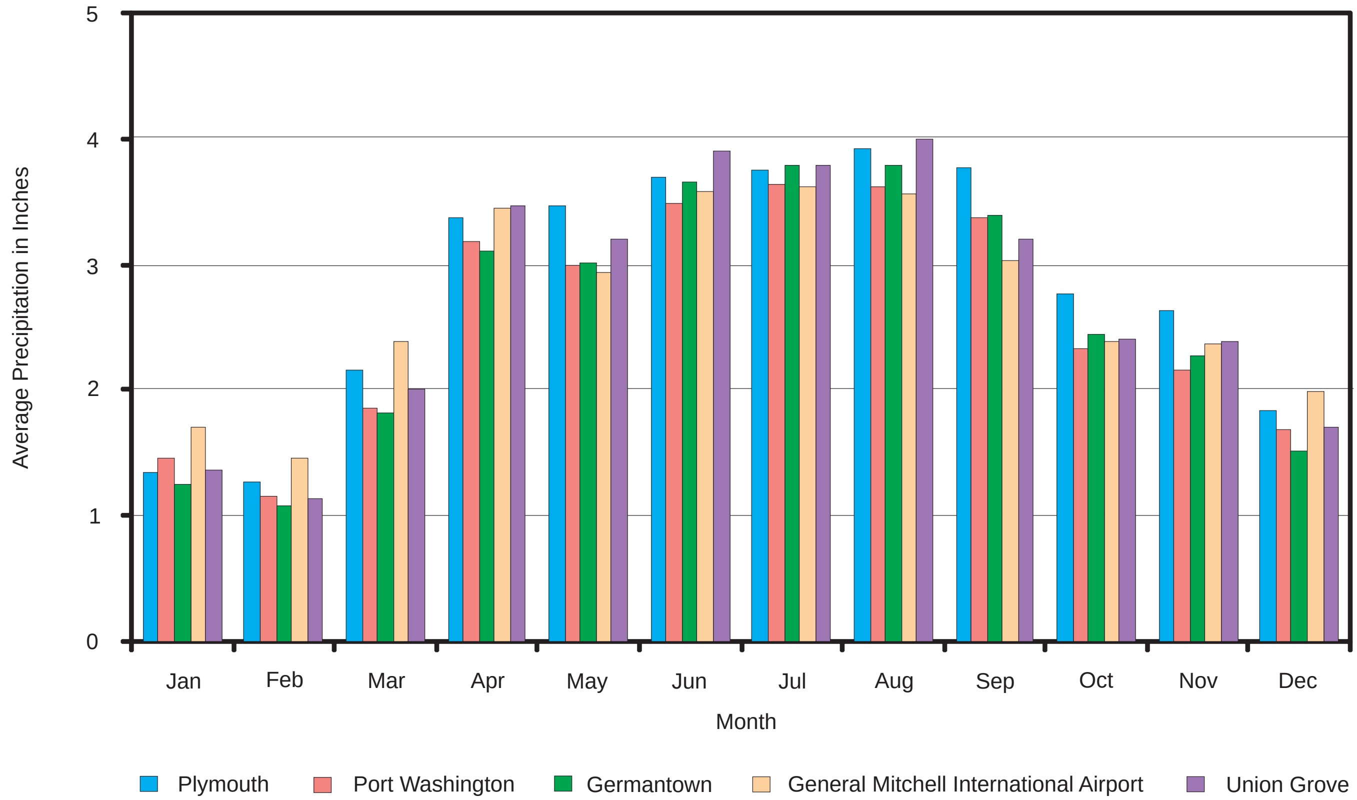
Snow cover is an important determinant of the depth of frost penetration and of the duration of frozen ground. The thermal conductivity of snow cover is less than one-fifth that of moist soil, and, thus, heat loss from the soil to the cold atmosphere is greatly inhibited by an insulating snow cover. An early, major snowfall that is retained on the ground as a substantial snow cover will inhibit or prevent frost development in unfrozen ground and may even result in a reduction or elimination of frost in already frozen ground. If an early, significant snow cover is maintained by additional regular snowfall throughout the winter season, frozen ground may not develop at all or, at most, a relatively shallow frost penetration will occur. Frost depth is also dependent on vegetal cover and soil type. Assuming similar soil types, for example, frost will penetrate more deeply into bare, unprotected soil than into soil covered with an insulating layer of sod.

Data on frost conditions for the Region are available on a semimonthly basis, from late November through mid-April, as shown in Table 25, and are based upon data for a 33-year period of record extending from 1961 through 1993. These data are provided for representative locations on a semimonthly basis by funeral directors and cemetery officials. Since cemetery soils are normally overlaid by an insulating layer of turf, the frost depths shown in Table 25 should be considered minimum values. Frost depths in excess of four feet have been observed in Southeastern Wisconsin. During the period in which frost depth observations have been made in Southeastern Wisconsin, one of the deepest regionwide frost penetrations occurred in early March 1963, when 25 to 30 inches of frost depth occurred throughout the Region. Even deeper frost depths, over 36 inches, were observed throughout the Region in January and February 1977. The Milwaukee and West Allis City Engineers reported over five feet of frost beneath some city streets in January and February 1977.

The data indicate that frozen ground is likely to exist throughout the study area for approximately four months each winter season, extending from late November through March, with more than 10 inches of frost normally occurring during January, February, and the first half of March. Historical data indicate that the most severe frost conditions normally occur in February, when 14 or more inches of frost depth may be expected.

Figure 3

PRECIPITATION CHARACTERISTICS AT SELECTED LOCATIONS WITHIN OR NEAR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1950-2003



Source: National Climatic Data Center, Wisconsin State Climatologist, and SEWRPC.

Evaporation

Evaporation is the natural process in which water is transformed from the liquid or solid state to the vaporous state and returned to the atmosphere. Total evaporation includes evaporation from water and snow surfaces and directly from the soil and also includes evaporation of precipitation intercepted on, or transpired by, vegetation. The magnitude of, and annual variation in, evaporation from water surfaces and the relation of the evaporation to precipitation are important because of the key role of this process in the hydrologic cycle of a watershed.

On the basis of the limited pan evaporation data available, pan evaporation for the study area averages about 29 inches annually, somewhat less than the total annual evaporation. During the period from May through October, the total average pan evaporation of about 24 inches exceeds precipitation. However, pan evaporation is not indicative of total evaporation in the study area, in part, because, the area of surface waters in the study area is much smaller than the total area of the study area. In addition, pan evaporation has been found to typically be 40 percent higher than actual evaporation from reservoirs.[8] On an annual basis, reservoir evaporation typically equals 0.7 times pan evaporation, and the multiplier varies substantially on a month-to-month basis. Thus, in the modeling, potential evapotranspiration estimated from other meteorological variables is used to compute the water balance.

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[8]*R.K. Linsley, Jr., M.A. Kohler, and J.L.H. Paulhus,* Hydrology for Engineers*, 1982.*

Table 24

SNOW COVER PROBABILITIES AT MILWAUKEE BASED ON DATA FOR 1900-1993

Month and Day	Snow Cover[a]									
	1.0 inch or more		5.0 inches or more		10.0 inches or more		15.0 inches or more		Average (inches)	
	Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Number of Occurrences[b]	Probability of Occurrences[c]	Per Occurrence[d]	Overall[e]
November 15	5	0.06	0	0.00	0	0.00	0	0.00	1.3	0.1
November 30	16	0.18	2	0.02	1	0.01	0	0.00	2.9	0.5
December 15	41	0.46	14	0.16	0	0.00	0	0.00	3.5	1.5
December 31	48	0.51	14	0.15	2	0.02	0	0.00	3.6	1.9
January 15	59	0.63	30	0.31	6	0.07	4	0.04	5.6	3.3
January 31	64	0.68	30	0.34	13	0.15	5	0.06	6.3	4.3
February 15	63	0.68	33	0.37	12	0.13	5	0.06	6.2	4.1
February 28	37	0.39	12	0.13	4	0.04	1	0.01	4.4	1.2
March 15	29	0.31	9	0.10	4	0.04	0	0.00	3.8	1.2
March 31	8	0.09	1	0.01	1	0.01	0	0.00	2.7	0.2

[a] *Data pertain to snow depth on the ground as it was measured at the time and place of observation and are not direct measures of average snowfall.*

[b] *Number of occurrences is the number of times during the period of record when measurements revealed that the indicated snow depth was reached or exceeded on the indicated date.*

[c] *Probability of occurrence for a given snow depth and date is computed by dividing the number of occurrences by 94, the number of years recorded, and is defined as the probability that the indicated snow cover will be reached or exceeded on the indicated date.*

[d] *Average snow cover per occurrence is defined as the sum of all snow cover measurements in inches for the indicated date divided by the number of occurrences for that date, that is, the number of occurrences in which 1.0 inch or more of snow cover was recorded.*

[e] *Overall average snow cover is defined as the sum of all snow cover measurements in inches for the indicated date divided by 94, that is, the number of observation times.*

Source: U.S. Department of Commerce, National Climatic Data Center; Wisconsin Statistical Reporting Service; and SEWRPC.

Table 25

AVERAGE FROST DEPTHS IN SOUTHEASTERN WISCONSIN: LATE NOVEMBER TO MID-APRIL

Month and Day	Nominal Frost Depth (inches)[a]
November 30	1.0
December 15	3.6
December 31	6.4
January 15	10.2
January 31	12.7
February 15	14.5
February 28	14.5
March 15	12.5
March 31	7.3
April 1-15	5.2[b]

[a]*Based on 1961-1993 frost-depth data for cemeteries as reported by funeral directors and cemetery officials. Since cemeteries have soils that are overlaid by an insulating layer of turf, the frost depths should be considered minimum values.*

[b]*Average depth from April 1 through April 15.*

Source: Wisconsin Agricultural Reporting Service, Snow and Frost in Wisconsin, *October 1978 and November 1979; Wisconsin Agricultural Statistics Service 1994; and SEWRPC.*

Wind

Over the seasons of the year, prevailing winds in the regional water quality management plan update study area follow a clockwise directional pattern, northwesterly in the late autumn and winter, northeasterly in the spring, and southwesterly in the summer and early autumn. Based on data from Milwaukee, wind velocities in the study area may be expected to be less than five miles per hour about 6 percent of the time, between five and 12 miles per hour about 52 percent of the time, and in excess of 12 miles per hour about 42 percent of the time. The highest average wind velocities occur during March and April, the lowest annual wind velocities occur during August. During any month, peak gusts in excess of 40 miles per hour may be expected.

Daylight and Sky Cover

The annual variation in the time of sunrise and sunset and the daily hours of sunlight for the watersheds are presented in Figure 4. The data shown in the figure are from the southern portion of the study area. Time of sunrise and sunset and the daily hours of sunlight do vary with latitude; however, the greatest difference in day length between the southern and northern extremes of the study area that occurs during the year is about seven minutes. Given this, the data in Figure 4 can be considered representative of the entire study area. Information on expected sky cover in the form of the expected percentage of clear, partly cloudy, and cloudy days each month is summarized in Figure 5. These daylight and sky-cover data are useful in planning outdoor construction and maintenance work and in analyzing and explaining diurnal changes in observed surface water quality. For example, marked changes in measured stream dissolved oxygen levels are normally correlated with the transition from daytime to nighttime conditions, when photosynthetic oxygen production by algae and aquatic plants is replaced by oxygen utilization through respiration by those plants. As illustrated in Figure 4, the duration of daylight ranges from a minimum of 9.0 hours on about December 22, at the winter solstice, to a maximum of 15.4 hours on about June 21, at the summer solstice.

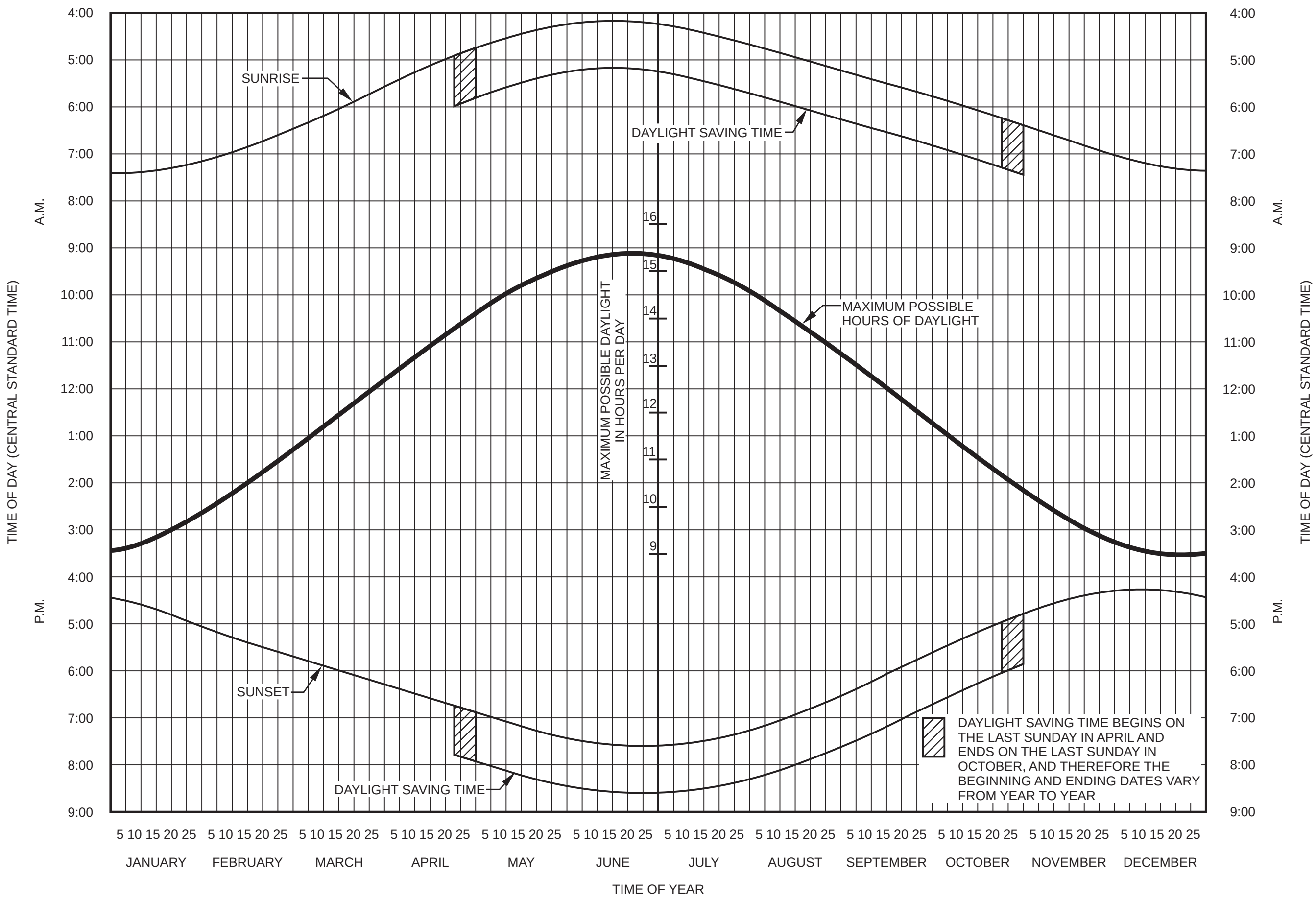
Mean monthly sky cover between sunrise and sunset varies somewhat during the year. The smallest amount of daytime sky cover may be expected to occur during the four-month period from July through October, when the mean monthly daytime sky cover is at, or slightly above, 0.5. Clouds or other obscuring phenomena are most prevalent during the five months from November through March, when the mean monthly daytime sky cover is about 0.6. Furthermore, during the summer months, as shown in Figure 5, about one-third of the days may be expected to be categorized as clear, one-third as partly cloudy, and one-third as cloudy. Greater sky cover occurs in the winter, however, when over one-half of the days are classified as cloudy, with the remainder being about equally divided between “partly cloudy” and “clear” classifications.

Physiography and Topography

Glaciation has largely determined the physiography, topography, and soils within the regional water quality management plan update study area. Physiographic features or surficial landforms within the study area have resulted from the underlying bedrock and the overlying glacial deposits of the watershed. There is evidence of several stages of glaciation in the study area, and the last and most influential in terms of present physiography and topography was the Wisconsin stage which is believed to have ended approximately 11,000 years ago.

Figure 4

SUNSET, SUNRISE, AND DAY LENGTH IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



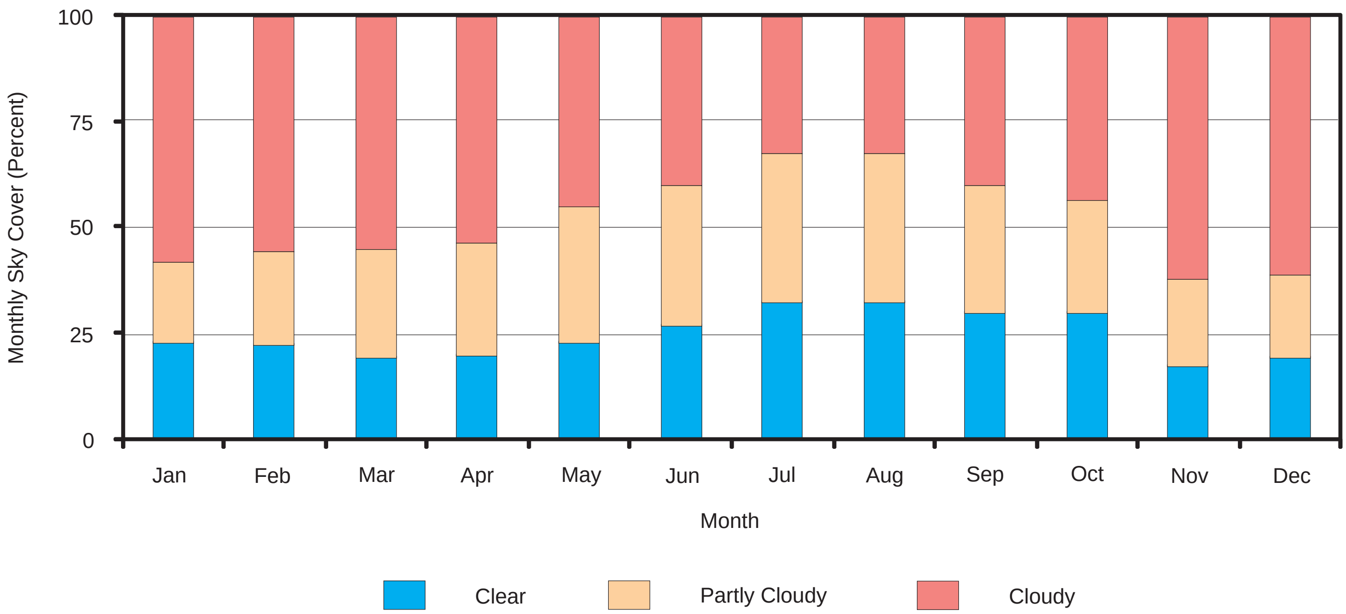
Source: Adapted by SEWRPC from National Weather Service and U.S. Naval Observatory data.

The variation in elevation within the study area is shown on Map 13. Land slopes in the study area may be classified into three major groups: slight (0 to 6 percent), moderate (7 to 12 percent), and steep (greater than 12 percent). As shown on Map 14, approximately 81 percent of the study area is characterized as having slight slopes, 12 percent as having moderate slopes, and 8 percent as having steep slopes (Table 26).

One of the dominant physiographic and topographic features within the study area is the Kettle Moraine, an interlobate glacial deposit or moraine, formed between the Green Bay and Lake Michigan lobes of the continental glacier that moved in a generally southerly direction from its origin in what is now Canada. The Kettle Moraine, which is oriented in a general northeast-southwest direction across the northwestern portion of the study area, is a complex system of hummocky sand and gravel. Some of its features include kames (crudely stratified conical hills), kettles (holes that mark the site of buried glacial ice blocks that became separated form the ice mass and melted to form depressions), eskers (long, narrow ridges of drift deposited in tunnels of ice), and abandoned drainageways. It forms some of the most attractive and interesting landscapes within the study area, and is the area of the highest elevation and the area of greatest local elevation difference, or relief. The Kettle Moraine includes areas around Holy Hill in eastern Washington County that are the topographic high points within the study area.

Figure 5

AVERAGE MONTHLY SKY COVER AT GENERAL MITCHELL INTERNATIONAL AIRPORT, MILWAUKEE, WISCONSIN: 1948-2003



NOTE: Based on Milwaukee sky cover data. The monthly data are similar to those observed at Madison and Green Bay, which suggests that there is very little variation in this monthly data for the larger geographic region relative to the regional water quality management plan update study area, represented by these three national weather service stations. Therefore, the Milwaukee sky cover data may be considered applicable to the study area. Sky cover consists of clouds or obscuring phenomena, and is expressed in tenths. A day is classified as clear if the sky cover during the daylight period is 0-0.3, partly cloudy if the sky cover is 0.4-0.7, and cloudy if the sky cover is 0.8-1.0. Monthly sky cover indicates, by month, the percentage of days that historically have been clear, partly cloudy, or cloudy.

Source: National Climatic Data Center, Wisconsin State Climatologist, and SEWRPC.

The remainder of the study area is covered by a variety of glacial landforms and features, including rolling landscapes of heterogeneous material deposited beneath the ice; terminal moraines, consisting of material deposited at the forward margins of the ice sheet; lacustrine basins, which are former glacial lake sites; outwash plains, formed by the action of flowing glacial meltwater; drumlins, elongated teardrop shaped mounds of glacial deposits streamlined parallel to the flow of the glacier; and eskers.

Currently, natural surface drainage is poorly developed and very complex within the study area due to the effects of the relatively recent glaciation. The land surface is complex as a result of being covered by glacial deposits, containing thousands of closed depressions that range in size from potholes to large areas. Significant portions of the study area are covered by wetlands and many streams are mere threads of water through these wetlands.

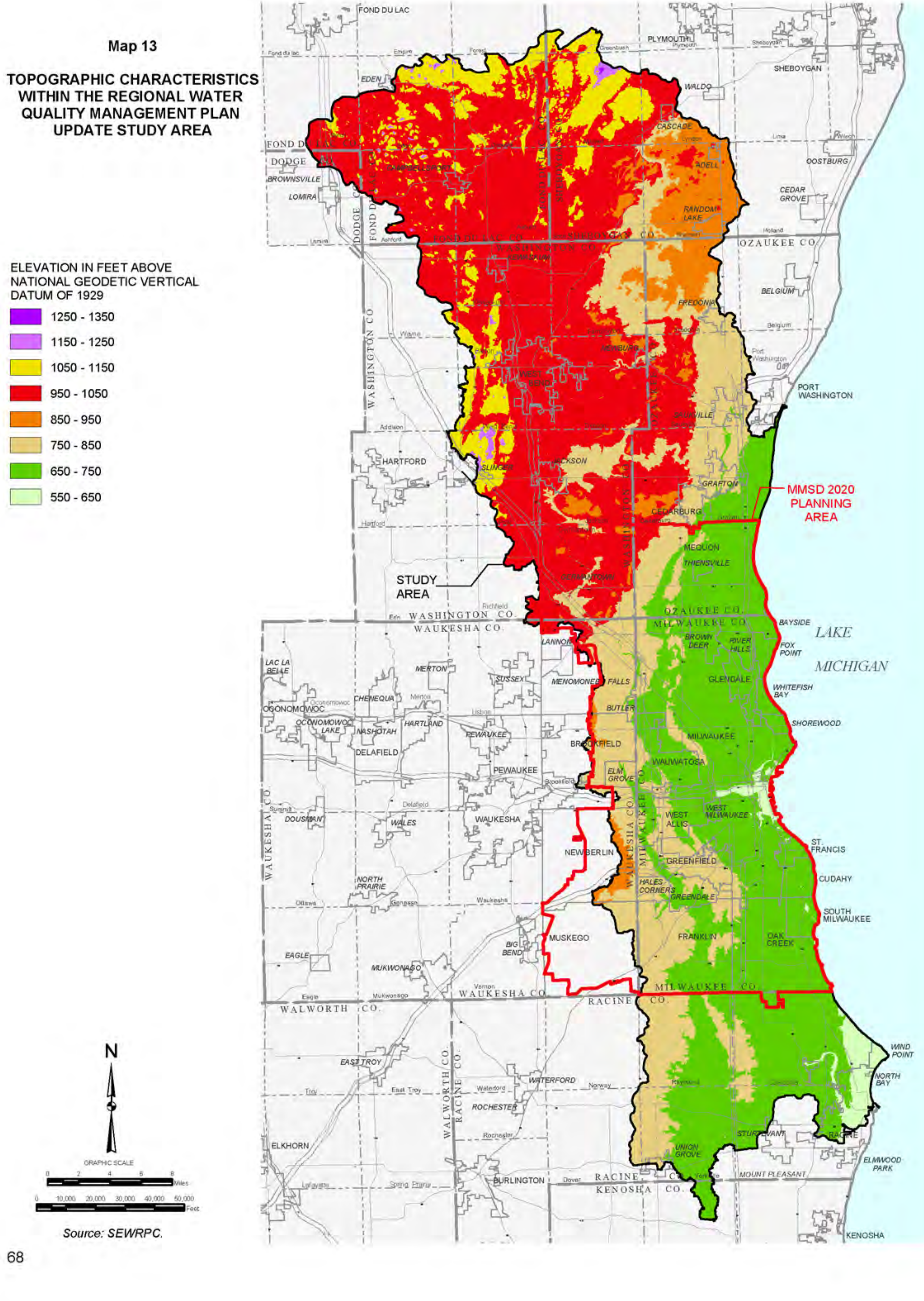
Air Quality

Air quality is an important determinant of the quality of life and the economy in the study area. In addition, surface water quality can be directly or indirectly impacted by air quality. Because of these considerations, this section of the report summarizes the current air quality conditions and programs most directly impacting the study area. However, it should be recognized that air quality problem resolution is not being specifically addressed in this planning program.

In accordance with the requirements of the Clean Air Act, the USEPA has set national ambient air quality standards (NAAQS) for six criteria pollutants, including carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), particulate matter (PM), ozone (O3), and sulfur dioxide (SO2), which are considered harmful to public

Map 13

TOPOGRAPHIC CHARACTERISTICS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

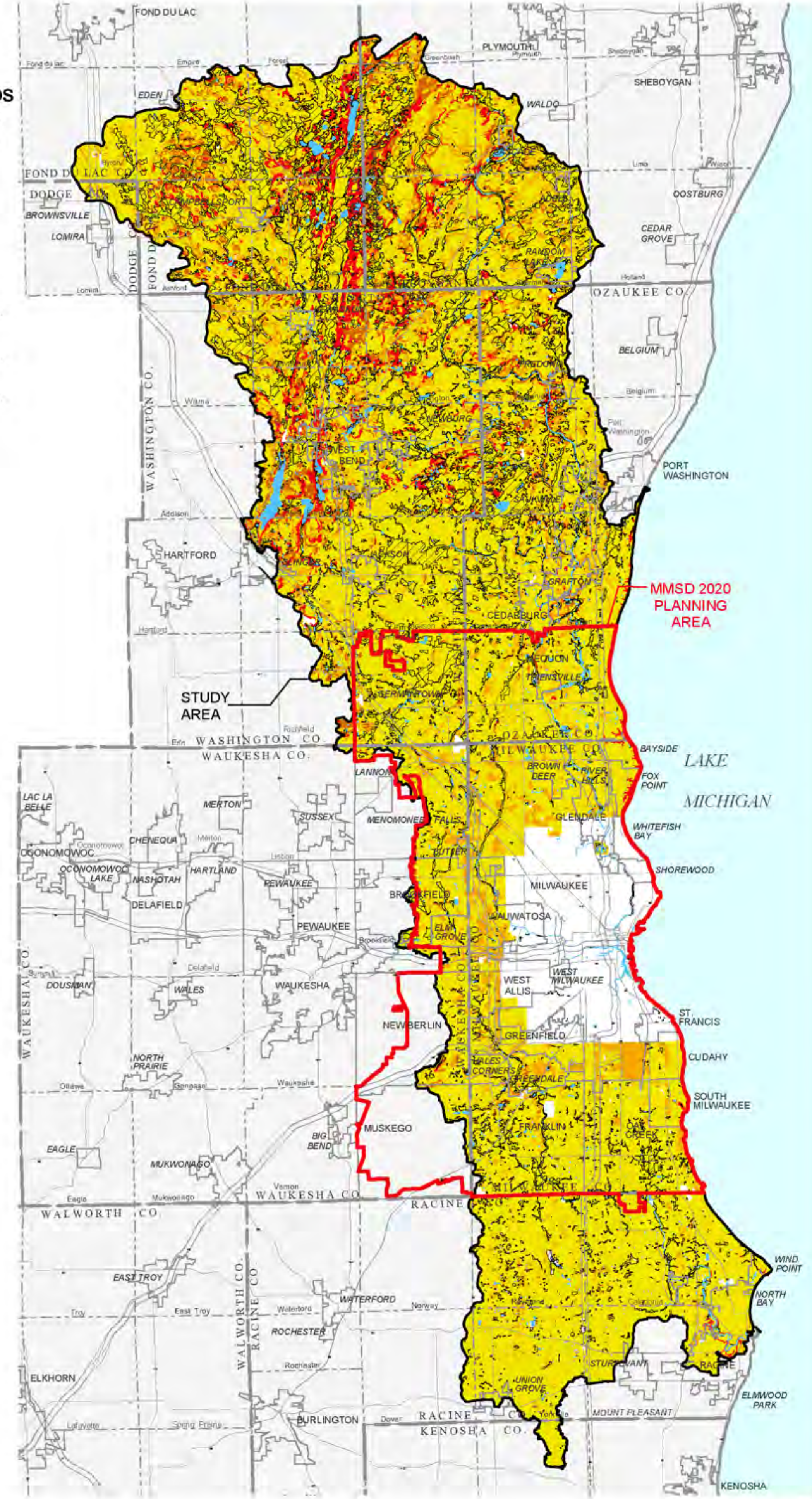


Source: SEWRPC.

Map 14

SLOPE ANALYSIS AND WETLANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- SOILS HAVING SLOPES RANGING FROM 0 TO 6 PERCENT
- SOILS HAVING SLOPES RANGING FROM 7 TO 12 PERCENT
- SOILS HAVING SLOPES RANGING FROM 13 TO 20 PERCENT
- SOILS HAVING SLOPES OF 20 PERCENT OR MORE
- NO SOIL SURVEY DATA/ SLOPE UNDETERMINED
- WETLANDS
- SURFACE WATER



GRAPHIC SCALE
0 2 4 6 8 Miles
0 10,000 20,000 30,000 40,000 50,000 Feet

Source: SEWRPC.

Table 26

SOIL SLOPE CLASSIFICATIONS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000

	Watershed							
	Lake Michigan Direct Drainage		Kinnickinnic River		Menomonee River		Milwaukee River	
Category	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
0 to 6 Percent	24,078	92.1	13,979	88.6	73,516	84.6	338,816	75.6
6 to 12 Percent	1,027	3.9	1,796	11.4	12,105	13.9	56,560	12.6
12 to 20 Percent	32	0.1	5	0.0	1,121	1.3	28,432	6.4
Greater than 20 Percent	1,004	3.9	- -	- -	148	0.2	24,217	5.4
Total	26,141	100.0	15,780	100.0	86,890	100.0	448,025	100.0

	Watershed					
	Oak Creek		Root River		Total	
Category	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
0 to 6 Percent	16,214	89.9	115,423	91.2	582,024	80.7
6 to 12 Percent	1,709	9.4	9,605	7.6	82,802	11.5
12 to 20 Percent	65	0.4	1,145	0.9	30,800	4.3
Greater than 20 Percent	52	0.3	317	0.3	25,738	3.5
Total	18,040	100.0	126,490	100.0	721,366	100.0

Source: SEWRPC.

health and the environment. The WDNR, in cooperation with the USEPA, conducts a comprehensive air quality management program designed to meet these standards and to otherwise protect air quality in the State. The WDNR air management program includes operation of a network of air quality monitors and a series of rules that limit emission for air pollution sources based upon various criteria. To ensure facilities meet their emission limits, the WDNR uses tools, such as air pollution control permits, compliance inspections, emission testing, and emission reports and certifications.

Areas not meeting the NAAQS for one or all of the criteria pollutants are designated as nonattainment areas by the USEPA. In areas where observed pollutant levels exceed the established NAAQS, and are designated as “nonattainment” areas by the USEPA, growth and development patterns may be constrained. For example, industry seeking to locate or expand in a designated nonattainment area, or close enough to impact upon it, must apply special emission control technologies. In addition, new or expanding industries may be required to obtain a greater than one-for-one reduction in emissions from other sources in the vicinity so as to provide a net improvement in ambient air quality or to purchase emission offset credits. In order to change a designation as a nonattainment area, it is necessary to demonstrate compliance with the NAAQS and petition the USEPA for redesignation of the nonattainment areas.

All of the study area currently meets all NAAQS, with the exception of the ozone standards in portions of the study area. Because of standard exceedences, the USEPA has designated seven counties within, or partially within, the study area as ozone nonattainment areas. These counties include Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha Counties.

Ozone is formed when precursor pollutants, such as volatile organic compounds and nitrogen oxides, react in the presence of sunlight. The ozone air quality problem within seven counties of the study area is a complex problem because ozone is meteorologically dependant. Peak ozone levels typically occur during hot and dry summer-time conditions. In addition, the ozone problem in a portion of the study area is believed to be attributable in large part to precursor emissions which are generated in the large urban areas located to the south and southeast and carried by prevailing winds into the study area. The full resolution of the ozone problem, thus, remains beyond the control of the study area and State and can be effectively addressed only through a multi-state abatement effort. Over the past decade, the combination of local controls and offsets implemented within and external to the seven counties noted, along with national vehicle emissions control requirements, have resulted in a significant improvement in ambient air quality, and projections of future emissions indicate a continued decline in precursor emissions and a continued improvement in air quality.

The ozone levels in the State of Wisconsin, which are relatable to the USEPA eight-hour standard, are shown in Figure 6[9] for years 2001 through 2003. The standard was exceeded in all of the counties within the study area which directly border on Lake Michigan, with the levels in the inland counties of Dodge, Fond du Lac, Washington, and Waukesha Counties, not exceeding the standard. Similar data are not yet available for the years 2002 through 2004. However, the summer of 2004 was cooler and, thus, the values for 2002 through 2004 are lower.

In addition to the pollutants discussed above, atmospheric mercury is an important pollutant because of its potential public health risks. The health risks include those associated with fish consumption advisories which are in place for most of the surface waters in the State of Wisconsin. The WDNR has established mercury emission reduction requirements for coal-fired electric utility boilers.

Soils

The nature of the soils within the regional water quality management plan update study area has been determined primarily by the interaction between the parent glacial deposits covering Southeastern Wisconsin and topography, climate, plants, animals, and time. In Southeastern Wisconsin, soils have only developed in the past approximately 11,000 years, which, in a geologic sense, is not a long period of time. Soils usually compose only the upper two to four feet of unconsolidated materials at the earth's surface. Soils are the basis of agricultural production, provide the foundation for buildings and roads, and if properly used, aid in the treatment and recycling of wastes from homes. Soil characteristics, particularly depth, texture, and permeability, are significant factors in determining the rate and extent of groundwater recharge and the degree of natural protection against contamination.

Land characteristics, such as slope, vegetation type, and type of rock or unconsolidated material will, in conjunction with the soil, determine the overall potential of the environment to protect groundwater. These land characteristics along with climate, particularly temperature and precipitation, and time determines what kinds of soil develop.

In order to assess the significance of these soil types to sound regional development, the Commission, in cooperation with the then U.S. Soil Conservation Service (now the U.S. Natural Resources Conservation Service), published SEWRPC Planning Report No. 8, *Soils of Southeastern Wisconsin*, June 1966. The regional soil survey not only has resulted in the mapping of soils within the Region in great detail and provided data on the physical, chemical, and biological properties of the soils, but also has provided interpretations of the soil properties for planning, engineering, agricultural, and resource conservation purposes.

Map 15 shows the hydrologic soil groups within the study area. Soils within the study area have been categorized into four main hydrologic groups, as indicated in Table 27. Soils that could not be categorized were included in an "other" group. About 8 percent of the drainage area is covered by well drained soils, about 44 percent by

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[9]*Historically, exceedences of the ozone standards have been considered using both the one-hour and the eight-hour standards established by the USEPA. The one-hour ozone standard was revoked by the USEPA June 15, 2005, and an eight-hour standard became effective. The eight-hour standard for ozone is 0.085 ppm and it is calculated as the fourth highest peak daily eight-hour running value for the most recent three consecutive years.*

Figure 6

ANNUAL AVERAGE FOURTH HIGHEST PEAK DAILY RUNNING EIGHT-HOUR OZONE VALUES WISCONSIN DEPARTMENT OF NATURAL RESOURCES OZONE MONITORING SITES: 2001-2003

NOTE: Criteria to attain the eight-hour ozone NAAQS at a site: The average of the annual fourth highest peak daily eight-hour running ozone values for the most recent three consecutive years of data (i.e., Design Value ["DV"]) is less than or equal to 0.08 parts per million (ppm, numerically equivalent to 84 ppb). Sites whose eight-hour 03 DVs are 84 ppb or less are denoted by white circles on this map. Shaded counties (named in italicized brackets): Counties in which at least one WDNR ozone monitor is located that has an average of its annual fourth highest peak daily eight-hour ozone values for 2001-2003 in excess of the eight-hour ozone NAAQS of 0.08 ppm (84 ppb). These monitoring sites are denoted by dark circles.

[a]*The Pleasant Prairie site is also referred to as Chiwaukee.*

Source: Wisconsin Department of Natural Resources Bureau of Air Management.

Map 15

HYDROLOGIC SOIL GROUPS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

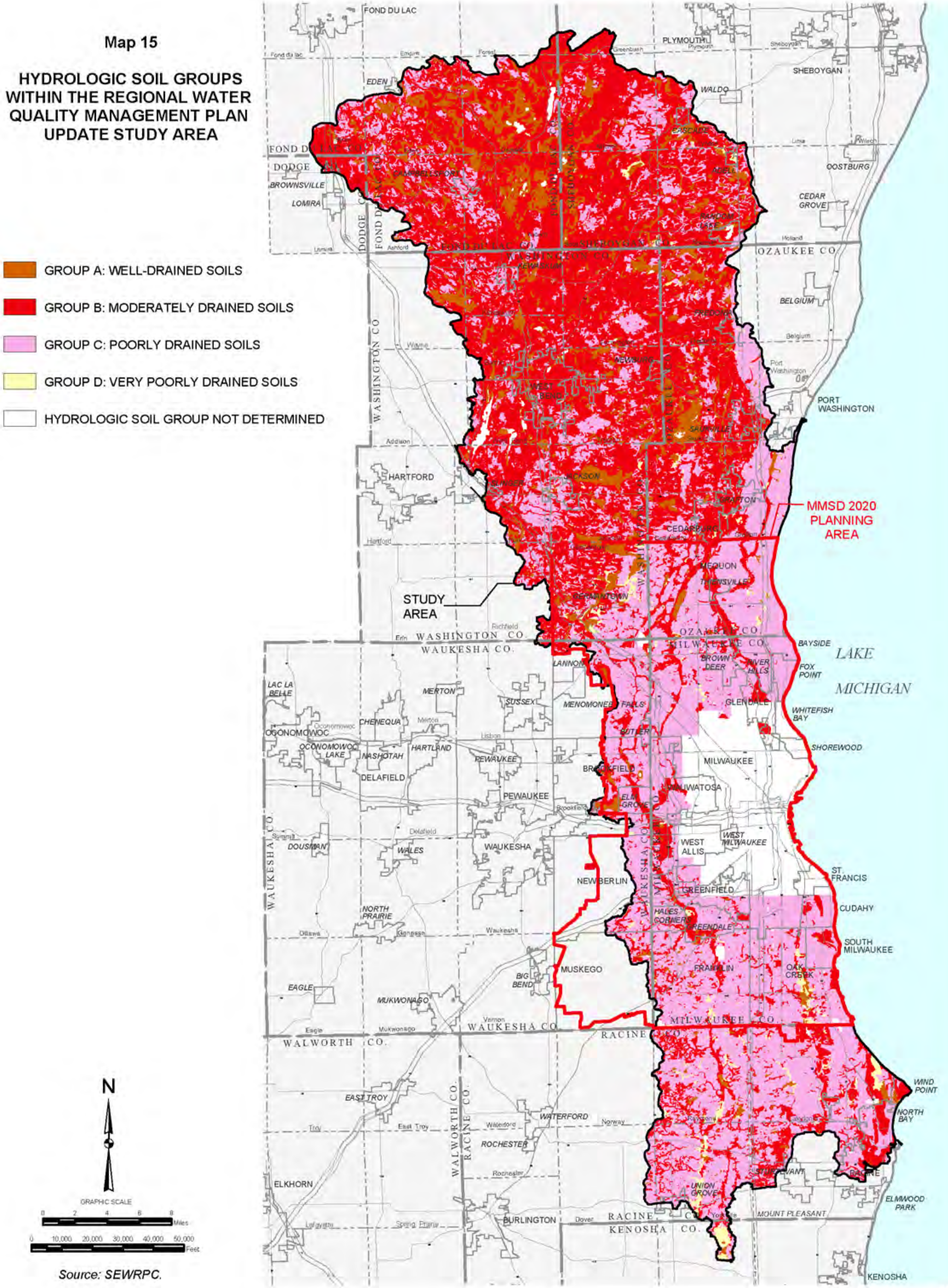


Table 27

GENERAL HYDROLOGIC SOIL TYPES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000

		Watershed													
		Lake Michigan Direct Drainage		Kinnickinnic River		Menomonee River		Milwaukee River		Oak Creek		Root River		Total	
Group	Soil Characteristics	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
A	Well drained; very rapidly to rapid permeability; low shrink-swell potential	507	2.0	- -	- -	4,209	5.0	47,953	11.0	661	4.0	2,791	2.0	56,121	8.0
B	Moderately well drained; texture intermediate between coarse and fine; moderately rapid to moderate permeability; low to moderate shrink-swell potential	4,165	16.0	426	3.0	19,606	22.0	262,985	59.0	2,606	14.0	26,916	21.0	316,704	44.0
C	Poorly drained; high water table for part or most of the year; mottling, suggesting poor aeration and lack of drainage, generally present in A to C horizons	15,012	57.0	3,209	20.0	45,755	53.0	105,187	23.0	14,119	78.0	91,213	72.0	274,495	38.0
D	Very poorly drained; high water table for most of the year; organic or clay soils; clay soils having high shrink-swell potential	720	3.0	- -	- -	1,745	2.0	2,446	<1.0	528	3.0	3,503	3.0	8,942	1.0
Other	Group not determined	5,738	22.0	12,144	77.0	15,575	18.0	29,454	7.0	125	1.0	2,068	2.0	65,102	9.0
- -	Total	26,142	100.0	15,779	100.0	86,890	100.0	448,025	100.0	18,039	100.0	126,491	100.0	721,366	100.0

Source: SEWRPC.

moderately drained soils, about 38 percent by poorly drained soils, and about 1 percent by very poorly drained soils. About 9 percent of the drainage area is covered by disturbed soils that could not be classified. The areal extent of these soils and their locations within the study area are shown in Map 15. The detailed soils data were utilized in the study area planning program in the hydrologic modeling, the identification of areas having limitations for urban development utilizing onsite waste disposal systems and for development utilizing public sanitary sewer service, the identification of prime agricultural lands, and the delineation of primary environmental corridors.

Vegetation

Watershed vegetation at any given time is determined by a variety of factors, including climate, topography, soils, proximity to bedrock, drainage, occurrence of fire, and human activities. Because of the temporal and spatial variability of these factors and the sensitivity of different forms of vegetation to these factors, vegetation in the regional water quality management plan update study area watersheds is a changing mosaic of different types. The terrestrial vegetation in the study area occupy sites which may be subdivided into three broad classifications: prairie, wetland, and woodland.

Prairies

Prairies are treeless or generally treeless areas dominated by perennial native grasses. Prairies consist of five basic types that include low prairie, mesic or moderately moist prairie, dry-mesic prairie, dry prairie, and savanna. Prairies, which once covered extensive areas of Southeastern Wisconsin, have been reduced to scattered remnants, primarily in the southern portions of the study area. The chief causes of the loss of prairies is their conversion to urban and agricultural use and the suppression of wildfires, which had served to constrain the advancing shrubs and trees that shade out the prairie plants. The location, extent, type, and quality of wetland, woodland, and prairie areas are important determinants of the environmental quality of the watersheds throughout the regional water quality management plan update study area. Such areas can, for example, support a variety of outdoor recreational activities. They offer aesthetic values, contributing to the beauty and visual diversity of the landscape and functioning as visual and acoustic shields or barriers. Such areas, as well as the vegetation contained within them have important scientific value and serve important ecological functions, since they are typically, on a unit area basis, biologically the most productive areas of the watershed, provide continuous wildlife range and sanctuary for native biota, and help to maintain surface water quality by functioning as sediment and nutrient traps. Many of the remaining prairies are encompassed with the natural areas and critical species habitat sites described later in this section.

Wetlands

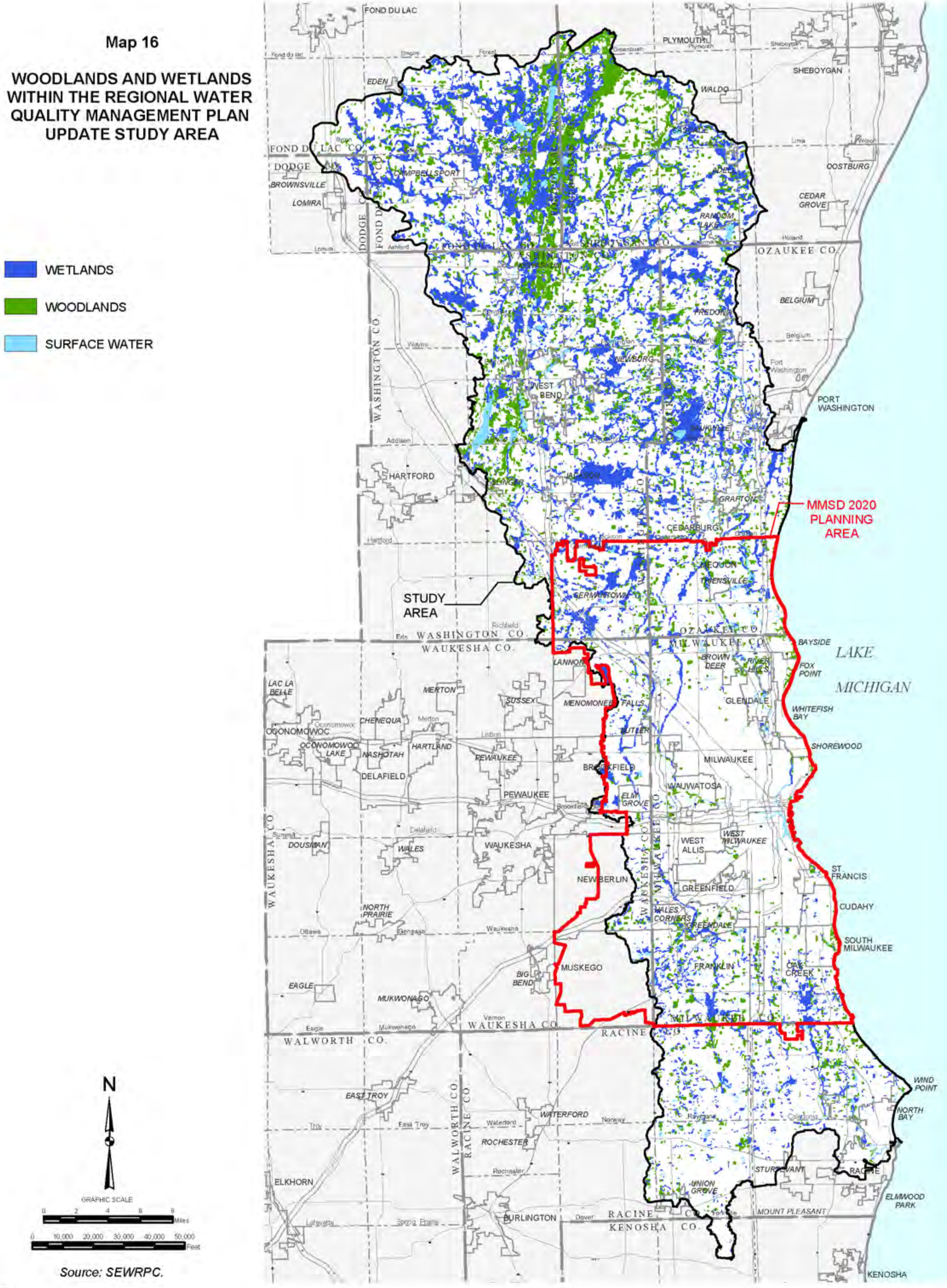
Wetlands generally occur in depressions and near the bottom of slopes, particularly along lakeshores and stream banks, and on large land areas that are poorly drained. Wetlands may, however, under certain conditions, occur on slopes and even on hilltops. Wetlands perform an important set of natural functions which include support of a wide variety of desirable, and sometimes unique, forms of plant and animal life; water quality protection; stabilization of lake levels and streamflows; reduction in stormwater runoff by providing areas for floodwater impoundment and storage; protection of shoreline from erosion; and provision of groundwater discharge areas.

As identified in the regional water quality management plan update study area land use inventory, wetlands encompassed about 128 square miles, or 11 percent of the total study area, in 2000. Those wetlands are shown on Map 16. The wetlands shown on Map 16 are based upon the Wisconsin Wetland Inventory completed in 1985 by the WDNR to help protect wetlands, and updated to the year 2000 as part of the regional water quality management plan update land use inventory. It should be noted that, in addition to the wetlands shown in Map 16, certain other areas have been identified by the U.S. Natural Resources Conservation Service as farmed wetlands, which are subject to Federal wetland regulations.

Wetlands and their boundaries are continuously changing in response to changes in drainage patterns and climatic conditions. While wetland inventory maps provide a sound basis for areawide planning, detailed field investigations are often necessary to precisely identify wetland boundaries for individual tracts of land at a given point in time.

Map 16

WOODLANDS AND WETLANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



Source: SEWRPC.

Woodlands

Three woodland types are recognized in the regional water quality management plan update study area: northern upland hardwoods, southern upland hardwoods, and northern upland conifers. The northern and southern upland hardwood types are the most common in the study area. The remaining stands of trees within the study area consist largely of even-aged mature, or nearly mature specimens, with insufficient reproduction and saplings to maintain the stands when the old trees are harvested or die of disease or age. Located largely on ridges and slopes and along lakes and streams, woodlands are a natural resource of immeasurable value. Woodlands enhance the natural beauty of, and are essential to the overall environmental wellbeing of the study area.

As identified in the regional water quality management plan update study area land use inventory, upland woodlands encompassed about 77 square miles, or 7 percent of the total area of the study area, in 2000. It should be noted that lowland wooded areas, such as tamarack swamps, are classified as wetlands in the land use inventory. Existing upland woodlands in the study area, as identified in the year 2000 land use inventory, are identified on Map 16.

Surface Water and Groundwater Resources

Surface water resources, lakes and streams and their associated floodlands, form the most important element of the natural resource base of the regional water quality management plan update study area. Their contribution to the economic development, recreational activity, and aesthetic quality of the watersheds is immeasurable. Lake Michigan is a major source of water for domestic, municipal, and industrial users in the Greater Milwaukee watersheds. Understanding the interaction of the surface water and groundwater resources is essential to sound water resource planning. Both the surface water and the groundwater are interrelated components of the hydrologic system.[10] Accordingly, both these elements of the hydrologic system are described herein. The groundwater resources of the watersheds are hydraulically connected to the surface water resources inasmuch as the former provide the base flow of streams. The groundwater resources constitute the major source of supply for domestic, municipal, and industrial water users located in the northern portion of the study area and those resources are discussed below.

Lakes and Ponds

There are more than 120 named lakes and ponds greater than two acres in area within the regional water quality management plan update study area, of which 21 lakes are greater than 50 acres in area and are capable of supporting a variety of recreational uses.[11] The total surface area of these 21 lakes is 3,438 acres, or less than 1 percent of the total study area. More than three quarters of the 3,438 acres is comprised of nine lakes all greater than 100 acres in size that include: Silver, Big Cedar, and Little Cedar Lakes in Washington County; Auburn, Kettle Moraine, and Long Lakes in Fond du Lac County; Mud Lake in Ozaukee County; and Ellen and Random Lakes in Sheboygan County. Ponds and other surface waters are present in relatively smaller proportions, totaling less than 200 acres in area throughout the study area. These lakes and smaller bodies of water provide residents of the regional water quality management plan update study area and persons from outside the study area with a variety of aesthetic and recreational opportunities and also serve to stimulate the local economy by attracting recreational users. The major lakes in the study area are shown on Map 17. More-detailed mapping and information on the lakes is presented in Chapter III of this report and in an accompanying technical report.[12]

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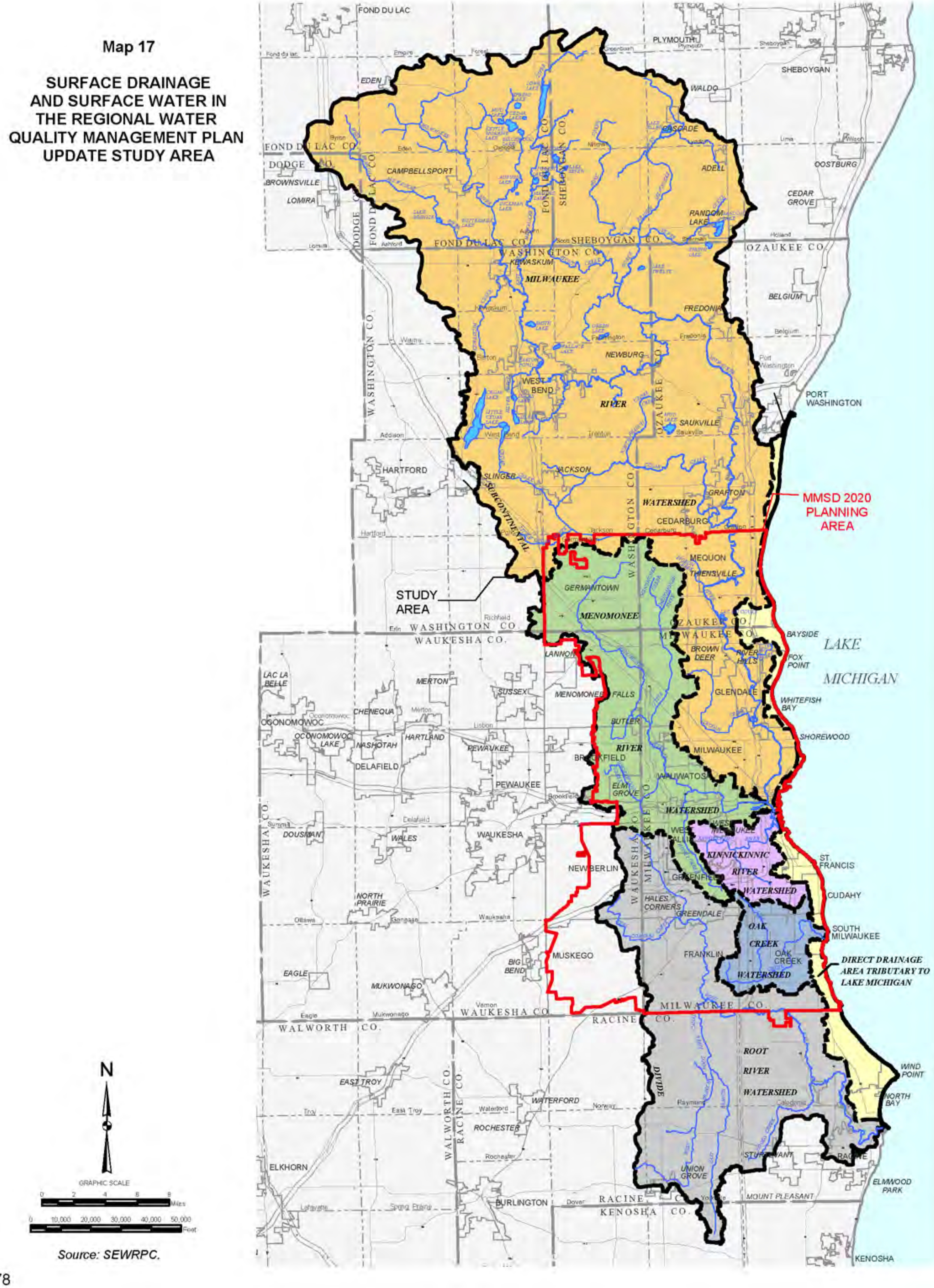
[10]*Thomas C. Winter, Judson W. Harvey, O. Lehn Franke, William M. Alley,* Ground water and surface water; a single resource, *USGS Circular 1139.*

[11]*Wisconsin Department of Natural Resources PUBL WT 704-2001,* State of the Milwaukee River Basin, *August, 2001; Wisconsin Department of Natural Resources PUBL WT-700-2002,* State of the Root-Pike River Basin, *May, 2002.*

[12]*SEWRPC Technical Report No. 39,* op. cit.

Map 17

SURFACE DRAINAGE AND SURFACE WATER IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



Source: SEWRPC.

Streams and Channel Conditions
Water from rainfall and snowmelt flows into stream systems by one of two pathways; either directly flowing overland as surface water runoff into streams or infiltrating into the soil surface and eventually flowing underground into streams as groundwater. Ephemeral streams generally flow only during the wet season. Streams that flow year-round are called perennial streams and are primarily sustained by groundwater during dry periods. The surface water drainage systems and the 1,010 miles of mapped streams are shown on Map 17 on a study area basis. More-detailed mapping and information on the stream system is presented in Chapter III of this report and in an accompanying technical report.[13]

Viewed from above, the network of water channels that form a river system displays a branchlike pattern as shown in Figure 6. A stream channel that flows into a larger channel is called a tributary of that channel. The entire area drained by a single river system is termed a drainage basin, or watershed. Stream size increases downstream as more and more tributary segments enter the main channel. A classification system based on the position of a stream within the network of tributaries, called stream order, was developed by Robert E. Horton and later modified by Arthur Strahler. In general, the lower stream order numbers correspond to the smallest headwater tributaries and are shown as the Order 1 or first-order streams in Figure 7. Second-order streams (Order 2) are those that have only first-order streams as tributaries, and so on (Figure 7). As water travels from headwater streams toward the mouth of larger rivers, streams gradually increase their width and depth and the amount of water they discharge also increases. It is important to note that over 80 percent of the total length of Earth's rivers and streams are headwater streams (first- and second-order), which is similar to the case in terms of the watersheds within the regional water quality management plan update study area.

To better understand stream systems and what shapes their conditions, it is important to understand the effects of both spatial and temporal scales. Streams can be theoretically subdivided into a continuum of habitat sensitivity to disturbance and recovery time as shown in Figure 8.[14] Microhabitats, such as a handful-sized patch of gravel, are most susceptible to disturbance and river systems and watersheds, or drainage basins, the least. Furthermore, events that affect smaller-scale habitat characteristics may not affect larger-scale system characteristics, whereas large disturbances can directly influence smaller-scale features of streams. For example, on a small spatial scale, deposition at one habitat site may be accompanied by scouring at another site nearby, and the reach or segment does not appear to change significantly. In contrast, a large-scale disturbance, such as a debris flood, is initiated at the segment level and reflected in all lower levels of the hierarchy (reach, habitat, microhabitat). Similarly, on a temporal scale, siltation of microhabitats may disturb the biotic community over the short term. However, if the disturbance is of limited scope and intensity, the system may recover quickly to pre-disturbance levels.[15] In contrast, extensive or prolonged disturbances, such as stream channelization due to ditching and tile drainage practices, have resulted in longer term impacts throughout the study area.

The most important fundamental aspects of stream systems are that 1) the entire fluvial system is a continuously integrated series of physical gradients in which the downstream areas are longitudinally linked and dependent upon the upstream areas; and 2) that streams are intimately connected to their adjacent terrestrial setting, in other

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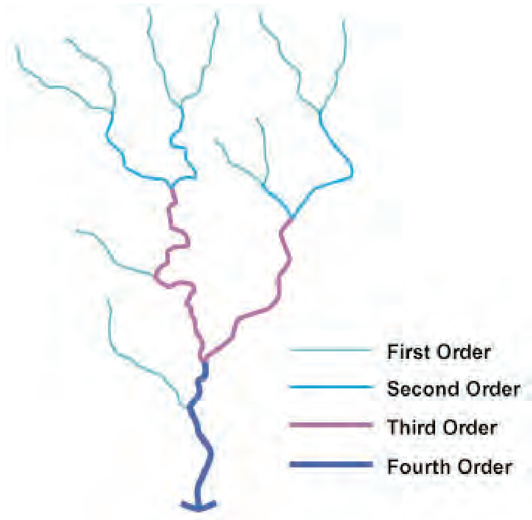
[13]Ibid.

[14]*C.A. Frissell and others, "A Hierarchical Framework for Stream Classification: Viewing Streams in a Watershed Context,"* Journal of Environmental Management*, Volume 10, pages 199-214, 1986.*

[15]*G.J. Niemi and others, "An Overview of Case Studies on Recovery of Aquatic Systems From Disturbance,"* Journal of Environmental Management*, Volume 14, pages 571-587, 1990.*

Figure 7

TYPICAL STREAM NETWORK PATTERNS BASED ON HORTON'S CLASSIFICATION SYSTEM



Source: Oliver S. Owen and others, Natural Resource Conservation: Management for a Sustainable Future.

words the land-stream interaction is crucial to the operation of stream ecosystem processes. In this regard, land uses have a significant impact on stream channel conditions and associated biological responses.[16]

Floodlands

The natural floodplain of a river is a wide, flat-to-gently sloping area contiguous with, and usually lying on both sides of, the channel. The floodplain, which is normally bounded on its outer edges by higher topography, is gradually formed over a long period of time by the river during flood stage as that river meanders in the floodplain, continuously eroding material from concave banks of meandering loops while depositing it on the convex banks. A river or stream may be expected to occupy and flow on its floodplain on the average of approximately once every two years and, therefore, the floodplain should be considered to be an integral part of a natural stream system.

How much of the natural floodplain will be occupied by any given flood will depend upon the severity of that flood and, more particularly, upon its elevation, or stage. Thus, an infinite number of outer limits of the natural floodplain may be delineated, each set of limits related to a specified flood recurrence interval. The Southeastern Wisconsin Regional Planning Commission, therefore, has for over 40 years recommended that the natural floodplains of a river or stream be more specifically defined as those lands inundated by a flood having a recurrence interval of 100 years (or a 1 percent annual chance of occurrence), with the natural floodlands being defined as consisting of the river channel plus the 100-year floodplain. Mapped floodplains in the study area are shown on Map 18. A floodway is that designated portion of the floodlands required to convey the 100-year recurrence interval flood discharge. The floodway, which includes the channel, is that portion of the floodlands least suited for human habitation. All fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities, or would themselves be subject to flood damage, should be prohibited in the floodway.

The floodplain fringe is that portion of the 100-year recurrence interval floodplain lying outside the floodway. Floodwater depths and velocities are small in this area compared to those in the floodway and, therefore, in a developed urban floodplain fringe area, further development may be permitted, although restricted and regulated so as to minimize flood damage.

For zoning purposes, the floodplain fringe may be divided into districts related to floodplain storage and natural resource characteristics. Although the floodplain fringe does not convey floodwaters, it does provide a volume of storage which affects the magnitude and timing of flood peaks. If the analyses conducted for the delineation of the

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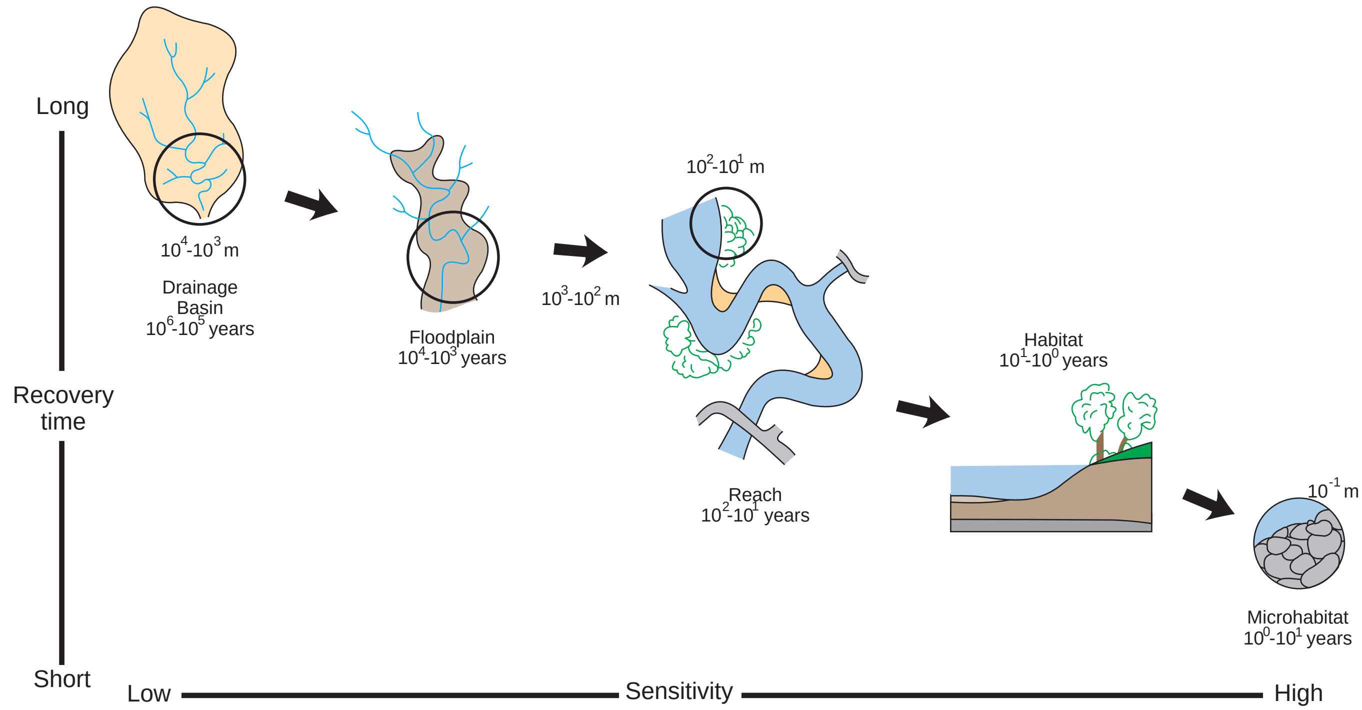
[16]*Lizhu Wang and others, "Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams,"* Fisheries*, Volume 22, No. 6, June 1997; Jana S. Stewart and others, "Influences of Watershed, Riparian-Corridor, and Reach-Scale Characteristics on Aquatic Biota in Agricultural Watersheds,"* Journal of the American Water Resources Association*, Volume 37, No. 6, December 2001; Faith A. Fitzpatrick and others, "Effects of Multi-Scale Environmental Characteristics on Agricultural Stream Biota in Eastern Wisconsin,"* Journal of the American Water Resources Association*, Volume 37, No. 6, December 2001.*

Figure 8

RELATION BETWEEN RECOVERY TIME AND SENSITIVITY TO DISTURBANCE FOR DIFFERENT HIERARCHICAL SPATIAL SCALES ASSOCIATED WITH STREAM SYSTEMS



Source: C.A. Frissell and others, "A Hierarchical Framework for Stream Habitat Classification: Viewing Streams in a Watershed Context," Environmental Management*, Vol. 10, and SEWRPC.*

floodplain boundaries of a stream, or a system of streams, include consideration of the effect of storage volume in the floodplain fringe, a flood storage zone should be designated. Such a zone may include a conservancy district, which includes wetlands in the floodplain fringe, as well as a storage district, which includes lands located outside of wetlands.

The delineation of the natural floodlands in rural or largely undeveloped watersheds is extremely important to sound planning and development. Flood hazard delineations have many practical uses, including identification of areas which are not well suited to urban development but which could be prime locations for needed park and open space areas, identification of flood hazard areas possibly requiring structural or nonstructural floodland management measures, delineation of hazard areas for flood insurance purposes, and provision of stage and probability data needed to quantify flood damages in monetary terms.

Geology and Groundwater Resources

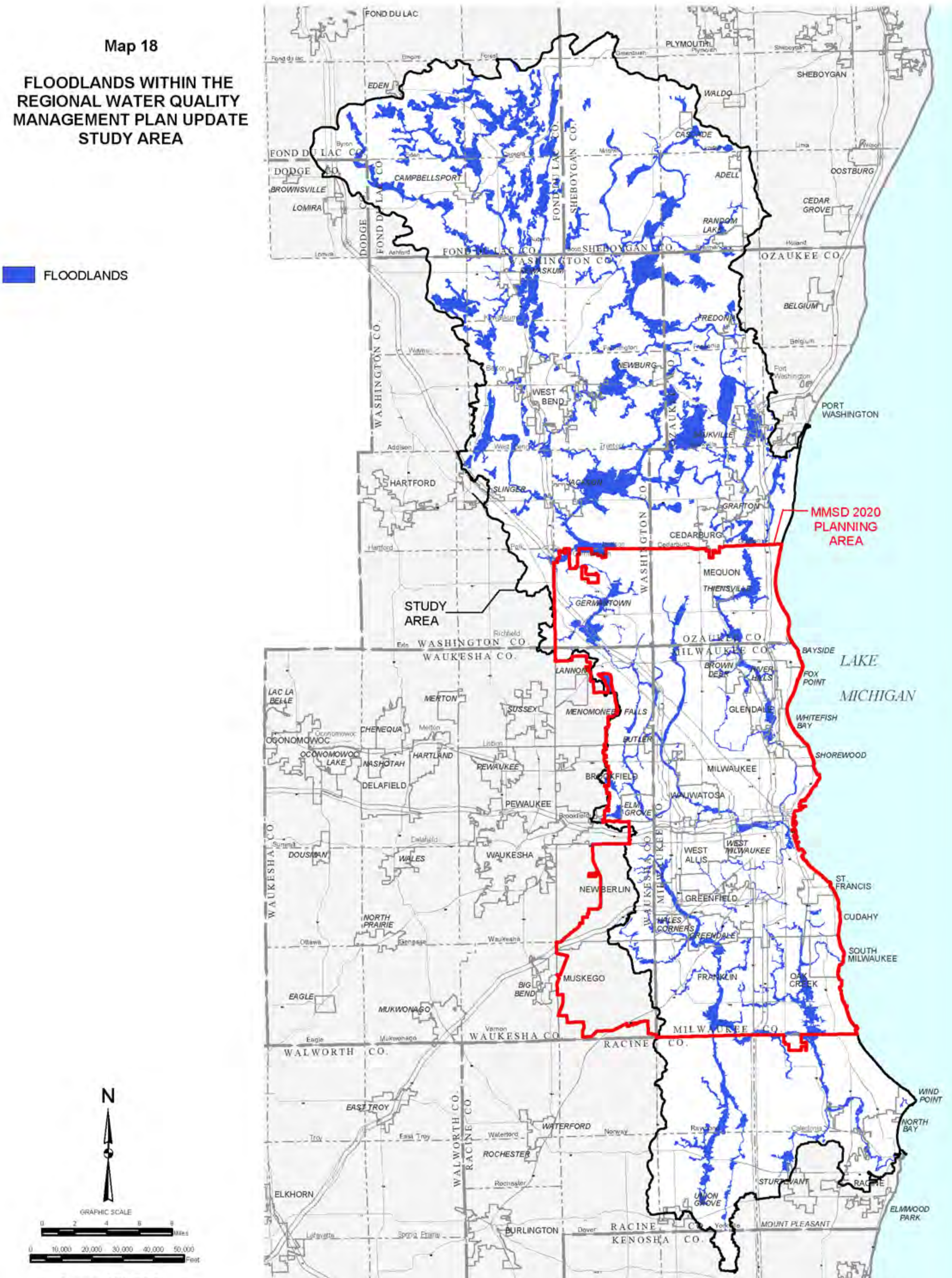
Groundwater resources constitute another key element of the natural resource base of the regional water quality management plan update study area. Groundwater not only sustains lake levels and wetlands and provides the base flows of streams in the study area, but it also comprises a major source of water supply for domestic, municipal, and industrial water users in the northern portion of the study area.

Groundwater occurs within three major aquifers that underlie the study area. From the land's surface downward, they are: 1) the sand and gravel deposits in the glacial drift; 2) the shallow dolomite strata in the underlying bedrock; and 3) the deeper sandstone, dolomite, siltstone, and shale strata. Because of their proximity to the land's surface and hydraulic interconnection, the first two aquifers are commonly referred to collectively as the "shallow

Map 18

FLOODLANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

FLOODLANDS



Source: SEWRPC.

aquifer," while the latter is referred to as the deep aquifer. Within the study area, the shallow and deep aquifers are separated by the Maquoketa shale, which forms a relatively impermeable barrier between the two aquifers (see Figure 9).

Recharge to the sand and gravel aquifer occurs primarily through infiltration of precipitation that falls on the land surface directly overlying the aquifer. Within the study area, the rate of recharge to the sand and gravel aquifer varies depending on the permeability of the overlying glacial till.

Recharge to the Silurian aquifer occurs primarily through infiltration of precipitation that seeps through the glacial drift above the aquifer. As with the sand and gravel aquifer, the rate of recharge varies with the permeability of the glacial drift. Some additional recharge to the Silurian aquifer occurs as lateral subsurface inflow from the west.

Recharge to the sandstone aquifer, located in the Cambrian and Ordovician strata occurs in the following three ways: 1) seepage through the relatively impermeable Maquoketa shale, 2) subsurface inflow from natural recharge areas located to the west in Waukesha, Jefferson, and Dodge Counties, and 3) seepage from wells that are hydraulically connected to both the Niagara and the sandstone aquifers. Although the natural gradient of groundwater movement within the sandstone aquifer is from west to east, concentrated pumping which has occurred over the years has reversed the gradient so that groundwater now flows from the east toward a cone of depression located in the vicinity of the Milwaukee-Waukesha county line in the west-central portion of the study area.

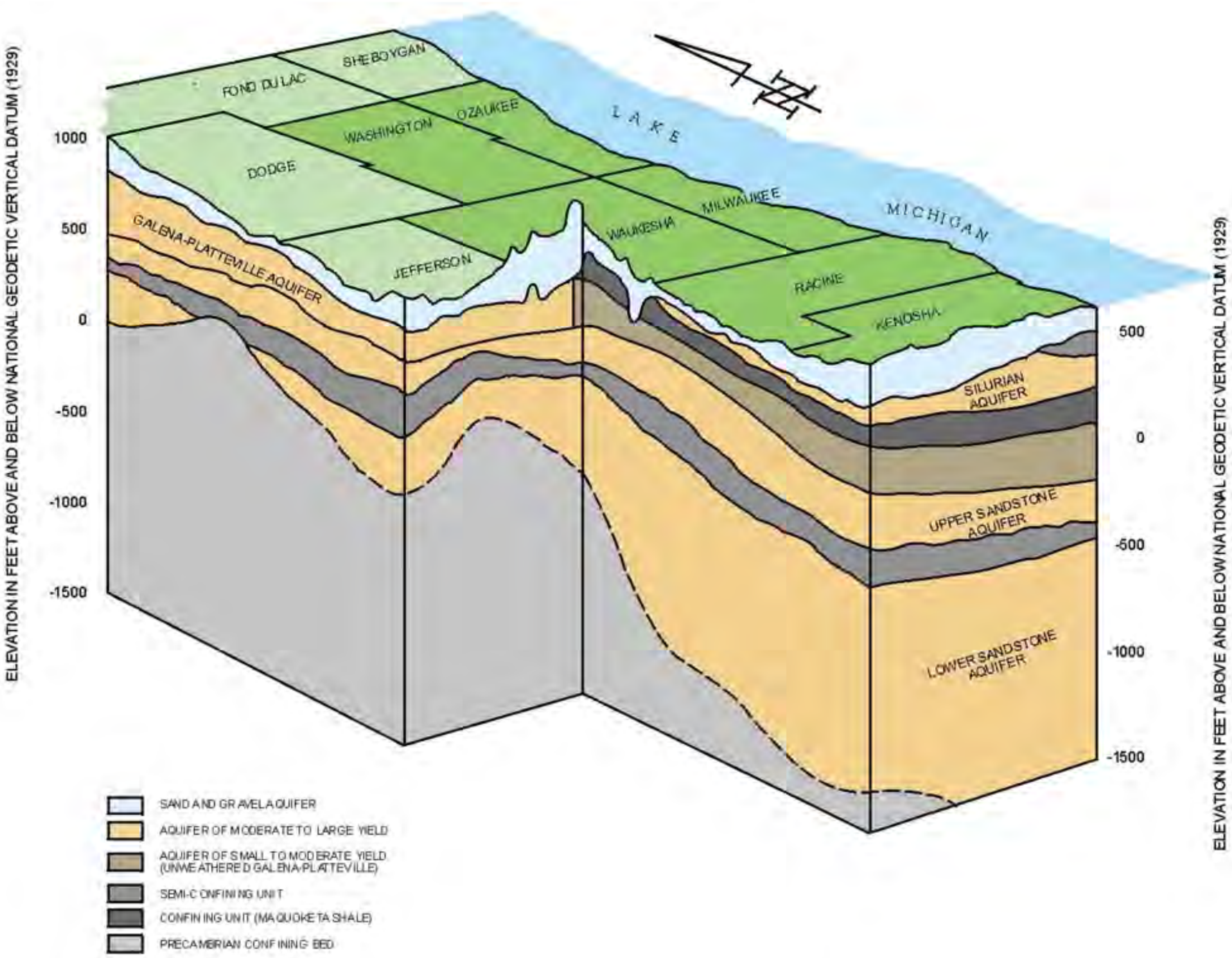
Like surface water, groundwater is susceptible to depletion in quantity and to deterioration in quality as a result of urban and rural development. Consequently, water quality management planning must appropriately consider the potential impacts of urban and rural development on this important resource. Water quality management and land use planning must also take into account, as appropriate, natural conditions which may limit the use of groundwater as a source of water supply, including the relatively high levels of naturally occurring radium in groundwater in the deep sandstone aquifer, found in certain areas of the Region. Other considerations which may limit the uses of groundwater include decreasing aquifer levels and increasing concentrations of dissolved solids and other constituents.

Springs are areas of concentrated discharge of groundwater at the land surface. Alone, or in conjunction with numerous smaller seeps, they may provide the source of base flow for streams and serve as a source of water for lakes, ponds, and wetlands. Conversely, under certain conditions, streams, lakes, ponds, and wetlands may be sources of recharge that create springs. The magnitude of discharge from a spring is a function of several factors, including the amount of precipitation falling on the land surface, the occurrence and extent of recharge areas of relatively high permeability, and the existence of geologic and topographical conditions favorable to discharge of groundwater to the land surface.

SEWRPC, working with the U.S. Geological Survey, Wisconsin Geological and Natural History Survey, the University of Wisconsin-Milwaukee, and the Wisconsin Department of Natural Resources, recently completed two major groundwater studies for the Region that will be important resources for regional and local planning. These studies include a regional groundwater inventory and analysis and the development of a regional groundwater aquifer simulation model. The groundwater inventory and analysis findings are presented in SEWRPC Technical Report No. 37, *Groundwater Resources of Southeastern Wisconsin*, June 2002. The aquifer simulation model is documented in SEWRPC Technical Report No. 41, *A Regional Aquifer Simulation Model for Southeastern Wisconsin*, June 2005. As described in Chapter X, important groundwater recharge areas were identified under this Regional water quality management planning update. Delineation of those areas utilized the results of the inventory and analysis work and the aquifer model. In addition, the Wisconsin Department of Natural Resources in conjunction with local water utilities has undertaken an effort to identify areas of contribution to municipal wells that can be used for well protection planning.

Figure 9

AQUIFER SYSTEMS IN SOUTHEASTERN WISCONSIN



Source: Eaton, 1997; Mai and Dott, 1985; Peters, 1997; and Young, 1992.

Fish and Wildlife Resources

Fish and wildlife have educational and aesthetic values, perform important functions in the ecological system, and are the basis for certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of those areas are, therefore, important determinants of the overall quality of the environment in the regional water quality management plan update study area.

Fisheries

The majority of streams in the regional water quality management plan update study area are warmwater and generally low gradient, although short moderate-gradient stretches with well-developed pool-riffle structure occur as well as some coldwater streams primarily in the northern portions of the study area. The headwater area streams (first- and second-order) are generally too small to support sportfish on a permanent basis, but are capable of supporting forage fish species. It is important to note that many headwater streams are frequently utilized during the spring high-water flow season by sportfishes, such as northern pike, as spawning and juvenile rearing areas that exist no where else in the watershed. Further downstream in the stream networks (third- through fifth-order) the stream gets large enough to have the potential to hold fishable populations of sportfish species.

The distribution and abundance of fishes in rivers and streams may be used as an indication of both short- and long-term changes in water quality and general instream ecological conditions. There are several advantages to using fish life as an indicator of the water quality and general ecological health of a stream system. First, fish occupy multiple trophic levels in the aquatic food chain feeding on a variety of vegetation, insects, as well as other fishes and their presence, therefore, implies the presence and health of many other types of plants and animals upon which they feed. Second, fish live continuously for generations in a waterbody, and therefore over time come to reflect the condition of that waterbody. Finally, fish have been well studied; therefore, more accurate identification of fish species and more complete descriptions of fish life histories are available than is the case for other aquatic species, permitting relationships between fish and their environment to be well assessed.

An Index of Biotic Integrity (IBI)[17] was used to classify the fishery and environmental quality in this stream system using fish survey data from various sampling locations of the regional water quality management plan update study area watersheds.[18] The IBI consists of a series of fish community attributes that reflect basic structural and functional characteristics of biotic assemblages: species richness and composition, trophic and reproductive function, and individual abundance and condition.[19] Detailed data on the biotic index is provided in Chapter III of this report and in an accompanying technical report.[20]

In Wisconsin, high-quality warmwater streams are characterized by many native species, darters, suckers, sunfish, and intolerant species (species that are particularly sensitive to water pollution and habitat degradation). Tolerant fish species are capable of persisting under a wide range of degraded conditions and are also typically present within high-quality warmwater streams, but do not dominate. Tolerant species may also include nonnative fishes, such as carp, as well as many native species, such as bullheads and creek chubs. Insectivores (fish that feed primarily on small invertebrate bugs) and top carnivores (fish that feed on other fish, vertebrates, or large invertebrate bugs) are generally common. Omnivores (fish that feed on both plant and animal material) are also generally common, but do not dominate. Simple lithophilous spawners which are species that lay their eggs directly on large substrate, such as clean gravel or cobble, without building a nest or providing parental care for the eggs are also generally common. In addition, deformities, eroded fins, lesions, or tumors on fish species in high-quality streams are generally few to none.

Streams located within urbanized areas, such as Lincoln Creek, Kinnickinnic River, and Oak Creek, have very-poor to poor warmwater IBI scores. Underwood Creek and the Root River watershed also have degraded fish communities resulting in very poor to fair warmwater IBI scores. Species richness is much lower in these

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[17]*Although the fish IBI is useful for assessing environmental quality and biotic integrity in warmwater streams, this index is most effective when used in combination with additional data on physical habitat, water quality, macro-invertebrates, and other biota when evaluating a site.*

[18]*John Lyons, "Using the Index of Biotic Integrity (IBI) to Measure Environmental Quality in Warmwater Streams of Wisconsin," United States Department of Agriculture,* General Technical Report NC-149, *1992. John Lyons and others, "Development and Validation of an Index of Biotic Integrity for Coldwater Streams in Wisconsin,"* North American Journal of Fisheries Management, *Volume 16, No. 2, May 1996.*

[19]*John Lyons,* General Technical Report NC-149, *op. cit. The Wisconsin IBI described here consists of 10 basic metrics, plus two additional metrics (termed "correction factors") that affect the index only when they have extreme values. These 12 metrics are: Species Richness and Composition—total number of native species, darter species, sucker species, sunfish species, intolerant species, and percent (by number of individuals) that are tolerant species; Trophic and Reproductive Function—Percent that are omnivores, insectivores, top carnivores, and simple lithophilous spawners; and Fish Abundance and Condition—number of individuals (excluding tolerant species) per 300 meters sampled and percent with deformities, eroded fins, lesions, or tumors (DELT). The last two metrics are not normally included in the calculation of the IBI, but they can lower the overall IBI score if they have extreme values (very low number of individuals or high percent DELT fish).*

[20]*SEWRPC Technical Report No. 39,* op. cit.

watersheds than expected, tolerant species dominate, and intolerant species are absent. The only sportfish present in appreciable numbers is the highly tolerant green sunfish, and most individuals of this species are small. The Little Menomonee River does not contain intolerant species, but it does have extremely low numbers of northern pike. The Little Menomonee River has been channelized, which undoubtedly affects the fish community. Conversely, the East Branch of the Milwaukee River contains a high quality warmwater fish community with a high diversity of species and a large portion of this segment of stream has been classified as exceptional resource water. The East Branch contains good numbers of the rock bass, an intolerant sportfish, small numbers of the intolerant Iowa darter, and a few northern pike and good numbers of bluegill. Headwater tributaries within the North and East and West Branches of the Milwaukee River also contain several high quality coldwater trout stream fish assemblages. The Lower Milwaukee River estuary and harbor area has recently shown signs of significant improvement in the quality of the fishery, since removal of the North Avenue dam and major habitat improvements in the late 1990s, which opened up an additional 9.6 kilometers of stream with Lake Michigan.[21] The smallmouth bass, which is an intolerant fish species, have dramatically increased in abundance within this area.

In addition to resident stream fishes within the river systems themselves, certain fishes, including highly sought after game fishes, such as walleye, steelhead, and salmon, regularly migrate between these streams and Lake Michigan. Typically these migrations occur in spring and fall for breeding purposes, but such migrations may occur at other times of the year depending upon the characteristics of the particular strain. In particular the steelhead fishery in the Root River system provides an example of a highly managed fishery, where multiple strains of steelhead have been introduced to provide a high quality year-round fishery. This fishery is supported by the WDNR Root River Steelhead Facility located in Lincoln Park, Racine County. This facility, established in 1992-93, processes approximately 500,000 steelhead annually, using a system of fish ladders, holding ponds, and laboratory facilities to enhance reproduction. Similarly, the WDNR has actively stocked and continues to manage the anadromous salmon fishery using more traditional stocking techniques in other stream systems tributary to Lake Michigan, including the Milwaukee River. Recently these programs have been expanded to include the stocking of lake sturgeon which historically were known to be present in this River system. The net result of all of these programs is a restored fishery that has contributed to significantly improved recreational sport fishing in the Lake and its tributary stream systems.

Wildlife

Wildlife in the regional water quality management plan update study area includes upland game, such as white-tailed deer, rabbit and squirrel; predators, such as coyote, fox, and raccoon; game birds, such as pheasant; marsh furbearers, such as beaver and muskrat; migratory and resident song birds; and waterfowl. In addition, amphibians and reptiles are common to the study area, and include toads, and salamanders, as well as turtles and snakes. The spectrum of wildlife species originally present in the watershed has, along with the habitat, undergone tremendous alterations since settlement by Europeans and the subsequent clearing of forests, plowing of the oak savannas and prairies, and draining of wetlands for agricultural purposes. Modern-day activities that can adversely affect wildlife and wildlife habitat include the excessive use of fertilizers and pesticides, road salting, heavy traffic and resulting disruptive noise levels and damaging air pollution, the introduction of domestic animals, and the fragmentation and isolation of remaining habitat areas for urban and agricultural uses. It is therefore important to consider protection and preservation of remaining wildlife habitat in the watershed, along with development objectives.

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[21]*Wisconsin Department of Natural Resources PUB-FH-510-2004,* An Evaluation of Walleye Population Restoration Efforts in the Lower Milwaukee River and Harbor, Wisconsin, 1995-2003*, January 2004.*

Endangered, Threatened, and Rare Fauna

Sixty-seven animal species that have been listed as endangered, threatened, or of special concern occur within the study area.[22] As designated by the Wisconsin Department of Natural Resources, 10 of these species have been classified as endangered and 12 as threatened. One Wisconsin designated special concern species, the bald eagle (*Haliaeetus leucocephalus*), a migrant species through the watershed, has also been designated as a Federal threatened species (see Table 28).

In addition, a total of 45 animal species, mostly waterfowl and songbirds, have been listed as species of special concern. Many of these species are restricted to the extensive prairie, and wetland areas which remain in the study area. Maintenance of suitable prairie and wetland habitat areas in the watershed will likely help to maintain good populations of these special concern species, thereby contributing to the maintenance of adequate and stable statewide populations of these species. Conversely, failure to maintain such habitat, given its extensive occurrence within the watershed, could contribute to a substantial decline in such species.

Wildlife Habitat

Wildlife habitat areas within the regional water quality management plan update study area, were identified by the Southeastern Wisconsin Regional Planning Commission and the Wisconsin Department of Natural Resources and categorized as either Class I, Class II, or Class III habitat areas. Wildlife habitat areas provide valuable recreation opportunities and constitute an invaluable aesthetic asset to the watershed. The following five major characteristics were used to identify high value wildlife habitats: balanced diversity, adequate area to meet territorial requirements of major species, vegetation, location, and disturbance. Class I wildlife habitat areas are habitats of the highest value in the Region in that they contain a good diversity of wildlife, are adequate in size to meet all habitat requirements for the species concerned, and are generally located in proximity to other wildlife habitat areas. Class II wildlife habitat areas generally lack optimal conditions for one of the three aforementioned criteria for a Class I area. However, they do retain a good plant and animal diversity. Class III wildlife habitat areas are remnant in nature in that they generally lack optimal conditions for two or more of the three aforementioned criteria for Class I wildlife habitat but are, nevertheless, important if located in close proximity to other wildlife habitat areas, if they provide travel corridors linking other habitat areas, if they provide important forage habitat, or if they provide the only available range in an area. It is in this respect that Class III wildlife habitat areas may also serve as regionally significant habitat in Southeastern Wisconsin.

As a result of urban and agricultural activity and the associated decrease in woodlands, wetlands, prairies, and other natural areas, wildlife habitat in the regional water quality management plan update study area has been seriously depleted. The habitat that remains generally consists of land parcels that have not to date been considered suitable for cultivation or urban development. Much of the remaining habitat has been modified or has deteriorated; some of these remaining habitat areas are being increasingly encroached upon by encircling urban development and agricultural uses.

As a consequence of the decrease in wildlife habitat, the wildlife population within the watershed has decreased. The fish, amphibian, reptile, bird, and mammal species once abundant in the watershed have diminished in type and quantity wherever intensive urbanization and agricultural land uses have occurred. Certain wildlife species, such as some songbirds, have the capacity to exist in small islands of undeveloped land within the urban and agricultural land complex or to adapt to this type of landscape, but this characteristic is not generally shared by most wildlife.

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[22]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1977; SEWRPC Technical Report No. 39,* op.cit.

Table 28

ENDANGERED AND THREATENED SPECIES AND SPECIES OF SPECIAL CONCERN IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Common Name	Scientific Name	Status under the U.S. Endangered Species Act	Wisconsin Status
Butterflies and Moths			
Broad-winged Skipper	*Poanes viator*	Not listed	Special concern
Buck Moth	*Hemileuca maia*	Not listed	Special concern
Dion Skipper	*Euphyes dion*	Not listed	Special concern
Great Copper	*Lycaena xanthoides*	Not listed	Special concern
Karner Blue	*Lycaeides melissa samuelis*	Endangered	Special concern[a]
Liatris Borer Moth	*Papaipema beeriana*	Not listed	Special concern
Little Glassy Wing	*Pompeius verna*	Not listed	Special concern
Mulberry Wing	*Poanes massasoit*	Not listed	Special concern
Regal Fritillary	*Speyeria indalia*	Not listed	Endangered
Swamp Metalmark	*Calephelis muticum*	Not listed	Endangered
Two-spotted Skipper	*Euphyes bimacula*	Not listed	Special concern
Dragonfiles and Damselflies			
Amber-Winged Spreadwing	*Lestes eurinus*	Not listed	Special concern
Elegant Spreadwing	*Lestes inaequalis*	Not listed	Special concern
Gilded River Cruiser	*Macromia pacifica*	Not listed	Special concern
Great Spreadwing	*Archilestes grandis*	Not listed	Special concern
Green-Striped Darner	*Aeshna verticalis*	Not listed	Special concern
Lemon-faced Emerald	*Somatochlora ensigera*	Not listed	Special concern
Silphium Borer Moth	*Papaipema silphii*	Not listed	Endangered
Slaty Skimmer	*Libellula incesta*	Not listed	Special concern
Slender Bluet	*Enallagma traviatum*	Not listed	Special concern
Swamp Spreadwing	*Lestes vigilax*	Not listed	Special concern
Unicorn Clubtail	*Arigomphus villosipes*	Not listed	Special concern
Other Insects			
Red-Tailed Prairie Leafhopper	*Aflexia rubranura*	Not listed	Endangered
Crustacea			
Prairie Crayfish	*Procambarus gracilis*	Not listed	Special concern
Molluscs			
Creek Heelspitter	*Lasmigona compressa*	Not listed	Special concern
Elktoe	*Alasmidonta marginata*	Not listed	Special concern
Ellipse	*Venustaconcha ellipsiformis*	Not listed	Threatened
Tapered Vertigo	*Vertigo elatior*	Not listed	Special concern
Fish			
American Eel	*Anguilla rostrata*	Not listed	Special concern
Banded Killifish	*Fundulus diaphanus*	Not listed	Special concern
Bloater	*Coregonus hoyi*	Not listed	Special concern[b]
Greater Redhorse	*Moxostoma valenciennesi*	Not listed	Threatened
Lake Chubsucker	*Erimyzon sucetta*	Not listed	Special concern
Lake Herring	*Coregonus artedi*	Not listed	Special concern
Lake Sturgeon	*Acipenser fulvescens*	Not listed	Special concern[b]
Least Darter	*Etheostoma microperca*	Not listed	Special concern
Longear Sunfish	*Lepomis magalotis*	Not listed	Threatened
Pugnose Shiner	*Notropis anogenus*	Not listed	Threatened
Redfin Shiner	*Lythrurus umbratilis*	Not listed	Threatened
Redside Dace	*Clinostomus elongatus*	Not listed	Special concern
Striped Shiner	*Luxilus chrysocephalus*	Not listed	Endangered
Weed Shiner	*Notropis texanus*	Not listed	Special concern
Reptiles and Amphibians			
Blanchard's Cricket Frog	*Acris crepitans blanchardi*	Not listed	Endangered
Blanding's Turtle	*Emydoidea blandingii*	Not listed	Threatened
Bullfrog	*Rana catesbeiana*	Not listed	Special concern[b]
Butler's Garter Snake	*Thamnophis butleri*	Not listed	Threatened
Northern Ribbon Snake	*Thamnophis sauritus*	Not listed	Endangered
Pickerel Frog	*Rana palustris*	Not listed	Special concern
Queen Snake	*Regina septemvittata*	Not listed	Endangered
Spotted Salamander	*Ambystoma maculatum*	Not listed	Special concern

Table 28 (continued)

Common Name	Scientific Name	Status under the U.S. Endangered Species Act	Wisconsin Status
Birds			
Acadian Flycatcher	*Empidonax virescens*	Not listed	Threatened
Black Tern	*Chlidonias niger*	Not listed	Special concern[c]
Black-Crowned Night Heron	*Nycticorax nycticorax*	Not listed	Special concern[c]
Cerulean Warbler	*Dendroica cerulea*	Not listed	Threatened
Common Tern	*Sterna hirundo*	Not listed	Endangered
Foster's Tern	*Sterna forsteri*	Not listed	Endangered
Grasshopper sparrow	*Ammodramus savannarum*	Not listed	Special concern[c]
Hooded Warbler	*Wilsonia citrina*	Not listed	Threatened
Kentucky Warbler	*Oporornis formosus*	Not listed	Threatened
Louisiana Waterthrush	*Seiurus motacilla*	Not listed	Special concern[c]
Northern Harrier	*Circus cyaneus*	Not listed	Special concern[c]
Northern Pintail	*Anas acuta*	Not listed	Special concern[c]
Pine Siskin	*Carduelis pinus*	Not listed	Special concern[c]
Red-Shouldered Hawk	*Buteo lineatus*	Not listed	Threatened
Upland Sandpiper	*Bartramia longicauda*	Not listed	Special concern[c]
Mammals			
Bobcat	*Lynx rufus*	Not listed	Special concern
Franklin's Ground Squirrel	*Spermophilus franklinii*	Not listed	Special concern
Plants			
American Fever-Few	*Parthenium integrifolium*	Not listed	Threatened
American Gromwell	*Lithospermum latifolium*	Not listed	Special concern
American Sea-Rocket	*Cakile edentula*	Not listed	Special concern
Arrow Arum	*Peltandra virginica*	Not listed	Special concern
Autumn Coral-Root	*Corallorhiza odontorhiza*	Not listed	Special concern
Blue Ash	*Fraxinus quadrangulata*	Not listed	Threatened
Bluestem Goldenrod	*Solidago caesia*	Not listed	Endangered
Bog Bluegrass	*Poa paludigena*	Not listed	Threatened
Capitate Spikerush	*Eleocharis olivacea*	Not listed	Special concern
Christmas Fern	*Polystichum arcostichoides*	Not listed	Special concern
Climbing Fumitory	*Adlumia fungosa*	Not listed	Special concern
Clinton Woodfern	*Dryopteris clintoniana*	Not listed	Special concern
Cluster Fescue	*Festuca paradoxa*	Not listed	Special concern
Clustered Broomrape	*Orobanche fasciculate*	Not listed	Threatened
Common Bog Arrow-Grass	*Triglochin maritime*	Not listed	Special concern
Cooper's Milkvetch	*Astragalus neglectus*	Not listed	Endangered
Cuckooflower	*Cardamine pratensis*	Not listed	Special concern
Downy Willow-Herb	*Epilobium strictum*	Not listed	Special concern
Dwarf Lake Iris	*Iris lacustris*	Threatened	Threatened
False Hop Sedge	*Carex lupuliformis*	Not listed	Endangered
Few-Flower Spikerush	*Eleocharis quinqueflora*	Not listed	Special concern
Forked Aster	*Aster furcatus*	Not listed	Threatened
Giant Pinedrops	*Pterospora andromedea*	Not listed	Endangered
Great Indian-Plantain	*Cacalia muehlenbergii*	Not listed	Special concern
Green Arrow-Arum	*Peltandra virginica*	Not listed	Special concern
Hairy Beardtongue	*Penstemon hirsutus*	Not listed	Special concern
Handsome Sedge	*Carex Formosa*	Not listed	Threatened
Harbinger-of-Spring	*Erigenia bulbosa*	Not listed	Endangered
Heart-Leaved Plantain	*Plantago cordata*	Not listed	Endangered
Heart-Leaved Skullcap	*Scutellaria ovata*	Not listed	Special concern
Hemlock Parsley	*Conioselinum chinense*	Not listed	Endangered
Hooker Orchis	*Platanthera hookeri*	Not listed	Special concern
Indian Cucumber-Root	*Medeola virginiana*	Not listed	Special concern
Kentucky Coffee-Tree	*Gymnocladus dioicus*	Not listed	Special concern
Large Roundleaf Orchid	*Platanthera orbiculata*	Not listed	Special concern
Leafy White Orchis	*Platanthera dilatata*	Not listed	Special concern
Lesser Fringed Gentian	*Gentianopsis procera*	Not listed	Special concern
Livid Sedge	*Carex livida*	Not listed	Special concern
Low Nutrush	*Scleria verticillata*	Not listed	Special concern
Many-Headed Sedge	*Carex sychnocephala*	Not listed	Special concern
Marbleseed	*Onosmodium molle*	Not listed	Special concern
Marsh Arrow-Grass	*Triglochin palustre*	Not listed	Special concern
Marsh Blazing Star	*Liatris spicata*	Not listed	Special concern
Marsh Willow-Herb	*Epilobium palustre*	Not listed	Special concern

Table 28 (continued)

Common Name	Scientific Name	Status under the U.S. Endangered Species Act	Wisconsin Status
Plants (continued)			
Northern Bog Sedge	*Carex gynocrates*	Not listed	Special concern
Northern Yellow Lady's-Slipper	*Cypripedium parviflorum*	Not listed	Special concern
Ohio Goldenrod	*Solidago ohioensis*	Not listed	Special concern
One-Flowered Broomrape	*Orabanche uniflora*	Not listed	Special concern
Pale Green Orchid	*Platanthera flava*	Not listed	Threatened
Prairie Indian Plantain	*Cacalia tuberose*	Not listed	Threatened
Prairie Parsley	*Polytaenia nuttallii*	Not listed	Threatened
Prairie White-Fringed Orchid	*Platanthera leucophaea*	Threatened	Endangered
Purple Bladderwort	*Utricularia purpurea*	Not listed	Special concern
Purple False Oats	*Trisetum melicoides*	Not listed	Endangered
Purple Milkweed	*Asclepias purpurascens*	Not listed	Endangered
Ram's-head Lady's Slipper	*Cypripedium arietinum*	Not listed	Threatened
Ravenfoot Sedge	*Carex crus-corvi*	Not listed	Endangered
Reflexed Trillium	*Trillium recurvatum*	Not listed	Special concern
Round-Leaved Orchis	*Amerorchis rotundifolia*	Not listed	Threatened
Roundstem Foxglove	*Agalinis gaffingeri*	Not listed	Threatened
Sand Reed-Grass	*Calamovilfa longifolia*	Not listed	Threatened
Seaside Spurge	*Euphorbia polygonifolia*	Not listed	Special concern
Showy Lady's-Slipper	*Cypripedium reginae*	Not listed	Special concern
Slender Sedge	*Carex lasiocarpa*	Not listed	Special concern
Slenderleaf Sundew	*Drosera linearis*	Not listed	Threatened
Slim-Stem Small-Reedgrass	*Calamagrostis stricta*	Not listed	Special concern
Small White Lady's Slipper	*Cypripedium candidum*	Not listed	Threatened
Small Yellow Lady's-Slipper	*Cypripedium calceolus*	Not listed	Special concern
Smooth Black-Haw	*Viburnum prunifolium*	Not listed	Special concern
Snow Trillium	*Trillium nivale*	Not listed	Threatened
Sparse-Flowered Sedge	*Carex tenuflora*	Not listed	Special concern
Spotted Pondweed	*Potamogeton pulcher*	Threatened	Endangered
Sticky False-Asphodel	*Tofieldia glutinosa*	Not listed	Threatened
Streambank Wheatgrass	*Elymus lanceolaus*	Not listed	Threatened
Swamp Pink	*Helonias bullata*	Not listed	Special concern
Tufted Hairgrass	*Deschampsia caespitosa*	Not listed	Special concern
Twinleaf	*Jeffersonia diphylla*	Not listed	Special concern
Variegated Horsetail	*Equisetum variegatum*	Not listed	Special concern
Wafer-Ash	*Ptelea trifoliate*	Not listed	Special concern
Waxleaf Meadowrue	*Thalictrum revolutum*	Not listed	Special concern
Whip Nutrush	*Scleria triglomerata*	Not listed	Special concern
White Adder's-Mouth	*Malaxis brachypoda (Malaxis monophyllos)*	Not listed	Special concern
Wild Licorice	*Glycyrrhiza lepidota*	Not listed	Special concern
Yellow Gentian	*Gentiana alba*	Not listed	Threatened

[a]*This species is federally protected as endangered or threatened but not designated as endangered or threatened by the Wisconsin Department of Natural Resources.*

[b]*Taking of this species is regulated by the establishment of open and closed seasons.*

[c]*This species is fully protected under by Federal and State laws under the Migratory Bird Act of 1918.*

Source: Wisconsin Department of Natural Resources, Wisconsin State Herbarium, Wisconsin Society of Ornithology, and SEWRPC.

Environmentally Sensitive Areas

One of the most important tasks completed under the regional planning program for Southeastern Wisconsin has been the identification and delineation of those areas of the Southeastern Wisconsin Region in which concentrations of recreational, aesthetic, ecological, and cultural resources occur, resources which should be preserved and protected. Similar delineations were completed for the regional water quality management plan update study area within Dodge, Fond du Lac, and Sheboygan Counties. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and natural beauty of the study area: 1) lakes, rivers, and streams and their associated shorelands and floodlands, 2) wetlands, 3) woodlands, 4) prairies, 5) wildlife habitat areas, 6) wet, poorly drained, or organic soils, and 7) rugged terrain and high-relief topography. While the foregoing elements comprise the integral parts of the natural resource base, there are five additional elements which, although not part of the natural resource base per se, are closely related to, or centered on, that base and are a determining factor in identifying and delineating areas with recreational, aesthetic, ecological, and cultural value: 1) existing park and open space sites, 2) potential park and open space sites, 3) historic sites, 4) significant scenic areas and vistas, and 5) natural and scientific areas. The delineation of these 12 natural resource and natural resource-related elements on a map results in a pattern of relatively narrow, elongated areas which have been termed "environmental corridors" and have been delineated by the Southeastern Wisconsin Regional Planning Commission.[23]

Primary Environmental Corridors

Primary environmental corridors include a wide variety of important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors in the regional water quality management plan update study area are primarily located along major stream valleys, around major lakes, and along the northern Kettle Moraine. As indicated in Table 29, primary environmental corridors encompassed about 185 square miles, or about 16 percent of the study area, in 2000. These primary environmental corridors contain almost all of the best remaining woodlands, wetlands, and wildlife habitat areas in the study area, and represent a composite of the best remaining elements of the natural resource base. Primary environmental corridors in the regional water quality management plan update study area are shown on Map 19.

Secondary Environmental Corridors

Secondary environmental corridors connect with primary environmental corridors, and are at least 100 acres in size and one mile in length. Secondary environmental corridors are generally located along the small perennial and intermittent streams within the regional water quality management plan update study area. In 2000, secondary environmental corridors encompassed about 27 square miles, or about 2 percent of the total area of the study area. Secondary environmental corridors also contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive urban or agricultural purposes. Secondary environmental corridors facilitate surface water drainage, maintain pockets of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. Secondary environmental corridors in the regional water quality management plan update study area are shown on Map 19.

Isolated Natural Resource Areas

Smaller concentrations of natural resource base elements that are separated physically from the environmental corridors by intensive urban or agricultural land uses have also been identified within the regional water quality management plan update study area. These natural areas, which are at least five acres in size, are referred to as isolated natural resource areas. Widely scattered throughout the study area, isolated natural resource areas encompassed about 28 square miles, or about 3 percent of the total study area, in 2000. These smaller pockets of wetlands, woodlands, surface water, or wildlife habitat exist within the study area. Isolated natural resource areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend unique aesthetic character or natural diversity to an area. These isolated natural resource areas should also be protected and preserved in their natural state whenever possible. Isolated natural resource areas in the regional water quality management plan update study area are shown on Map 19.

Natural Areas and Critical Species Habitat Sites

Natural areas, as defined by the Wisconsin Natural Areas Preservation Council, are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact

[23]*A detailed description of the process of delineating environmental corridors in Southeastern Wisconsin is presented in the March 1981 issue (Volume 4, No. 2) of the* SEWRPC Technical Record.

Table 29

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000

Watershed	Primary Environmental Corridors		Secondary Environmental Corridors		Isolated Natural Resource Areas		Total Environmental Corridors and Isolated Natural Resource Areas	
	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Lake Michigan Direct Drainage	2,829	0.4	68	<0.1	515	0.1	3,412	0.5
Kinnickinnic River	135	<0.1	193	<0.1	115	<0.1	443	0.1
Menomonee River	7,270	1.0	2,328	0.3	1,339	0.2	10,937	1.5
Milwaukee River	101,325	14.0	9,725	1.3	11,431	1.6	122,481	16.9
Oak Creek	691	0.1	1,163	0.2	206	<0.1	2,060	0.3
Root River	6,045	0.8	3,593	0.5	4,199	0.6	13,837	1.9
Total	118,295	16.4	17,070	2.4	17,805	2.5	153,170	21.2

Source: SEWRPC.

native plant and animal communities believed to be representative of the pre-European settlement landscape. Natural areas are classified into one of the following three categories:

1. Natural area of Statewide or greater significance (NA-1)

2. Natural area of countywide or regional significance (NA-2)

3. Natural area of local significance (NA-3)

Classification of an area into one of these three categories is based upon consideration of several factors. These factors include the diversity of plant and animal species and community types present; the structure and integrity of the native plant or animal community; the extent of disturbance by human activity, such as logging, grazing, water level changes, and pollution; the commonness of the plant and animal communities present; any unique natural features within the area; the size of the area; and the educational value. Natural areas form an element of the wildlife habitat base of the study area.

A comprehensive inventory of natural area sites in the regional water quality management plan update study area was completed in 1994 by area naturalists and by the Regional Planning Commission staff. It is important to note that this inventory did not specifically include areas within Sheboygan, Fond du Lac, and Dodge Counties, except for areas that are immediately adjacent to or shared by the northern boundaries of Ozaukee and Washington Counties. However, as shown in Table 30 and Map 20, there are total of five and three State natural areas identified by the WDNR Bureau of Endangered Resources within Fond du Lac and Sheboygan Counties, respectively. As indicated in Table 30, and illustrated on Map 20, there were 187 natural area sites inventoried in the study area that encompassed a total of about 20,700 acres, or approximately 3 percent of the study area. In addition, the 1994 natural areas inventory also included an inventory of critical species habitat sites located in the study area, except for areas within Sheboygan, Fond du Lac, and Dodge Counties. Critical species are those species of plant and animals that are considered endangered, threatened, or of special concern. The majority of critical species habitat sites are located within identified natural areas of the study area; however, a few are located outside of the known natural areas. Table 30 identifies 47 critical species habitat sites that are outside of the abovementioned natural area sites.

SUMMARY

The regional water quality management plan update study area is a complex of natural and man-made features that interact to provide a changing environment for human life. Future changes in the ecosystems of the study area

Map 19

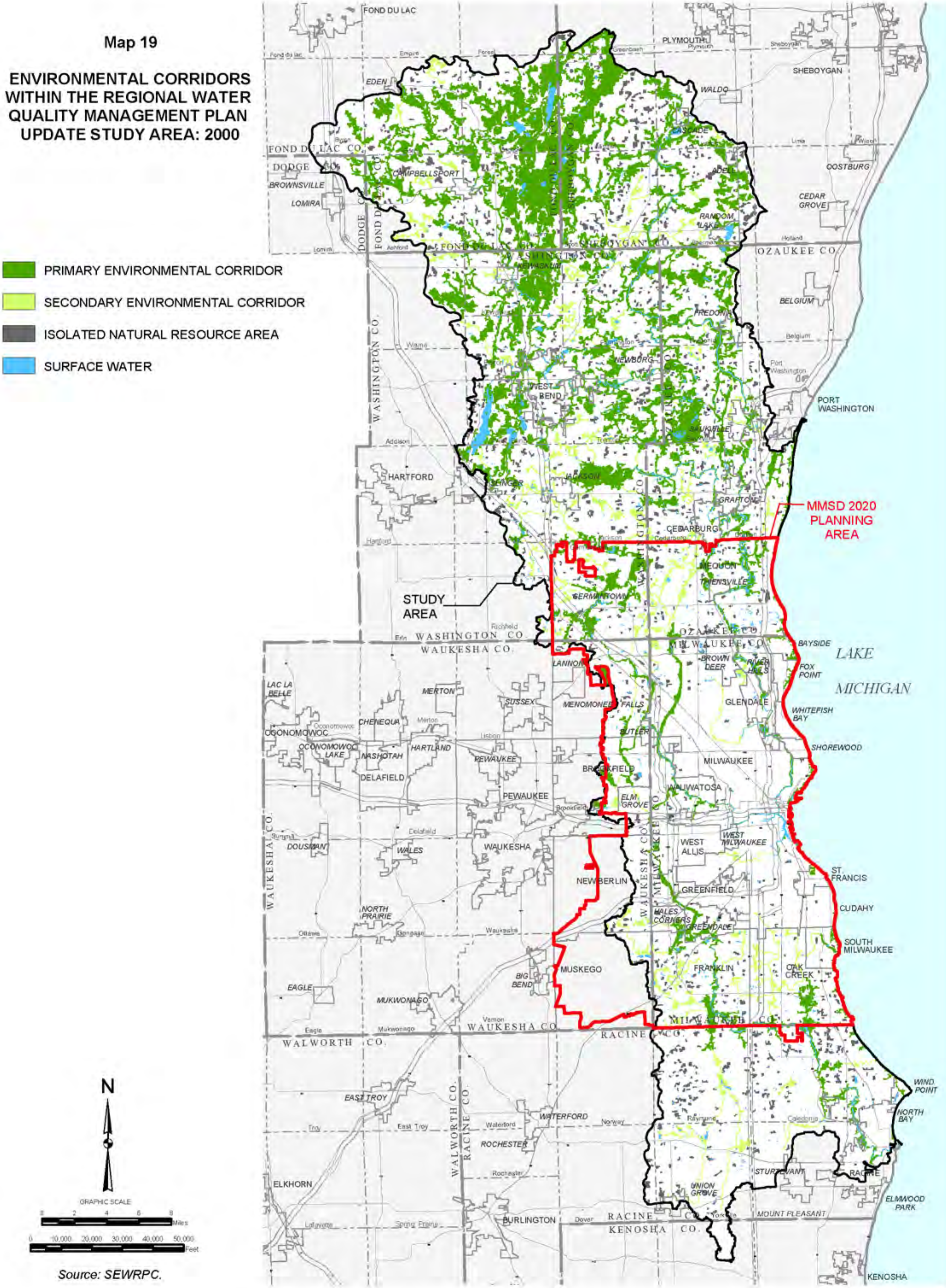
ENVIRONMENTAL CORRIDORS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000

PRIMARY ENVIRONMENTAL CORRIDOR

SECONDARY ENVIRONMENTAL CORRIDOR

ISOLATED NATURAL RESOURCE AREA

SURFACE WATER



Source: SEWRPC.

Table 30

KNOWN NATURAL AREAS AND CRITICAL SPECIES HABITAT SITES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1994

Number on Map 20	Site Name or Description	Watershed	Classification Code[a]
	Fond du Lac County		
1	Crooked Lake Wetlands	Milwaukee River	SNA
2	Milwaukee River Tamarack Lowlands & Dundee Kame	Milwaukee River	SNA
3	Haskell Noyes Woods	Milwaukee River	SNA
4	Milwaukee River and Swamp	Milwaukee River	SNA
5	Spring Lake	Milwaukee River	SNA
83	Kettle Moraine Driver Woods	Milwaukee River	NA-3
	Milwaukee County		
1	Root River Canal Woods	Root River	NA-2, CSH
2	Root River Wet-Mesic Woods-West	Root River	NA-2, CSH
3	Rawson Park Woods	Oak Creek	NA-2
4	Cudahy Woods	Oak Creek	NA-2
5	Falk Park Woods	Oak Creek	NA-2
6	Root River Wet-Mesic Woods-East	Root River	NA-2, CSH
7	Greenfield Park Woods	Menomonee River, Root River	NA-2
8	St. Francis Seminary Woods	Lake Michigan Direct Tributary	NA-2
9	Warnimont Park Fens	Lake Michigan Direct Tributary	NA-2
10	Grobschmidt Park Wetlands and Upland Woods	Root River	NA-3
11	Root River Parkway Woods	Root River	NA-3
12	Whitnall Park Woods-South	Root River	NA-3
13	Monastery Lake Wetlands	Root River	NA-3
14	Mission Hills Wetlands	Root River	NA-3
15	Franklin (Puetz Road) Woods	Oak Creek	NA-3
16	Fitzsimmons Road Woods	Oak Creek, Root River	NA-3
17	Oakwood Park Oak Woods	Root River	NA-3
18	Root River Parkway Prairie	Root River	NA-3
19	Ryan Creek Woods	Root River	NA-3
20	Franklin Oak Woods and Oak Savanna	Root River	NA-3
21	Elm Road Woods	Root River	NA-3
22	Grant Park Woods-South	Oak Creek, Lake Michigan Direct Tributary	NA-3
23	Grant Park Woods-Old Growth	Lake Michigan Direct Tributary	NA-3
24	Esch-Honadel Woods	Oak Creek	NA-3
25	Wood Creek Woods	Oak Creek	NA-3
26	Wedge Woods	Oak Creek	NA-3
27	Oak Creek Low Woods	Oak Creek, Root River	NA-3
28	Root River Riverine Forest	Root River	NA-3, CSH
29	Whitnall Park Woods-North	Root River	NA-3
30	Menomonee River Swamp-South	Menomonee River	NA-3
31	Harley-Davidson Woods	Menomonee River	NA-3
32	Currie Park Low Woods	Menomonee River	NA-3
33	Blue Mound Country Club Woods	Menomonee River	NA-3
34	Wil-O-Way Woods	Menomonee River	NA-3
35	Jacobus Park Woods	Menomonee River	NA-3
36	Downer Woods	Milwaukee River	NA-3
37	Bradley Woods	Menomonee River	NA-3
38	Brown Deer Park Woods	Milwaukee River	NA-3
39	Harbinger Woods	Menomonee River	NA-3
40	Menomonee River Swamp-North	Menomonee River	NA-3
41	Haskell Noyes Park Woods	Menomonee River	NA-3
42	Schlitz Audubon Center Woods and Beach	Lake Michigan Direct Tributary	NA-3
43	Kletzsch Park Woods	Milwaukee River	NA-3
44	Elm Road Woods-North	Root River	CSH
45	Meyers Woods	Oak Creek	CSH
46	PPG Woods	Root River	CSH
47	Fittshur Wetland	Oak Creek	CSH
48	Bender Park Woods and Clay Banks	Lake Michigan Direct Tributary	CSH
49	Bender Park Woods-South	Lake Michigan Direct Tributary	CSH
50	Oak Creek Power Plant Woods	Lake Michigan Direct Tributary	CSH

Table 30 (continued)

Number on Map 20	Site Name or Description	Watershed	Classification Code[a]
	Milwaukee County (continued)		
51	Warnimont Park Woods	Lake Michigan Direct Tributary	CSH
52	Underwood Parkway Woods	Menomonee River	CSH
53	Stadium Bluff Woods	Menomonee River	CSH
54	Cambridge Bluff Woods	Milwaukee River	CSH
55	Brynwood Country Club Woods	Milwaukee River	CSH
56	Fox Point Clay Bluffs	Lake Michigan Direct Tributary	CSH
	Ozaukee County		
1	Fairy Chasm State Natural Area	Lake Michigan Direct Tributary	NA-1, CSH
2	Kurtz Woods State Natural Area	Milwaukee River	NA-1
3	Riveredge Creek and Ephemeral Pond State Natural Area	Milwaukee River	NA-1, CSH
4	Cedarburg Bog State Natural Area	Milwaukee River	NA-1, CSH
5	Sapa Spruce Bog State Natural Area	Milwaukee River	NA-1
6	Cedarburg Beech Woods State Natural Area	Milwaukee River	NA-2, CSH
7	Pigeon Creek Low and Mesic Woods	Milwaukee River	NA-2
8	Donges Bay Gorge	Lake Michigan Direct Tributary	NA-2, CSH
9	Milwaukee River Mesic Woods	Milwaukee River	NA-2
10	Duck's Limited Bog	Milwaukee River	NA-2
11	Riveredge Mesic Woods	Milwaukee River	NA-2, CSH
12	Kinnamon Conifer Swamp	Milwaukee River	NA-2
13	South Conifer Swamp	Milwaukee River	NA-2
14	Max's Bog	Milwaukee River	NA-2
15	Huiras Lake Woods and Bog	Milwaukee River	NA-2
16	Janik's Woods	Milwaukee River	NA-2
18	Highland Road Woods	Milwaukee River	NA-3
19	Pigeon Creek Maple Woods	Milwaukee River	NA-3
20	Solar Heights Low Woods	Menomonee River	NA-3
21	Triple Woods	Menomonee River	NA-3
22	Ville de Parc Riverine Forest	Milwaukee River	NA-3
23	Mequon Wetland	Milwaukee River	NA-3
24	Mole Creek Swamp	Milwaukee River	NA-3
25	Cedar-Sauk Low Woods	Milwaukee River	NA-3
26	Grafton Woods	Milwaukee River	NA-3
27	Sherman Road Woods	Milwaukee River	NA-3
28	Five Corners Swamp	Milwaukee River	NA-3
29	Cedar Creek Forest	Milwaukee River	NA-3
30	Cedar Heights Gorge	Lake Michigan Direct Tributary	NA-3
31	Lions Den Gorge	Lake Michigan Direct Tributary	NA-3
32	Ulao Lowland Forest	Milwaukee River	NA-3
33	Hanson' Lake Wetland	Milwaukee River	NA-3
34	Knollwood Road Bog	Milwaukee River	NA-3
35	Hawthorne Drive Forest	Milwaukee River	NA-3
36	Spring Lake Marsh	Milwaukee River	NA-3
37	Spring Lake Beech Forest	Milwaukee River	NA-3
38	County Line Low Woods	Milwaukee River	NA-3
39	Beekeeper Bog	Milwaukee River	NA-3
40	Department of Natural Resources Lowlands	Milwaukee River	NA-3
41	Pioneer Road Lowlands	Milwaukee River	NA-3
42	Cedar Valley Swamp	Milwaukee River	NA-3
43	Evergreen Road Bog	Milwaukee River	NA-3
44	Kohler Road Woods	Milwaukee River	NA-3
45	Waubeka Low Woods	Milwaukee River	NA-3
49	Stauss Woods	Menomonee River	CSH
50	Pecard Sedge Meadow	Milwaukee River	CSH
51	Eastbrook Road Woods	Milwaukee River	CSH
52	Cedarburg Road West	Milwaukee River	CSH
53	Cedar-Sauk Upland Woods	Milwaukee River	CSH
	Racine County		
1	Root River Canal Woods	Root River	NA-2, CSH
3	Renak-Polak Maple-Beech Woods State Natural Area	Root River	NA-1, CSH
4	Kansasville Railroad Prairie	Root River	NA-1
5	Franksville Railroad Prairie	Root River	NA-1
6	Root River Wet-Mesic Woods-East	Root River	NA-2, CSH

Table 30 (continued)

Number on Map 20	Site Name or Description	Watershed	Classification Code[a]
	Racine County (continued)		
13	Union Grove Railroad Prairie	Root River	NA-2
20	County Line Riverine Woods	Root River	NA-2
21	Hunts Woods	Root River	NA-2
22	Caledonia Wildlife Area	Root River	NA-2, CSH
23	Cliffside Park Woods and Clay Banks	Root River	NA-2, CSH
28	Root River Riverine Forest	Root River	NA-3, CSH
39	Ives Grove Woods	Root River	NA-3
40	Sylvania Railroad Prairie	Root River	NA-3
46	Kimmel Woods	Root River	NA-3
47	Seven Mile Road Woods	Root River	NA-3
48	Zirbes Woods	Root River	NA-3
49	Caledonia Low Woods	Root River	NA-3
50	Foley Road Woods-West	Root River	NA-3
51	Foley Road Woods-East	Root River	NA-3
52	Tabor Woods	Lake Michigan Direct Tributary, Root River	NA-3
53	Power Plant Ravine Woods	Lake Michigan Direct Tributary	NA-3
59	Ives Grove Prairie Remnant	Root River	CSH
62	Washington Park Woods	Root River	CSH
68	Sherwood Property	Root River	CSH
69	River Meadow Woods	Root River	CSH
70	Forked Aster Site	Root River	CSH
71	Caledonia Sanitary Sewer Right-of-Way	Root River	CSH
72	Caledonia Site South	Root River	CSH
73	Root River Bluff	Root River	CSH
74	Hoods Creek Swamp	Root River	CSH
75	Breakers Woods	Lake Michigan Direct Tributary	CSH
76	Dominican Ravine	Lake Michigan Direct Tributary	CSH
77	Wind Point	Lake Michigan Direct Tributary	CSH
78	North Bay Ravine and Beach	Lake Michigan Direct Tributary	CSH
79	Four Mile Road Woods	Root River	CSH
80	Caledonia Low Woods	Root River	CSH
81	River Bend Upland Woods	Root River	CSH
82	Root River Strip Woods	Root River	CSH
86	Cliffside Park Old Fields	Lake Michigan Direct Tributary	CSH
	Sheboygan County		
1	Butler Lake Flynn's Spring	Milwaukee River	SNA
2	Johnson Hill Kame	Milwaukee River	SNA
3	Kettle Hole Woods	Milwaukee River	SNA
38	County Line Low Woods	Milwaukee River	NA-3
	Washington County		
1	Kewaskum Maple-Oak Woods State Natural Area	Milwaukee River	NA-1, CSH
3	Germantown Swamp	Menomonee River	NA-1
5	Paradise Lake Fen	Milwaukee River	NA-1
6	Milwaukee River Floodplain Forest State Natural Area	Milwaukee River	NA-1
7	Smith Lake and Wetlands	Milwaukee River	NA-1
15	Mud Lake Swamp	Milwaukee River	NA-2
16	Big Cedar Lake Bog	Milwaukee River	NA-2
19	Jackson Swamp	Milwaukee River	NA-2, CSH
21	Lac Lawrann Conservancy Upland Woods and Wetlands	Milwaukee River	NA-2
22	Blue Hills Woods	Milwaukee River	NA-2, CSH
23	Silverbrook Lake Woods	Milwaukee River	NA-2
24	Gilbert Lake Tamarack Swamp	Milwaukee River	NA-2, CSH
25	Hacker Road Bog	Milwaukee River	NA-2
26	Muth Woods	Milwaukee River	NA-2
27	Little Cedar Lake Wetlands	Milwaukee River	NA-2
28	Schoenbeck Woods	Milwaukee River	NA-2
29	Bellin Bog	Milwaukee River	NA-2
30	Reinartz Cedar Swamp	Milwaukee River	NA-2
31	Wayne Swamp	Milwaukee River	NA-2
32	Kettle Moraine Drive Bog	Milwaukee River	NA-2

Table 30 (continued)

Number on Map 20	Site Name or Description	Watershed	Classification Code[a]
	Washington County (continued)		
33	Glacial Trail Forest	Milwaukee River	NA-2, CSH
34	St. Michael's Woods	Milwaukee River	NA-2, CSH
35	North Branch Woods	Milwaukee River	NA-2
36	Myra Wetlands	Milwaukee River	NA-2
49	Faber-Pribyl Woods	Menomonee River	NA-3
50	Hoelz Swamp	Menomonee River	NA-3
51	Lake Park Swamp	Menomonee River	NA-3
52	Schoessow Woods	Menomonee River	NA-3
53	USH 41 Swamp	Menomonee River	NA-3, CSH
54	Kleinman Swamp	Menomonee River	NA-3
59	Mueller Woods	Milwaukee River	NA-3, CSH
60	Slinger Upland Woods	Milwaukee River	NA-3
62	Kowalske Swamp	Milwaukee River	NA-3
63	Sherman Road Swamp	Milwaukee River	NA-3
65	Newark Road Wetland	Milwaukee River	NA-3
66	Sunset Park Wetlands	Milwaukee River	NA-3
67	Albecker Park Wetlands	Milwaukee River	NA-3
68	Silver Creek Marsh	Milwaukee River	NA-3
69	University Fen	Milwaukee River	NA-3
70	CTH Z Upland Woods and Wetlands	Milwaukee River	NA-3
71	Ziegler Woods	Milwaukee River	NA-3
72	Sandy Knoll Swamp	Milwaukee River	NA-3
73	Sandy Knoll Wetlands	Milwaukee River	NA-3
74	Poplar Road Lacustrine Forest	Milwaukee River	NA-3
75	Fellenz Hardwood Swamp	Milwaukee River	NA-3
76	Paradise Drive Tamarack Swamp	Milwaukee River	NA-3
77	Camp Wowitan Wetlands	Milwaukee River	NA-3
78	Schalla Tamarack Swamp	Milwaukee River	NA-3
81	Stockcar Swamp	Milwaukee River	NA-3, CSH
83	Kettle Moraine Drive Woods	Milwaukee River	NA-3
84	STH 28 Woods	Milwaukee River	NA-3
85	Smith Lake Swamp	Milwaukee River	NA-3
86	Lange Hardwoods	Milwaukee River	NA-3
87	Wildwood Hardwood Swamp	Milwaukee River	NA-3
88	Milwaukee River Swamp	Milwaukee River	NA-3
89	Lizard Mound Woods	Milwaukee River	NA-3
90	Green Lake Bog	Milwaukee River	NA-3
91	Jackson Woods	Milwaukee River	CSH
94	Riesch Woods	Milwaukee River	CSH
95	Silver Lake Swamp	Milwaukee River	CSH
96	Cameron Property	Milwaukee River	CSH
97	Fechters Woods	Milwaukee River	CSH
98	High School Woods	Milwaukee River	CSH
101	Silver Lake	Milwaukee River	CSH
102	Gilbert Lake	Milwaukee River	CSH
	Waukesha County		
33	Zion Woods	Menomonee River	NA-2
35	Held Maple Woods	Menomonee River	NA-2, CSH
36	Menomonee Falls Tamarack Swamp	Menomonee River	NA-2, CSH
39	Harbinger Woods	Menomonee River	NA-3
40	Menomonee River Swamp - North	Menomonee River	NA-3
51	Luther Park Cemetery Prairie	Root River	NA-3
83	Wirth Swamp	Menomonee River	NA-3
84	Bishops Woods	Menomonee River	NA-3
85	Brookfield Swamp	Menomonee River	NA-3
99	Menomonee River Swamp	Menomonee River	NA-3
100	Theater Swamp	Menomonee River	NA-3
101	Clarks Woods	Menomonee River	NA-3
118	Elm Grove Road Pond	Menomonee River	CSH
120	Glass-Glick Woods	Menomonee River	CSH
121	Heritage Woods	Menomonee River	CSH

Table 30 Footnotes

NOTE: Identification numbers are those that were assigned for SEWRPC Planning Report No. 42, *A Regional Natural Resources and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.

[a]*NA-1 identifies Natural Area sites of statewide or greater significance*
NA-2 identifies Natural Area sites of countywide or regional significance
NA-3 identifies Natural Area sites of local significance
SNA, or State Natural Area, identifies those sites officially designated as State Natural Areas by the State of Wisconsin Natural Areas Preservation Council
CSH identifies a critical plant and/or bird species habitat site.

Source: Wisconsin Department of Natural Resources and SEWRPC.

and the favorable or unfavorable impact of those changes on the quality of life within the study area will largely be determined by human actions. The regional water quality management plan update rationally directs those actions so as to affect favorably the overall quality of life in the study area. This chapter describes the man-made features and natural resource base of the study area, thereby establishing a factual base upon which the regional water quality management plan update process was built.

The 1,127-square-mile regional water quality management plan update study area consists of the Kinnickinnic River, Menomonee River, Milwaukee River, Oak Creek, and Root River watersheds along with lands directly tributary to Lake Michigan, the Milwaukee Harbor Estuary, and the nearshore Lake Michigan Area. The study area encompasses nine counties, 18 cities, 32 villages, and 38 towns.

The 2000 resident population of the study area was approximately 1,281,000 persons. This represented a decrease from the approximately 1,323,000 persons residing in the study area in 1970. While population has declined in the study area since 1970, the number of households has increased. In 2000, total employment in the study area was about 829,000.

In 2000, urban land uses encompassed about 367 square miles, or 33 percent of the study area. Areas considered “nonurban” under the land use inventory include agricultural lands, wetlands, woodlands, extractive, and unused rural lands, and encompassed about 760 square miles or 67 percent of the study area. Since 1980, conversion of land from rural to urban uses has been occurring at a rate of about 1,600 acres per year.

The public utility base of the study area most applicable to the regional water quality management plan update includes sanitary sewerage, water supply, and stormwater management systems, as well as solid waste landfills. Approximately 95 percent of the resident population is served by sanitary sewer systems. These systems include 17 public and three private sewage treatment plants within the study area. In addition, some residents of the study area are served by sewage treatment plants that are located and that discharge outside of the study area. Approximately 90 percent of the resident population is served by public water supply systems.

The study area experiences a typical Midwestern climate with an average annual precipitation of 32.20 inches and average annual temperature of 45.7 degrees Fahrenheit. The physiography, topography, and soils of the study area have largely been determined by the underlying bedrock and overlying glacial deposits. This contributes to a complex surface drainage pattern with respect to channel cross-sectional shape, channel slope, degree of stream sinuosity, and floodland shape and width. The heterogeneous character of the surface drainage system is due partly to the natural effect of glaciation superimposed on the bedrock and partly to channel modifications and other results of urbanization in the study area. About 1,010 miles of mapped streams drain the study area.

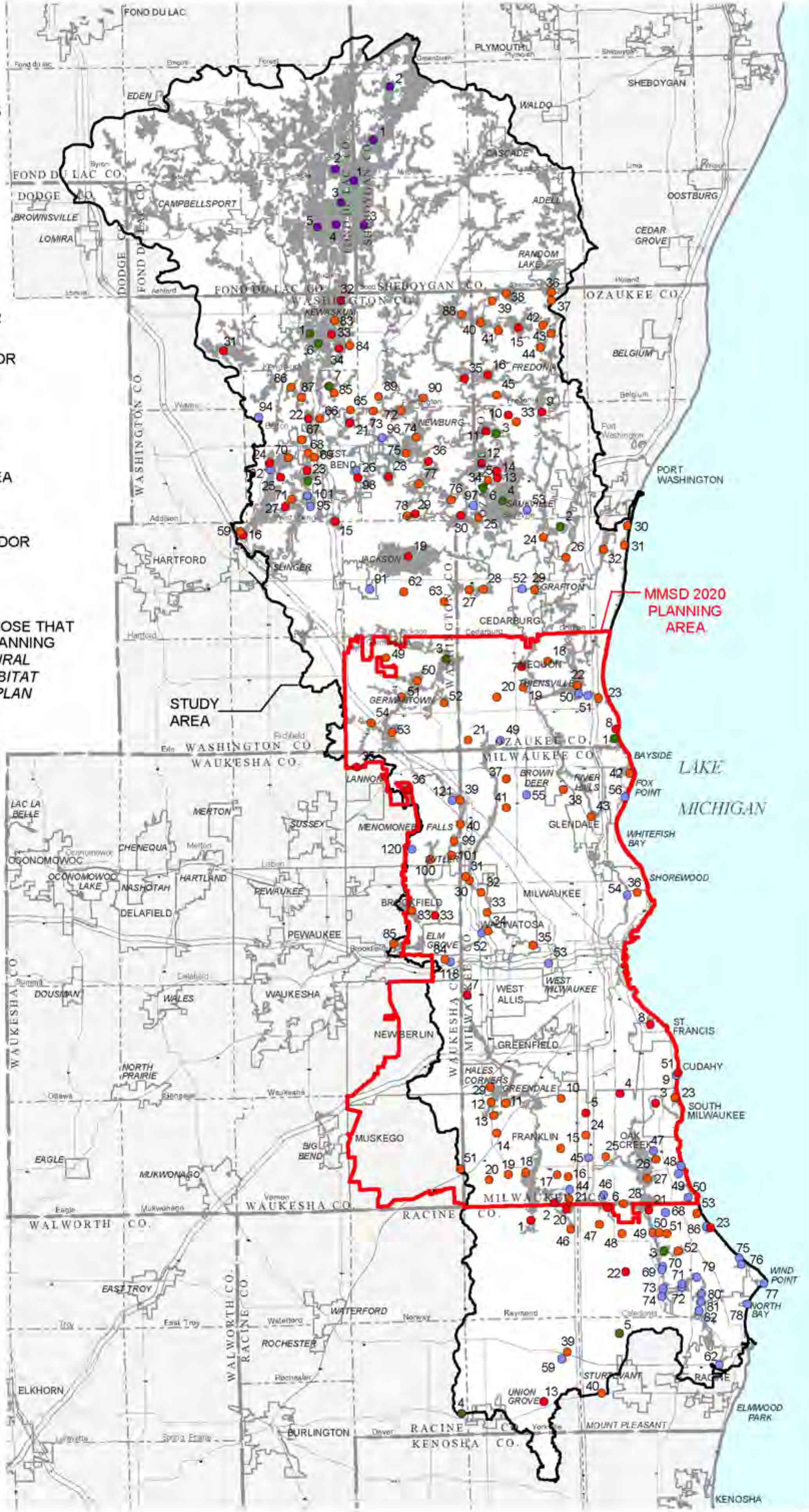
The groundwater system in the study area consists of a shallow and deep aquifer system, with the shallow aquifer being directly connected to the surface water system. Thus, it is important to consider groundwater resources as an important component of the regional water quality management plan update. Because of its largely rural character, along with a mix of urbanized areas and the presence of important environmentally sensitive areas, the study area continues to support diverse fish and wildlife resources. The environmental corridors and isolated natural resource areas encompass about 240 square miles, or about 21 percent of the study area.

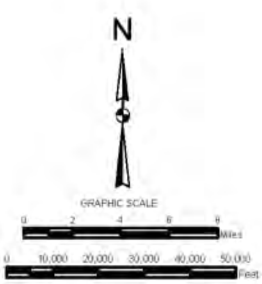
Map 20

KNOWN NATURAL AREAS AND CRITICAL SPECIES HABITAT SITES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 1994

- NATURAL AREA OF STATEWIDE OR GREATER SIGNIFICANCE (NA-1)
- NATURAL AREA OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (NA-2)
- NATURAL AREA OF LOCAL SIGNIFICANCE (NA-3)
- CRITICAL SPECIES HABITAT SITE
- DESIGNATED STATE NATURAL AREA BY WDNR BUREAU OF ENDANGERED RESOURCES
- PRIMARY ENVIRONMENTAL CORRIDOR
- 15 IDENTIFICATION NUMBER (SEE TABLE 30)

NOTE: IDENTIFICATION NUMBERS ARE THOSE THAT WERE ASSIGNED FOR SEWRPC PLANNING REPORT NO. 42, *A REGIONAL NATURAL AREAS AND CRITICAL SPECIES HABITAT PROTECTION AND MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN.*





Source: SEWRPC.

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Chapter III

EXISTING AND HISTORICAL SURFACE WATER AND GROUNDWATER CONDITIONS

INTRODUCTION

A basic premise of the Commission water quality management planning is that the human activities within a watershed affect, and are affected by, surface and groundwater quality conditions. This is especially true in the urban and urbanizing areas of the greater Milwaukee watersheds where the effects of human activities on water quality tend to overshadow natural influences. The hydrologic cycle provides the principal linkage between human activities and the quality of surface and ground waters in that the cycle transports potential pollutants from human activities to the environment and from the environment into the sphere of human activities.

Comprehensive water quality planning efforts such as the regional water quality management plan update should include an evaluation of historical, present, and anticipated water quality conditions and the relationship of those conditions to existing and probable future land and water uses. The purpose of this chapter is to summarize the available information as to the extent to which surface waters and ground waters in the greater Milwaukee watershed have been and are polluted. More specifically, this chapter summarizes current water pollution problems in the watersheds utilizing field data from a variety of water quality studies, most of which were conducted during the past three decades. The information summarized herein provides an important basis for development and testing of the alternative water quality control plan elements presented in Chapter IX of this report. More-detailed information on surface and groundwater conditions in the greater Milwaukee watersheds is presented in SEWRPC Technical Report No. 39, *Water Quality and Sources of Pollution in the Greater Milwaukee Watersheds,* which is a companion report to this water quality plan.

QUANTITY OF SURFACE WATER

Since 1975, measurements of discharge have been taken at a number of locations along streams in the greater Milwaukee watersheds. The period of record for many of these stations is rather short, with data collection occurring over periods ranging from several months to a few years. Some stations have longer periods of record.

Figure 10 compares discharge during the baseline period to historical conditions on a monthly basis at several gauges along the mainstems of major rivers and streams.[1] As shown in the legend of the figure, the background of

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[1]*The baseline period used for the Kinnickinnic River, Menomonee River, and Oak Creek watersheds was 1998-2001. As this study progressed, data became available and were incorporated into the analyses. Because of this, the baseline period used for the Milwaukee River and Root River watersheds was 1998-2004. Those baseline periods adequately represent conditions in the study area and the MMSD planning area following the construction of major MMSD sewerage system facilities, including the Inline Storage System.*

Figure 10

HISTORICAL AND BASE PERIOD FLOW IN STREAMS IN THE GREATER MILWAUKEE WATERSHEDS: 1975-2004

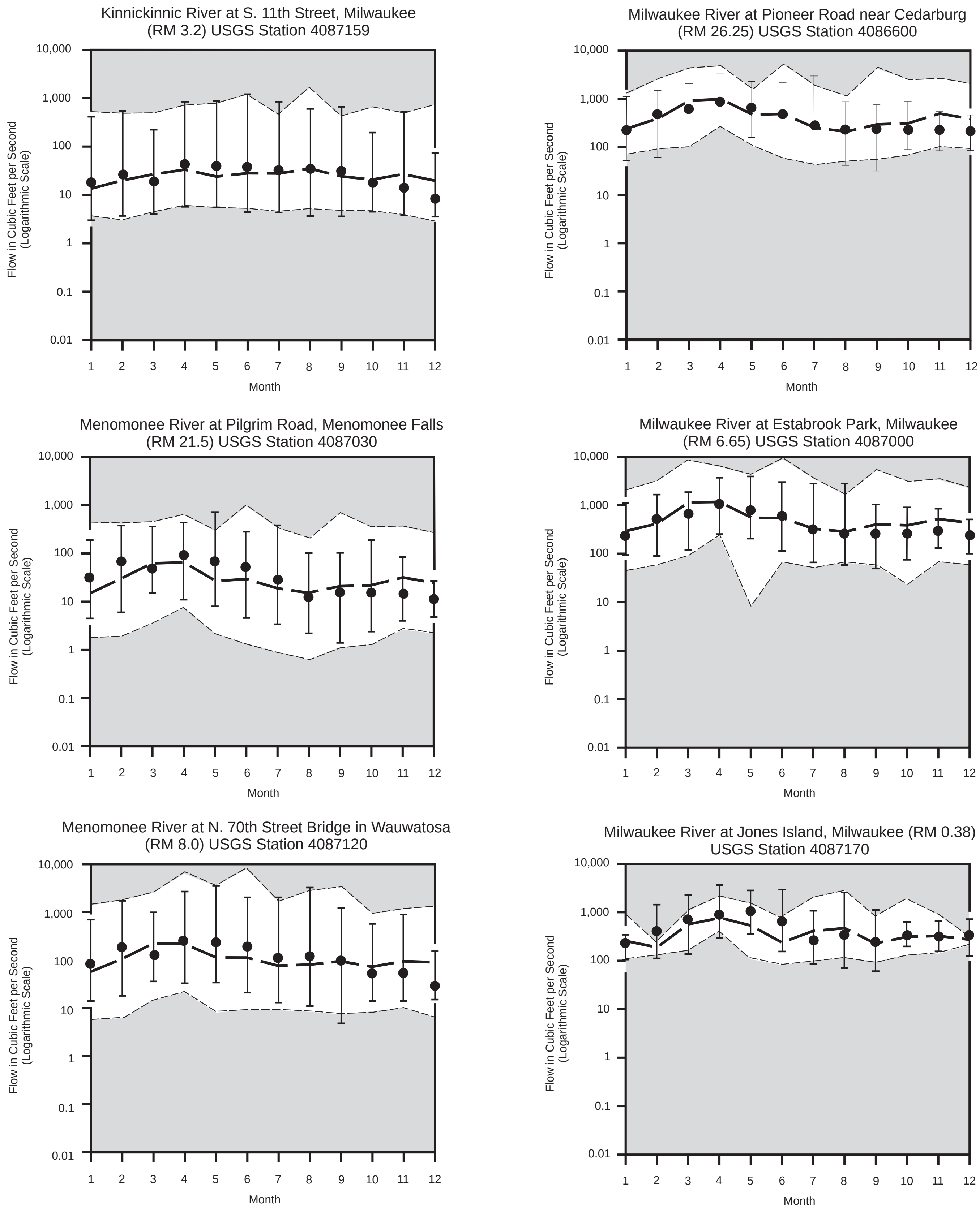
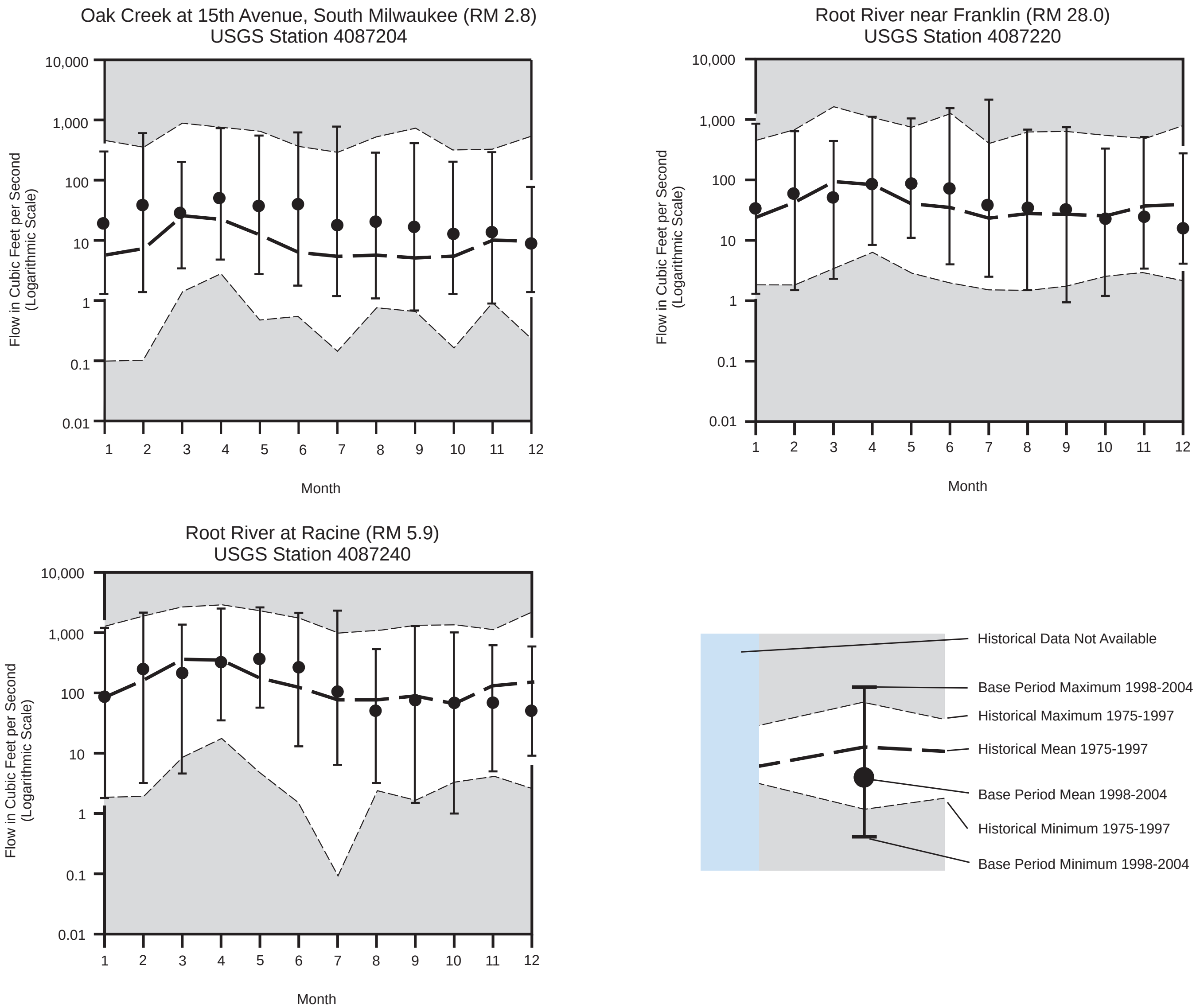


Figure 10 (continued)



NOTE: Because of differences in data availability, the periods of record differ among these streams. For the Menomonee and Kinnickinnic Rivers and Oak Creek, the period of record was 1975-2001. For the Milwaukee and Root Rivers, the period of record was 1975-2004.

Source: U.S. Geological Survey and SEWRPC.

the graph summarizes the historical conditions. The white area in the graphs shows the range of values observed during the period 1975-1997. The upper and lower boundaries between the white and gray areas show historical maxima and minima, respectively. A blue background indicates months for which no historical data were available. The dashed black line plots monthly mean discharge for the historical period. Overlaid on this background is a summary of baseline conditions from the period since 1998. The black dots show monthly mean discharge for that period. The black bars show the monthly ranges of discharge for the same period.

Similar annual patterns are seen in mean discharge at several sites during the historical period. Mean monthly streamflow tended to reach a low point during the winter. At most stations, this occurred during January. Mean monthly discharge rose from this low point to a peak in March or April associated with spring snowmelt and rains. It then declined slightly through the spring and summer. At some stations, discharge declined more rapidly through the autumn to the winter minimum. At other stations, discharge increased slightly during the fall to a peak in December. Considerable variability was associated with these patterns, but some of this variability is more likely attributed to sampling conditions rather than actual changes in discharge.

The pattern of discharge observed during the baseline period since 1998 shows both similarities and differences from this historical pattern. At most stations, baseline period discharge was generally within historical ranges. There was one major exception to this. During winter and spring months, monthly maximum discharges during the baseline period were higher than the historical monthly maxima at the station at Jones Island along the Milwaukee River. This may reflect the small amount of historical data available at this station. The pattern observed during the baseline period showed the following three differences from the pattern observed during the historical period.

- At most stations the low point in monthly mean discharge appears to have shifted such that it occurred in the month of December during the baseline period.

- Baseline period streamflow in Oak Creek was higher than that seen during the historical period. While the range of baseline period streamflow was generally within historical ranges, during most months mean streamflow during the baseline period was higher than mean streamflow during the historical period. Monthly minimum streamflow during most months of the baseline period was higher than the historical monthly minima, in some months by about a factor of eight. In June and July, monthly maximum streamflows during the base period were higher than historical maxima. These trends suggest that baseflow has increased in Oak Creek.

- During the baseline period monthly mean discharge at stations along the Kinnickinnic, Menomonee, and Root Rivers during the late spring and early summer was higher then historical means. This was not observed at most stations along the mainstem of the Milwaukee River.

In order to estimate the relative contributions of discharge from the Kinnickinnic, Menomonee, and Milwaukee Rivers to the harbor, flow fractions were calculated for the S. 11th Street station along the Kinnickinnic River, the N. 70th Street station along the Menomonee River, and the Estabrook Park station along the Milwaukee River relative to the discharge at the Jones Island station near the mouth of the Milwaukee River using the procedure described in Chapter III of SEWRPC Technical Report No. 39. Several generalizations emerge from this analysis:

- The Milwaukee River is the dominant source of discharge to the harbor. Median discharge at the gage at Estabrook Park represents about 75 percent of the median discharge at Jones Island.

- The Menomonee River accounts for much of the remaining discharge into the harbor. Median discharge at the gage at N. 70th Street represents slightly more than 13 percent of the median discharge at Jones Island.

- The Kinnickinnic River contributes only a small portion of the discharge entering the harbor. Median discharge at S. 11th Street represents less than 3 percent of the median discharge at Jones Island.

- About 9 percent of the discharge at the gage at Jones Island is not accounted for by discharge at the gages on the three Rivers. This represents contributions entering the Rivers between their respective gages and the Jones Island gage and contributions from at least one tributary, Woods Creek, as well as direct runoff.

An additional aspect of water quantity is the level of water in Lake Michigan. Water levels in the Lake undergo a seasonal cycle, rising from February to July and falling during the rest of the year. The seasonal rise from February to July reflects the pattern of higher runoff and lower evaporation during that period in comparison to the remainder of the year. In a typical one-year period, the range in average monthly Lake Michigan levels may be expected to be about 0.3 meters. While longer period fluctuations have been observed in Lake Michigan, there appears to be a general lowering in lake level since the early 1970s. Large declines in lake level were observed following the maximum levels achieved in 1986 and 1997. In fact, the decline since 1997 is the largest drop observed since records have consistently been kept, beginning in 1860. It is not clear whether the current decline represents a long-term trend or reflects an additional fluctuation.[2] The long-term average Lake Michigan level, based on data collected from 1918 into 2006 is about 176.45 meters above International Great Lakes Datum of 1985 (IGLD85), or 578.90 feet above IGLD85, or 579.43 feet above National Geodetic Vertical Datum, 1929 adjustment. Daily average lake levels have been below that long-term average since early in 1999.

SURFACE WATER QUALITY CONDITIONS IN THE GREATER MILWAUKEE WATERSHEDS: 1975-2004

Water Quality of Streams

The earliest systematic collection of water quality data in streams of the greater Milwaukee watersheds occurred in the 1960s.[3] Data collection after that was sporadic until the 1970s. Since then, considerable data have been collected, especially on the mainstems of the major rivers and streams. The major sources of data include the Milwaukee Metropolitan Sewerage District (MMSD), the Wisconsin Department of Natural Resources (WDNR), the U.S. Geological Survey (USGS), the Washington County Land and Water Conservation Division, the City of Racine Health Department, the University of Wisconsin-Milwaukee, and the U.S. Environmental Protection Agency’s (USEPA) STORET legacy and modern databases. Most of the data were obtained from sampling stations along the mainstems of the major rivers and streams. In addition, sufficient data were available for several tributaries to assess baseline period water quality for several water quality parameters. These tributaries are listed in Table 31. The data record for other tributary streams in the greater Milwaukee watersheds is fragmentary.

For analytic purposes, data from four time periods were examined: 1975-1986, 1987-1993, 1994-1997, and 1998-2001.[4] Bimonthly data records exist from several of MMSD’s long-term monitoring stations beginning in 1975. After 1986, MMSD no longer conducted sampling during the winter months. In 1994, the Inline Storage System (ISS) or Deep Tunnel came online. The remaining period since 1998 defines the baseline water quality conditions of the river systems.

Water quality parameters from the streams of the greater Milwaukee watersheds were examined for the presence of several different types of trends: changes along the length of the stream, changes at individual sampling stations over time, and seasonal changes throughout the year. Changes over time were assessed both on an annual and a seasonal basis. In addition, for the mainstems of the Kinnickinnic, Menomonee, and Milwaukee Rivers, differences between average values from sampling stations located in upstream areas and the average values of parameters from sampling stations in the Milwaukee River estuary were assessed using analysis of variance (ANOVA). Data were log-transformed for some parameters, in order to meet the normal distribution assumption of ANOVA. Maps 21 through 26 and Table 31 show the 42 sampling stations along the mainstems of the major rivers and streams, designated by their River Mile locations, which had sufficiently long periods of sampling to be used for these analyses. Where sufficient data were available, water quality parameters from tributary streams were examined for the presence of trends. It is important to note that only limited data were available to assess baseline water quality conditions for tributary streams.

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[2]*Additional, detailed information on historical Lake Michigan levels is set forth in SEWRPC Technical Record, Volume 4, No. 5, December 1989.*

[3]*SEWRPC Technical Report No. 4,* Water Quality and Flow of Streams in Southeastern Wisconsin, *April 1964.*

[4]*The baseline period used for the Kinnickinnic River, Menomonee River, and Oak Creek watersheds was 1998-2001. As this study progressed, data became available and were incorporated into the analyses. Because of this, the baseline period used for the Milwaukee River and Root River watersheds was 1998-2004 and the baseline period used for streams of the Lake Michigan direct drainage area was 2002-2005.*

Table 31

SAMPLE SITES USED FOR ANALYSIS OF WATER QUALITY TRENDS IN THE STREAMS OF THE GREATER MILWAUKEE WATERSHEDS

Location	River Mile	Period of Record	Data Sources
Kinnickinnic River Watershed			
Wilson Park Creek Outfall at General Mitchell International Airport	5.12[a]	1996-2001	USEPA, USGS
Wilson Park Creek Infall at General Mitchell International Airport near Grange Avenue	3.63[a]	1996-2001	USEPA, USGS
Wilson Park Creek at St. Luke's Hospital	0.03[a]	1996-2001	USEPA, USGS
Kinnickinnic River at S. 27th Street	4.90[b]	1981-2001	MMSD, USGS
Kinnickinnic River at S. 11th Street	3.20[b]	1983-2001	USGS
Kinnickinnic River at S. 7th Street	2.80[b]	1975-2001	MMSD, USEPA, USGS
Kinnickinnic River at S. 1st Street	1.40[b]	1980-2001	MMSD, USGS
Kinnickinnic River at Greenfield Avenue (extended)	0.60[b]	1982-2001	MMSD
Kinnickinnic River at the Jones Island ferry	0.20[b]	1982-2001	MMSD
Menomonee River Watershed			
Menomonee River at N. County Line Road	23.50[b]	1964-1975, 1982-2001	MMSD, SEWRPC
Menomonee River at N. 124th Street	13.50[b]	1985-2001	MMSD, USEPA, USGS
Menomonee River at W. Hampton Avenue	12.50[b]	1985-2001	MMSD
Menomonee River at N. 70th Street	8.00[b]	1964-2001	MMSD, SEWRPC, USEPA, USGS
Menomonee River at N. 25th Street	1.80[b]	1984-2001	MMSD
Menomonee River at Muskego Avenue	0.90[b]	1975-2001	MMSD, USEPA
Menomonee River at Burnham Canal	0.80[b]	1992-2001	MMSD
Menomonee River at S. 2nd Street	0.00[b]	1980-2001	MMSD
Milwaukee River Watershed			
West Branch Milwaukee River at Drumlin Drive near Lomira	15.90[b]	1998-1999, 2001	USEPA, USGS
Kewaskum Creek at USH 45 at Kewaskum	0.10[b]	1998-1998	USEPA, USGS
Parnell Creek near Dundee	0.75[c]	1996-1997, 2001-2002	USGS
East Branch Milwaukee River at New Fane	5.71[b]	1993, 1995, 2004	USEPA, USGS, WDNR
Quaas Creek upstream of Decorah Road near West Bend	0.52[b]	2000-2003	UW-Milwaukee, Washington County Land and Water Conservation Division
Quaas Creek at Decorah Road near West Bend	0.32[b]	1998-1999	USEPA, USGS
Batavia Creek Near Batavia	0.10[d]	1993-1994, 1998-1999	USEPA, USGS
North Branch Milwaukee River near Random Lake	10.09[b]	1992-1995, 2001-2002	USGS
North Branch Milwaukee River near Fillmore	2.22[b]	2004	USGS
Polk Springs Creek downstream of CTH Z near Jackson	2.25[e]	1998-2001, 2003-2004	USEPA, USGS, Washington County Land and Water Conservation Division
Cedar Creek at STH 60 near Cedarburg	6.77[b]	1970, 1973-1987, 1990-2004	USGS, WDNR
Cedar Creek at Columbia Road at Cedarburg	4.74[b]	1990-1991, 1994-1995, 2001	USGS
Cedar Creek at Highland Road at Cedarburg	4.04[b]	1990-1991, 1994-1995, 2001	USGS
Southbranch Creek at W. Bradley Road	1.45[b]	1999-2002	MMSD
Southbranch Creek at N. 55th Street	1.25[b]	1999-2002	MMSD
Southbranch Creek at N. 47th Street	0.75[b]	1999-2002	MMSD
Southbranch Creek at N. Teutonia Avenue	0.20[b]	1999-2002	MMSD
Lincoln Creek at N. 60th Street	8.42[b]	1997-2002	MMSD
Lincoln Creek at N. 51st Street	6.92[b]	1997-2002	MMSD
Lincoln Creek at N. 55th Street	5.86[b]	1997-2002	MMSD
Lincoln Creek at N. 47th Street	3.33[b]	1992-2004	MMSD, USEPA, USGS, WDNR
Lincoln Creek at N. Sherman Boulevard	3.03[b]	2003-2004	USGS
Lincoln Creek at N. Green Bay Avenue	0.42[b]	1997-2002	MMSD
Milwaukee River above Dam at Kewaskum	78.10[f]	2004	USGS
Milwaukee River at CTH M near Newburg	57.70[f]	2004	USGS
Milwaukee River at Waubeka	45.44[f]	2004	USGS
Milwaukee River at Pioneer Road near Cedarburg	26.25[f]	1981-2004	MMSD, USEPA, USGS, WDNR
Milwaukee River at W. Brown Deer Road	14.99[f]	1975, 1981-2002	MMSD, USEPA
Milwaukee River at W. Silver Spring Drive	8.49[f]	1975, 1976, 1981-2002	MMSD, USEPA
Milwaukee River at N. Port Washington Road	6.91[f]	1975, 1981-2002	MMSD
Milwaukee River at Estabrook Park	6.65[f]	1971-2004	USEPA, USGS, WDNR
Milwaukee River at North Avenue Dam	3.10[f]	1975-1976, 1979-2002	MMSD, USEPA, USGS

Table 31 (continued)

Location	River Mile	Period of Record	Data Sources
Milwaukee River Watershed (continued)			
Milwaukee River at Walnut Street	2.25[f]	1975, 1980-2002	MMSD
Milwaukee River at E. Wells Street	1.41[f]	1975, 1980-2002	MMSD, USEPA
Milwaukee River at N. Water Street	0.78[f]	1975, 1980-2002	MMSD
Milwaukee River at Union Pacific Railroad (formerly Chicago & Northwestern Railway)	0.44[f]	1975, 1982-2002	MMSD
Oak Creek Watershed			
Mitchell Field Drainage Ditch at W. College Avenue	1.80[g]	1998-2001	USEPA, USGS
North Branch of Oak Creek at W. Puetz Road	0.90[g]	1975-1976, 1990, 1996	USEPA
Oak Creek at W. Ryan Road	10.10[f]	1985-2001	MMSD
Oak Creek at STH 38	9.10[f]	1985-2001	MMSD
Oak Creek at Forest Hill Road	6.30[f]	1985-2001	MMSD
Oak Creek at S. Pennsylvania Avenue	4.70[f]	1975-1976, 1985-2001	MMSD, USEPA
Oak Creek at 15th Avenue	2.80[f]	1972-1982, 1984-2001, 2004	MMSD, USGS
Oak Creek at Oak Creek Parkway east of STH 32	1.00[f]	1985-2001	MMSD
Oak Creek at Oak Creek Parkway east of S. Lake Drive	0.30[f]	1995-2001	MMSD
Root River Watershed			
Husher Creek at 7 1/2 Mile Road	0.30[h]	1981-1982, 1996, 2001	USEPA, USGS
Root River Canal near Franklin	3.50[h]	1975-1981, 1985-1994, 2001	USGS
Root River at W. Cleveland Avenue	41.50[f]	1999-2001	MMSD
Root River at W. National Avenue and W. Oklahoma Avenue	41.00[f]	1999-2001	MMSD
Root River at W. Cold Spring Road	39.20[f]	1999-2001	MMSD
Root River at W. Grange Avenue	36.70[f]	1975-1976, 1981-1982, 1996, 1999-2001, 2004	MMSD, USEPA, USGS, WDNR
Root River at W. Ryan Road	28.00[f]	1971-1982, 1985-1994, 1996, 1999-2001, 2004	MMSD, USGS, WDNR
Root River at S. County Line Road	23.80[f]	1999-2001	MMSD
Root River at Johnson Park	11.50[f]	1977-1983, 1986-1990, 1992-2005	City of Racine, USEPA, WDNR
Root River below Horlick Dam, Racine	5.90[f]	1975-1994, 1996-1999, 2002, 2004-2005	City of Racine, USEPA, USGS
Root River near Mouth	0.40[f]	1996-1997, 1999, 2004-2005	City of Racine, USGS
Lake Michigan Direct Drainage Area			
Fish Creek at W. Port Washington Road and Katherine Lane	1.25[f]	2002-2005	MMSD
Fish Creek at Broadmoor Drive and Union Pacific Railway	0.70[f]	2002-2005	MMSD

[a]*River mile is measured as distance from the confluence with the mainstem of the Kinnickinnic River.*

[b]*River mile is measured as distance from the confluence with the mainstem of the Milwaukee River.*

[c]*River mile is measured as distance from the confluence with the East Branch Milwaukee River.*

[d]*River mile is measured as distance from the confluence with the North Branch Milwaukee River.*

[e]*River mile is measured as distance from the confluence with Cedar Creek.*

[f]*River mile is measured as distance from the confluence with Lake Michigan.*

[g]*River mile is measured as distance from the confluence with Oak Creek.*

[h]*River mile is measured as distance from the confluence with the mainstem of the Root River.*

Source: SEWRPC.

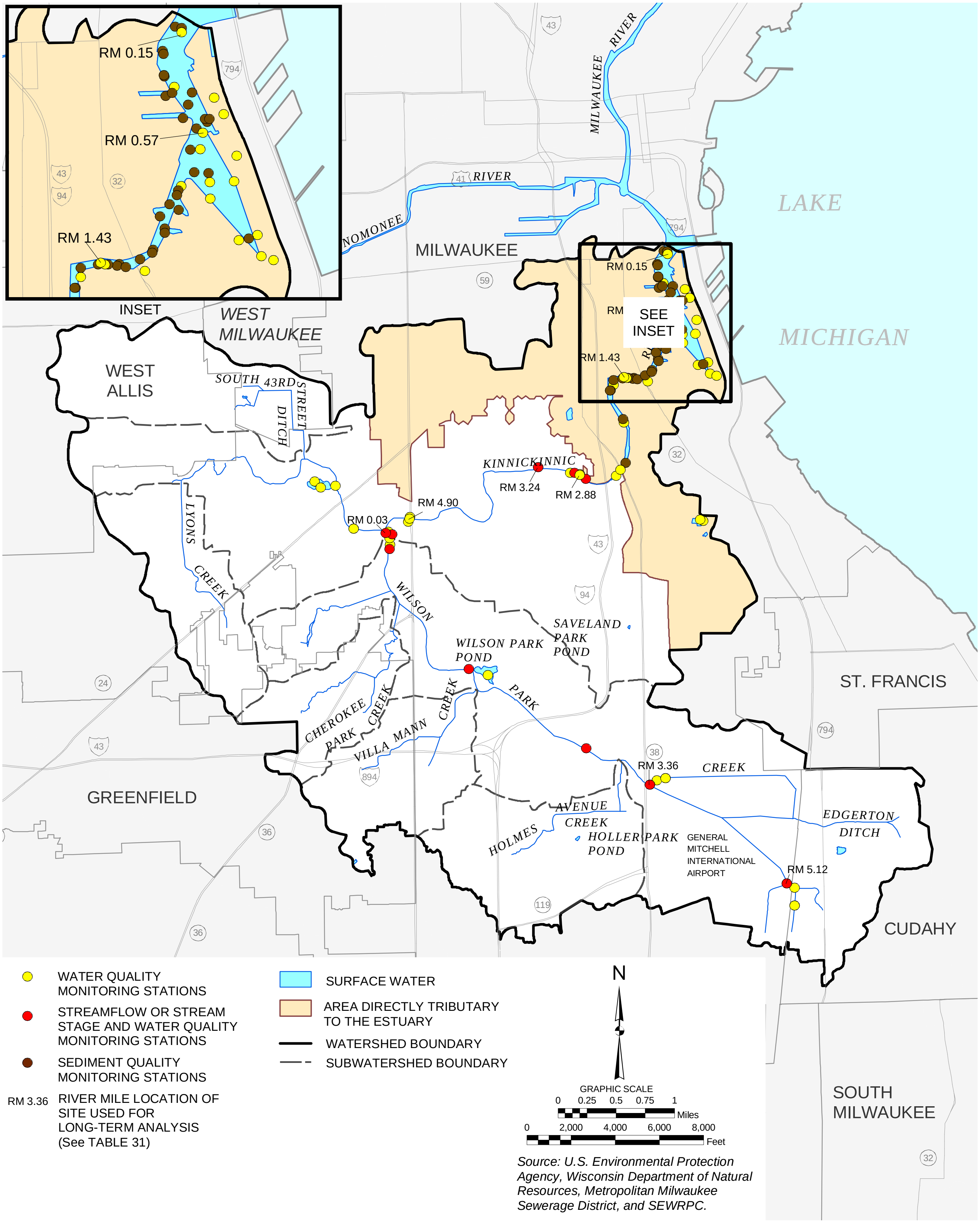
Bacterial and Biological Parameters

Bacteria

Based on data for all of the sampling locations analyzed, median concentrations of fecal coliform bacteria in the major streams and rivers of the greater Milwaukee watersheds during the period of record ranged from about 50 to 20,000 cells per 100 milliliters (ml). Fecal coliform counts varied over eight orders of magnitude, ranging from less than one cell per 100 ml to over 2 million cells per 100 ml. Counts in most samples exceeded the standard

Map 21

WATER AND SEDIMENT QUALITY MONITORING STATIONS WITHIN THE KINNICKINNIC RIVER WATERSHED: 1975-2001



WATER QUALITY MONITORING STATIONS

STREAMFLOW OR STREAM STAGE AND WATER QUALITY MONITORING STATIONS

SEDIMENT QUALITY MONITORING STATIONS

RM 3.36 RIVER MILE LOCATION OF SITE USED FOR LONG-TERM ANALYSIS (See TABLE 31)

SURFACE WATER

AREA DIRECTLY TRIBUTARY TO THE ESTUARY

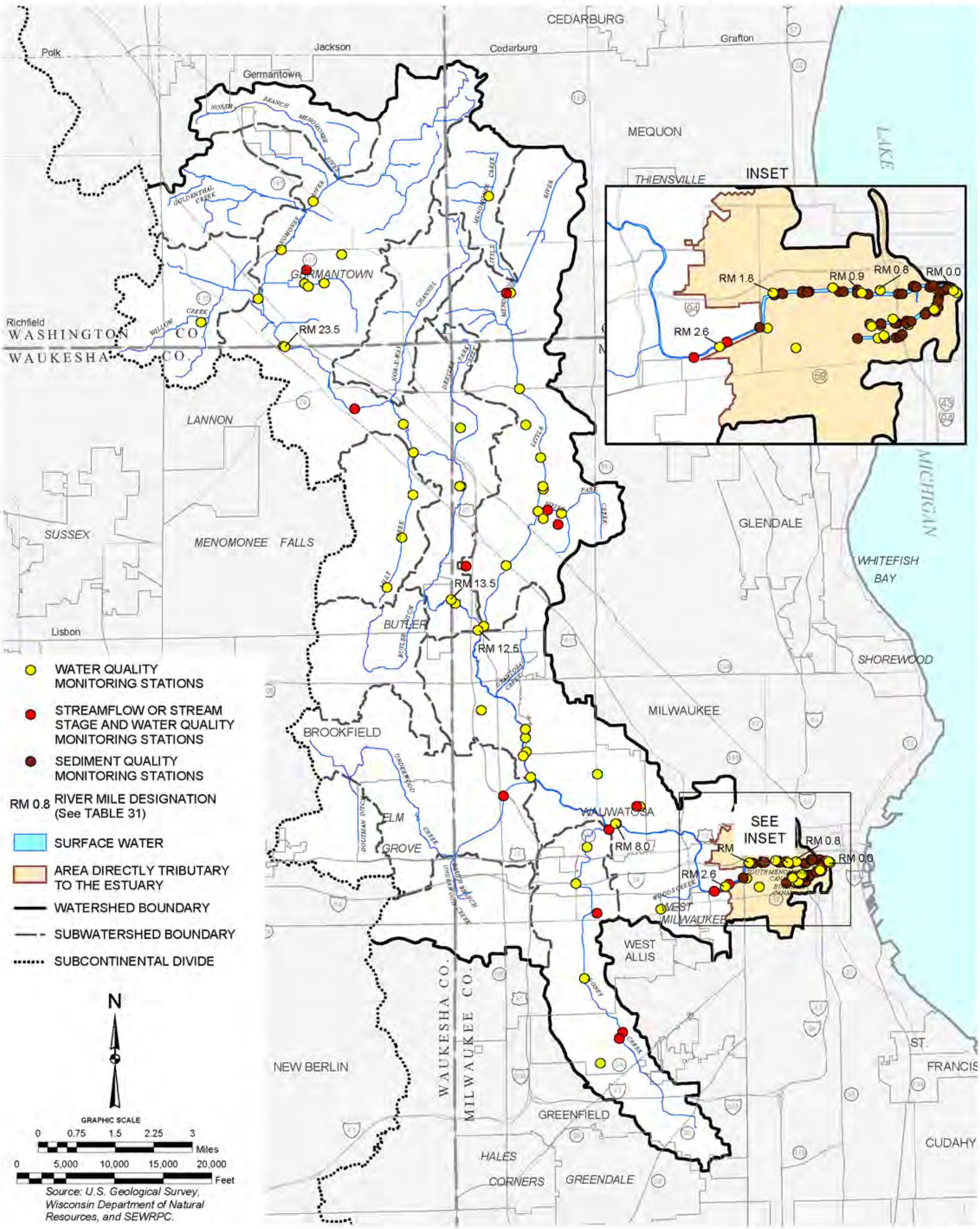
WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

Source: U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Metropolitan Milwaukee Sewerage District, and SEWRPC.

Map 22

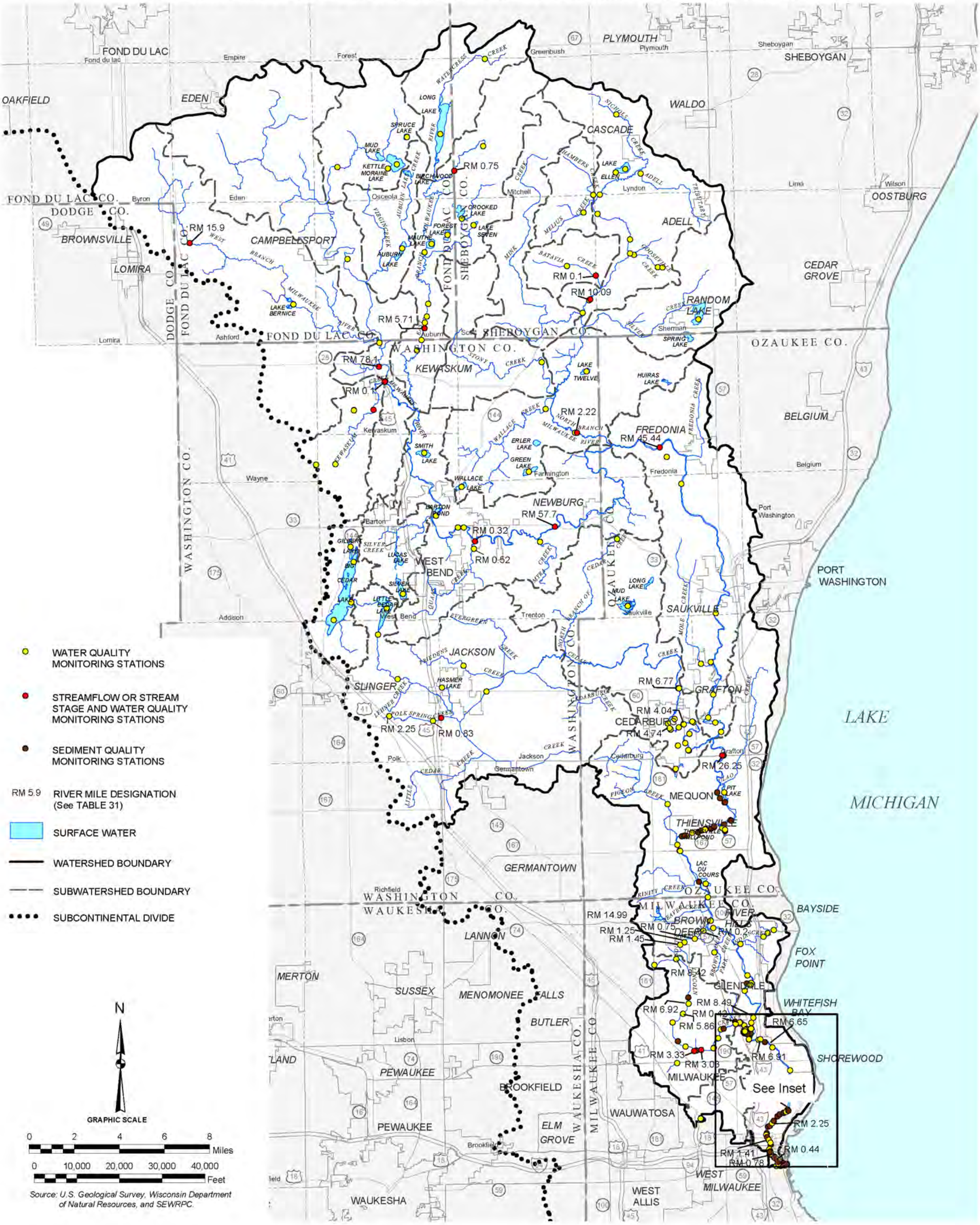
WATER AND SEDIMENT QUALITY MONITORING STATIONS WITHIN THE MENOMONEE RIVER WATERSHED: 1975-2001



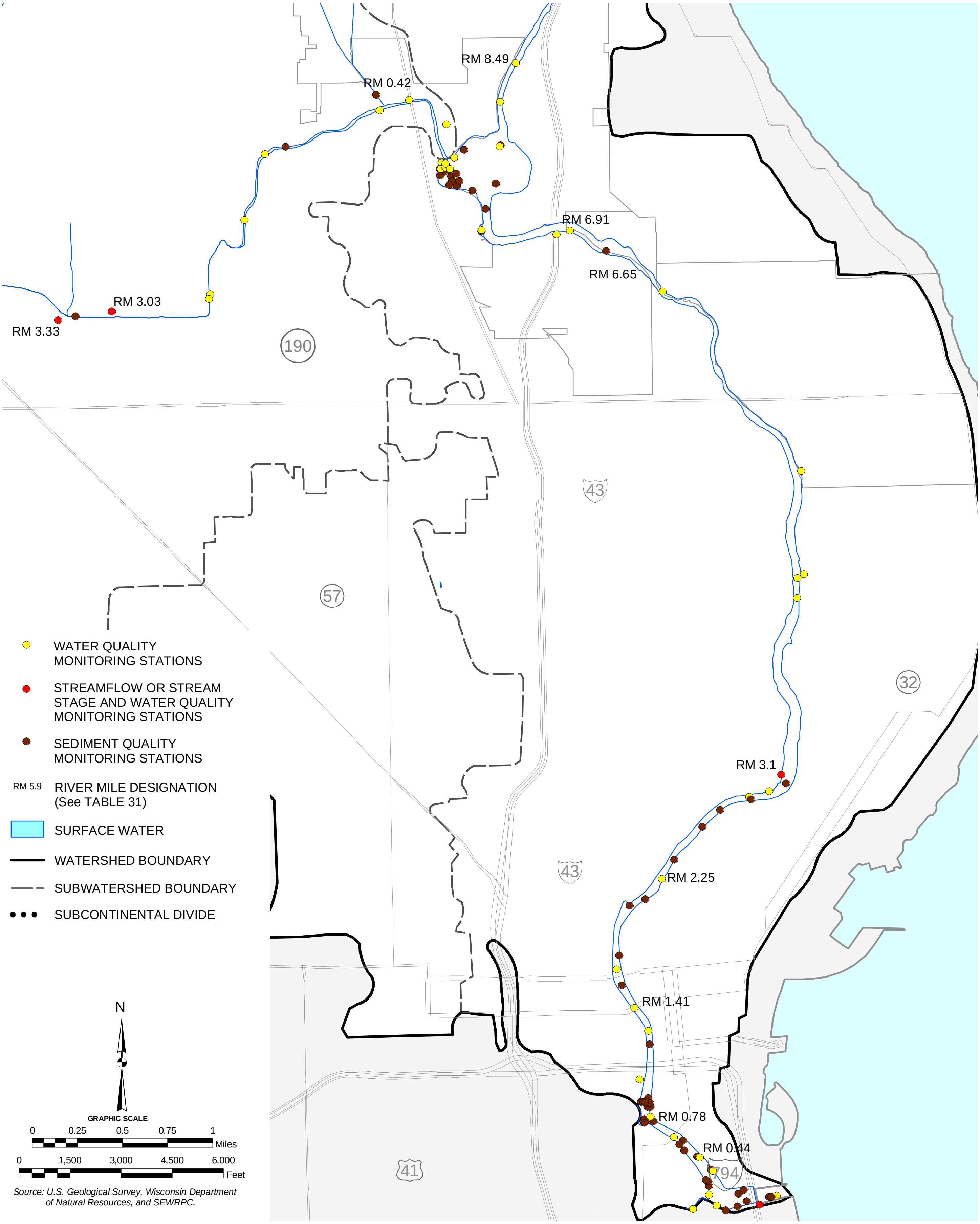
Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

Map 23

WATER AND SEDIMENT QUALITY MONITORING STATIONS WITHIN THE MILWAUKEE RIVER WATERSHED: 1975-2004



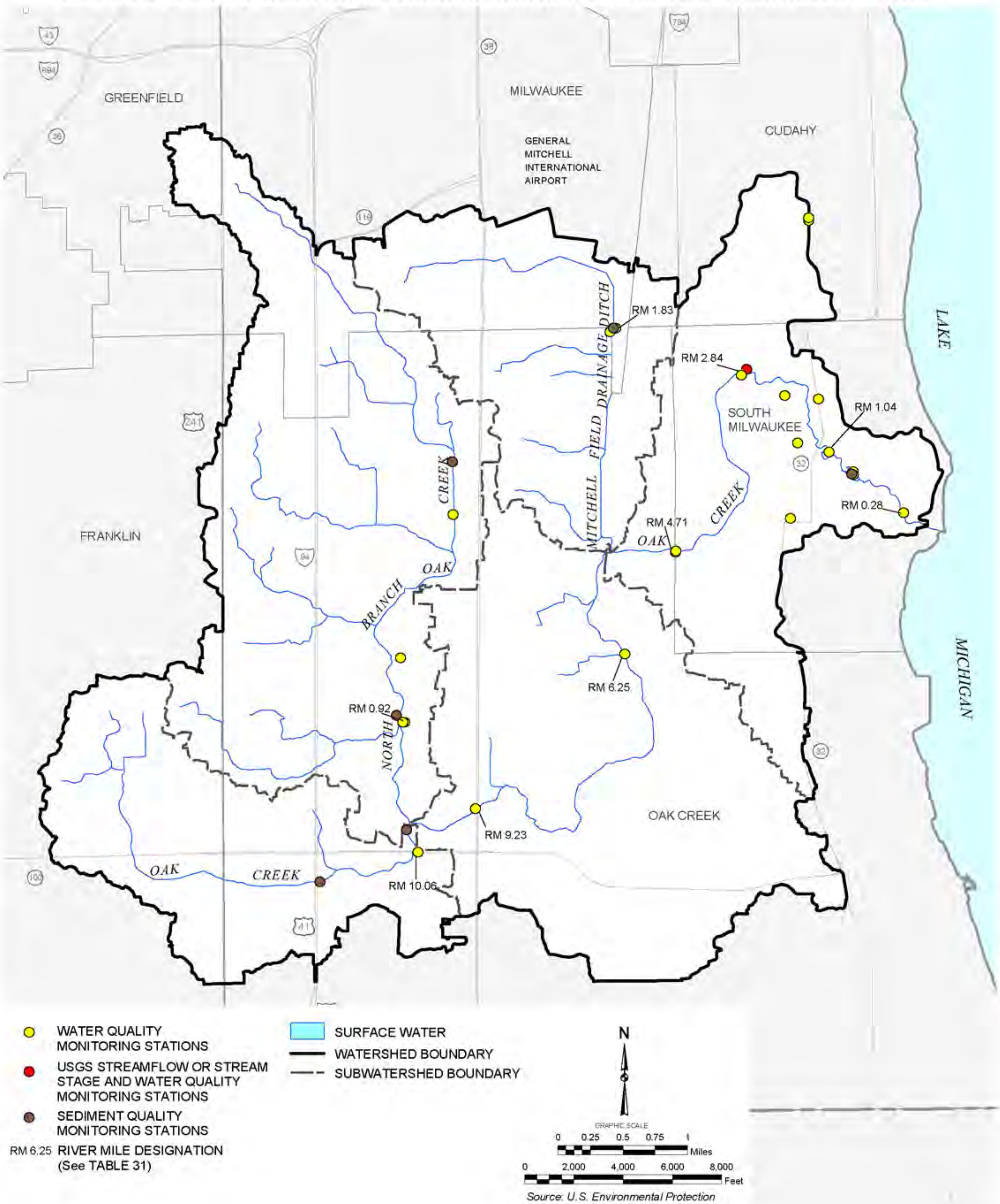
INSET to Map 23



Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

Map 24

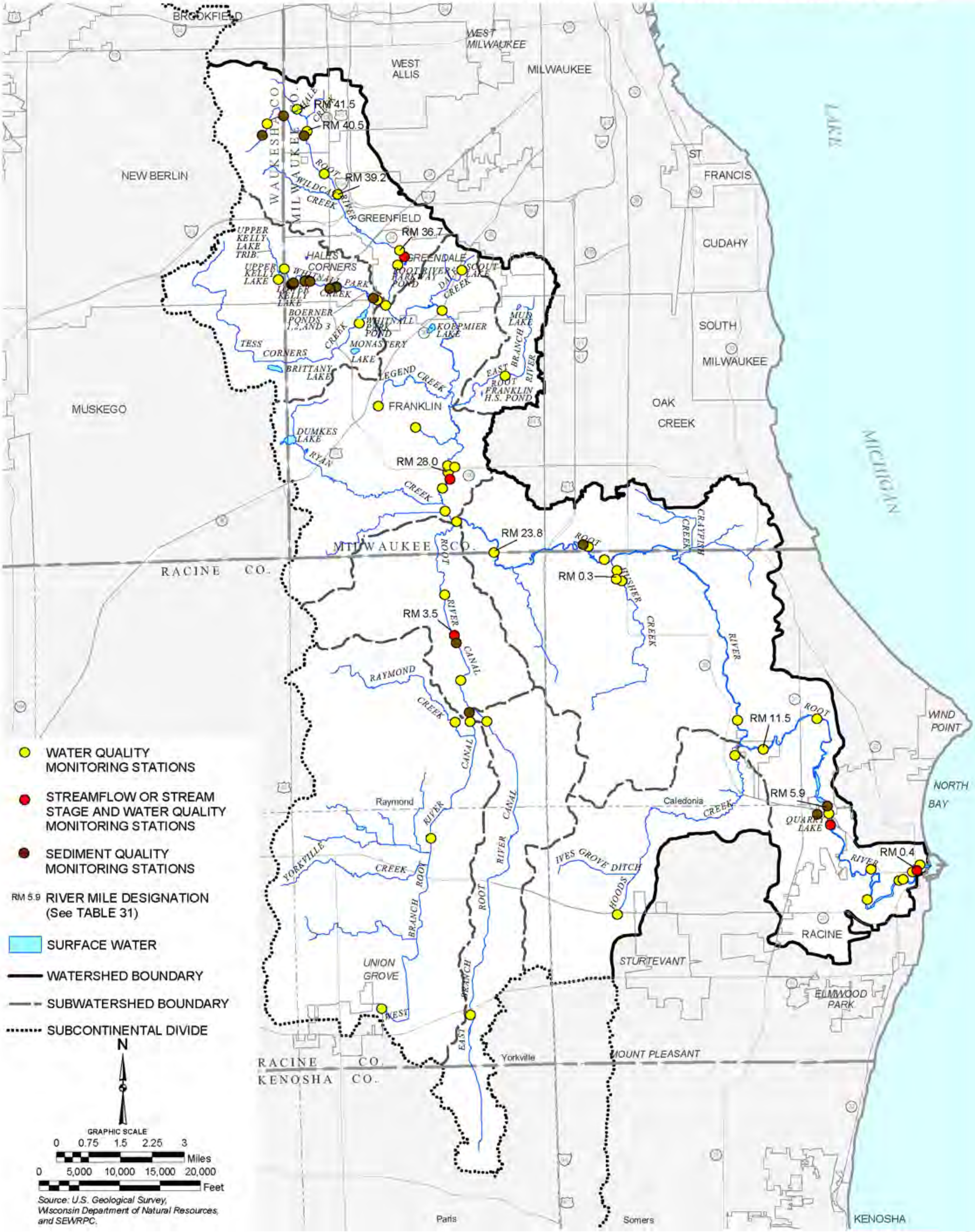
WATER AND SEDIMENT QUALITY MONITORING STATIONS WITHIN THE OAK CREEK WATERSHED: 1975-2001



Source: U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Metropolitan Milwaukee Sewerage District, and SEWRPC.

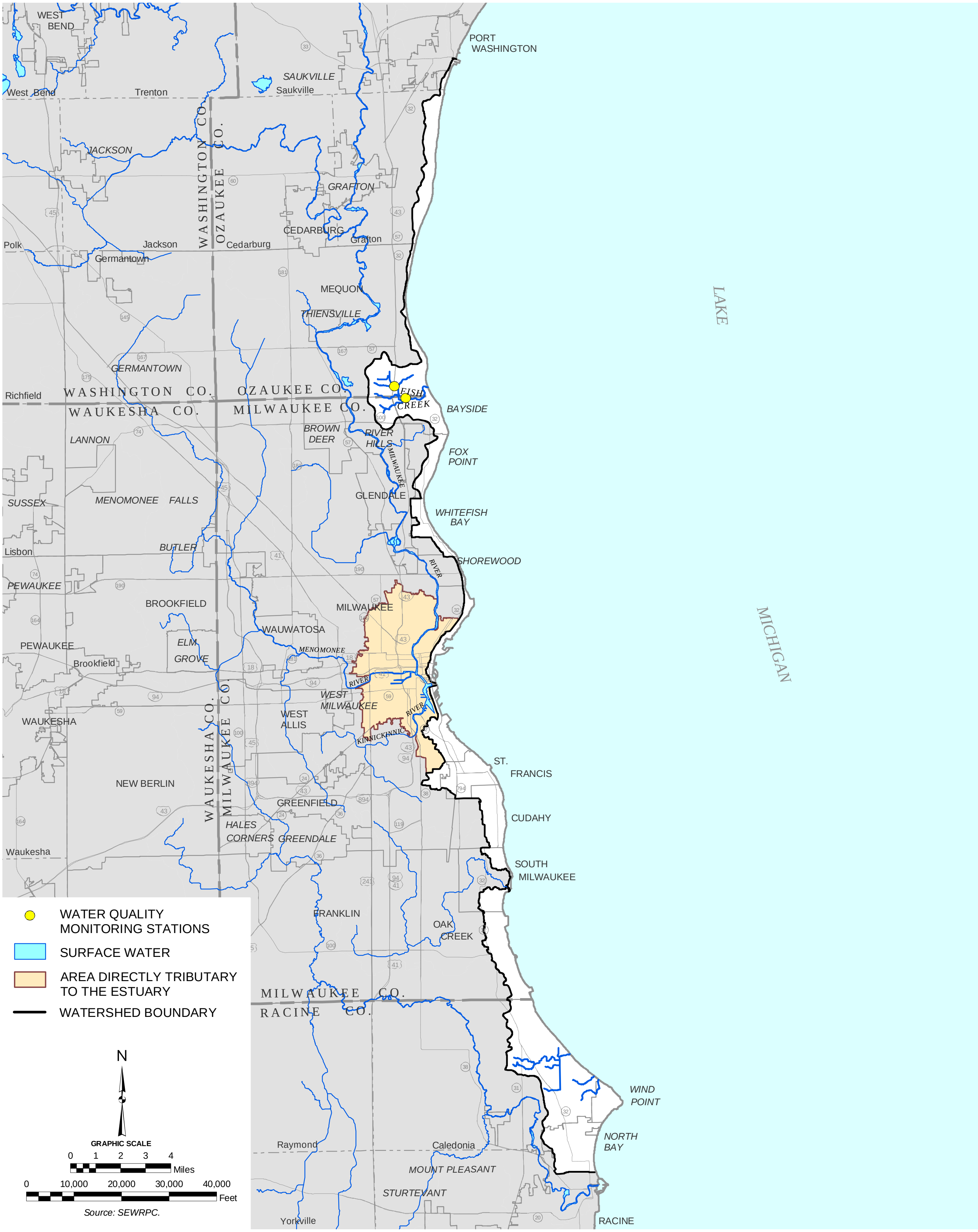
Map 25

WATER AND SEDIMENT QUALITY MONITORING STATIONS WITHIN THE ROOT RIVER WATERSHED: 1975-2004



Map 26

WATER QUALITY MONITORING STATIONS WITHIN THE AREA DIRECTLY TRIBUTARY TO LAKE MICHIGAN: 2002-2005



for full recreational use of 200 cells per 100 ml. In addition, in many samples the fecal coliform bacteria concentrations in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers exceeded the variance standard of 1,000 cells per 100 ml for the Milwaukee River estuary. Figure 11 shows that after 1994, concentrations of fecal coliform bacteria in the estuary sections of the Menomonee River decreased relative to concentrations in earlier periods. Similar decreases were seen after 1994 in the estuary sections of the Kinnickinnic and Milwaukee Rivers. The occurrence of these reductions coincides with the period during which the Inline Storage System came on line. It suggests that, since 1994, reductions in inputs from combined sewer overflows related to use of the Inline Storage System have reduced loadings of fecal coliform bacteria into the estuary. In the Menomonee River, this has reduced loadings of fecal coliform bacteria to the point that mean concentrations of these bacteria in the estuary are significantly lower than the mean concentrations of these bacteria in the sections of the River upstream of the estuary and outside of the combined sewer area.

In most of the major streams of the greater Milwaukee watersheds, variation in fecal coliform bacteria concentration occurs along the length of the streams. Table 32 shows that there were statistically significant trends toward concentrations of fecal coliform bacteria increasing from upstream to downstream along the portions of the mainstems of the Menomonee and Milwaukee Rivers upstream of the estuary. By contrast, in the Root River a statistically significant trend toward concentrations of fecal coliform decreasing from upstream to downstream was detected. In addition, since 1994, median concentrations of fecal coliform bacteria in the estuary sections of the Kinnickinnic, Menomonee, and Milwaukee Rivers have tended to decrease from upstream to downstream. This may be the result of dilution effects from the influence of Lake Michigan.

A summary of time-based trends in fecal coliform bacteria concentrations is shown in Table 33. At 51 percent of the sampling stations along the major streams and rivers of the study area, no statistically significant trends over time were detected in fecal coliform bacteria concentrations. Significant trends toward decreasing concentrations were detected at about 41 percent of sampling stations. Sampling stations with decreasing trends tend to occur at stations along the Kinnickinnic, Menomonee, and Milwaukee Rivers (Table 34), especially in the estuary portions of these Rivers. The reductions at these stations may reflect reduced loadings of fecal coliform bacteria in the combined sewer service area related to the Inline Storage System coming online. Fecal coliform bacteria concentrations tend to be positively correlated with concentrations of biochemical oxygen demand, especially in the Milwaukee River estuary, and with concentrations of several nutrients including ammonia, dissolved phosphorus, total phosphorus, and total nitrogen. These correlations may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into surface waters. Fecal coliform bacteria concentrations are also strongly positively correlated with concentrations of *E. coli* reflecting the fact that *E. coli* constitute a major component of fecal coliform bacteria. The long-term trends toward declining fecal coliform bacteria concentrations at several stations represent a long-term improvement in water quality.

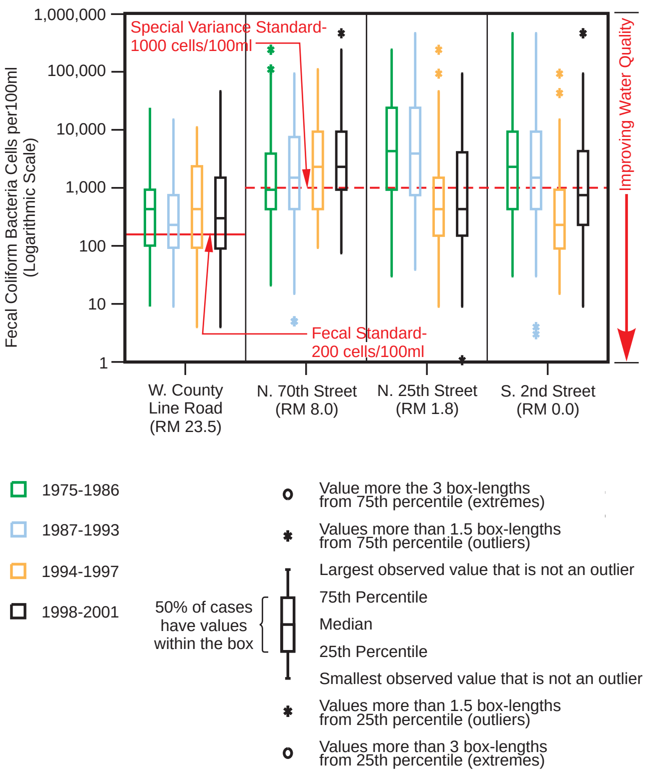
The MMSD began regular sampling for *E. coli* at some sampling stations along the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers in 2000 and at one station along Oak Creek in 2004. In addition, the City of Racine Health Department monitors *E. coli* concentrations at several sites along the Root River in the City of Racine. Concentrations of *E. coli* at stations along the mainstems of the major streams and rivers ranged from 0.5 cells per 100 ml to 160,000 cells per 100 ml. During the baseline period, mean concentrations of *E. coli* in the estuary portion of the Milwaukee River were significantly higher than mean concentrations in the portion of the River upstream from the estuary. Statistically significant increasing trends in *E. coli* concentration were detected from upstream to downstream along the portions of the Menomonee and Milwaukee Rivers upstream from the estuary (Table 32). Few statistically significant time-based trends were detected in *E. coli* concentrations (Tables 33 and 34). It is important to note that the short-term data record for *E. coli* precludes detection of long-term trends. Because *E. coli* is a major component of fecal coliform bacteria, long-term trends in the concentration of fecal coliform bacteria should give an indication of likely trends in *E. coli* concentration.

Chlorophyll-a

Concentrations of chlorophyll-*a* at sampling stations along the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 628.4 micrograms per liter (μg/l). Over the period of record, the mean concentration of chlorophyll-*a* in the Kinnickinnic River was 8.64 μg/l, the

Figure 11

FECAL COLIFORM BACTERIA CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

mean concentration of chlorophyll-*a* in the Menomonee River was 9.28 μg/l, the mean concentration of chlorophyll-*a* in the Milwaukee River was 28.3 μg/l, the mean concentration of chlorophyll-*a* in Oak Creek was 4.67 μg/l, and the mean concentration of chlorophyll-*a* in the Root River was 5.87 μg/l. Chlorophyll-*a* concentrations in the Milwaukee River tend to be higher and more variable than those in the Kinnickinnic, Menomonee, and Root Rivers and Oak Creek. Figure 12 shows that after 1993, chlorophyll-*a* concentrations at sampling stations in the estuary portions of the Menomonee River decreased. Similar decreases in chlorophyll-*a* concentrations occurred after 1993 at sampling stations in the estuary portion of the Kinnickinnic River. These changes occurred at roughly the time when the Inline Storage System came online and may reflect reductions of nutrient inputs related to the reduction in the number of combined sewer overflows. While this pattern was observed at one station in the estuary portion of the Milwaukee River, at most of the sampling stations in the estuary portion of the Milwaukee River, decreases in chlorophyll-*a* concentrations occurred after 1997. Chlorophyll-*a* concentrations at most stations along Oak Creek increased over time, though at some stations concentrations decreased slightly after 1997. Relatively few historical data are available for chlorophyll-*a* concentrations at most long-term sampling stations along the Root River. Concentrations of chlorophyll-*a* at the Johnson Park station were higher during the period 1994-1997 than they were during the period 1987-1993. During the period 1998-2005, chlorophyll-*a* concentrations at this station were lower than during either of the previous periods.

In most of the Rivers, chlorophyll-*a* concentrations vary along the length of the River. In Oak Creek and the Root River and in the sections of the Menomonee and Milwaukee Rivers upstream from the estuary, there were statistically significant trends toward chlorophyll-*a* concentrations increasing from upstream to downstream (Table 32).

Table 33 shows that at most sampling stations, there was no evidence of statistically significant time-based trends in chlorophyll-*a* concentration. Most of the trends that were detected were trends toward decreasing concentration over time. These trends were observed mostly at sampling stations in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers (Table 34). A trend toward chlorophyll-*a* concentration decreasing over time was also detected at the Johnson Park station along the Root River. By contrast, statistically significant trends toward chlorophyll-*a* concentration increasing over time were detected at several stations along Oak Creek.

At some stations, chlorophyll-*a* concentrations are positively correlated with water temperatures. Since chlorophyll-*a* concentrations strongly reflect algal productivity, this correlation probably reflects the higher growth rates that photosynthetic organisms are able to attain at higher temperatures. At some stations, chlorophyll-*a* concentrations are negatively correlated with concentrations of nutrients, such as ammonia, nitrate, and dissolved phosphorus. This reflects the role of these compounds as nutrients for algal growth. As algae grow, they remove these compounds from the water and incorporate them into cellular material. The decrease in

Table 32

UPSTREAM TO DOWNSTREAM TRENDS IN WATER QUALITY PARAMETERS FROM SITES IN THE GREATER MILWAUKEE RIVER WATERSHEDS: 1975-2004[a]

Constituent	Menomonee River[a,b]	Milwaukee River[a,b]	Oak Creek[a]	Root River[a]
Bacteria and Biological				
Fecal Coliform[c]	↑	↑	0	↓
E. coli[c]	↑	↑	- -	0
Chlorophyll-*a*[c]	↑	↑	↑	↑
Chemical				
Alkalinity	↓	↓	0	↓
Biochemical Oxygen Demand[c]	0	↑	0	↑
Chloride[c]	↑	↑	↓	↓
Dissolved Oxygen	↑	↓	↑	0
Hardness	↓	↓	0	↓
pH	↑	0	↑	↑
Specific Conductance	↑	↓	↓	↓
Temperature	- -	0	↑	↑
Suspended Material				
Total Suspended Sediment	0	↑	- -	0
Total Suspended Solids	↓	↓	↑	↓
Nutrients				
Ammonia[c]	↓	↓	↓	0
Kjeldahl Nitrogen[c]	↓	0	0	↑
Nitrate[c]	↓	↓	↑	↑
Nitrite[c]	↓	↓	0	↑
Organic Nitrogen[c]	↓	↑	0	↑
Total Nitrogen[c]	↓	↓	0	↑
Dissolved Phosphorus[c]	↓	↓	↓	↑
Total Phosphorus[c]	↓	0	0	↑
Metals				
Arsenic[c]	0	↑	0	- -
Cadmium[c]	↓	↓	0	0
Chromium[c]	0	↓	0	↓
Copper[c]	↑	0	0	↓
Lead[c]	0	0	0	↓
Mercury[c]	0	0	0	↓
Nickel[c]	0	↓	0	0
Zinc[c]	↑	↑	0	↓

NOTE: The following symbols were used:

↑ Indicates a statistically significant increase from upstream to downstream.
↓ Indicates a statistically significant decrease from upstream to downstream.
0 Indicates that no trend was detected.

[a]*Trends were assessed through linear regression analysis and more detailed results can be found in the corresponding chapters of Technical Report No. 39.*

[b]*Upstream to downstream trends were assessed only in the portion of the river upstream from the Milwaukee River estuary.*

[c]*These data were log-transformed before being entered into regression analysis.*

Source: SEWRPC.

chlorophyll-*a* concentrations in the estuary represent an improvement in water quality. Chlorophyll-*a* concentrations at some stations are negatively correlated with alkalinity. This reflects both the role of carbon dioxide in photosynthesis and the activity of carbon dioxide dissolved in water. When carbon dioxide dissolves in water, it combines with water to form carbonic acid. This can dissociate to release bicarbonate and carbonate ions.

Table 33

ANNUAL TRENDS IN WATER QUALITY PARAMETERS AT SAMPLING STATIONS IN THE GREATER MILWAUKEE WATERSHEDS: 1975-2001[a]

Constituent	Trend (percent sampling stations)[b,c]		
	Entire Study Area		
	Increase	Decrease	No Change
Bacteria and Biological			
Fecal Coliform[d]	8	41	51
E. coli[d]	3	0	41
Chlorophyll-*a*[d]	8	26	62
Chemical/Physical			
Alkalinity	8	10	77
Biochemical Oxygen Demand[d]	0	85	15
Chloride[d]	72	0	28
Dissolved Oxygen	18	18	64
Hardness	15	3	77
pH	3	46	51
Specific Conductance	41	8	51
Suspended Material			
Total Suspended Sediment	0	5	15
Total Suspended Solids	18	13	64
Nutrients			
Ammonia[d]	0	82	18
Kjeldahl Nitrogen[d]	8	26	66
Nitrate[d]	38	10	52
Nitrite[d]	10	8	77
Organic Nitrogen[d]	33	5	59
Total Nitrogen[d]	28	18	66
Dissolved Phosphorus[d]	31	18	51
Total Phosphorus[d]	16	38	46
Metals			
Arsenic[d]	0	74	5
Cadmium[d]	0	90	3
Chromium[d]	5	56	33
Copper[d]	67	18	15
Lead[d]	0	77	18
Mercury[d]	3	41	49
Nickel[d]	0	49	44
Zinc[d]	64	3	28

[a]*Trends were assessed through linear regression analysis. A trend was considered significant if the regression showed a significant slope at P = 0.05 or less. Because MMSD stopped sampling during the winter in 1987, data from winter months are not included in the annual trend analysis.*

[b]*Trends were assessed at five sampling stations along the Kinnickinnic River, eight sampling stations along the Menomonee River, 10 sampling stations along the Milwaukee River, seven sampling stations along Oak Creek, and nine sampling stations along the Root River.*

[c]*For any constituent, the total percentage of sampling stations assessed along a river may not add up to 100 percent because data at some sampling stations were insufficient for assessing time-based trends.*

[d]*These data were log-transformed before being entered into regression analysis.*

Source: SEWRPC.

Alkalinity is a measure of these forms of inorganic carbon in water. During photosynthesis algae and plants remove carbon dioxide from the water, reducing alkalinity.

The trends toward decreasing chlorophyll-*a* concentrations at sampling stations in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers and at Johnson Park along the Root River represent

Table 34

ANNUAL TRENDS IN WATER QUALITY PARAMETERS AT SAMPLING STATIONS IN THE GREATER MILWAUKEE WATERSHEDS: 1975-2001[a]

Constituent	Trend (percent sampling stations)[b,c]														
	Kinnickinnic River			Menomonee River			Milwaukee River			Oak Creek			Root River		
	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change
Bacteria and Biological															
Fecal Coliform[d]	0	80	20	12	50	38	0	70	30	14	0	86	11	11	78
E. coli[d]	0	0	60	12	0	38	0	0	70	0	0	0	0	0	33
Chlorophyll-*a*[d]	0	60	40	0	50	50	0	20	80	43	0	57	0	11	67
Chemical/Physical															
Alkalinity	0	0	100	0	25	75	30	0	70	0	14	86	0	11	67
Biochemical Oxygen Demand[d]	0	100	0	0	100	0	0	100	0	0	100	0	0	33	67
Chloride[d]	100	0	0	75	0	25	90	0	10	71	0	29	33	0	67
Dissolved Oxygen	20	0	80	50	0	50	10	30	60	0	43	57	11	11	78
Hardness	0	0	100	0	12	88	60	0	40	0	0	100	0	0	78
pH	0	20	80	0	50	50	10	40	50	0	100	0	22	0	78
Specific Conductance	40	0	60	38	12	50	100	0	0	0	0	100	11	22	67
Suspended Material															
Total Suspended Sediment	0	0	0	0	0	25	0	0	20	0	0	14	0	22	11
Total Suspended Solids	0	60	40	38	12	50	40	0	60	0	0	100	0	11	67
Nutrients															
Ammonia[d]	0	60	40	0	100	0	0	100	0	0	100	0	0	44	56
Kjeldahl Nitrogen[d]	20	40	40	12	50	38	0	30	70	0	0	100	11	11	78
Nitrate[d]	60	0	40	37	38	25	90	0	10	0	0	100	0	11	89
Nitrite[d]	40	0	60	0	38	62	0	10	90	0	14	86	0	0	78
Organic Nitrogen[d]	80	0	20	38	0	62	0	10	90	57	0	43	22	11	67
Total Nitrogen[d]	60	0	40	12	25	63	60	0	40	0	0	100	11	0	89
Dissolved Phosphorus[d]	60	20	20	50	25	25	10	30	60	57	0	43	0	11	89
Total Phosphorus[d]	40	40	20	12	50	38	0	80	20	43	0	57	0	11	89
Metals															
Arsenic[d]	0	100	0	0	88	12	10	90	0	0	100	0	0	11	89
Cadmium[d]	0	100	0	0	100	0	0	100	0	0	100	0	0	56	11
Chromium[d]	40	20	40	0	75	25	10	70	20	0	29	71	0	56	22
Copper[d]	100	0	0	88	0	12	70	10	20	100	0	0	0	67	33
Lead[d]	0	100	0	0	88	12	0	100	0	0	100	0	0	11	67
Mercury[d]	0	100	0	0	62	38	0	50	40	0	14	86	11	0	67
Nickel[d]	0	20	80	0	62	38	0	70	30	0	0	100	0	67	0
Zinc[d]	40	0	60	88	0	12	90	10	0	100	0	0	0	0	78

[a]*Trends were assessed through linear regression analysis. A trend was considered significant if the regression showed a significant slope at P = 0.05 or less. Because MMSD stopped sampling during the winter in 1987, data from winter months are not included in the annual trend analysis.*

[b]*Trends were assessed at five sampling stations along the Kinnickinnic River, eight sampling stations along the Menomonee River, 10 sampling stations along the Milwaukee River, seven sampling stations along Oak Creek, and nine sampling stations along the Root River.*

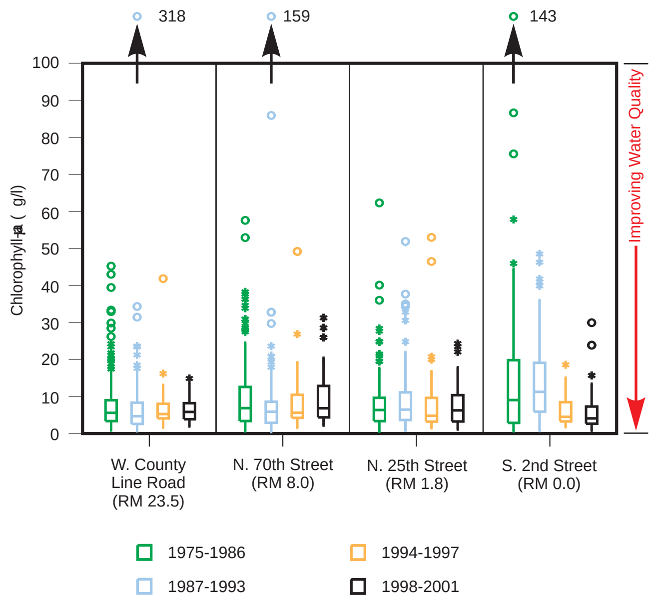
[c]*For any constituent, the total percentage of sampling stations assessed along a river may not add up to 100 percent because data at some sampling stations were insufficient for assessing time-based trends.*

[d]*These data were log-transformed before being entered into regression analysis.*

Source: SEWRPC.

Figure 12

CHLOROPHYLL-*a* CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



NOTE: See Figure 11 for description of symbols.

Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

improvements in water quality. The trends toward increasing chlorophyll-*a* concentrations at some stations in Oak Creek represent a decrease in water quality.

Chemical and Physical Parameters

Temperature

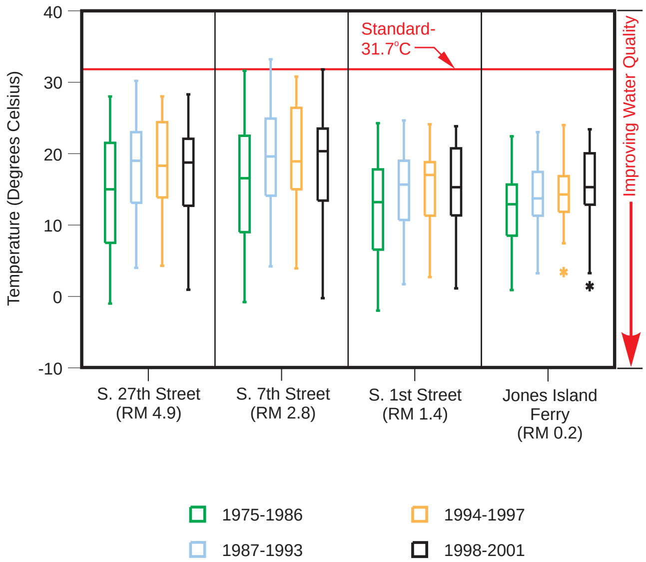
Water temperatures from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from the freezing point to over 34 degrees Celsius (ºC). The annual median water temperature in the Kinnickinnic River during the period 1998-2001 ranged from 18.9ºC at the sampling station at S. 27th Street up to 20.3ºC at the station at S. 7th Street and down to 15.3ºC at the station at the Jones Island Ferry. The annual median water temperature in the Menomonee River during the period 1998-2001 ranged from 14.3ºC at the sampling station at W. County Line Road to 19.0ºC at the station at S. 2nd Street. The annual median water temperature in the Milwaukee River during the period 1998-2004 ranged from 15.0ºC at W. Silver Spring Drive to 19.0ºC at CTH M near Newburg. The annual median water temperature in Oak Creek during the period 1998-2001 ranged from 13.0 degrees Celsius (ºC) at the sampling station at W. Ryan Road up to 15.7ºC at the station at the Oak Creek Parkway site east of S. Lake Drive. The annual median water temperature in the Root River during the period 1998-2005 ranged from 14.4 ºC at the sampling station at the intersection of W. National Avenue and W. Oklahoma Avenue up to 19.5ºC at the station near the mouth of the River.

Because of the complexity of these temperature trends, they were further analyzed using a three-factor analysis of variance. This type of analysis tests for statistically significant differences among mean temperatures based upon three different factors which may account for any differences. In addition, it tests for significant effects on mean temperatures of any interactions between the factors. In this instance, the independent factors examined were sampling station, season, and the time periods. Because of differences in data availability, different time periods were examined for each watershed. For the Kinnickinnic River and Oak Creek, the periods examined were 1982-1986, 1987-1993, 1994-1997, and 1998-2001. For the Menomonee River the periods examined were 1985-1994 and 1995-2001. For the Milwaukee River the periods examined were 1975-1986, 1987-1993, 1994-1997, and 1998-2004. The data from the Root River watershed were not adequate for performing this analysis. In all watersheds, data from winter months were not included in this analysis because of the small number of samples taken during the winter.

For the Kinnickinnic and Menomonee Rivers, the results of these analyses suggest that the estuary and the section of the Rivers upstream from the estuary experience different temperature regimes. In the Kinnickinnic River, annual mean water temperatures at the stations upstream from the estuary are four to five degrees Celsius higher than annual mean water temperature at the stations in the estuary (Figure 13). The lower water temperatures in the estuary may result from the effects of a complex mixing regime involving water from the Kinnickinnic River, the Milwaukee River, and the Milwaukee Harbor. The difference in mean temperatures between estuary and upstream stations are less pronounced in the fall than in the spring or summer. Since the period 1982-1986, mean temperatures in the Kinnickinnic River have increased. In the Menomonee River, mean water temperatures generally were warmer downstream. The only exception to this trend occurred in the lower estuary

Figure 13

WATER TEMPERATURE AT SITES ALONG THE MAINSTEM OF THE KINNICKINNIC RIVER: 1975-2001



NOTE: See Figure 11 for description of symbols.

Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

at the confluence with the Milwaukee River. The increases in mean water temperature at the sampling stations in the estuary may reflect a number of factors including stagnation of water within Burnham Canal, the influence of the We Energies power plant thermal discharge and influx of Lake Michigan water from the outer harbor areas.

For the Milwaukee River, this analysis revealed no statistically significant differences among mean water temperatures at different sampling stations. The results did indicate that mean water temperatures in the Milwaukee River were significantly lower during the period 1975-1986 than during subsequent periods. In addition, the analysis found a significant interaction between the effects of sample site and season. Seasonal differences in mean water temperature were less pronounced at the two stations farthest downstream, N. Water Street and the Union Pacific Railroad. These differences most likely result from interactions with water from Lake Michigan.

For Oak Creek, the results of this analysis suggest that water temperature at the sampling station farthest upstream, the W. Ryan Road station, are significantly cooler than those at the other stations. The analysis did not detect any differences among the time periods.

For the Kinnickinnic River, the data show slight trends toward increasing water temperature at two stations in the estuary, the Jones Island Ferry and E. Greenfield Avenue (extended) stations. For the most part, at individual stations annual mean water temperatures have increased over time in the Menomonee River. In the Milwaukee River, slight trends toward increasing water temperatures were detected at three estuary stations: E. Wells Street, N. Water Street, and the Union Pacific Railroad. These trends account for a very small portion of the variation in the data and are likely attributable to slight increasing trends during summer months. Few trends over time were detected in temperatures along Oak Creek or the Root River. For the Root River, the data show a slight trend toward increasing water temperature at the stations below the Horlick dam and a slight trend toward decreasing water temperatures at the station near the mouth of the River.

The trends toward increasing water temperature at some sampling stations represent a reduction in water quality.

Alkalinity

Values of alkalinity in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from 3.5 milligrams per liter (mg/l) expressed as the equivalent concentration of calcium carbonate (mg/l as $CaCO_3$) to 999.0 mg/l as $CaCO_3$. There were differences among the major streams and rivers in the mean values of alkalinity during the period of record. These means were 176.3 mg/l as $CaCO_3$ in the Kinnickinnic River, 228.1 mg/l as $CaCO_3$ in the Menomonee River, 235.6 mg/l as $CaCO_3$ in the Milwaukee River, 247.3 mg/l as $CaCO_3$ in Oak Creek, and 273.0 mg/l as $CaCO_3$ in the Root River. In general, alkalinity tended to be higher in upstream portions of these Rivers than in the downstream portions. Two sets of trends indicate this. First, in the Kinnickinnic, Menomonee, and Milwaukee Rivers, analysis of variance (ANOVA) showed that mean concentrations of alkalinity tended to be significantly lower in the estuary portions of the Rivers than in the portions upstream from the estuary. Second, in the Menomonee, Milwaukee, and Root Rivers, regression analysis showed the presence of statistically significant trends toward decreasing alkalinity from upstream to downstream (Table 32). These differences may reflect differences in the relative importance of groundwater and surface runoff on the chemistry of water in the Rivers with surface runoff becoming increasing influential downstream. In addition, these differences may reflect the influence of water from Lake Michigan on the chemistry of the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers. Few sampling stations along any of the Rivers showed evidence of time-based trends in alkalinity (Tables 33 and 34). A strong seasonal pattern in alkalinity is apparent at many stations. Alkalinity concentrations are low in late winter or early spring. They increase to a peak that occurs in late spring. Following this they rapidly decline to a low point in mid summer. This is followed by a gradual increase during late summer and fall months to a second peak in late fall. There is moderate variation around this pattern. Alkalinity concentrations in the Rivers are generally strongly positively correlated with hardness, pH, specific conductance, and concentrations of chloride, all parameters which, like alkalinity, measure amounts of dissolved material in water. In addition, alkalinity concentrations in the Rivers are negatively correlated with total suspended solids. At some stations, alkalinity concentrations tend to be negatively correlated with temperature, reflecting the fact that alkalinity indirectly measures concentrations of carbon dioxide in water and that the solubility of gases in water decreases with increasing temperature. Alkalinity at some stations is negatively correlated with chlorophyll-*a* concentrations, reflecting the removal of carbon dioxide from water through photosynthesis.

Biochemical Oxygen Demand (BOD)

Concentrations of biochemical oxygen demand (BOD) in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 76.5 mg/l. There were differences among the major streams and rivers in the mean values of BOD during the period of record. These means were 3.37 mg/l in the Kinnickinnic River, 2.80 mg/l in the Menomonee River, 2.90 mg/l in the Milwaukee River, 2.24 mg/l in Oak Creek, and 3.04 mg/l in the Root River. Figure 14 shows BOD concentrations at sampling stations along the mainstem of the Milwaukee River. At most stations, concentrations of BOD decreased over time. Concentrations of BOD also decreased over time at most sampling stations along the other major streams and rivers in the study area. These decreases represent statistically significant trends (Tables 33 and 34). During the periods before 1994, the mean value of BOD at stations in the estuary portion of the Menomonee River was significantly higher than the mean value of BOD at the stations upstream from the estuary. This indicates that the water in the estuary contained a higher concentration of organic material. The sampling stations in the estuary are the only stations on the Menomonee River within the combined sewer overflow area, suggesting that overflows from the combined sewers may have been contributing to higher amounts of organic material in the water of the estuary than in the water of the reaches upstream from the estuary. In 1994, this relationship changed. From this year onward, there were no statistically significant differences between the mean concentrations of BOD in the estuary and the reaches upstream of the estuary. This change coincides with the Inline Storage System coming on line. It suggests that, since 1994, reductions in inputs from combined sewer overflows related to use of the Inline Storage System have reduced loadings of organic material into the estuary to levels below concentrations that would produce significant differences in BOD between the estuary and the section of the River upstream of the estuary.

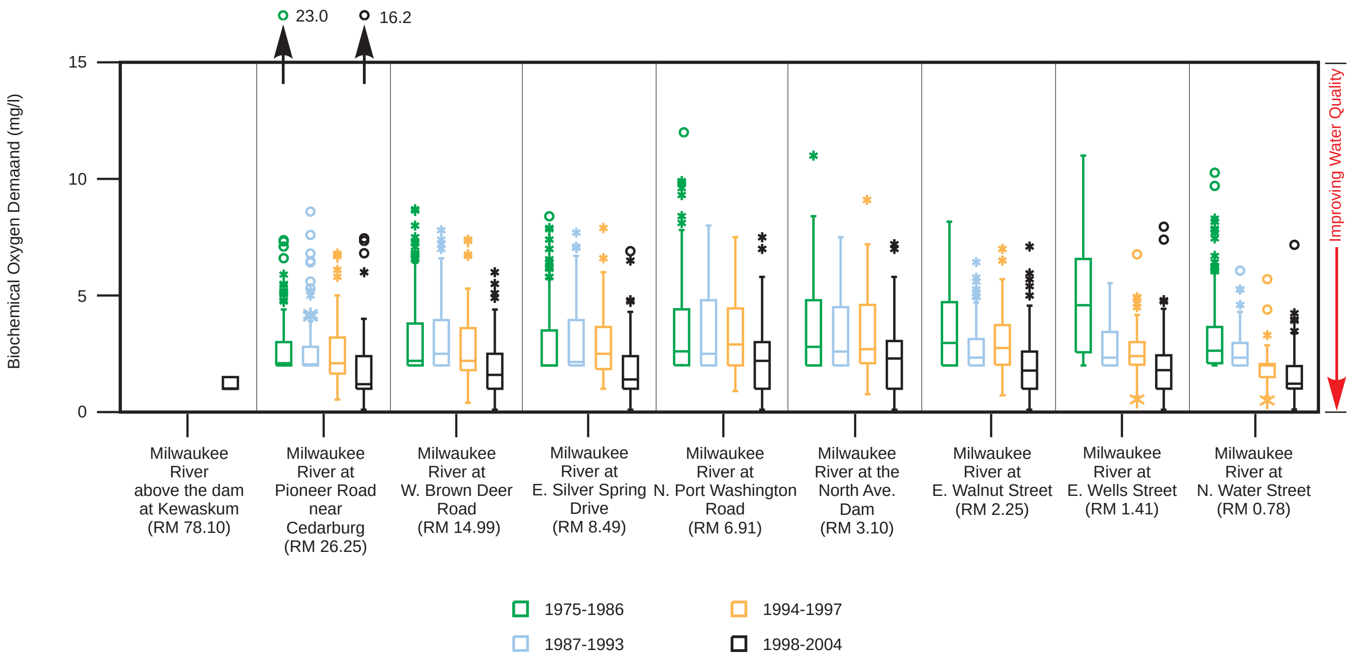
Several other factors may influence BOD concentrations in surface waters. BOD concentrations at some sampling stations are positively correlated at most stations with concentrations of fecal coliform bacteria and some nutrients such as ammonia, organic nitrogen, and total phosphorus. These correlations may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into surface waters. Decomposition of organic material in the sediment acts as a source of BOD to the overlying water. The declining trend in BOD concentrations over time detected at stations along the mainstem of the River represent an improvement in water quality.

Chloride

Concentrations of chloride in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from 1.0 mg/l to 999.0 mg/l. There were differences among the major streams and rivers in the mean concentrations of chloride during the period of record. These means were 99.0 mg/l in the Kinnickinnic River, 99.9 mg/l in the Menomonee River, 50.1 mg/l in the Milwaukee River, 158.6 mg/l in Oak Creek, and 142.7 mg/l in the Root River. All sampling stations show wide variations between minimum and maximum values. In the Kinnickinnic and Menomonee Rivers, concentrations of chloride occasionally

Figure 14

BIOCHEMICAL OXYGEN DEMAND AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004



NOTE: See Figure 11 for description of symbols.

Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

exceeded Wisconsin's chronic toxicity criteria for fish and aquatic life of 395 mg/l and acute toxicity criteria for fish and aquatic life of 757 mg/l. In the Milwaukee River, concentrations of chloride were generally below these standards. In Oak Creek and the Root River, concentrations occasionally exceeded the chronic toxicity criteria and rarely exceeded the acute toxicity criteria. Figure 15 shows that chloride concentrations at sampling stations along the Milwaukee River increased over time. This increase was observed in the other Rivers as well. Statistically significant trends toward chloride concentrations increasing were detected at most sampling stations (Tables 33 and 34). Chloride concentrations at several sampling stations show a strong seasonal pattern. For the period during which winter data are available, mean chloride concentrations were highest in winter or early spring. This is likely to be related to the use of deicing salts on streets and highways. These concentrations declined through the spring to reach lows during summer and fall.

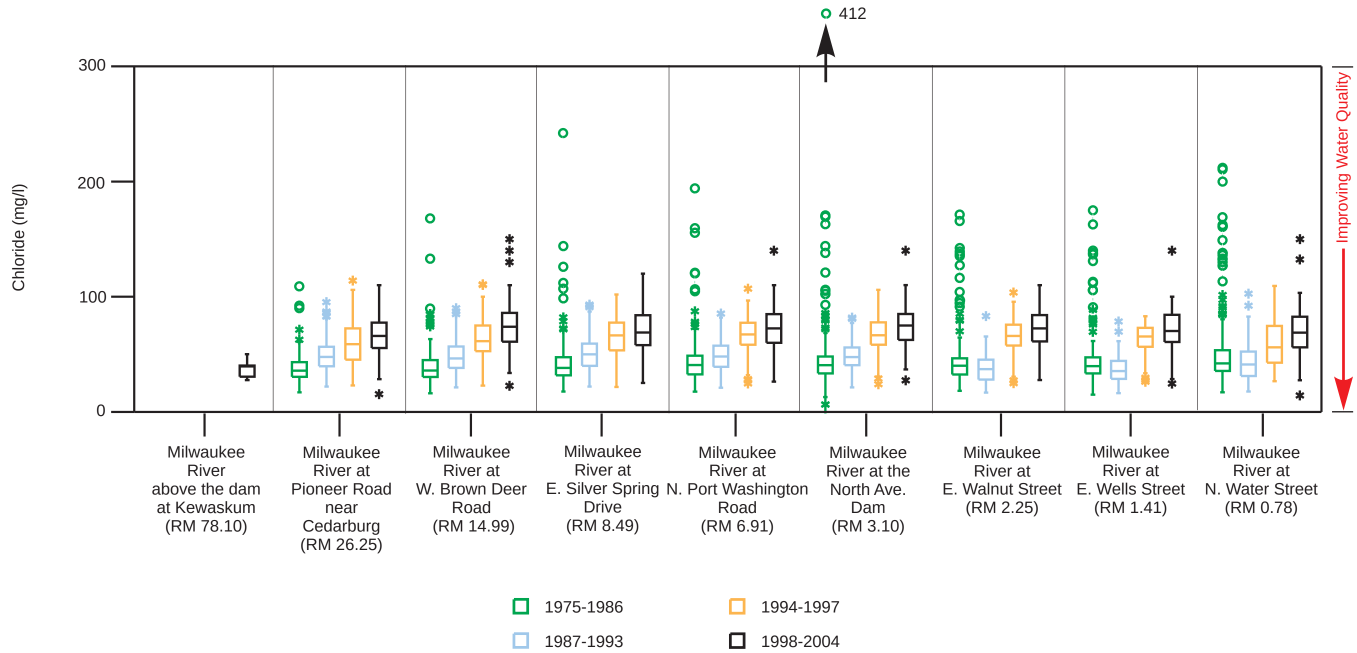
Chloride concentrations show strong positive correlations with alkalinity, hardness, and specific conductance, all parameters which, like chloride, measure amounts of dissolved material in water. This may reflect common mechanisms of entry into surface waters. In addition, chloride concentrations at many sampling stations are strongly negatively correlated with temperature, reflecting the use of deicing salts on streets and highways during cold weather. The increase in chloride concentrations in the streams of the greater Milwaukee watersheds represents a decline in water quality.

Dissolved Oxygen

Over the period of record, the mean concentration of dissolved oxygen in the major streams of the greater Milwaukee watersheds ranged from concentrations which were undetectable to concentrations in excess of saturation. Over the period of record, the mean concentration of dissolved oxygen in the Kinnickinnic River was 9.4 mg/l, the mean concentration of dissolved oxygen in the Menomonee River was 8.2 mg/l, the mean concentration of dissolved oxygen in the Milwaukee River was 9.4 mg/l, the mean concentration of dissolved

Figure 15

CHLORIDE CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004



NOTES: See Figure 11 for description of symbols.

Standards not shown on the graph are a planning standard of 1,000 mg/l; an acute toxicity for aquatic life standard of 757 mg/l; and a chronic toxicity for aquatic life standard of 395 mg/l.

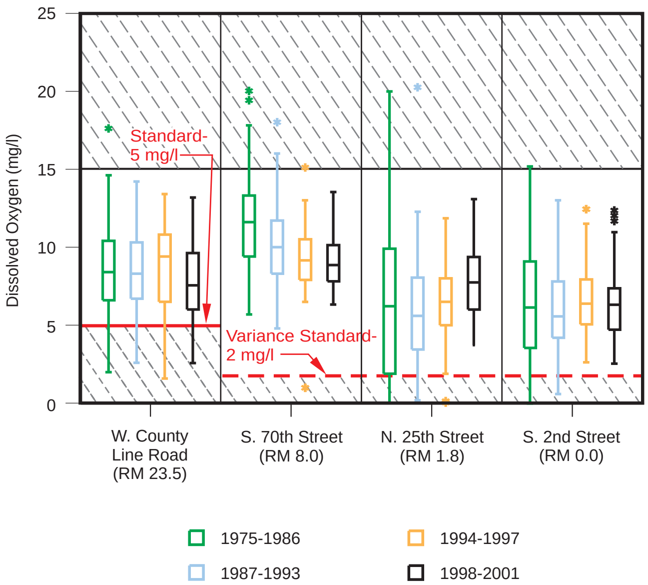
Source: *U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

oxygen in Oak Creek was 8.4 mg/l, and the mean concentration of dissolved oxygen in the Root River was 7.1 mg/l. In the Kinnickinnic, Menomonee, and Milwaukee Rivers, mean dissolved oxygen concentrations in the estuary portions of the Rivers were significantly lower than mean concentrations in the sections of the Rivers upstream from the estuary. Since 1998, concentrations of dissolved oxygen measured at some sampling stations have occasionally been below the fish and aquatic life standard of 5.0 mg/l, or in the sections of the Kinnickinnic, Menomonee, and Milwaukee Rivers subject to a variance standard under Chapter NR 104 of the *Wisconsin Administrative Code*, below the variance standard of 2.0 mg/l.

Dissolved oxygen concentrations at some sampling stations in the estuary portions of the Kinnickinnic and Menomonee Rivers increased after 1993. This is shown for the Menomonee River in Figure 16. Few statistically significant time-based trends were detected in dissolved oxygen concentrations (Table 33). Significant trends toward increasing dissolved oxygen concentration were detected at most of the estuary stations along the Menomonee River and one estuary station along the Kinnickinnic River (Table 34). In addition, when the data were examined for trends on a seasonal basis, statistically significant increasing trends in dissolved oxygen concentration during the summer were detected at three stations in the estuary portion of the Milwaukee River. These trends toward increasing dissolved oxygen concentrations in the estuary sections of these Rivers are a likely consequence of a reduction in loadings of organic pollutants from combined sewer overflows since MMSD's Inline Storage System went on line. The trends at these stations toward increasing dissolved oxygen concentration represent an improvement in water quality. By contrast, statistically significant trends toward decreasing dissolved oxygen concentration were detected at three sampling stations along Oak Creek. This represents a decrease in water quality.

Figure 16

DISSOLVED OXYGEN CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



NOTES: See Figure 11 for description of symbols.

140 percent saturation and higher can cause fish kills. A 15 mg/l dissolved oxygen concentration roughly translates to a saturation of approximately 150 percent at an average water temperature of 14 degrees Celsius.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

The data show strong seasonal patterns to the mean concentrations of dissolved oxygen. Concentrations of dissolved oxygen tend to be highest during the winter. They decline through spring to reach a minimum during the summer. Following this, they rise through the fall to reach maximum values in winter. This seasonal pattern is driven by changes in water temperature. The solubility of oxygen in water decreases with increasing temperature. In addition, the metabolic demands and oxygen requirements of most aquatic organisms, including bacteria, tend to increase with increasing temperature. Higher rates of bacterial decomposition when the water is warm may contribute to the declines in the concentration of dissolved oxygen observed during the summer. In addition to the reasons mentioned above, dissolved oxygen concentrations can also be affected by a variety of other factors including the presence of aquatic plants, sunlight, turbulence in the water, and the amount and type of sediment as summarized in Chapter II of SEWRPC Technical Report No. 39.

It is important to note that supersaturation of water with dissolved oxygen occasionally occurs at some sampling stations in the greater Milwaukee watersheds. Supersaturation of water with dissolved oxygen occurs when the water contains a higher concentration of dissolved oxygen than is normally soluble at ambient conditions of temperature and pressure. While oxygen concentrations in excess of saturation are detected at these stations throughout the year, the highest oxygen concentrations occur mostly during the spring and fall. Oxygen supersaturation is probably caused by high intensities of photosynthesis by attached algae growing in concrete-lined channels at and upstream of the sampling stations. This has two implications. First, because dissolved oxygen samples are often collected during the day, the dissolved oxygen concentration data presented may be less representative of average concentrations and more typical of maximum concentrations achieved during diurnal periods. Second, respiration by the same attached algae may cause steep declines in dissolved oxygen concentration at these stations at night when photosynthesis cannot occur due to lack of light.

Several other factors also affect dissolved oxygen concentrations in the streams of the greater Milwaukee watersheds. Settling of suspended material in areas of slower water velocity can transfer material from the water column to the sediment. Decomposition of organic matter contained in this material, through chemical and especially biological processes, removes oxygen from the overlying water, lowering the dissolved oxygen concentration. This can be particularly influential in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers, as indicated by the lower concentrations of total suspended solids (TSS) in the estuary (see the section on suspended material below). Second, influxes of water from Lake Michigan and other streams or Rivers may influence dissolved oxygen concentrations, especially in the downstream portions of the estuary. When dissolved oxygen concentrations in these waterbodies are higher than in the estuary, mixing may act to increase dissolved oxygen concentrations in the lower estuary. Third, at many sampling stations, dissolved oxygen concentrations are inversely correlated with ammonia and nitrite concentrations. This suggests that oxidation of ammonia and nitrite to nitrate through biologically mediated nitrification may also be acting to lower dissolved oxygen concentrations when concentrations of these compounds are high. Fourth, dissolved oxygen concentrations at many sampling stations are positively correlated with pH. This reflects the effect of photosynthesis on both of these parameters. During photosynthesis, algae and plants remove carbon dioxide from the water. This tends to raise the water's pH. At the same time, oxygen is released as a byproduct of the photosynthetic reactions. Fifth, in the case of the Kinnickinnic River, MMSD operates a flushing tunnel capable of pumping approximately 225 million gallons of water per day from Lake Michigan into the Kinnickinnic River through an outfall near Chase Avenue. Flushing through this tunnel acts to improve water quality in the estuary by increasing flow in the River and flushing stagnant water downstream. MMSD currently operates this tunnel when dissolved oxygen concentrations at the sampling station at S. 1st Street drop below 3.0 mg/l. Typically, flushing occurs six to 12 times per year. Sixth, in the estuary portion of the Menomonee River, We Energies operates an electric power generating plant which discharges cooling water into the River near the Burnham Canal sampling station. These discharges can raise water temperatures in the estuary, resulting in lower oxygen solubility.

Hardness

Values of hardness in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show considerable variability, ranging from 5.0 mg/l as $CaCO_3$ to 1,208 mg/l as $CaCO_3$. Some of this variability probably results from inputs of relatively soft water during storm events. There were differences among the major streams and rivers in the mean values of hardness during the period of record. These means were 253.0 mg/l as $CaCO_3$ in the Kinnickinnic River, 299.6 mg/l as $CaCO_3$ in the Menomonee River, 284.8 mg/l as $CaCO_3$ in the Milwaukee River, 372.4 mg/l as $CaCO_3$ in Oak Creek, and 373.6 mg/l as $CaCO_3$ in the Root River. These means are considered to represent very hard water. In general, hardness tended to be higher in upstream portions of these Rivers than in the downstream portions. Two sets of trends indicate this. First, in the Kinnickinnic, Menomonee, and Milwaukee Rivers, analysis of variance (ANOVA) showed that mean hardness tended to be significantly lower in the estuary portions of the Rivers than in the portions upstream from the estuary. Second, in the Menomonee, Milwaukee, and Root Rivers, regression analysis showed the presence of statistically significant trends toward decreasing hardness from upstream to downstream (Table 32). These differences may reflect differences in the relative importance of groundwater and surface runoff on the chemistry of water in the Rivers with surface runoff becoming increasingly influential downstream. In addition, these differences may reflect the influence of water from Lake Michigan on the chemistry of the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers. Few sampling stations along any of the Rivers showed evidence of time-based trends in hardness (Tables 33 and 34). Where trends were detected, they accounted for a small portion of the variation in the data. At most stations, there is little evidence for seasonal patterns in hardness. Hardness concentrations in the Rivers are generally strongly positively correlated with alkalinity, pH, specific conductance, and concentrations of chloride, all parameters which, like hardness, measure amounts of dissolved material in water. In addition, hardness concentrations at some stations are negatively correlated with total suspended solids.

pH

Values of pH in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from 7.4 standard units to 8.5 standard units. There were differences among the major streams and rivers in the mean values of pH during the period of record. These means were 7.9 standard units in the Kinnickinnic River, 7.9 standard units in the Menomonee River, 8.2 standard units in the Milwaukee River, 7.7 standard units in Oak Creek, and 7.7 standard units in the Root River. At most stations, pH varied only by $\pm$ 1.0 standard unit from the stations' mean values. In general, pH tended to be significantly lower in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers than in the portions upstream from the estuary. In the Root River and Oak Creek and in the portion of the Menomonee River upstream from the estuary, regression analysis showed the presence of statistically significant trends toward increasing pH from upstream to downstream (Table 32). Time-based trends in pH were detected at about half of the sampling stations (Table 33). At some stations along the Menomonee and Milwaukee Rivers and most stations along Oak Creek, statistically significant trends toward decreasing pH were detected (Table 34). By contrast, statistically significant trends toward increasing pH were detected at some stations along the Root River. The causes of these trends are not known. During the spring months, pH tended to be higher in the Rivers than during summer or fall. Positive correlations were found between pH in the Rivers and alkalinity, hardness, specific conductance, and concentrations of chloride, all parameters which, like pH, measure amounts of dissolved material in water. In general, these correlations were not as common or as strong as the correlations among alkalinity, hardness, and specific conductance. In addition, pH was positively correlated with dissolved oxygen concentration and, at some stations, concentrations of chlorophyll-*a*. These correlations reflect the effect of photosynthesis on these parameters. During photosynthesis, algae and plants remove carbon dioxide from the water. This tends to raise the water's pH. At the same time, oxygen in released as a byproduct of the photosynthetic reactions. If sufficient nutrients are available, this results in increased algal growth, which is reflected in higher chlorophyll-*a* concentrations.

Specific Conductance

Values of specific conductance in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show considerable variability, ranging from below the limit of detection to 8,280 microSiemens per centimeter (μS/cm). Some of this variability may reflect the discontinuous nature of inputs of dissolved material into surface waters. Runoff associated with storm events can have a major influence on the concentration of dissolved material in surface waters. The first runoff from a storm event transports a large pulse of salts and other dissolved material from the watershed into waterbodies. This will tend to raise specific conductance. Later runoff associated with the event will be relatively dilute. This will tend to lower specific conductance. The mean values of specific conductance during the period of record were 778.7 μS/cm in the Kinnickinnic River, 841.9 μS/cm in the Menomonee River, 635.7 μS/cm in the Milwaukee River, 1,138.4 μS/cm in Oak Creek, and 979.4 μS/cm in the Root River. In the Kinnickinnic, Menomonee, and Milwaukee Rivers, mean values of specific conductance were lower in the estuary than in reaches upstream from the estuary (Table 32). This probably results from the greater volume of water passing through the estuary and from interactions with Lake Michigan. The data show a seasonal pattern of variation in specific conductance. For those years in which data were available, specific conductance was highest during the winter. It then declined during the spring to reach lower levels in the summer and fall. Statistically significant time-based trends in specific conductance were detected at about half of the sampling stations (Table 33). Most of the trends detected were toward increasing specific conductance and were detected at stations along the Kinnickinnic and Milwaukee Rivers (Table 34). Trends toward decreasing specific conductance were detected at a few stations, mostly at stations along the Root River or in upstream areas of the Menomonee River. Specific conductance in streams in the greater Milwaukee watersheds shows strong positive correlations with alkalinity, chloride, and hardness, all parameters which, like specific conductance, measure amounts of dissolved material in water. At many stations, specific conductance also shows negative correlations with water temperature, reflecting the fact that specific conductance tends to be lower during the summer. The increases in specific conductance in the Kinnickinnic and Milwaukee Rivers indicate that the concentrations of dissolved materials in water in these Rivers are increasing and represent a decline in water quality.

Suspended Material

Concentrations of total suspended solids (TSS) in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show considerable variability, ranging from below the limit of detection to 1,400 mg/l. The mean concentrations of TSS during the period of record were 20.5 mg/l in the Kinnickinnic River, 21.4 mg/l in the Menomonee River, 25.1 mg/l in the Milwaukee River, 30.9 mg/l in Oak Creek, and 22.1 mg/l in the Root River. In the Kinnickinnic, Menomonee, and Milwaukee Rivers, mean concentrations of TSS were lower in the estuary than reaches upstream from the estuary. This reflects the fact that portions of the estuary act as a settling basin in which material suspended in water sink and fall out into the sediment. At most sampling stations, no significant time-based trends were detected in TSS concentrations (Table 33). Statistically significant trends toward increasing TSS over time were detected at a few sampling stations in the estuary sections of the Menomonee and Milwaukee Rivers (Table 34). TSS concentrations showed strong positive correlations with total phosphorus concentrations, reflecting the fact that total phosphorus concentrations include a large particulate fraction. TSS concentrations were also positively correlated with concentrations of fecal coliform bacteria and nutrients. TSS concentrations showed negative concentrations with water quality parameters that measure amounts of dissolved materials in water, including alkalinity, hardness, and specific conductance.

In addition to TSS, total suspended sediment concentration was sampled at four sites along the mainstem of the Milwaukee River and four sites along the mainstem of the Root River. The mean values for total suspended sediment concentration over the period of record were 33.7 mg/l in the Milwaukee River and 41.3 mg/l in the Root River. Values in individual samples ranged between 1.0 mg/l and 323.0 mg/l. Statistically significant trends toward decreasing total suspended sediment concentrations were detected at two stations along the Root River. These results should be interpreted with caution as they result from comparison of concentrations from one to two years in the mid-1970s to concentrations from 2004 and may be more reflective of changes in methodology than changes in concentration in the River. It is important to note that total suspended sediment concentrations are not comparable to TSS concentrations.[5]

Nutrients

Nitrogen Compounds

Concentrations of total nitrogen in the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 17.26 milligrams per liter measured as nitrogen (mg/l as N). The mean concentrations of total nitrogen during the period of record were 1.52 mg/l as N in the Kinnickinnic River, 1.68 mg/l as N in the Menomonee River, 1.87 mg/l as N in the Milwaukee River, 1.19 mg/l as N in Oak Creek, and 2.38 mg/l as N in the Root River. Figure 17 shows changes in total nitrogen concentrations over time since 1975 at several sampling stations along the mainstem of Oak Creek. Similar patterns of change in total nitrogen occurred at most sampling stations in the study area. At all stations with data records extending back before 1987, concentrations of total nitrogen during the period 1987-1993 were lower than during the period 1975-1986. At most stations, concentrations of total nitrogen increased in subsequent periods. At a few stations, this increase did not begin until after 1993. Similarly, at a few stations, mean concentrations decreased after 1997. In the Kinnickinnic and Menomonee Rivers, concentrations of total nitrogen were higher in the estuary than in the sections of these Rivers upstream from the estuary. Sediment deposits in the estuary have been shown to release ammonia to the overlying water.[6] This difference may be a consequence of that release. The opposite pattern was seen in the Milwaukee River. In this River, mean concentrations of total nitrogen were higher in the section of the River upstream of the estuary than in the estuary. This could be the result of either lower rates of ammonia release from sediment in,[7] or larger volumes of water flowing through, the Milwaukee River portion of the estuary. In addition, statistically significant trends toward total nitrogen concentrations decreasing from upstream to downstream were detected along the Menomonee and Milwaukee Rivers (Table 32). By contrast, a trend toward total nitrogen concentrations increasing from upstream to downstream was detected in the Root River. Statistically significant time-based trends in total nitrogen concentrations were not detected at most sampling stations, however, significant trends toward increasing total nitrogen concentration were detected at several stations (Table 33). These were located mostly in upstream areas of the Kinnickinnic and Milwaukee Rivers (Table 34). The concentration of total nitrogen at some stations is positively correlated with the concentrations of nitrate and organic nitrogen, reflecting the fact that these tend to be the major forms of nitrogen compounds in the River. In addition, concentrations of total nitrogen were positively correlated with concentrations of total phosphorus at most stations. This probably reflects the nitrogen and phosphorus contained in particulate organic matter in the water, including live material such as plankton and detritus.

Total nitrogen is a composite measure of several different compounds which vary in their availability to algae and aquatic plants and vary in their toxicity to aquatic organisms. Common constituents of total nitrogen include ammonia, nitrate, and nitrite. In addition a large number of nitrogen-containing organic compounds, such as

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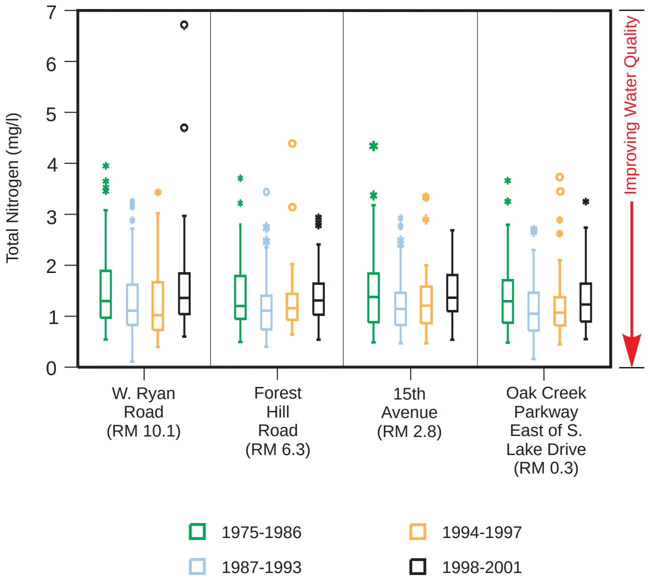
[5]*J.R.. Gray, G.D. Glysson, L.M. Turcios, and G.E. Schwartz,* Comparability of Suspended-Sediment Concentrations and Total Suspended Solids Data, *U.S. Geological Survey Water-Resources Investigations Report No. 00-4191, 2000.*

[6]*J. Val Klump, Patrick D. Anderson, Donald C. Szmania, and Kim Weckerly, Milwaukee Harbor Sediment Oxygen Demand Study Final Report,* Great Lakes WATER Institute Technical Report No. 2004-B1, *2004.*

[7]Ibid.

Figure 17

TOTAL NITROGEN CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF OAK CREEK: 1975-2001



NOTE: See Figure 11 for description of symbols.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

amino acids, nucleic acids, and proteins commonly occur in natural waters. These compounds are usually reported as organic nitrogen.

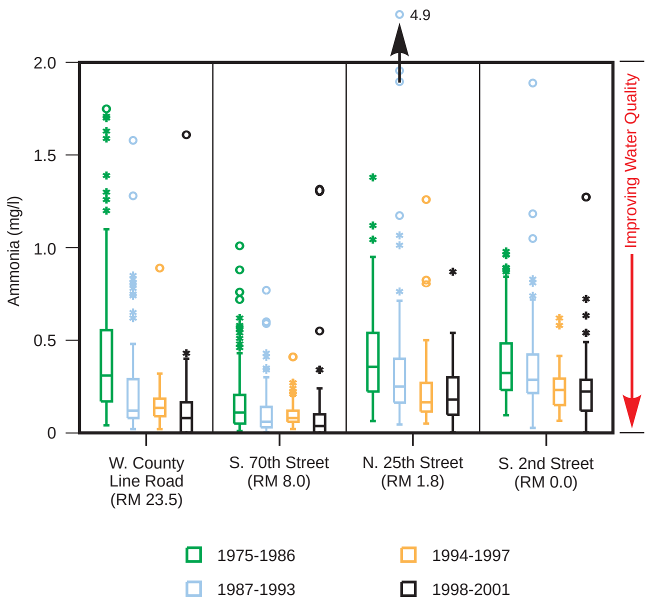
Ammonia concentrations in the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 8.6 mg/l as N. The mean concentrations of ammonia during the period of record were 0.35 mg/l as N in the Kinnickinnic River, 0.26 mg/l as N in the Menomonee River, 0.20 mg/l as N in the Milwaukee River, 0.19 mg/l as N in Oak Creek, and 0.16 mg/l as N in the Root River. Figure 18 shows that ammonia concentrations have decreased over time at most stations along the mainstem of the Menomonee River. Similar decreases occurred at sampling stations along the mainstems of the other major streams and rivers in the study area. These decreases represent significant decreasing trends in ammonia concentrations (Tables 33 and 34). Mean ammonia concentrations in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers tended to be higher than the mean concentrations in the portions of these Rivers upstream from the estuary. As noted above, sediment deposits in the estuary have been shown to release ammonia to the overlying water.[8] This difference may be a consequence of that release. Ammonia concentrations in the Milwaukee River tended to be higher during the winter than during other seasons. In the other watersheds, no clear seasonal pattern was detected in ammonia concentrations. In the sections of the Menomonee and Milwaukee Rivers upstream from the estuary and along the length of Oak Creek, there were significant trends toward ammonia concentrations decreasing from upstream to downstream (Table 32). Ammonia concentrations at some stations, especially in the estuary, are positively correlated with concentrations of fecal coliform bacteria. This may reflect common sources and modes of transport into the River for these two pollutants. Ammonia concentrations at some stations were also negatively correlated with chlorophyll-*a* concentrations. This reflects the role of ammonia as a nutrient for algal growth. During periods of high algal productivity, algae remove ammonia from the water and incorporate it into cellular material.

Nitrate concentrations in the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 30.27 mg/l as N. The mean concentrations of nitrate during the period of record were 0.55 mg/l as N in the Kinnickinnic River, 0.67 mg/l as N in the Menomonee River, 0.78 mg/l as N in the Milwaukee River, 0.51 mg/l as N in Oak Creek, and 2.38 mg/l as N in the Root River. In the Kinnickinnic, Menomonee, and Milwaukee Rivers and Oak Creek, the general pattern of changes in nitrate concentrations at most stations were similar to the changes in concentrations of total nitrogen. At all stations, concentrations of nitrate during the period 1987-1993 were lower than during the period 1975-1986. In subsequent periods, concentrations of nitrate increased. At a few stations, this increase began after 1993. This suggests that the changes over time in nitrate concentrations may be driving the changes over time in total nitrogen concentrations. In the Root River, nitrate concentrations appear to be increasing, however, at the Johnson Park station concentrations decreased after 1993. In the sections of the Menomonee and Milwaukee Rivers upstream from the estuary, there are statistically significant trends toward nitrate concentrations decreasing from upstream to

[8]Ibid.

Figure 18

AMMONIA CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



NOTES: See Figure 11 for description of symbols.

Standard is dependent on ambient temperature and pH which indicate ammonia concentrations did not exceed those toxicity standards.

Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

downstream. The relationship between the mean concentrations of nitrate in the estuary and in the sections of the Kinnickinnic, Menomonee, and Milwaukee Rivers upstream from the estuary differs among the three Rivers. In the Kinnickinnic River, mean nitrate concentrations in the estuary were higher than mean nitrate concentrations in the section of the River upstream of the estuary during all periods. The situation was more complicated in the Menomonee River. During the period from 1975 to 1986, the mean concentration in the estuary was lower than the mean concentration at the stations upstream from the estuary. From 1987-1994, there was no significant difference between the mean concentration in the estuary and the mean concentration in the reaches upstream from the estuary. After 1993, the mean concentrations in the estuary were higher than those in the reaches upstream. A complicated pattern was also observed in the Milwaukee River. During the period 1975-1986, mean concentrations of nitrate in the estuary were lower than those in the section of the River upstream from the estuary. During the periods 1987-1993 and 1994-1997, there were no statistically significant differences between mean nitrogen concentrations in these two sections of the River. During the period 1998-2004, concentrations of nitrate in the estuary were lower than those in the section of the River upstream from the estuary. Table 33 shows that statistically significant time-based trends in nitrate concentrations were detected at fewer than half of the sampling stations. At most of the stations where trends were detected, the trends were toward increasing nitrate concentration. These increasing trends occurred at sampling stations in the estuary portions of the Kinnickinnic and Menomonee Rivers and at most stations along the Milwaukee River (Table 34). The data show evidence of seasonal variations in nitrate concentration. In most of the major streams and rivers, nitrate concentration was highest in the winter and lowest during summer or early fall. In the Root River, the concentrations of nitrate tended to be lower during the winter. Nitrate concentrations at some stations were negatively correlated with concentrations of chlorophyll-*a* and organic nitrogen. These correlations reflect the role of nitrate as a nutrient for algal growth. During periods of high algal productivity, algae remove nitrate from water and incorporate it into cellular material.

The mean concentrations of nitrite during the period of record were 0.037 mg/l as N in the Kinnickinnic River, 0.038 mg/l as N in the Menomonee River, 0.024 mg/l as N in the Milwaukee River, 0.028 mg/l as N in Oak Creek, and 0.135 mg/l as N in the Root River. Nitrite concentrations showed more variability than nitrate. This probably reflects the fact that nitrite in oxygenated water tends to oxidize to nitrate fairly quickly. In the Milwaukee and Menomonee Rivers, the mean concentrations of nitrite in the estuary portions of the Rivers tended to be higher than the mean concentrations in the portions of the Rivers upstream from the estuary. The cause of this difference is not known. The relationship between mean nitrite concentrations in the estuary and the section of the River upstream in the Kinnickinnic River was more complicated. During the period 1975-1993, mean nitrite concentrations were significantly higher in the estuary. During the period 1994-1997, this relationship changed. Mean nitrite concentrations during this period were significantly higher in the section of the River upstream from the estuary. No significant differences were detected between the mean concentration of nitrite at the stations in the estuary and the mean concentration of nitrite at the stations upstream from the estuary during the period 1998-2001. Few statistically significant time-based trends were detected in nitrite concentration (Table 33). Trends toward increasing nitrite concentrations were detected at a few stations, mostly in the upstream reaches of the Kinnickinnic River (Table 34). Trends toward decreasing nitrite concentrations were detected at a few stations, mostly in the upstream reaches of the Menomonee River.

Concentrations of organic nitrogen at sampling stations along the mainstems of the five major streams and rivers of the greater Milwaukee watersheds showed considerable variability with concentrations ranging from undetectable to over 16 mg/l as N. During the period of record the mean concentrations of organic nitrogen were 0.61 mg/l as N in the Kinnickinnic River, 0.72 mg/l as N in the Menomonee River, 0.90 mg/l as N in the Milwaukee River, 0.63 mg/l as N in Oak Creek, and 0.80 mg/l as N in the Root River. While at most sampling stations, statistically significant time-based trends were not detected in organic nitrogen concentrations, trends toward increasing concentrations were detected at several stations (Tables 33 and 34). No consistent seasonal pattern was found in organic nitrogen concentration. Organic nitrogen concentrations in the Milwaukee and Root Rivers tended to be high during summer. By contrast, organic nitrogen concentrations in Oak Creek tended to be high during early spring. There was no apparent seasonal pattern in organic nitrogen concentrations in the Kinnickinnic or Menomonee Rivers. Organic nitrogen concentrations at several stations show a positive correlation with temperature. In addition, they show positive correlations at several stations with concentrations of BOD, fecal coliform bacteria, and total phosphorus. These correlations may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into the River. In addition, aerobic metabolism of many organic nitrogen compounds requires oxygen and thus these compounds contribute to BOD. The correlation with total phosphorus concentrations reflects the roles of phosphorus and nitrogen as nutrients for algal growth. During periods of high algal productivity, algae remove dissolved phosphorus and nitrogen compounds from the water and incorporate them into cellular material.

Several processes can influence the concentrations of nitrogen compounds in a waterbody. Primary production by plants and algae will result in ammonia and nitrate being removed from the water and incorporated into cellular material. This effectively converts the nitrogen to forms which are detected only as total nitrogen. Decomposition of organic material in sediment can release nitrogen compounds to the overlying water. Bacterial action may convert some nitrogen compounds into others.

Several things emerge from analysis of nitrogen chemistry in the major streams and rivers of the greater Milwaukee watersheds:

- The relative proportions of different nitrogen compounds in the Kinnickinnic, Menomonee, and Milwaukee Rivers and Oak Creek appear to be changing with time.

- Ammonia concentrations in all five major streams and rivers have decreased over time. This represents an improvement in water quality.

- Where trends exist in the Kinnickinnic and Menomonee Rivers and Oak Creek, the concentrations of organic nitrogen compounds seem to be increasing over time. Although for surface waters there are no standards for this constituent, the increases in concentration may be an indication of declining water quality.

- Where trends exist in the Milwaukee River and the upper reaches of the Kinnickinnic River, the concentrations of nitrate seem to be increasing over time. Although for surface waters there are no standards for this constituent, the increases in concentration may be an indication of declining water quality.

- Concentrations of total nitrogen have been increasing at several stations along the mainstem of the Milwaukee River. This represents a decrease in water quality.

- In the Kinnickinnic and Menomonee Rivers, there are distinct differences, with respect to forms of nitrogen, between the estuary and the sections upstream from the estuary. In particular, total nitrogen, nitrate, and ammonia tend to be found in higher concentrations in the estuary. This may be due, in part, to release of ammonia from sediment in the estuary.

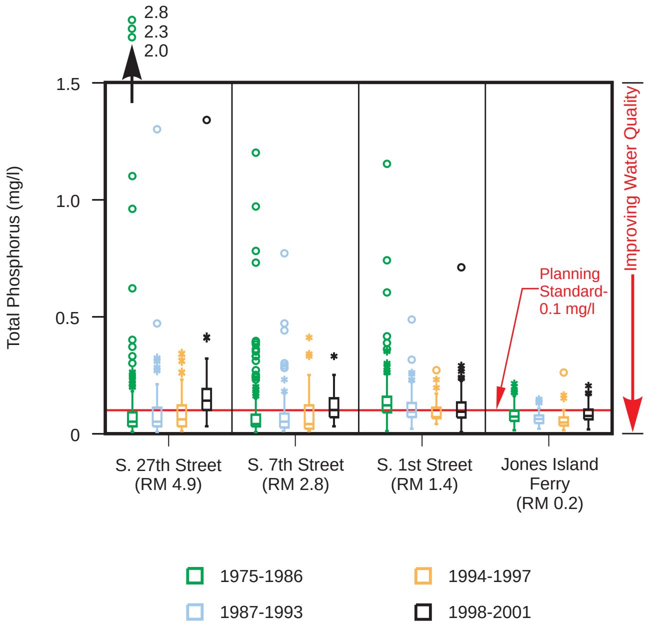
Total and Dissolved Phosphorus
Two forms of phosphorus are commonly sampled in surface waters: dissolved phosphorus and total phosphorus. Dissolved phosphorus represents the form that can be taken up and used for growth by algae and aquatic plants. Total phosphorus represents all the phosphorus contained in material dissolved or suspended within the water, including phosphorus contained in detritus and organisms and attached to soil and sediment.

Concentrations of total phosphorus in the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 3.00 mg/l. The mean concentrations of total phosphorus during the period of record were 0.095 mg/l in the Kinnickinnic River, 0.116 mg/l in the Menomonee River, 0.129 mg/l in the Milwaukee River, 0.085 mg/l in Oak Creek, and 0.123 mg/l in the Root River. Concentrations of dissolved phosphorus in the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 3.00 mg/l. The mean concentrations of dissolved phosphorus during the period of record were 0.033 mg/l in the Kinnickinnic River, 0.044 mg/l in the Menomonee River, 0.050 mg/l in the Milwaukee River, 0.030 mg/l in Oak Creek, and 0.052 mg/l in the Root River. Figure 19 shows changes in total phosphorus concentrations over time since 1975 at several sampling stations along the mainstem of the Kinnickinnic River. At stations in downstream sections of the Kinnickinnic River, total phosphorus concentrations decreased after 1986 and rose again after 1997. This pattern also occurred at stations along the Menomonee River. At stations in upstream sections of the Kinnickinnic River, total phosphorus concentrations increased continually, with sharp increases at some stations after 1997. This pattern also occurred at stations along Oak Creek. A third pattern occurred at most estuary stations along the Milwaukee River. At these stations, concentrations of total phosphorus during the period 1987-1993 were lower than concentrations of total phosphorus during the period 1975-1986. This decrease was followed by increases in concentrations of total phosphorus in the subsequent periods. The pattern followed by concentrations of total phosphorus at stations in the section of the Milwaukee River upstream from the estuary was similar, except that the decrease occurred later, following the period 1987-1994. Total phosphorus concentrations at some stations along the Root River were lower during the period 1998-2004 than during the period 1994-1997. This may not accurately represent trends in this watershed because, at some stations, data prior to 1998 were collected only during summer months when total phosphorus concentrations tend to be higher than during the fall or early spring. Statistically significant time-based trends in the concentrations of dissolved phosphorus and total phosphorus were detected at several sampling stations (Table 33). Trends toward increasing concentrations of dissolved phosphorus were detected at several sites, but especially in upstream reaches of the Kinnickinnic River and downstream reaches of the Menomonee River and Oak Creek (Table 34). These trends represent a decrease in water quality. Trends toward decreasing concentrations of dissolved phosphorus were detected at several sites, but especially in upstream reaches of the Milwaukee River. Trends toward increasing concentrations of total phosphorus were detected at several sites, but especially in upstream reaches of the Kinnickinnic River and downstream reaches of Oak Creek. These trends represent a decrease in water quality. Trends toward decreasing concentrations of total phosphorus were detected at several sites, but especially along much of the Menomonee and Milwaukee Rivers and in downstream reaches of the Kinnickinnic River. Regardless of these long-term trends, increases in total phosphorus were observed at several sampling stations after 1997.

Figure 20 shows the annual mean total phosphorus concentration at sampling stations along the mainstems of the Kinnickinnic River and Oak Creek. Mean annual total phosphorus concentration in the Kinnickinnic River increased sharply after 1996. An increase also occurred in mean annual total phosphorus in the Menomonee River after 1996. While mean annual total phosphorus concentrations from the years 1996-2002 in the Milwaukee River were within the range of variation from previous years, they increased after 1996. This increase was not as sharp as the increases observed in the Kinnickinnic and Menomonee Rivers. For the most part, mean annual total phosphate concentrations in Oak Creek were within the range of variation from previous years. This was also observed for the Root River. One possible cause of the increases observed in the Kinnickinnic, Menomonee, and

Figure 19

TOTAL PHOSPHORUS CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE KINNICKINNIC RIVER: 1975-2001



NOTE: See Figure 11 for description of symbols.

Source: *U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

Milwaukee Rivers is phosphorus loads from facilities discharging noncontact cooling water drawn from municipal water utilities. Several water utilities in the greater Milwaukee watersheds treat their municipal water with orthophosphate or polyphosphate to inhibit release of copper and lead from pipes in the water system and private residences. The City of Milwaukee, for example, began treating its municipal water with orthophosphate in 1996. In 2004, for instance, concentrations of orthophosphate in plant finished water from the Milwaukee Water Works ranged between 1.46 mg/l and 2.24 mg/l,[9] considerably above average concentrations of total phosphorus observed in these streams. The lack of increase in mean annual total phosphorus in Oak Creek and the Root River may be due to the small number of facilities discharging noncontact cooling water and the numbers of utilities not treating their municipal water with phosphate compounds in these watersheds.

Dissolved phosphorus concentrations at many stations were negatively correlated with concentrations of chlorophyll-*a*. Total phosphorus concentrations were positively correlated with temperature, chlorophyll-*a* concentrations, and concentrations of organic nitrogen and total nitrogen. These correlations reflect the roles of phosphorus and nitrogen as nutrients for algal growth. During periods of high algal productivity, algae remove dissolved phosphorus and nitrogen compounds from the water and incorporate them into cellular material. Because the rates of biological reactions are temperature dependent, these periods tend to occur when water temperatures are warmer. At many stations, concentrations of total phosphorus were also positively correlated with concentrations of BOD and fecal coliform bacteria. This correlation may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into the River.

Metals

Arsenic

Concentrations of arsenic in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show moderate variability, ranging from below the limit of detection to 14.0 micrograms per liter (μg/l). The mean concentrations of arsenic during the period of record were 1.93 μg/l in the Kinnickinnic River, 1.85 μg/l in the Menomonee River, 1.94 μg/l in the Milwaukee River, 1.56 μg/l in Oak Creek, and 1.57 μg/l in the Root River. At nearly all sampling stations in the Kinnickinnic River, Menomonee River, Milwaukee River, and Oak Creek watersheds for which sufficient data were available to assess time-based trends, statistically significant trends were detected toward decreasing concentrations of arsenic (Tables 33 and 34). There were not a sufficient number of samples in the Root River watershed to assess time-based trends in arsenic concentration. The declines in arsenic concentration may reflect changes in the number and types of industry present in the greater Milwaukee watersheds, such as the loss of tanneries which utilized arsenic in the processing of hides. In addition, sodium arsenate has not been used in herbicides since the 1960s. Arsenic concentrations in the greater Milwaukee watersheds show no evidence of seasonal variation. The reductions in arsenic concentrations in streams of the greater Milwaukee watersheds represent an improvement in water quality.

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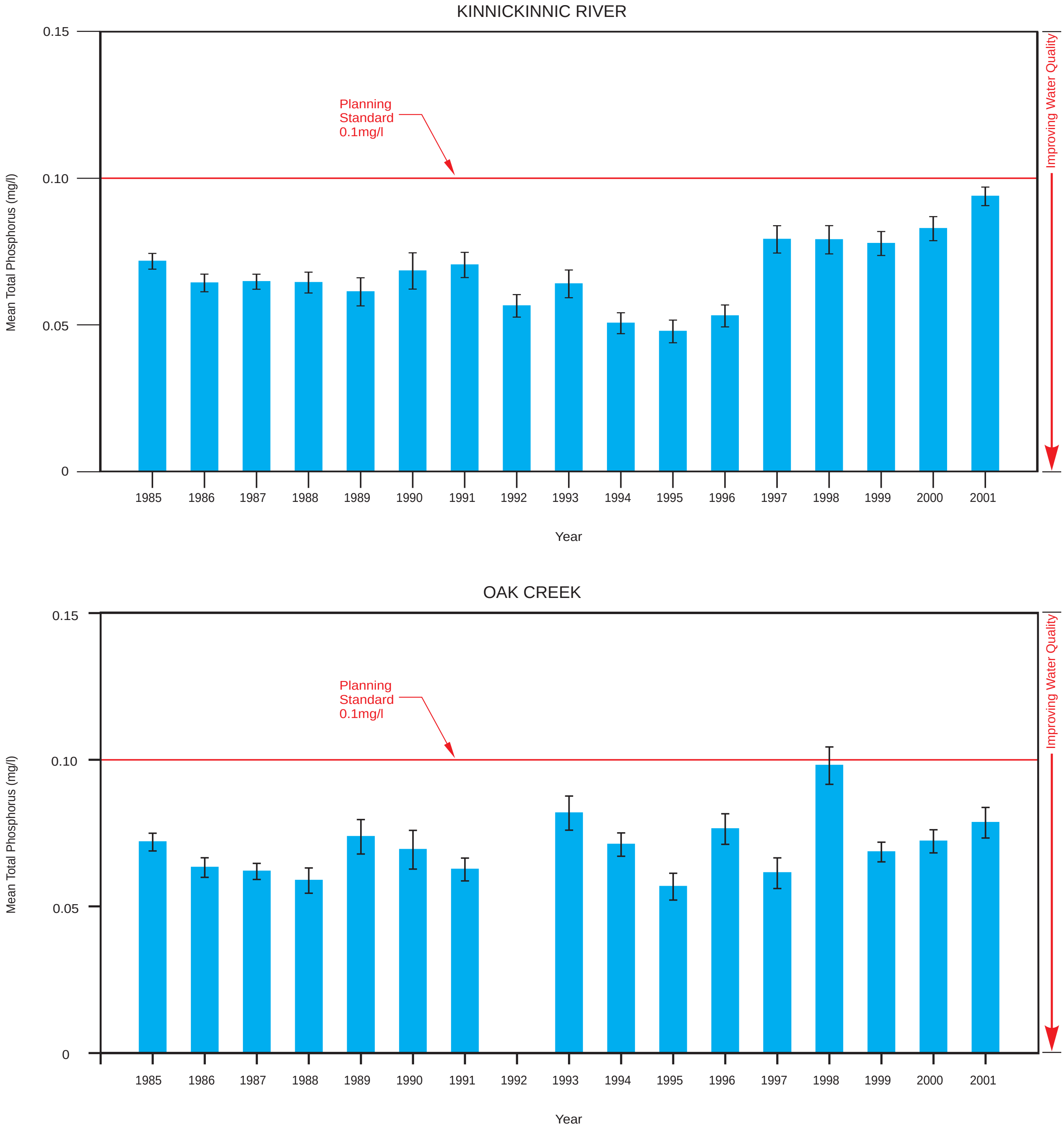
[9] *Milwaukee Water Works,* Annual Water Quality Report, 2004, *February 2005.*

Figure 20

MEAN ANNUAL CONCENTRATION OF TOTAL PHOSPHORUS IN THE KINNICKINNIC RIVER AND OAK CREEK: 1985-2001



NOTE: Error bars (I) represent one standard error of the mean.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

Cadmium

Concentrations of cadmium in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show moderate variability, ranging from below the limit of detection to 27.0 μg/l. The mean concentrations of cadmium during the period of record were 1.70 μg/l in the Kinnickinnic River, 1.70 μg/l in the Menomonee River, 1.53 μg/l in the Milwaukee River, 1.92 μg/l in Oak Creek, and 0.08 μg/l in the Root River. At nearly all sampling stations, statistically significant trends were detected toward decreasing concentrations of cadmium (Tables 33 and 34). These declines in cadmium concentration may reflect changes in the number and types of industry present in the greater Milwaukee watersheds, reductions due to treatment of industrial discharges, and reductions in atmospheric deposition of cadmium to the Great Lakes region. Cadmium concentrations in the greater Milwaukee watersheds show no evidence of seasonal variation. The reductions in cadmium concentrations in the streams of the greater Milwaukee watersheds represent an improvement in water quality.

Chromium

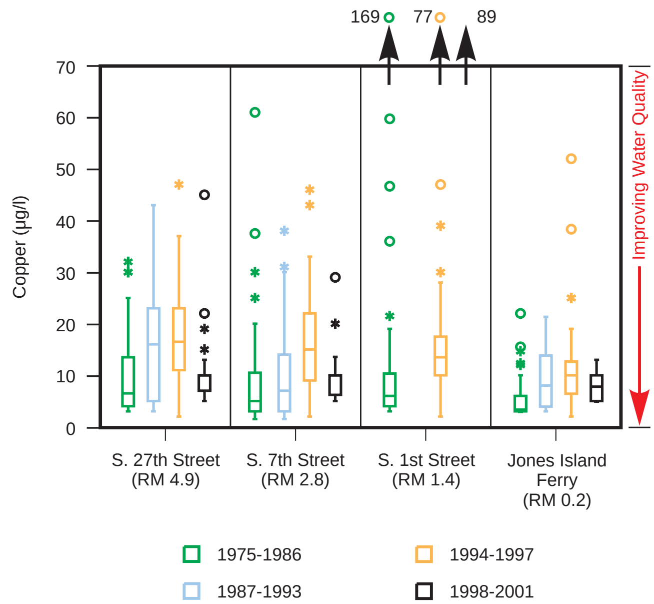
Concentrations of chromium in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show considerable variability, ranging from below the limit of detection to 8,866 μg/l. The mean concentrations of chromium during the period of record were 9.8 μg/l in the Kinnickinnic River, 10.8 μg/l in the Menomonee River, 14.2 μg/l in the Milwaukee River, 7.7 μg/l in Oak Creek, and 10.1 μg/l in the Root River. Analysis of time-based trends suggests that chromium concentrations are declining within much, though not all, of the greater Milwaukee watersheds (Tables 33 and 34). The decline in chromium concentration in this area may reflect the loss of industry in some parts of the watersheds and the decreasing importance of the metal plating industry in particular, as well as the establishment of treatment of discharges instituted for the remaining and new industries since the late 1970s. There is no evidence of seasonal variation in chromium concentrations in the streams of the greater Milwaukee watersheds. The decline in chromium concentrations represents an improvement in water quality.

Copper

Concentrations of copper in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 413 μg/l. The mean concentrations of copper during the period of record were 10.8 μg/l in the Kinnickinnic River, 11.0 μg/l in the Menomonee River, 9.0 μg/l in the Milwaukee River, 8.2 μg/l in Oak Creek, and 7.8 μg/l in the Root River. Moderate variability was associated with these means. Figure 21 shows that prior to 1987, the median concentrations of copper in the Kinnickinnic River increased over time at all stations. This increase in median copper concentrations continued through the period 1994-1997. During the period 1998-2001, the median concentration of copper declined at all sampling stations. In general, mean copper concentrations followed the pattern described for median concentrations. This pattern was observed in all of the watersheds except the Root River watershed where there were insufficient historical copper data to assess long-term trends. Despite the recent declines, most sampling stations show significant increasing trends in copper concentrations (Tables 33 and 34). Table 32 shows that there were no consistent longitudinal trends in copper concentration. In addition, there was no evidence of seasonal variation in copper concentrations. Wear and tear of brake pads and other metal components of vehicles is a major source of copper to the environment. Once deposited on impervious surfaces, stormwater runoff may carry this metal into surface waters. While copper compounds are also used in lake management for algae control, the Kinnickinnic River, Menomonee River, Root River, and Oak Creek watersheds contain no major lakes and few ponds. This makes it unlikely that algicides constitute a major source of copper in surface waters in these watersheds. Copper compounds were used for control of algae and swimmer’s itch in some lakes in the Milwaukee River watersheds; however, despite the presence of some outliers, the range of copper concentrations observed in this watershed does not greatly differ from the ranges observed in the other four watersheds. At some stations, copper concentrations showed moderately strong positive correlations with zinc concentrations. This reflects the fact that many of the same sources release these two metals to the environment. In addition, at some stations, copper concentrations showed negative correlations with pH, reflecting the fact that the solubility of copper increases with decreasing pH. The trend toward increasing copper concentration in streams of the greater Milwaukee watersheds represents a decline of water quality.

Figure 21

COPPER CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE KINNICKINNIC RIVER: 1975-2001



NOTES: See Figure 11 for description of symbols.

Copper acute and chronic toxicity standards depend on ambient hardness which indicates that copper concentrations exceeded these standards in 2 percent and up to 23 percent of samples in the estuary and upstream of the estuary, respectively.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

Lead

The mean concentrations of lead over the period of record were 33.1 μg/l in the Kinnickinnic River, 33.6 μg/l in the Menomonee River, 26.5 μg/l in the Milwaukee River, 41.8 μg/l in Oak Creek, and 4.34 μg/l in the Root River. This last mean is lower than the others, because few data are available for lead concentrations in the Root River prior to 1999. These means are not representative of current conditions in the greater Milwaukee watersheds because lead concentrations in the water of the Rivers have been decreasing since the late 1980s. Figure 22 shows this decrease at sampling stations along the Milwaukee River. At most sampling stations in the greater Milwaukee watersheds for which sufficient data exist to assess trends in lead concentrations, baseline period monthly mean lead concentrations are quite low when compared to historical means and ranges. These decreases represent statistically significant decreasing trends (Tables 33 and 34). During the period since 1998, the mean concentration of lead in samples collected from the major streams and rivers of the greater Milwaukee watersheds was 4.9 μg/l. A major factor causing the decline in lead concentrations has been the phasing out of lead as a gasoline additive. From 1983 to 1986, the amount of lead in gasoline in the United States was reduced from 1.26 grams per gallon (g/gal) to 0.1 g/gal. In addition, lead was completely banned for use in fuel for on-road vehicles in 1995. The major drop in lead concentrations in water in the Rivers followed this reduction in use. In freshwater, lead has a strong tendency to adsorb to particulates suspended in water.[10] As these particles are deposited, they carry the adsorbed lead into residence in the sediment. Because of this, the lower concentrations of lead in the water probably reflect the actions of three processes: reduction of lead entering the environment, washing out of lead into the estuary and Lake Michigan, and deposition of adsorbed lead in the sediment. Lead concentrations in the streams of the greater Milwaukee watersheds show no evidence of patterns of seasonal variation. The decrease in lead concentrations over time represents an improvement in water quality.

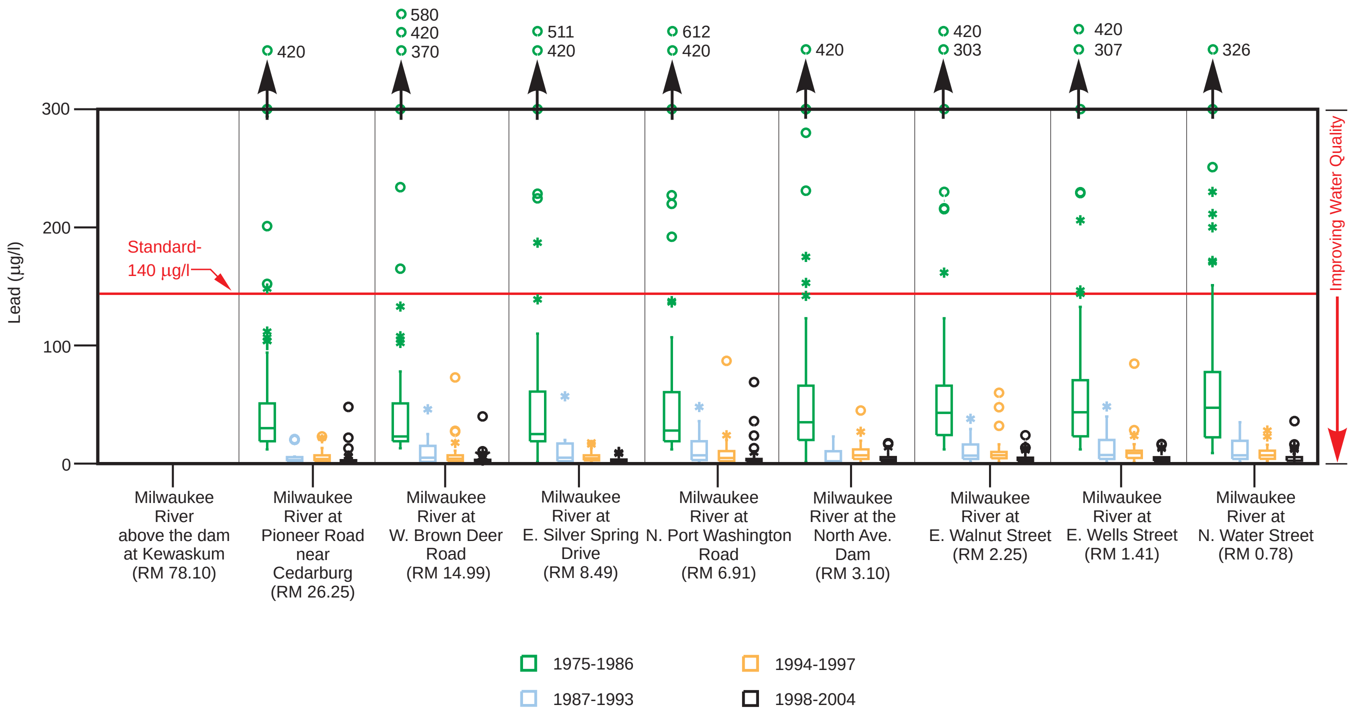
Mercury

Few historical data exist on the concentrations of mercury in the water of the major streams and Rivers of the greater Milwaukee watersheds. Most sampling for mercury in water in these streams occurred during and after 1995. In Oak Creek, most sampling occurred after 1999. Concentrations of mercury in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds ranged from below the limit of detection to 2.84 μg/l. The mean concentrations of mercury over the period of record were 0.060 μg/l in the Kinnickinnic River, 0.093 μg/l in the Menomonee River, 0.105 μg/l in the Milwaukee River, 0.079 μg/l in Oak Creek, and 0.103 μg/l in the Root River. Analysis of time-based trends showed statistically significant trends toward mercury concentrations decreasing at several sampling stations in every watershed except the Root River

[10]*H.L. Windom, T. Byrd, R.G. Smith, and F. Huan, "Inadequacy of NASQUAN Data for Assessing Metal Trends in the Nation's Rivers,"* Environmental Science and Technology, *Volume 25, 1991.*

Figure 22

LEAD CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MILWAUKEE RIVER: 1975-2004



NOTE: See Figure 11 for description of symbols.

Source: *U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.*

watershed (Tables 33 and 34). In the Root River watershed, a statistically significant trend toward increasing mercury concentration was detected at one sampling station. Mercury concentrations in the streams of the greater Milwaukee watersheds show no evidence of patterns of seasonal variation. The trends toward decreasing mercury concentrations at several sites represent improvements in water quality. The trend toward increasing mercury concentrations at one sampling station along the Root River represents a decrease in water quality.

Nickel

While there were outliers, concentrations of nickel in samples collected from the mainstems of most of the five major streams and rivers of the greater Milwaukee watersheds showed moderate variability, ranging from below the limit of detection to 3,811 µg/l. The mean concentrations of nickel during the period of record were 11.8 µg/l in the Kinnickinnic River, 11.2 µg/l in the Menomonee River, 13.5 µg/l in the Milwaukee River, 11.2 µg/l in Oak Creek, and 10.6 µg/l in the Root River. With one exception, no trends in nickel concentration were found along the lengths of the Rivers. There was a statistically significant trend toward nickel concentrations decreasing from upstream to downstream in the portion of the Milwaukee River upstream from the estuary. This trend accounted for a small portion of the variation in the data. Analysis of time-based trends suggests that nickel concentrations are declining within much, though not all, of the greater Milwaukee watersheds (Table 33). When examined on an annual basis, statistically significant trends toward nickel concentrations decreasing over time were detected at sampling stations in every watershed except the Oak Creek watershed (Table 34). When examined on a seasonal basis, significant trends toward decreasing nickel concentrations were detected during the spring and fall at stations along Oak Creek. Many, though not all, of the decreasing trends detected accounted for a small portion of the variation in the data. There is no evidence of seasonal variation in nickel concentrations in the streams of the greater Milwaukee watersheds. The decreases in nickel concentrations represent an improvement in water quality.

Zinc

Concentrations of zinc in samples collected from the mainstems of the five major streams and rivers of the greater Milwaukee watersheds show considerable variability, ranging from below the limit of detection to 660 μg/l. The mean concentrations of zinc during the period of record were 34.4 μg/l in the Kinnickinnic River, 24.4 μg/l in the Menomonee River, 18.2 μg/l in the Milwaukee River, 20.8 μg/l in Oak Creek, and 19.1 μg/l in the Root River. In the Menomonee and Milwaukee Rivers, zinc concentrations tended to be higher in the estuary than in the portions of the Rivers upstream from the estuary. The opposite pattern was seen in the Kinnickinnic River. Figure 23 shows that zinc concentrations at four sampling stations along the mainstem of the Menomonee River increased over time. Similar increases were observed at sampling stations along the Kinnickinnic and Milwaukee Rivers and Oak Creek. At many stations, these increases represent statistically significant increasing trends (Tables 33 and 34). There were insufficient historical data to assess time-based trends in zinc concentration along the Root River. The increases in zinc concentration may be caused by an increased amount of vehicle traffic in parts of the watersheds. Wear and tear on automobile brake pads and tires are major sources of zinc to the environment. In addition, zinc can be released to stormwater by corrosion of galvanized gutters and roofing materials. Stormwater can carry zinc from these sources into surface waters. There is no evidence of seasonal variation in zinc concentrations in the streams of the greater Milwaukee watersheds. The increases in zinc concentrations represent a decrease in water quality.

Organic Compounds

In February, March, and May 2004, the USGS sampled water from 14 sites in the greater Milwaukee watersheds for the presence of several organic compounds dissolved in water. The stations sampled included S. 11th Street along the mainstem of the Kinnickinnic River in the Kinnickinnic River watershed; N. 70th Street and Pilgrim Road along the mainstem of the Menomonee River and stations along Honey, Underwood, and Willow Creeks and the Little Menomonee River in the Menomonee River watershed; Pioneer Road, Estabrook Park, and Jones Island along the mainstem of the Milwaukee River and N. 47th Street along Lincoln Creek in the Milwaukee River watershed; 15th Avenue along the mainstem of Oak Creek in the Oak Creek watershed; and W. Grange Avenue and upstream of W. Ryan Road along the mainstem of the Root River in the Root River watershed. No samples were collected from streams in the Lake Michigan direct drainage area. Compounds detected include bromoform, a disinfectant byproduct; isophorone, a solvent; carbazole, a component of dyes, lubricants, and pesticides; triphenyl phosphate, a plasticizer; several flame retardant chemicals such as tri(2-chloroethyl) phosphate, tri(dichloroisopropyl) phosphate, tributyl phosphate, and triphenyl phosphate; and nonionic detergent metabolites such as p-nonylphenol and diethoxynonylphenol. These last two compounds are known to be endocrine disruptors.

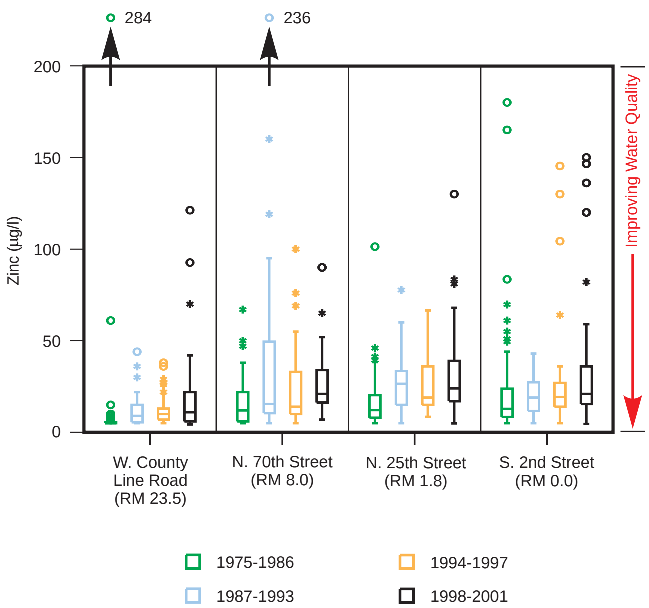
In addition, Wilson Park Creek in the Kinnickinnic River watershed and the Mitchell Field Drainage Ditch in the Oak Creek watershed were sampled in 1999 and 2000 for the presence of chemical deicing compounds. Ethylene glycol was not detected in the samples collected from the Mitchell Field Drainage Ditch. At one site along Wilson Park Creek, propylene glycol was detected in slightly over half the samples with concentrations ranging from below the limit of detection to 4,150 mg/l and ethylene glycol was detected in about one third of the samples with concentrations ranging from below the limit of detection to 650 mg/l. Downstream from this site, at a sampling station near the confluence with the Kinnickinnic River, propylene glycol was detected in about one third of the samples with concentrations ranging from below the limit of detection to 250 mg/l.

Pharmaceuticals and Personal Care Products

During fall 2001, Lincoln Creek at N. 47th Street and the Milwaukee River at Estabrook Park, both sites in the Milwaukee River watershed, were sampled for the presence of caffeine in water. In addition, in February, March, and May 2004, the USGS sampled water from 14 sites in the greater Milwaukee watersheds for the presence of several compounds found in pharmaceuticals and personal care products. This sampling was conducted at the same stations sampled for organic compounds (see above). Compounds commonly detected in these samples included the stimulant caffeine, the nicotine metabolite cotinine, the insect repellant N,N-diethylmetatoluamide (DEET), and the fragrance and flavoring agents camphor and menthol. Compounds occasionally detected included the fragrances acetophenone, methyl salicylate, acetyl-hexamethyl-tetrahydro-naphthalene (AHTN),

Figure 23

ZINC CONCENTRATIONS AT SITES ALONG THE MAINSTEM OF THE MENOMONEE RIVER: 1975-2001



NOTES: See Figure 11 for description of symbols.

Acute and chronic toxicity standards for zinc depend upon ambient hardness which indicate zinc concentrations do not exceed these toxicity standards.

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

d-limonene, and hexahydrohexamethylcyclopentabenzopyran (HHCB); the perfume fixative benzophenone; and the cosmetic component triethyl citrate. The sources of these compounds to the watersheds are not known.

Water Quality of Lakes and Ponds

The greater Milwaukee watersheds contain 20 lakes with a surface area of 50 acres or more, as well as numerous other named lakes and ponds with surface areas of less than 50 acres. The 20 major lakes are all in the Milwaukee River watershed; there are no lakes with a surface area of 50 acres or more in the Kinnickinnic River, Menomonee River, Oak Creek, or Root River watersheds or in the Lake Michigan direct drainage area. The major lakes in the Milwaukee River watershed are Auburn Lake, Barton Pond, Big Cedar Lake, Crooked Lake, Forest Lake, Green Lake, Kettle Moraine Lake, Lac du Cours, Lake Ellen, Little Cedar Lake, Long Lake (Fond du Lac County), Lucas Lake, Mauthe Lake, Mud Lake (Fond du Lac County), Mud Lake (Ozaukee County), Random Lake, Silver Lake, Smith Lake, Spring Lake, Twelve Lake, and Wallace Lake. The physical characteristics of the lakes and ponds in the greater Milwaukee watersheds are given in Table 35.

Ratings of Trophic Condition

Lakes and ponds are commonly classified according to their degree of nutrient enrichment—or trophic status. The ability of lakes and ponds to support a variety of recreational activities and healthy fish and other aquatic life communities is often correlated with their degrees of nutrient enrichment. Three terms are generally used to describe the trophic status of a lake or pond: oligotrophic, mesotrophic, and eutrophic.

Oligotrophic lakes are nutrient-poor lakes and ponds. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes and ponds may provide excellent opportunities for swimming, boating, and waterskiing. Because of the naturally fertile soils and the intensive land use activities, there are relatively few oligotrophic lakes in southeastern Wisconsin.

Mesotrophic lakes and ponds are moderately fertile lakes and ponds which may support abundant aquatic plant growths and productive fisheries. However, nuisance growths of algae and macrophytes are usually not exhibited by mesotrophic lakes and ponds. These lakes and ponds may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes and ponds in southeastern Wisconsin are mesotrophic.

Eutrophic lakes and ponds are nutrient-rich lakes and ponds. These lakes and ponds often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If they are shallow, fish winterkills may be common. While portions of such lakes and ponds are not ideal for swimming and boating, eutrophic lakes and ponds may support very productive fisheries.

Table 35

LAKES AND PONDS OF THE GREATER MILWAUKEE RIVER WATERSHEDS

Name	Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Lake Type	Public Access
Kinnickinnic River					
Holler Park Pond	1	5	- -	Drainage lake	- -[a]
Humboldt Park Pond	4	3	2	Drainage lake	- -[a]
Jackson Park Pond	8	8	5	Drainage lake	- -[a]
Kosciuszko Park Pond	3	4	3	Seepage lake	- -[a]
Saveland Park Pond	1	6	- -	Drainage lake	- -[a]
Wilson Park Pond	9	5	3	Drainage lake	- -[a]
Menomonee River					
County Hospital Ponds	- -	- -	- -	- -	- -
Dretzka Park Ponds	- -	- -	- -	- -	- -
Edward Linder Pond	- -	- -	- -	- -	- -
Greenfield Park Pond	7	6	4	Seepage lake	- -[a]
Jacobus Park Pond	1	5	- -	Drainage lake	- -[a]
Lake Park East Pond	- -	- -	- -	- -	- -
Lake Park West Pond	- -	- -	- -	- -	- -
McCarty Pond	4	9	- -	Drainage lake	- -[a]
Menomonee Falls Mill Pond	- -	- -	- -	- -	- -
Menomonee Parkway Pond	2	4	- -	Drainage lake	- -[a]
Mitchell Park Pond	- -	- -	- -	- -	- -
Milwaukee County Zoo Pond	5	11	- -	Seepage lake	- -[a]
North Hills Club Ponds	- -	- -	- -	- -	- -
Noyes Park Pond	1	1	- -	Drainage lake	- -[a]
Rockfield Quarry Pond	3	27	- -	Seepage lake	- -
Schroedel Pond	5	8	- -	Seepage lake	- -
Washington Park Pond	11	5	3	Drainage lake	- -[a]
Willow Creek Pond	- -	- -	- -	- -	- -
Wood Hospital Pond	1	4	- -	Drainage lake	- -[a]
Milwaukee River					
Allis Lake	9	34	- -	Seepage lake	- -
Auburn Lake (Lake Fifteen)	107	29	14	Drainage lake	Walk in trail
Barton Pond	67	5	3	Drainage lake	Walk in trail
Batavia Pond	1	5	- -	Drainage lake	- -
Beechwood Lake	11	20	- -	Seepage lake	Boat ramp
Big Cedar Lake	932	105	34	Spring lake	Barrier free boat ramp
Birchwood Lake	31	- -	- -	- -	- -
Boltonville Pond	10	10	5	- -	- -
Brickyard Lake	1	4	- -	Seepage lake	- -
Brown Deer Park Pond	6	6	4	Drainage lake	- -[a]
Butler Lake	7	13	- -	Drainage lake	Boat Ramp
Buttermilk Lake	13	6	2	Seepage lake	Roadside
Butzke Lake	16	8	4	Drainage lake	Walk in trail
Cambellsport Millpond	22	10	4	Drainage lake	Walk in trail
Cascade Millpond	7	3	- -	Drainage lake	Walk in trail
Cedar Lake (Fond du Lac County)	19	19	9	Seepage lake	Walk in trail
Cedar Lake (Sheboygan County)	10	10	6	Seepage lake	Wilderness in public ownership
Cedarburg Pond	14	9	- -	Drainage lake	- -
Cedarburg Stone Quarry	6	10	- -	Seepage lake	- -
Chair Factory Millpond	6	7	- -	Drainage lake	- -
Columbia Pond	- -	- -	- -	- -	- -
Crooked Lake	91	32	12	Seepage lake	Barrier free boat ramp
Daly Lake	13	8	- -	Seepage lake	- -
Dickman Lake	9	12	7	Seepage lake	- -
Dineen Park Pond	2	5	- -	Drainage lake	- -[a]
Donut Lake	4	3	- -	Drainage lake	- -
Drzewiceki Lake	2	17	- -	Spring lake	- -
Ehne Lake	18	15	5	Spring lake	- -
Erler Lake	37	34	14	Spring lake	- -
Estabrook Park Lagoon	1	6	- -	Drainage lake	- -[a]
Forest Lake	51	32	11	Seepage lake	Walk in trail
Fromm Pit	4	28	- -	Spring lake	Navigable water
Gilbert Lake	44	30	3	Spring lake	Navigable water
Gooseville Millpond	38	7	- -	Drainage lake	- -
Gough Lake	5	29	- -	Seepage lake	- -
Grafton Millpond	25	8	- -	Drainage lake	Boat ramp
Green Lake	71	37	17	Seepage lake	Boat ramp

Table 35 (continued)

Name	Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Lake Type	Public Access
Milwaukee River (continued)					
Haack Lake	16	18	7	Drainage lake	- -
Hamilton Pond[b]	6	18	- -	Seepage lake	- -
Hanneman Lake	6	18	- -	Seepage lake	- -
Hansen Lake	6	9	- -	Seepage lake	- -
Hasmer Lake	15	34	17	Drainage lake	Walk in trail
Hawthorn Lake	8	12	- -	Seepage lake	- -
Hawthorn Hills Pond	- -	- -	- -	- -	- -
Horn Lake	12	30	- -	Seepage lake	- -
Hurias Lake	26	7	- -	Seepage lake	- -
Juneau Park Lagoon	15	6	4	Drainage lake	- -[a]
Kelling Lakes #1	1	7	- -	Seepage lake	Wilderness in public ownership
Kelling Lakes #2	1	7	- -	Seepage lake	Wilderness in public ownership
Kelling Lakes #3	3	7	- -	Seepage lake	Wilderness in public ownership
Keowns Pond	1	15	- -	Drainage lake	- -
Kettle Moraine Lake	227	30	6	Seepage lake	Roadside
Kewaskum Millpond	5	8	- -	Drainage lake	Walk in trail
Lake Bernice	35	11	5	Drainage lake	Roadside
Lake Ellen	121	42	16	Drainage lake	Barrier free boat ramp
Lake Lenwood	15	38	19	Spring lake	- -
Lake Seven	27	25	12	Seepage lake	Barrier free boat ramp
Lake Sixteen	8	13	- -	Seepage lake	- -
Lake Twelve	53	20	6	Spring lake	- -
Lehner Lake	3	22	15	Spring lake	- -
Lent Lake	8	7	- -	Drainage lake	Navigable water
Lime Kiln Millpond	4	7	- -	Drainage lake	Walk in trail
Lincoln Park Lagoon	- -	- -	- -	- -	- -
Lindon Pond	2	15	- -	Spring lake	- -
Little Cedar Lake	246	56	13	Drainage lake	Navigable water, boat launch
Little Drickens Lake	9	20	- -	Seepage lake	- -
Little Mud Lake	18	5	- -	Seepage lake	- -
Long Lake (Ozaukee County)	34	5	- -	Seepage lake	- -
Long Lake (Fond du Lac County)	417	47	22	Drainage lake	Boat ramp, barrier free pier
Lucas Lake	78	15	6	Drainage lake	- -
Mallard Hole Lake	2	6	- -	Seepage lake	Walk in trail
Mauthe Lake	78	23	12	Drainage lake	Boat ramp, barrier free pier
McGovern Park Pond	5	5	3	Drainage lake	- -[a]
Mee-Quon Park Pond	- -	- -	- -	- -	- -
Miller Lake	3	16	- -	Seepage lake	- -
Moldenhaur Lake	3	32	- -	Seepage lake	Walk in trail
Mud Lake (Ozaukee County)	245	4	3	Seepage lake	Wilderness in public ownership
Mud Lake (Fond du Lac County)	55	17	8	Drainage lake	- -
New Fane Millpond	5	5	3	Drainage lake	Navigable water
Newburg Pond	7	8	- -	Drainage lake	Walk in trail
Paradise Valley Lake	9	35	- -	Drainage lake	- -
Pit Lake	35	14	- -	Seepage lake	- -
Proschinger Lake	6	23	- -	Seepage lake	- -
Quaas Lake	7	12	- -	Spring lake	- -
Radke Lake	10	14	7	Seepage lake	- -
Random Lake	209	21	6	Drainage lake	Boat ramp
Roeckl Lake	3	12	- -	Seepage lake	- -
Ruck Pond	- -	- -	- -	- -	- -
Schwietzer Pond	8	4	- -	Drainage lake	- -
Senn Lake	16	8	6	Drainage lake	- -
Silver Lake	118	47	20	Drainage lake	Boat launch (County)
Smith Lake	86	5	3	Seepage lake	Boat ramp
Spring Lake (Fond du Lac County)	10	2	2	Seepage lake	- -
Spring Lake (Ozaukee County)	57	22	7	Seepage lake	- -
Spruce Lake	34	4	3	Seepage lake	Walk in trail
Thiensville Millpond	45	8	- -	Drainage lake	Boat ramp
Tily Lake	13	48	24	Spring lake	- -
Tittle Lake	17	26	- -	Drainage lake	Navigable water
Uihlein Pond	1	8	- -	Drainage lake	- -
Unnamed Lake (T11 R21E, Section 17)	12	5	- -	- -	- -
Wallace Lake	52	35	11	Spring lake	Boat ramp
Washington Park Pond	11	5	3	Drainage lake	- -[a]
Wire and Nail Pond	- -	- -	- -	- -	- -
Zeunert Pond	- -	- -	- -	- -	- -
Oak Creek					
Oak Creek Parkway Pond	5	8	5	Drainage lake	- -[a]

Table 35 (continued)

Name	Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Lake Type	Public Access
Root River					
Boerner Botanical Garden Pond No. 1	2	3	- -	Drainage lake	- -[a]
Boerner Botanical Garden Pond No. 2	1	4	- -	Drainage lake	- -[a]
Boerner Botanical Garden Pond No. 3	8	5	- -	Drainage lake	- -[a]
Dumkes Lake	7	11	- -	Seepage lake	- -
Franklin High School Pond	2	- -	- -	- -	- -
Koepmier Lake	8	35	- -	Seepage lake	- -
Lake Brittany	- -	- -	- -	Seepage lake	- -
Lower Kelly Lake	3	36	- -	Seepage lake	Walk in trail
Monastery Lake	12	30	- -	Seepage lake	- -
Mud Lake	5	21	- -	Seepage lake	- -[a]
North Golf Course Pond No. 1	1	4	- -	Drainage lake	- -[a]
North Golf Course Pond No. 2	1	4	- -	Drainage lake	- -[a]
North Golf Course Pond No. 3	3	8	- -	Drainage lake	- -[a]
Quarry Lake	20	64	- -	Seepage lake	Boat ramp
Root River Parkway Pond	8	17	- -	Seepage lake	- -[a]
Scout Lake	8	19	6	Seepage lake	- -[a]
Shoetz Park Pond	2	- -	- -	- -	- -
Upper Kelly Lake	12	31	- -	Spring lake	Boat ramp
Whitnall Park Pond	15	4	6	Drainage lake	- -[a]
Lake Michigan Direct Drainage Area					
Juneau Park Pond	15	6	4	Drainage lake	- -[a]
Sheridan Park Pond	1	8	4	Seepage lake	- -[a]

[a]*Private boats of any kind are not allowed on ponds in Milwaukee County Parks. Where available, commercial facilities provide boat liveries operated by the park.*

[b]*The dam at Hamilton Pond failed in 1996.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The Trophic State Index (TSI) assigns a numerical trophic condition rating based on Secchi-disc transparency, and total phosphorus and chlorophyll-*a* concentrations. The original Trophic State Index, developed by Carlson,[11] has been modified for Wisconsin lakes by the Wisconsin Department of Natural Resources using data on 184 lakes throughout the State.[12] The Wisconsin Trophic State Index (WTSI) ratings for Ellen, Forest, Green, and Wallace Lakes in the Milwaukee River watershed are shown in Figure 24 as a function of sampling date. Figure 25 shows the WTSI ratings for Big Cedar, Little Cedar, Long (Fond du Lac County), and Random Lakes in the Milwaukee River watershed as a function of sampling date.

Based on the Wisconsin Trophic State Index ratings shown, the eight lakes in the Milwaukee River watershed for which data were available may be classified as meso-eutrophic, although the Wisconsin Trophic State Index values ranged from oligotrophic to eutrophic during the periods of record. The data shown in Figures 24 and 25 suggest that the eight lakes behaved in a similar manner during the study period, although, for some of the lakes, the data are not sufficient to assess whether the trophic status of these lakes have changed over the study period. Nevertheless, viewed in their totality, it could be suggested that the eight lakes all behaved in a similar manner. Data on water clarity form the most complete data sets for all eight lakes, with Green, Big Cedar, Long, and Random Lakes having data sets that encompassed all or most of the study period.

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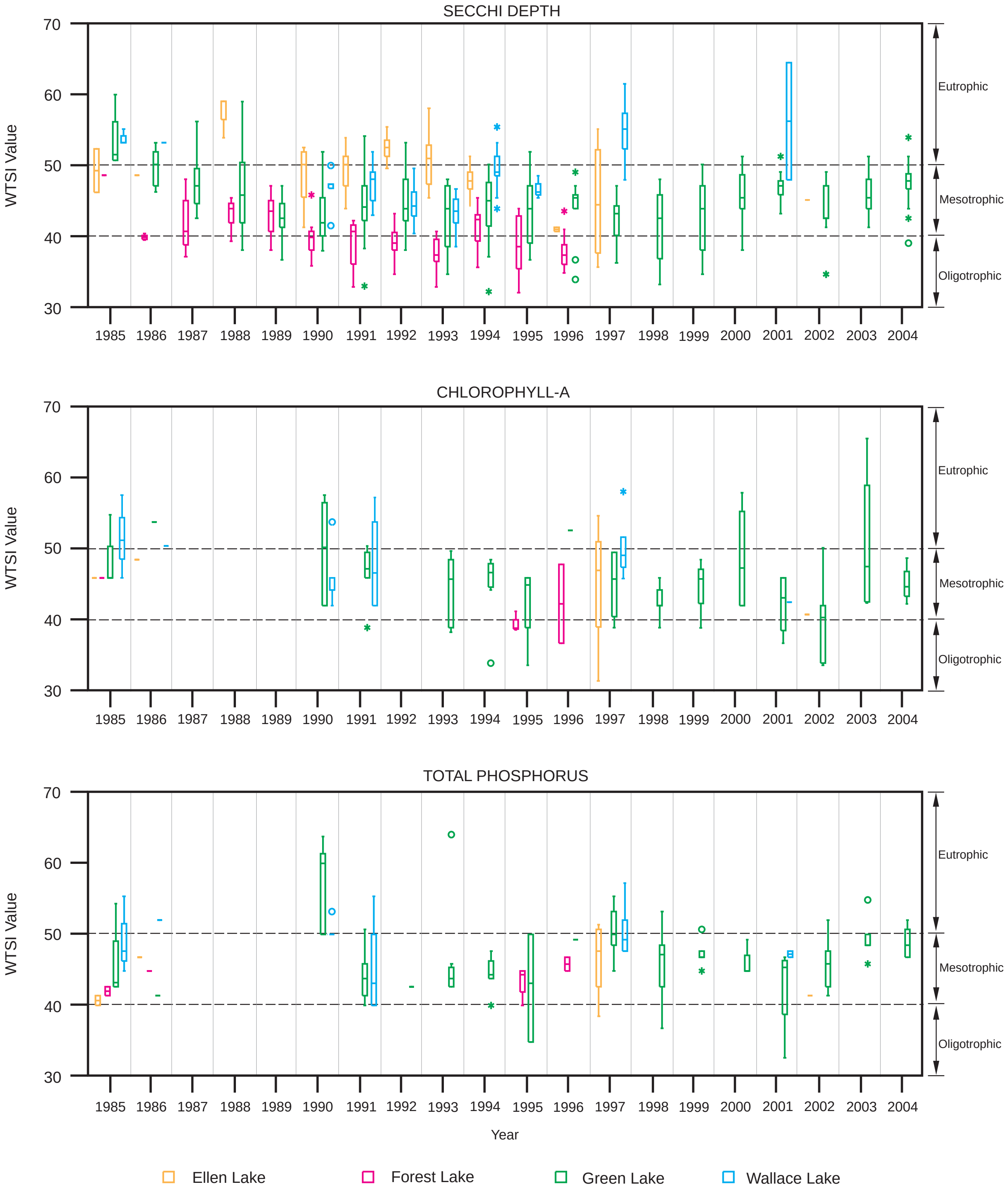
[11]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography, *Volume 22, 1977.*

[12]*R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings, *Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

Figure 24

WISCONSIN TROPHIC STATE INDEX (WTSI) OF LAKES UNDER 200 ACRES IN THE MILWAUKEE RIVER WATERSHED: 1985-2004

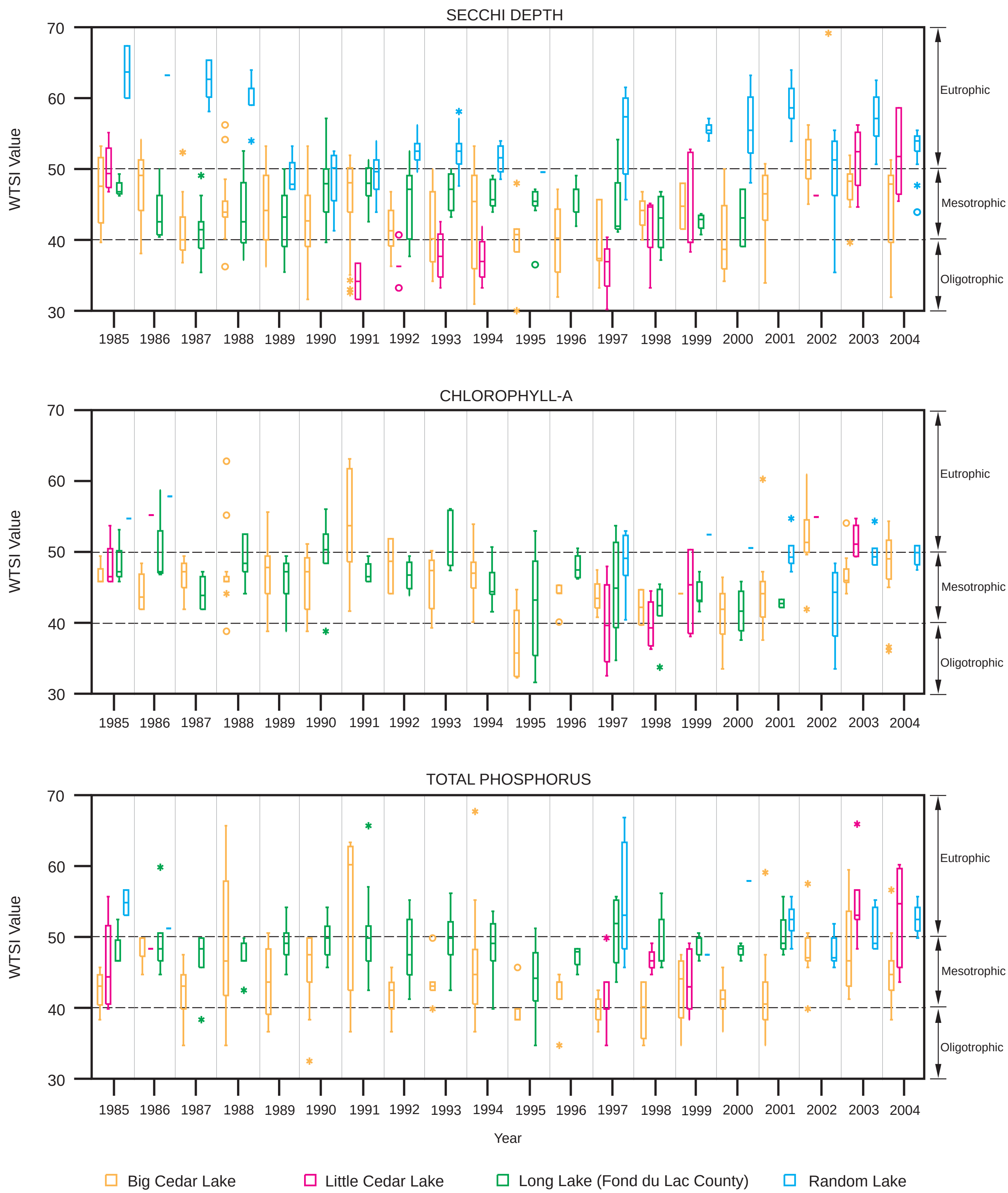


NOTE: See Figure 11 for description of symbols.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 25

WISCONSIN TROPHIC STATE INDEX (WTSI) OF LAKES OVER 200 ACRES IN THE MILWAUKEE RIVER WATERSHED: 1985-2004



NOTE: See Figure 11 for description of symbols.

Source: Wisconsin Department of Natural Resources and SEWRPC.

These data suggest an approximately decadal periodicity, with high WTSI values occurring during the mid-1980s, declining to lower values during the early 1990s, and returning to slightly high values toward the middle of the decade. This period repeated, with lower values being observed during the late 1990s. The significant degree of overlap between years, as shown in Figures 24 and 25, would suggest that these differences are more of degree than of statistical significance. These same distribution patterns are reflected in the chlorophyll-*a* and total phosphorus concentration data, to the extent that they are available. Also, the pattern of periodicity is consistent among both larger and smaller lakes, those with a surface area of less than 200 acres and those with a surface area of greater than 200 acres. Green, Long (Fond du Lac County), and Big Cedar Lakes have the most complete records among the eight lakes for which data are presented.

Based on the Wisconsin Trophic State Index ratings shown, Ellen Lake may be classified as meso-eutrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 45 to about 55, or from mesotrophic to slightly eutrophic as would be consistent with a meso-eutrophic status. Available chlorophyll-*a* data and total phosphorus data are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 46 to 49 in the mid-1980s to about 47 in 1997, while the median WTSI values based upon total phosphorus concentrations range from about 41 to 47 during the mid-1980s to about 48 in 1997. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Forest Lake may be classified as oligo-mesotrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 37 to about 45, or from oligotrophic to moderately mesotrophic. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 46 in the mid-1980s to about 39 to 43 in 1995 and 1996. The median WTSI values based upon total phosphorus concentrations range from about 41 to 45 during the mid-1980s to about 45 and 46 in 1995 and 1996. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Green Lake may be classified as mesotrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 42 to about 51, or from mesotrophic to slightly eutrophic as would be consistent with a mesotrophic status. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 40 in 2002 to about 50 in 1990, while the median WTSI values based upon total phosphorus concentrations range from about 43 during the mid-1980s to about 60 in 1990, although the majority of the total phosphorus-based WTSI values were at or below a value of 50.[13] The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Wallace Lake may be classified as meso-eutrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 44 in 1992 and 1993 to about 55 to 57 during 1997 and 2001, or from mesotrophic to moderately eutrophic. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 51 in the mid-1980s to about 46 in the early 1990s to about 49 in 1997. The median WTSI values based upon total phosphorus concentrations range from about 43 during 1991 to about 48 to 49 in 1985, 1997, and 2001. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

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[13]*The total phosphorus-based WTSI values reported during 1990 suggest that the Lake was eutrophic and high in total phosphorus; however, the corresponding Secchi disk and chlorophyll*-a *based WTSI values are inconsistent with this and suggest a mesotrophic classification.*

Based on the Wisconsin Trophic State Index ratings shown, Big Cedar Lake may be classified as mesotrophic.[14] The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 38 to about 51, or from slightly oligotrophic to slightly eutrophic as would be consistent with a mesotrophic status. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 36 in the mid-1990s to about 53 in 1991, while the median WTSI values based upon total phosphorus concentrations range from about 40 during the mid-1990s to about 60 in 1991. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Little Cedar Lake may be classified as meso-eutrophic.[15] The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 33 to about 52, or from oligotrophic to slightly eutrophic. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 40 in 1997 and 1998 to about 51 in 2003. The median WTSI values based upon total phosphorus concentrations range from about 40 during 1997 to about 54 and 55 in 2003 and 2004. The annual ranges set forth in Figure 25 suggest that any trends in WTSI ratings for this lake probably are the result of interannual variability, at least through the end of the 1990s, with consistently higher values being reported during the 2000s, which may be suggestive of a trend toward increasing trophic state during these more recent years.

Based on the Wisconsin Trophic State Index ratings shown, Long Lake (Fond du Lac County) may be classified as mesotrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 41 to about 48, consistent with a mesotrophic status. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the mesotrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 42 in the late-1990s to about 50 in the early 1990s, while the median WTSI values based upon total phosphorus concentrations range from about 44 during the mid-1990s to about 52 during the late-1990s. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Random Lake may be classified as eutrophic. The annual median WTSI ratings based on Secchi depth have ranged over the study period from about 48 to about 65, or from meso-eutrophic to highly eutrophic. Available chlorophyll-*a* data and total phosphorus data suggest that these values are largely within the meso-eutrophic range. Median WTSI values based upon chlorophyll-*a* concentrations range from about 46 in 2002 to about 50 in 2004. The median WTSI values based upon total phosphorus concentrations range from about 47 during 2002 to between about 53 and 55 in 1985, 1997, 2001 and 2004. The overlap of these annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Figure 26 shows the WTSI ratings for Lower Kelly, Scout, and Upper Kelly Lakes in the Root River watershed as a function of sampling date.

Based on the Wisconsin Trophic State Index ratings shown, Lower Kelly Lake may be classified as meso-eutrophic. The data shown in Figure 26 for this lake are not sufficient to assess whether the trophic status of this lake has changed over the study period.

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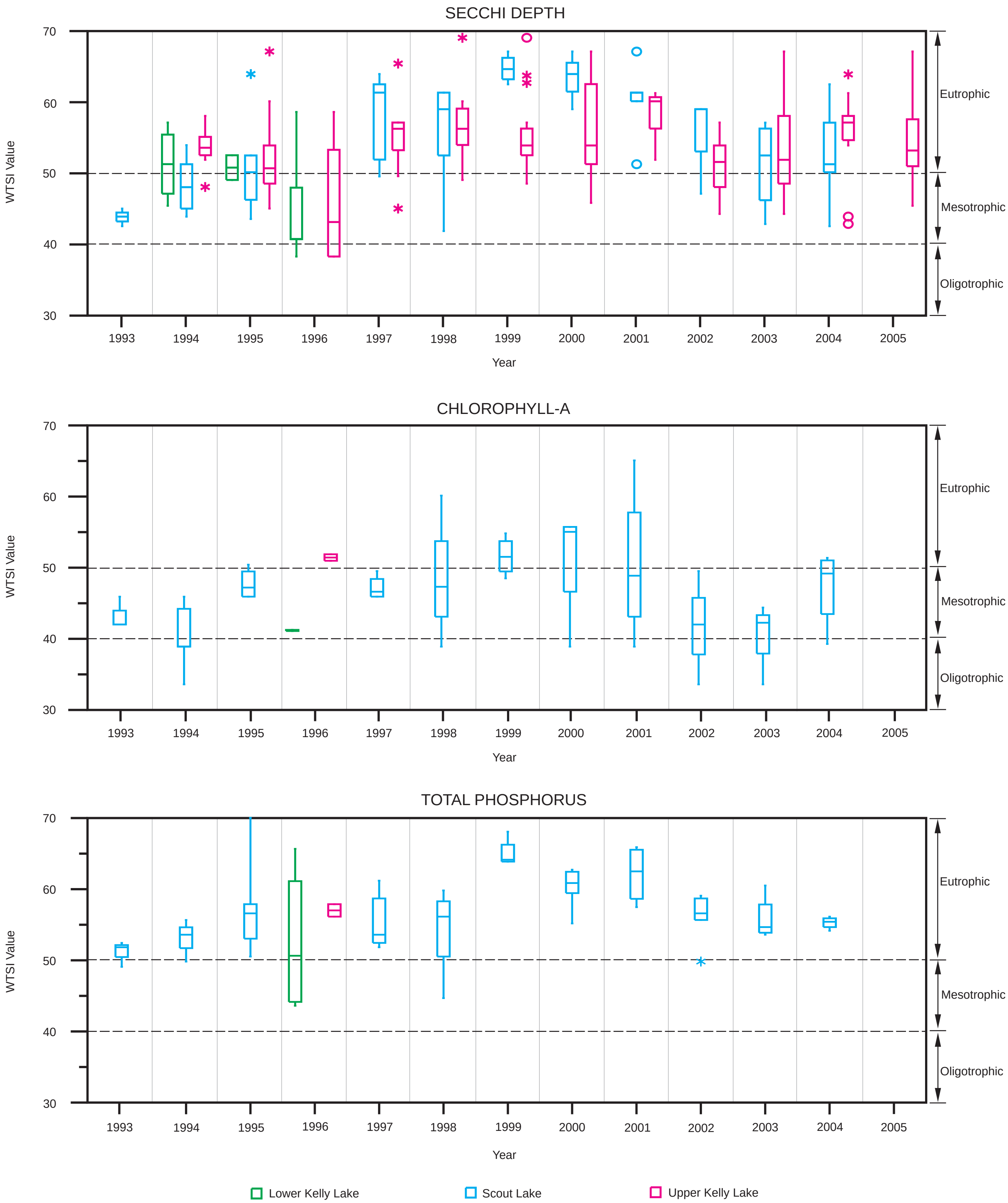
[14]*See also SEWRPC Memorandum Report No. 137,* A Water Quality Protection and Stormwater Management Plan for Big Cedar Lake, Washington County, Wisconsin, *Volume 1.* Inventory Findings, Water Quality Analyses, Recommended Management Measures, *August 2001.*

[15]*See also SEWRPC Memorandum Report No. 146,* An Aquatic Plant Management Plan for Little Cedar Lake, Washington County, Wisconsin, *May 2004.*

Figure 26

WISCONSIN TROPHIC STATE INDEX (WTSI) OF LAKES IN THE ROOT RIVER WATERSHED: 1993-2005



NOTE: See Figure 11 for description of symbols.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Based on the Wisconsin Trophic State Index ratings shown, Upper Kelly Lake may be classified as eutrophic. While the annual median WTSI rating based on Secchi depth has changed over the study period, the overlap of annual ranges suggests that any trends in WTSI ratings for this lake probably are the result of interannual variability.

Based on the Wisconsin Trophic State Index ratings shown, Scout Lake may be classified as eutrophic. While WTSI ratings for this lake have generally decreased since 1999, the overlap of annual ranges, the increases in the ratings based upon Secchi depth and chlorophyll-*a* since 2002, and the similarity of the pattern of change in the ratings based upon Secchi depth to the pattern of change of ratings for Upper Kelly Lake suggest that the changes in WTSI ratings for this lake probably are the result of interannual variability.

Bacterial Parameters

No data on concentrations of fecal coliform bacteria were available for lakes within the Milwaukee River watershed. Some limited data on concentrations of *E. coli* were available for four lakes. During the period 1998-2004, the concentrations of *E. coli* in 22 samples from Big Cedar Lake ranged between 37 cells per 100 ml and 62 cells per 100 ml, with a mean of 48.7 cells per 100 ml. During the period 1998-2004, the concentrations of *E. coli* in 29 samples from Green Lake ranged between 35 cells per 100 ml and 66 cells per 100 ml, with a mean of 44.8 cells per 100 ml. During 2004, the concentrations of *E. coli* in 4 samples from Little Cedar Lake ranged between 51 cells per 100 ml and 61 cells per 100 ml, with a mean of 52.8 cells per 100 ml. During the period 2002-2004, the concentrations of *E. coli* in 13 samples from Random Lake ranged between 40 cells per 100 ml and 55 cells per 100 ml, with a mean of 49.2 cells per 100 ml. The USEPA requires that beaches be posted with warning signs informing the public of increased health risks when the concentration of *E. coli* exceeds 235 cells per 100 ml. All of the samples collected from these four lakes during the baseline period are below this threshold.

In Quarry Lake in the Root River watershed, concentrations of fecal coliform bacteria during the years 1994-1998 range from undetectable to about 80 cells per 100 ml. Concentration of *E. coli* in this lake during the years 1999-2001 ranged from undetectable to about 90 cells per 100 ml. While bacterial concentrations showed much interannual variation, they tended to be highest during July and August. For most dates, the concentrations of bacteria in Quarry Lake were below the thresholds used for issuing advisories to swimmers.

Chemical and Physical Parameters

Data on water chemistry were available for twelve lakes in the Milwaukee River watershed: Auburn, Big Cedar, Ellen, Forest, Green, Kettle Moraine, Little Cedar, Long (Fond du Lac County), Mud (Fond du Lac County), Random, Silver, and Wallace Lakes, and three lakes from the Root River watershed: Lower Kelly, Scout, and Upper Kelly Lakes.

The temperature data indicate that the majority of lakes for which data are available thermally stratify during the summer months, with hypolimnetic water temperatures being about 5°C to 15°C below surface water temperatures on average. Lakes with a maximum depth of less than 35 feet typically have a lesser thermal gradient than the deeper lakes. During thermal stratification, a layer of relatively warm water floats on top of a layer of cooler water. Thermal stratification is a result of the differential heating of the lake water, and the resulting water temperature-density relationships at various depths within the lake water column. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 4°C. During stratification, the top layer, or epilimnion, of the waterbody is cut off from nutrient inputs from the sediment. At the same time, the bottom layer, or hypolimnion, is cut off from the atmosphere and sunlight penetration. Over the course of the summer, water chemistry conditions can become different between the layers of a stratified waterbody. In southeastern Wisconsin, the development of summer thermal stratification begins in late spring or early summer when surface waters begin to warm, reaches its maximum in late summer, and disappears in the fall when surface waters cool.

Average surface water temperatures ranged between about 20°C and 30°C, with the warmer surface water temperatures being reported from the lakes with a maximum depth of less than 30 feet. These lakes include Auburn, Kettle Moraine, Mud (Fond du Lac County), Random, and Scout Lakes. The deeper water lakes, with maximum depths greater than 45 feet, tended to have slightly cooler surface water temperatures during the period of record, ranging between 20°C and 25°C, during most years. These lakes include Big Cedar, Little Cedar, Long (Fond du Lac County), and Silver Lakes. Likewise, average hypolimnetic water temperatures typically ranged between 10°C and 20°C in the shallower lakes with maximum depths of less than 30 feet, and between 5°C and 15°C in the deeper water lakes. These temperature differences were sufficient to set up stable stratification within these lakes during most years.

During the summer, dissolved oxygen concentrations in the hypolimnia of the lakes tend to be substantially lower than dissolved oxygen concentrations at the surface. In the deeper lakes, with maximum depths of greater than 45 feet, the hypolimnia become anoxic during most summers. This was also seen in Scout Lake. This is consistent with the characterization of these lakes as meso-eutrophic or eutrophic waterbodies. The lower oxygen concentration in the hypolimnion results from depletion of available oxygen through chemical oxidation and microbial degradation of organic material in water and sediment.

Limited data on other water chemistry parameters were available for several of the lakes in the greater Milwaukee watersheds. Data for chloride are summarized in Figure 27. As has been noted for other lakes in southeastern Wisconsin, most lakes for which data were available in the greater Milwaukee watersheds show an increasing trend in chloride concentrations. This trend is most discernable in those lakes with longer term data sets. These trends suggest that most lakes within the watersheds have increased chloride levels over the period of record. During the 1970s, Lillie and Mason reported chloride concentrations of between 5.0 and 10 mg/l in Milwaukee River watershed lakes.[16] Since that time, concentrations in most lakes for which data are available have increased to between 20 and 50 mg/l. Sources of these chlorides include road salts applied to area roadways during the winter months, and water softener salts utilized in home water softeners year round. The relative proportions of these sources vary with proximity to major human settlements and road systems; however, geological sources of chloride in southeastern Wisconsin are few, leading to the conclusion that the rapid increase in chloride concentrations is of anthropogenic origin. Threshold concentrations for chloride, above which instream and in-lake biological impacts may be expected to be observed, are on the order of about 250 mg/l.[17] Consequently, while the lakes of the greater Milwaukee watersheds are well below this threshold, salinization of these lakes may be considered as an emerging issue of concern.

Water Quality of the Milwaukee Harbor Estuary and the Adjacent Nearshore Lake Michigan Areas

The earliest systematic collection of water quality data in the Milwaukee Harbor estuary occurred in the 1960s.[18] Data collection after that was sporadic until the 1970s. Since then, considerable data have been collected, both from stations along the mainstems of the Rivers making up the estuary and from stations within and adjacent to the outer harbor. The major sources of data include MMSD, the WDNR, the USGS, the University of Wisconsin-Milwaukee, and the USEPA's STORET legacy and modern databases. Much of these data were obtained from sampling stations along the mainstems of the Kinnickinnic, Menomonee, and Milwaukee Rivers. In addition, considerable data were obtained from survey stations in and adjacent to the outer harbor (Map 27).

Prior to the late 1970s, water quality data were sporadically collected from the nearshore area of Lake Michigan. Since then, considerable data have been collected. The major sources of data include MMSD, the WDNR, the University of Wisconsin-Milwaukee, and the City of Milwaukee Water Works.

The time periods examined for analytic purposes and graphical comparisons of baseline period water quality conditions to historical water quality conditions used for the Milwaukee Harbor estuary and the adjacent

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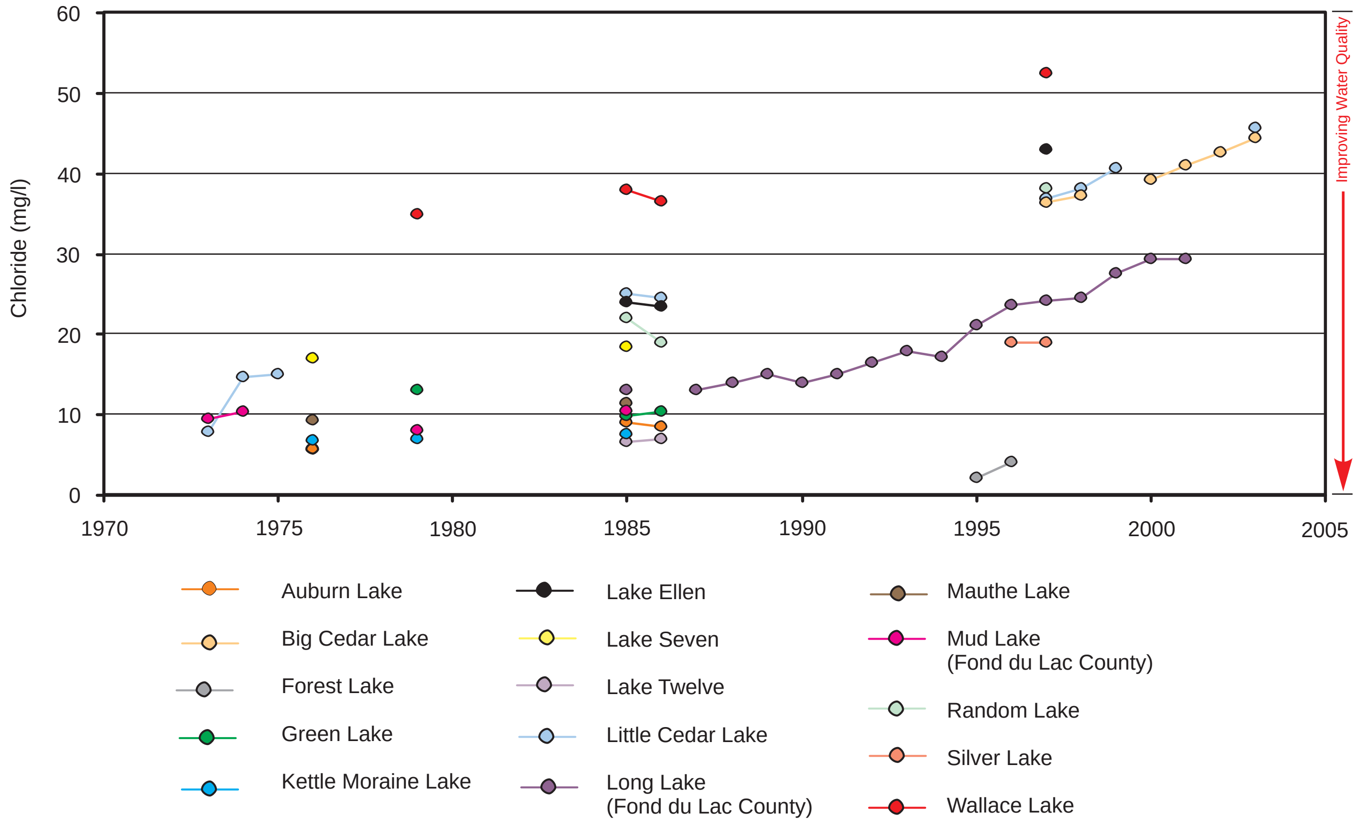
[16]*R.A. Lillie and J.W. Mason,* Limnological Characteristics of Wisconsin Lakes, *Wisconsin Department of Natural Resources Technical Bulletin No. 138, 1983.*

[17]*Fritz van der Leeden, Fred L. Troise, and David Keith Todd,* The Water Encyclopedia, *Lewis Publishers, 1990.*

[18]*SEWRPC Technical Report No. 4,* op. cit..

Figure 27

CHLORIDE CONCENTRATIONS IN LAKES IN THE MILWAUKEE RIVER WATERSHED: 1973-2004



Source: Wisconsin Department of Natural Resources and SEWRPC.

nearshore Lake Michigan areas were similar to those described previously in this chapter for the streams of the greater Milwaukee watersheds. Based on the availability of data, the period 1998-2004 defines the baseline water quality conditions in the outer harbor and the nearshore Lake Michigan areas.

Water quality parameters from the outer harbor and nearshore Lake Michigan areas were examined for the presence of two different types of trends: changes over time and seasonal changes throughout the year. Changes over time were assessed both on an annual and a seasonal basis. Map 27 and Table 36 show the sampling stations in and adjacent to the outer harbor which had sufficiently long periods of record to be used for these analyses. These sampling stations were aligned along four transects running through and adjacent to the outer harbor. West-east transect number 1 passes eastward through the outer harbor from the mouth of the Milwaukee River, through the main gap in the breakwall, to a sampling station outside the breakwall. North-south transect number 1 runs from north to south through the center of the outer harbor. North-south transect number 2 runs along the outside of the breakwall. Three sampling stations in this transect, OH-05, OH-07, and OH-09, are located at gaps in the breakwall. Two other stations, OH-06 and OH-08, are located along the breakwall itself. North-south transect number 3 consists of three stations that are located roughly one mile east of the breakwall. Map 27 and Table 36 also show the sampling stations in the nearshore Lake Michigan area used for these analyses. These sampling stations are divided into two groups, representing different surveys by MMSD. The first group of stations, the South Shore survey, is a relatively compact collection of stations located near the outfall from the MMSD South Shore wastewater treatment plant (WWTP). Data from sampling stations in this survey were analyzed along two transects (Map 27). West-east transect number 2 passes eastward through four stations as it runs outward from the lakeshore into Lake Michigan. North-south transect number 4 passes through five stations as it runs southward, roughly parallel to the shoreline. It is important to note that one sampling station in this survey, SS-01, is located

Map 27

WATER AND SEDIMENT QUALITY MONITORING STATIONS
WITHIN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN NEARSHORE AREA: 1975-2004

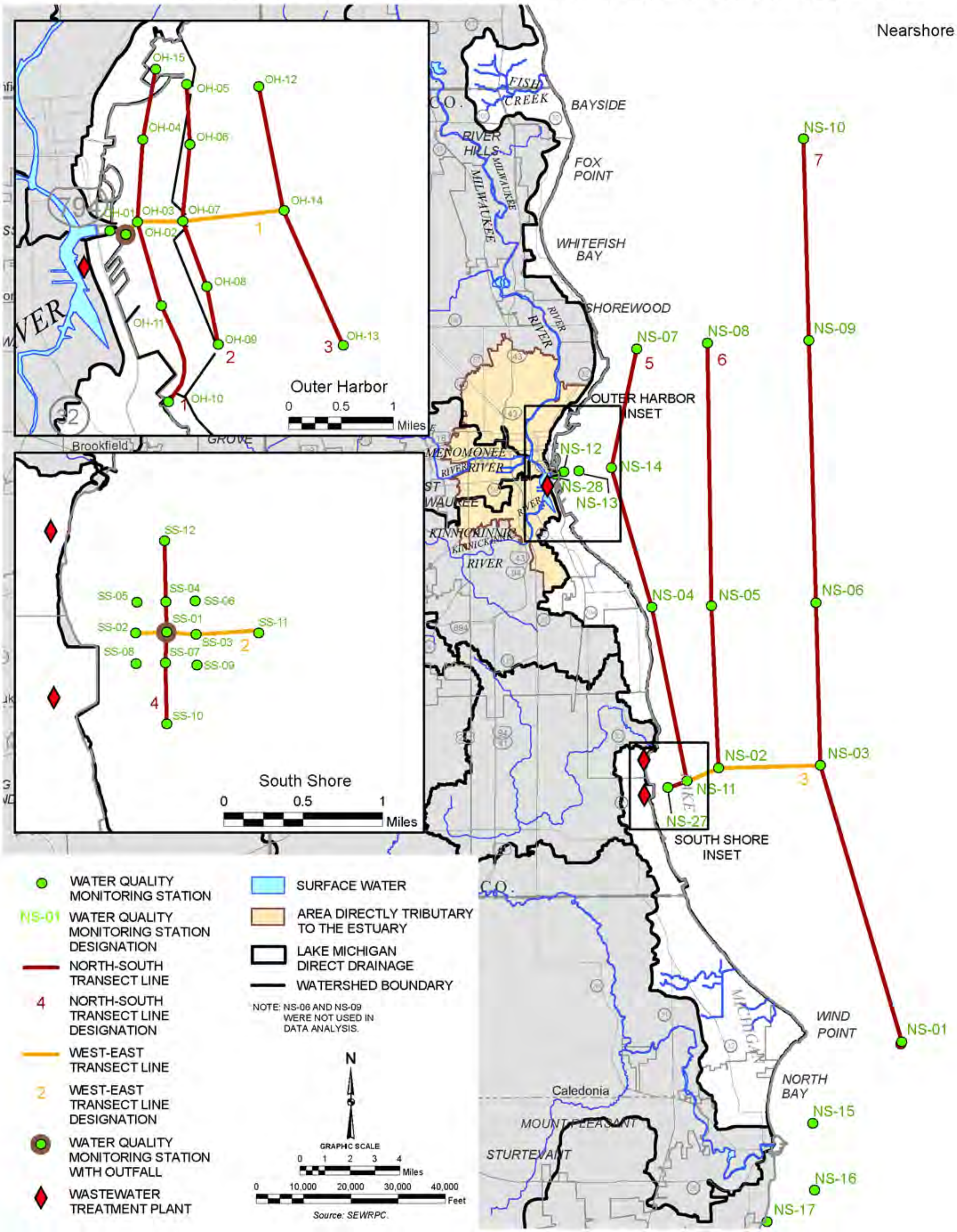


Table 36

SAMPLE SITES USED FOR ANALYSIS OF WATER QUALITY TRENDS IN THE MILWAUKEE OUTER HARBOR AND NEARSHORE LAKE MICHIGAN AREAS: 1975-2004

Location	Synonym[a]	Period of Record	Mean Depth (m) Surface	Mean Depth (m) Middle	Mean Depth (m) Bottom	Data Sources
Outer Harbor						
OH-01	NS-28	1979-2004	1.0	4.8	8.8	MMSD
OH-02	- -	1979-2004	1.0	4.6	8.4	MMSD
OH-03	NS-12	1979-2004	1.0	4.6	8.4	MMSD
OH-04	- -	1979-2004	1.0	2.8	5.0	MMSD
OH-05	- -	1979-2004	1.0	4.8	8.8	MMSD
OH-06	- -	1979-2004	1.0	5.3	10.1	MMSD
OH-07	NS-13	1979-2004	1.0	5.2	9.8	MMSD
OH-08	- -	1979-2004	1.0	5.3	10.1	MMSD
OH-09	- -	1979-2004	1.0	5.6	10.5	MMSD
OH-10	- -	1979-2004	1.0	3.0	5.4	MMSD
OH-11	- -	1979-2004	1.0	4.6	8.4	MMSD
OH-12	- -	1980-2004	1.0	6.1	11.4	MMSD
OH-13	- -	1980-2004	1.0	7.3	13.9	MMSD
OH-14	NS-14	1980-2004	1.0	8.0	15.5	MMSD
OH-15	- -	1980-2004	1.0	2.0	2.6	MMSD
Nearshore						
NS-01	- -	1980-2004	1.2	11.7	22.5	MMSD
NS-02	- -	1980-2004	1.2	5.5	10.2	MMSD
NS-03	- -	1980-2004	1.1	10.9	21.1	MMSD
NS-04	- -	1980-2004	1.2	2.8	4.8	MMSD
NS-05	- -	1980-2004	1.1	10.0	19.1	MMSD
NS-06	- -	1980-1992	1.3	15.5	26.1	MMSD
NS-07	- -	1980-2004	1.0	8.6	16.6	MMSD
NS-08	- -	1980-2004	1.0	17.8	33.2	MMSD
NS-09	- -	1980-1992	1.3	25.4	50.0	MMSD
NS-10	- -	1980-2004	1.2	37.8	71.8	MMSD
NS-11	SS-11	1980-2004	1.0	4.1	7.3	MMSD
NS-12	OH-03	1980-2004	1.0	4.2	7.4	MMSD
NS-13	OH-07	1980-2004	1.0	5.1	9.3	MMSD
NS-14	OH-14	1980-2004	1.0	8.0	14.8	MMSD
NS-15	- -	1987-1988	1.0	5.1	9.6	MMSD
NS-16	- -	1987-1988	1.0	4.8	8.7	MMSD
NS-17	- -	1987-1988	1.0	2.5	4.9	MMSD
NS-18	- -	1987-1988	1.0	4.1	8.0	MMSD
NS-19	- -	1987-1988	1.0	6.5	12.4	MMSD
NS-20	- -	1987-1988	1.0	9.3	19.4	MMSD
NS-21	- -	1987-1988	1.0	5.1	7.8	MMSD
NS-22	- -	1987-1988	1.0	4.8	9.6	MMSD
NS-23	- -	1987-1988	1.0	2.4	4.7	MMSD
NS-24	- -	1987-1988	1.0	4.8	9.3	MMSD
NS-25	- -	1987-1988	1.0	7.8	15.2	MMSD
NS-26	- -	1987-1988	1.0	20.1	41.3	MMSD
NS-27	SS-07	1998-2004	1.0	3.3	5.7	MMSD
NS-28	OH-01	1998-2004	1.0	4.4	8.0	MMSD
South Shore						
SS-01	- -	1979-2004	1.0	3.8	6.8	MMSD
SS-02	- -	1979-2004	1.0	2.9	5.3	MMSD
SS-03	- -	1979-2004	1.0	4.2	7.6	MMSD
SS-04	- -	1979-2004	1.0	3.7	6.8	MMSD
SS-05	- -	1979-2004	1.0	2.8	4.9	MMSD
SS-06	- -	1979-2004	1.0	4.1	7.6	MMSD
SS-07	NS-27	1979-2004	1.0	3.5	6.3	MMSD
SS-08	- -	1979-2004	1.0	2.8	5.0	MMSD
SS-09	- -	1979-2004	1.0	4.1	7.5	MMSD
SS-10	- -	1980-2004	1.0	3.3	6.0	MMSD
SS-11	NS-11	1980-2004	1.1	4.7	8.5	MMSD
SS-12	- -	1980-2004	1.0	3.7	6.8	MMSD

[a]*Synonymous stations are stations used in two surveys. While they represent the same location, sample collection by MMSD was conducted on different dates.*

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

at the site of the outfall from the South Shore WWTP. Most of the stations in the second group, the nearshore survey, are located in the nearshore area roughly between Fox Point and Wind Point. A few stations in this group are located south of Wind Point; however, they have rather short periods of record (Table 36). The nearshore stations were aligned along four transects (Map 27). West-east transect number 3 begins offshore from the City of Oak Creek and passes eastward through three stations. North-south transect number 5 includes five stations and is closest to the shore. North-south transect number 6 and north-south transect number 7 each pass through three stations. North-south transect number 7 is farthest from shore. Stations NS-06 and NS-09 were not included in this transect because no data were available from these stations after 1992.

Bacterial and Biological Parameters

Bacteria

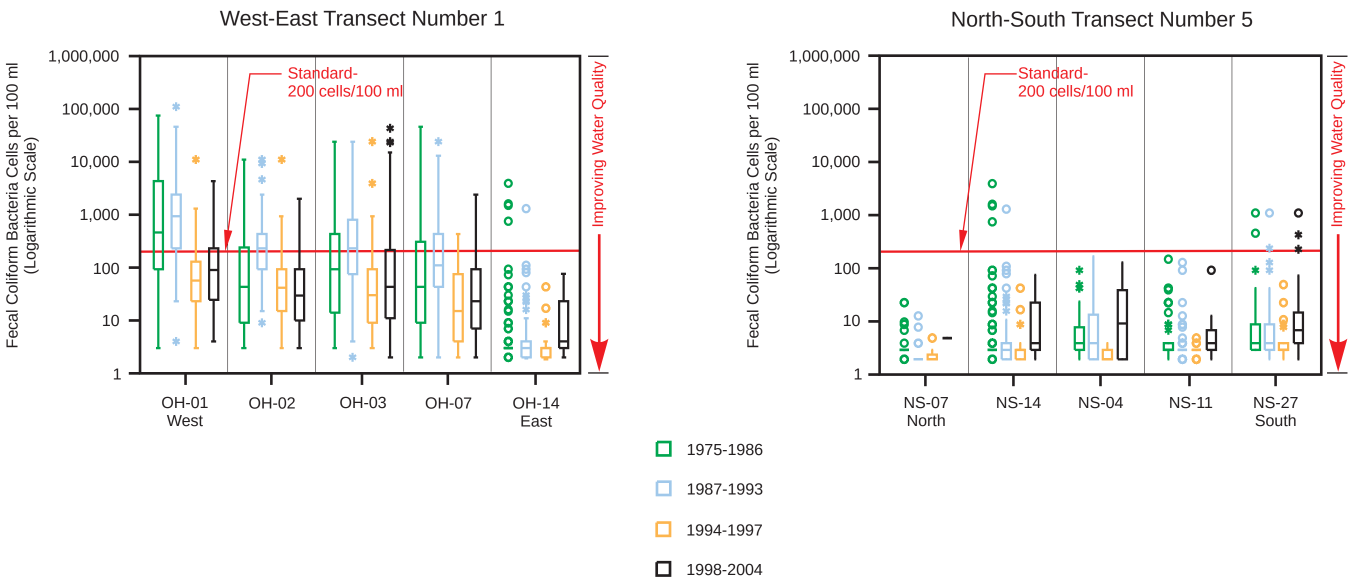
Over the period of record, the median concentration of fecal coliform bacteria in the Milwaukee Harbor estuary was about 930 cells per 100 milliliters (ml). The median concentrations of fecal coliform bacteria during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 430 cells per 100 ml, 930 cells per 100 ml, and 930 cells per 100 ml, respectively. Fecal coliform counts in the estuary varied over seven orders of magnitude, ranging from as low as one cell per 100 ml to over 2.4 million cells per 100 ml. Counts in many samples exceeded the standard of 1,000 cells per 100 ml applied by the variance covering the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers that are in the estuary. In addition, fecal coliform bacteria concentrations in the estuary in most samples exceeded the standard for full recreational use of 200 cells per 100 ml. Statistically significant trends toward concentrations of fecal coliform bacteria decreasing over time were detected at all sampling stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). In part, these trends reflect sharp decreases in fecal coliform bacteria count between the periods 1987-1993 and 1994-1997. The occurrence of these reductions coincides with the period during which the Inline Storage System came on line. This suggests that, since 1994, reductions in inputs from combined sewer overflows related to operation of the Inline Storage System have contributed to reduced loadings of fecal coliform bacteria into the estuary.

Figure 28 shows concentrations of fecal coliform bacteria at sampling stations along transects through the outer harbor and nearshore area. The median concentration of fecal coliform bacteria in the outer harbor during the period of record was 761 cells per 100 milliliters (ml). Fecal coliform bacteria counts in the outer harbor ranged from below the limit of detection to 110,000 cells per 100 ml. Concentrations of fecal coliform bacteria in the outer harbor tend to be about an order of magnitude lower than concentrations in the estuary. Concentrations of fecal coliform bacteria in the outer harbor tend to be one to two orders of magnitude higher than concentrations at stations in Lake Michigan outside of the harbor. Concentrations of fecal coliform bacteria at all stations in the outer harbor and along the breakwall decreased sharply after 1993. At several of these stations, these decreases reflect statistically significant trends toward decreasing concentrations of fecal coliform bacteria (Table 37). The occurrence of these reductions coincides with the period during which the Inline Storage System came on line. It suggests that, since 1994, reductions in inputs from combined sewer overflows related to operation of the Inline Storage System have contributed to reduced loadings of fecal coliform bacteria into the estuary and, consequently, loadings from the estuary into the outer harbor. At most sampling stations in the outer harbor, concentrations of fecal coliform bacteria increased between the periods 1994-1997 and 1998-2002. However, at most stations, the concentrations of fecal coliform bacteria observed during the period 1998-2002 were below the levels observed in the periods before 1994.

During the period of record, concentrations of fecal coliform bacteria in the nearshore Lake Michigan area ranged from below the limit of detection to 110,000 cells per 100 ml. The mean concentration was 526 cells per 100 ml. Given that the median concentration was four cells per ml, this mean is probably high due to the effects of a relatively small number of samples with unusually high concentrations. When analyzed on an annual basis, several sampling sites in the nearshore survey showed statistically significant trends toward decreasing fecal coliform concentrations (Table 37). At some stations, these trends accounted for small fractions of the variation observed.

Figure 28

FECAL COLIFORM BACTERIA CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND NEARSHORE LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Fecal coliform bacteria concentrations in the estuary tend to be positively correlated with concentrations of biochemical oxygen demand and with concentrations of several nutrients including ammonia, dissolved phosphorus, total phosphorus, and total nitrogen. These correlations may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into the estuary. Fecal coliform bacteria concentrations are also strongly positively correlated with concentrations of *E. coli*, reflecting the fact that *E. coli* constitute a major component of fecal coliform bacteria. In addition, fecal coliform bacteria concentrations at some stations in the estuary are negatively correlated with several measures of dissolved material such as alkalinity, chloride, hardness, and pH. In the outer harbor, concentrations of fecal coliform bacteria are positively correlated with concentrations of total phosphorus. The long-term trends toward declining fecal coliform bacteria concentrations represent an improvement in water quality.

MMSD began regular sampling for *E. coli* at sampling stations in the estuary and outer harbor in 2000. Median concentrations of *E. coli* in the Milwaukee Harbor estuary during the period 2000-2002 were 410 per 100 ml. The median concentrations of *E. coli* during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 290 cells per 100 ml, 520 cells per 100 ml, and 410 cells per 100 ml, respectively. Counts of *E. coli* in the estuary varied over six orders of magnitude, ranging from as low as 0.5 cells per 100 ml to 240,000 cells per 100 ml. No statistically significant differences in mean concentrations of *E. coli* were detected through ANOVA among the Kinnickinnic River, Menomonee River, and Milwaukee River portions of the estuary.

The median concentration of *E. coli* in the outer harbor during the period 2000-2002 was 22 cells per 100 ml. Counts of *E. coli* in the outer harbor varied over four orders of magnitude, ranging from below the limit of detection to 3,300 cells per 100 ml. Median concentrations of *E. coli* at sites in the outer harbor ranged between seven and 96 cells per 100 ml. Median concentrations of *E. coli* at sites outside the outer harbor were below the limit of detection.

Table 37

ANNUAL TRENDS IN WATER QUALITY PARAMETERS AT SAMPLING STATIONS IN THE MILWAUKEE OUTER HARBOR AND NEARSHORE LAKE MICHIGAN AREAS: 1975-2004[a]

	Trend (percent sampling stations)[b,c]								
	Outer Harbor			Nearshore			South Shore		
Constituent	Increase	Decrease	No Change	Increase	Decrease	No Change	Increase	Decrease	No Change
Bacteria and Biological									
Fecal Coliform[d]	0	53	47	0	71	29	8	0	92
E. coli[d]	0	0	60	0	0	21	0	0	66
Chlorophyll-*a*[d]	0	67	33	0	93	7	0	100	0
Chemical/Physical									
Alkalinity	7	0	93	0	0	100	0	25	75
Biochemical Oxygen Demand[d]	7	20	0	0	29	0	0	33	0
Chloride[d]	100	0	0	79	0	21	100	0	0
Dissolved Oxygen	0	53	47	0	21	79	0	100	0
Hardness	0	7	93	0	0	100	0	0	100
pH	47	7	46	29	0	71	75	0	25
Secchi Depth	100	0	0	100	0	0	100	0	0
Specific Conductance	0	87	13	0	29	14	0	100	0
Suspended Material									
Total Suspended Sediment	0	0	0	0	0	0	0	0	0
Total Suspended Solids	40	7	53	21	0	21	8	0	92
Nutrients									
Ammonia[d]	0	100	0	0	50	50	0	100	0
Kjeldahl Nitrogen[d]	0	87	13	0	29	71	0	25	75
Nitrate[d]	93	0	7	64	0	36	100	0	0
Nitrite[d]	27	33	40	14	21	65	8	75	17
Organic Nitrogen[d]	53	0	47	21	0	79	17	0	83
Total Nitrogen[d]	0	33	67	0	29	71	0	0	100
Dissolved Phosphorus[d]	20	0	80	50	0	50	92	0	8
Total Phosphorus[d]	7	60	33	64	21	15	25	0	75
Metals									
Arsenic[d]	86	0	7	93	0	7	8	0	92
Cadmium[d]	0	100	0	0	100	0	0	100	0
Chromium[d]	0	93	7	0	100	0	0	100	0
Copper[d]	13	0	87	14	0	86	0	0	100
Lead[d]	0	100	0	0	100	0	0	100	0
Mercury[d]	0	7	13	0	0	7	0	0	0
Nickel[d]	0	100	0	0	100	0	0	100	0
Zinc[d]	40	0	60	64	0	36	25	0	75

[a]*Trends were assessed through linear regression analysis. A trend was considered significant if the regression showed a significant slope at P = 0.05 or less. Because MMSD stopped sampling during the winter in 1987, data from winter months were not included in the annual trend analysis.*

[b]*Trends were assessed at 15 sampling stations from the outer harbor survey, 14 sampling stations in the nearshore survey, and 12 sampling stations from the South Shore survey.*

[c]*For any constituent, the total percentage of sampling stations assessed in a survey may not add up to 100 percent because data at some sampling stations were insufficient for assessing time-based trends.*

[d]*These data were log-transformed before being entered into regression analysis.*

Source: SEWRPC.

MMSD began regular sampling for *E. coli* at four long-term sampling stations in the nearshore survey in 2003. These stations were in or near the outer harbor. Concentrations of *E. coli* at these stations ranged from below the limit of detection to 3,300 cells per 100 ml. The mean concentration at these stations was 215 cells per 100 ml. Given that the median concentration was 20 cells per ml, this mean is probably high due to the effects of a relatively small number of samples with unusually high concentrations.

During 2003 and 2004, the University of Wisconsin-Milwaukee Great Lakes WATER Institute conducted studies on the transport and fate of bacteria through the estuary, outer harbor, and adjacent areas of Lake Michigan.[19] These studies included extensive surveys of *E. coli* concentrations to characterize transport of bacteria through the estuary and harbor and antibiotic resistance testing to determine whether fecal coliform bacteria including *E. coli* were derived from human sources. Among the results of these studies were the following findings:

- After a rainfall, bacterial pollution travels in a distinct plume with river water as it moves through the outer harbor and past the harbor breakwall,

- Concentrations of *E. coli* outside of the plume are lower than can be accounted for by the effects of dilution with lake water,

- During combined sewer overflow (CSO) events, *E. coli* concentrations decreased drastically outside of the harbor breakwall during overflows as the pollution plume mixed with lake water, and

- During overflow events, *E. coli* could not be detected at concentrations above the background concentration of 10 cells per 100 ml at distances greater than 3.1 miles from the harbor breakwall.

*Chlorophyll-*a

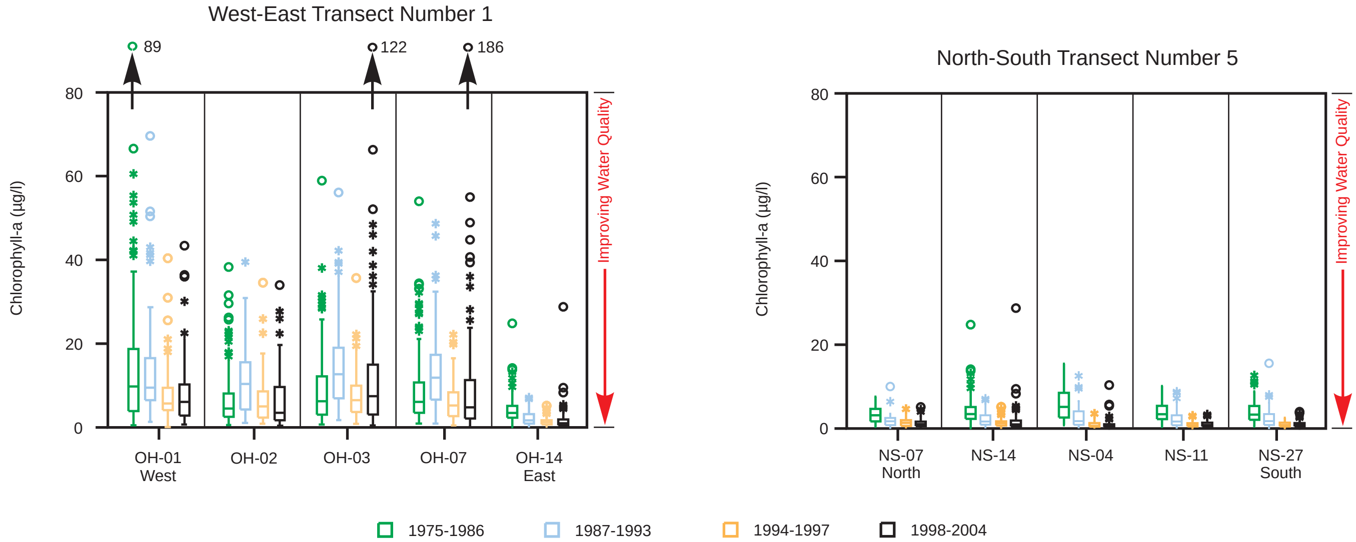
Over the period of record, the mean concentration of chlorophyll-*a* in the Milwaukee Harbor estuary was 16.6 μg/l. Individual samples of this parameter ranged from 0.1 μg/l to 382.0 μg/l. Significant differences were detected among the mean values of chlorophyll-*a* in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers. The mean concentration of chlorophyll-*a* in the portion of the Milwaukee River in the estuary was significantly higher than the mean concentrations of chlorophyll-*a* in the Kinnickinnic and Menomonee Rivers during all periods. During the baseline period, the mean concentration of chlorophyll-*a* in the portion of the Menomonee River in the estuary was higher than the mean concentration of chlorophyll-*a* in portion of the Kinnickinnic River in the estuary. Concentrations of chlorophyll-*a* have decreased in much of the estuary, especially in the Kinnickinnic River and Menomonee River portions. Statistically significant trends toward decreasing chlorophyll-*a* concentrations were detected at sampling stations in the estuary portions of both these rivers (see Appendix C in SEWRPC Technical Report No. 39). These changes occurred at roughly the time when the Inline Storage System came online and may reflect reductions of nutrient inputs related to the reduction in the number of combined sewer overflows. Decreases in chlorophyll-*a* concentrations have also been observed at sampling stations in the estuary portion of the Milwaukee River; however, these decreases generally took place after 1998.

Over the period of record, the mean concentrations of chlorophyll-*a* in the outer harbor and nearshore Lake Michigan areas were 8.9 μg/l and 4.9 μg/l, respectively. Figure 29 shows chlorophyll-*a* concentrations at stations along transects through the outer harbor and in the nearshore area. In all periods, chlorophyll-*a* concentrations were higher at sampling stations in, and immediately adjacent to, the outer harbor than at sampling stations farther outside the harbor. At most stations in the outer harbor, concentrations of chlorophyll-*a* increased between the periods 1975-1986 and 1987-1993. This increase was followed by a decrease after 1994. At some stations within the outer harbor, chlorophyll-*a* concentrations increased slightly after 1997. Chlorophyll-*a* concentrations in the nearshore area have decreased over time. The magnitude of the decreases varies among stations. The decreases in chlorophyll-*a* concentrations at sampling stations in the outer harbor and nearshore area represent statistically significant trends (Table 37). The decreases in chlorophyll-*a* concentrations in the harbor and nearshore area have been accompanied by improvements in the trophic status of the nearshore areas as measured by the Carlson

[19]*Sandra L. McLellan and Erika Jensen Hollis, Bacteria Source, Transport, and Fate Study—Phase I, Volume 3, University of Wisconsin Great Lakes WATER Institute Contribution No. 470, August 2005.*

Figure 29

CHLOROPHYLL-A CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND NEARSHORE LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Trophic State Indices and the Lake Trophic Status Index.[20] Several factors may account for the decrease in chlorophyll-*a* concentrations in the outer harbor and nearshore areas of Lake Michigan. Much of these decreases appear to be the result of filtering activities of zebra mussels and quagga mussels. Beds of zebra mussels containing 100,000 or more mussels per square meter have been reported in Lake Erie[21] and Lake Michigan.[22] Large adult zebra mussels have been observed to remove particles from water at rates over 1.5 liters per day through filter feeding.[23] This removal of phytoplankton from the water column coupled with reduced nutrient loads to the inner harbor, resulting from both reductions of combined sewer overflows since the Inline Storage System came online and nonpoint source pollution control efforts, may account for the decrease in chlorophyll-*a* concentrations in the inner harbor.

Several factors can affect chlorophyll-*a* concentration in the outer harbor and nearshore area. Phytoplankton populations, which chlorophyll-*a* concentrations estimate, are strongly influenced by the availability of nutrients, especially phosphorus and, during the spring diatom bloom, silica. Changes in levels of nutrient input can be

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[20]*Milwaukee Metropolitan Sewerage District, "Trophic State and Chlorophyll in the Milwaukee, Wisconsin Harbor and Surrounding Nearshore Waters," October 2001.*

[21]*F.L. Snyder, M.B. Hilgendorf, and D.W. Garton, "Zebra Mussels in North America: The Invasion and its Implications," Ohio Sea Grant, Ohio State University, Columbus, Ohio, http://www.sg.ohio-state.edu/fsearch.html, 1997.*

[22]*J.E. Marsden, N. Trudeau, and T. Keniry, "Zebra Mussel Study on Lake Michigan: Final Report to the Illinois Department of Conservation," Illinois Natural History Survey,* Technical Report No. 93/4, *1993.*

[23]*Jin Lei, Barry S. Payne, and Shiao Y. Wang, "Filtration Dynamics of the Zebra Mussel,* Dreissena polymorpha,*"* Canadian Journal of Fisheries and Aquatic Sciences, *Volume 48, 1996.*

reflected as changes in chlorophyll-*a* concentration. Grazing by zooplankton and other suspension feeding animals, such as zebra mussels, can remove phytoplankton from the water column, resulting in a decrease in the concentration of chlorophyll-*a*. At most stations in the estuary, outer harbor, and nearshore area chlorophyll-*a* concentrations are negatively correlated with concentrations of nitrate. In addition, chlorophyll-*a* concentrations in the estuary and outer harbor are negatively correlated with concentrations of dissolved phosphorus. This reflects the role of these compounds as nutrients for algal growth. As algae grow, they remove these compounds from the water and incorporate them into cellular material. Chlorophyll-*a* concentrations are also positively correlated with temperature, reflecting higher algal growth rates and standing crops during warmer weather. Chlorophyll-*a* concentrations at some stations are also negatively correlated with alkalinity. Since chlorophyll-*a* concentrations in water strongly reflect algal productivity, this correlation probably reflects lowering of alkalinity during photosynthesis through removal of inorganic carbon, mostly carbon dioxide, bicarbonate, and carbonate, from the water. The trends toward decreasing chlorophyll-*a* concentrations in the estuary, outer harbor, and nearshore area represent improvements in water quality.

Chemical and Physical Parameters

Temperature

The mean water temperature in the Milwaukee Harbor estuary during the period of record was 14.8 degrees Celsius (ºC). Water temperatures in individual samples ranged from 0ºC to 34.1ºC. The mean water temperatures during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 12.2ºC, 14.8ºC, and 13.0ºC, respectively. Analysis of variance showed that during all periods, the mean water temperature in the Menomonee River portion of the estuary was significantly higher than the mean water temperatures in the Kinnickinnic River and Milwaukee River portions of the estuary. During most periods, no statistically significant differences were found between mean water temperatures in the Kinnickinnic River and Milwaukee River portions of the estuary. Statistically significant trends toward increasing water temperature were detected at most sampling stations in the estuary, though at several stations these trends accounted for only a small portion of the variation in the data (see Appendix C in SEWRPC Technical Report No. 39).

The median water temperature in the outer harbor over the period of record was 12.5ºC. Water temperatures in individual samples ranged from 0.4ºC to 27.6ºC. Figure 30 shows water temperatures collected at sampling stations along transects through the outer harbor and nearshore area. Water temperatures of water flowing into the outer harbor from the estuary tended to be warmer than ambient water temperatures in the outer harbor. Similarly, water temperatures in the outer harbor tended to be warmer than water temperatures at stations outside the breakwall.

Figure 30 shows evidence of changes over time in the temperature regime in the outer harbor. Temperatures at most of the stations in or adjacent to the outer harbor appear to have remained stable or decreased over the three periods from 1987 through 2004. It is important to note that the increase in temperatures between the periods 1975-1986 and 1987-1993 shown in Figure 30 was due to the inclusion of data collected during the winter during the earlier period.[24] This apparent stability obscures the presence of some trends in the data. When examined on an annual basis, regression analysis revealed that there were statistically significant trends toward increasing water temperatures at most sampling stations in the outer harbor.[25] These trends appear to result, in part, from the annual warming of water in the outer harbor occurring earlier and the annual cooling of water in the outer harbor occurring later in recent years than they did during the past.

The median water temperature in the nearshore Lake Michigan area was 11.4ºC, with temperatures in individual samples ranging from 0ºC to 27.6ºC. There are several patterns in temperature data from the nearshore area. First,

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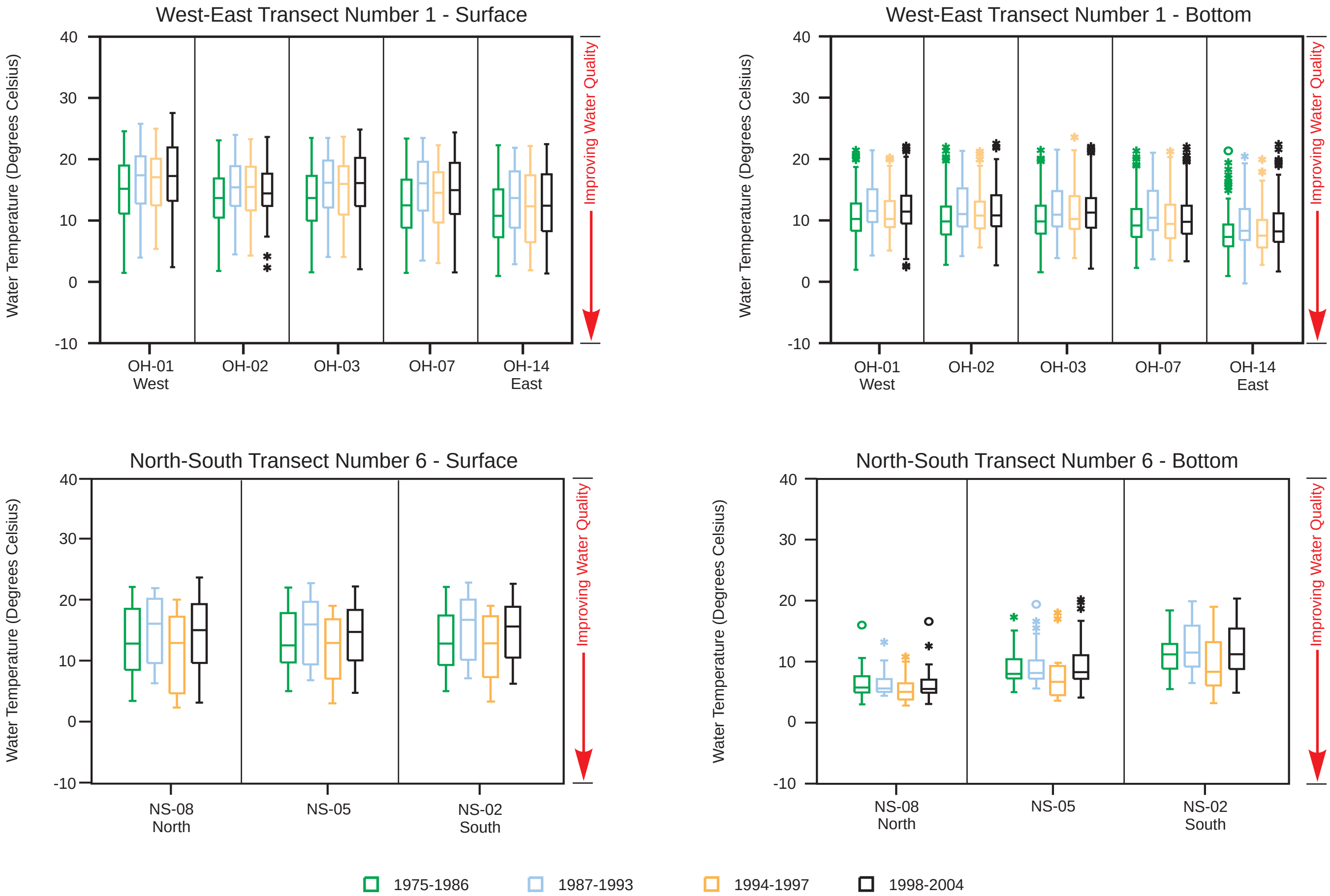
[24]*MMSD stopped sampling during the winter in 1987.*

[25]*The trend analysis of water temperatures excluded the winter data, which were only collected from 1975 through 1986.*

Figure 30

WATER TEMPERATURE AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

water temperatures tended to be higher in surface water samples than in samples collected from the bottom. This reflects thermal stratification of Lake Michigan during summer months (see the section on Water Quality of Lakes and Ponds above). In the open waters of Lake Michigan, the epilimnion may contain the upper 20 meters or more of the water column at the height of stratification. Nearer to shore, it may be thinner due to sediment resuspension from wind-driven turbulent mixing, upwelling, higher turbidity from sediment inputs from adjacent land, and algal growth. Second, temperatures in surface water tended to be lower at stations that were farther offshore; however, statistical analysis did not detect any significant differences or trends among stations based on distance from shore. Third, water temperatures in samples collected near the bottom showed considerable variation among sites. This variation tended to correspond to water depth with temperatures being cooler and showing less variability at deeper sites. Fourth, water temperatures at sampling stations in the nearshore area show a complicated pattern of change over time. At most stations, they increased between the periods 1975-1986 and 1987-1993, decreased after 1993, and increased after 1998. It is important to note that the increase between the periods 1975-1986 and 1987-1993 was due to the inclusion of data collected during the winter in the earlier period.

Baseline period mean water temperatures at station NS-11 exceeded historical means during the months of July and August. These higher mean water temperatures during summer months may reflect changes in summer wind patterns over the Great Lakes. Prevailing winds during summer months over southern Lake Michigan shifted from coming from the southwest during the 1980s to coming from the east during the 1990s.[26] This change in wind direction was accompanied by an increase in wind speed, especially during the month of August. It is important to note that this change in wind direction and speed represents the average condition during the summer. During any summer, there was variation in wind direction and speed. What this change in average condition means is that during summer months in the 1990s, winds coming from the east were much more common than they were during summer months in the 1980s. Any effects associated with easterly winds, should also be expected to be more common during the 1990s. A change in wind direction toward easterly winds would tend to push warmer, epilimnetic water toward the western shore of the Lake and might result in piling up of warmer water in the nearshore area. This sort of change would make the nearshore area more suitable for species whose thermal tolerances and preferences are more similar to the relatively warmer summer water temperatures seen during the 1990s. By contrast, the area may have become less suitable for species whose thermal tolerances and preferences are more similar to the relatively cooler summer water temperatures seen during the 1980s. This may be a factor in the recent resurgence of *Cladophora* as a nuisance alga.

Water temperatures in the estuary, outer harbor, and nearshore area are the result of a complex process driven by several factors. Ultimately, water temperatures in these areas are the result of solar heating and the seasonal cycle. In the outer harbor, the influx of relatively warm water from the estuary and solar heating tend to increase water temperatures while the influx of relatively cool water from Lake Michigan through the gaps in the breakwall tends to decrease water temperatures. The relative strengths of these influences will be affected by factors such as water levels in the Lake, the amount of discharge from the Rivers flowing into the estuary, and water clarity in the outer harbor. In the nearshore area, climatic factors such as wind patterns can affect water temperatures.

The trends toward increasing water temperature in estuary stations and some outer harbor stations represent a reduction in water quality.

Alkalinity

The mean value of alkalinity in the Milwaukee Harbor estuary over the period of record was 199.2 mg/l as $CaCO_3$. The data show moderate variability, ranging from 5.0 to 999.0 mg/l as $CaCO_3$. During all periods, except for the period 1987-1993, significant differences were detected among the mean values of alkalinity in the estuary portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers. Mean alkalinity in the Milwaukee River portion of the estuary was significantly higher than the mean alkalinity in both the Menomonee River and Kinnickinnic River portions of the estuary and mean alkalinity in the Menomonee River portion of the estuary was significantly higher than mean alkalinity in the Kinnickinnic River portion of the estuary. These differences may reflect differences in the relative importance of groundwater and surface runoff on the chemistry of water in different portions of the estuary with surface runoff having a greater influence on the water chemistry of the Kinnickinnic River portion of the estuary. The mean concentration of alkalinity in the outer harbor was 136.9 mg/l as $CaCO_3$. The range of variation in the outer harbor was greater than that seen in the estuary with values ranging from 5.0 to 1,531 mg/l as $CaCO_3$. The mean value of alkalinity in the nearshore Lake Michigan area was 128.9 mg/l as $CaCO_3$, with values ranging from 5.0 to 1,531 mg/l as $CaCO_3$. Few statistically significant time-based trends were detected in alkalinity in the estuary, outer harbor, and nearshore area. Trends toward increasing alkalinity were detected at a few stations, but these either accounted for a small portion of the variation in the data or were based on relatively small numbers of samples. Alkalinity concentrations in the estuary and outer harbor are strongly correlated with hardness, specific conductance, and concentrations of chloride, all parameters which, like alkalinity, measure amounts of dissolved material in water. At several stations in the estuary and outer harbor, alkalinity is negatively correlated with temperature, reflecting the fact that it indirectly measures concentrations of carbon dioxide in water and that solubility of gases in water decreases with increasing temperature. Few correlations were found between alkalinity and other water quality parameters in the nearshore survey.

[26] *James T. Waples and J. Val Klump, "Biophysical Effects of a Decadal Shift in Summer Wind Direction over the Laurentian Great Lakes,"* Geophysical Research Letters, *Volume 29, 2002.*

Biochemical Oxygen Demand

The mean concentration of BOD in the Milwaukee Harbor estuary during the period of record was 2.88 mg/l. Concentrations in individual samples varied from below the limit of detection to 52.43 mg/l. The mean values of BOD during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 2.76 mg/l, 2.88 mg/l, and 2.96 mg/l, respectively. Statistically significant differences were found among mean BOD concentrations in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary; however, the relationships among BOD concentrations in these sections of the estuary appear to be dynamic and changing over time. During the period 1998-2002, the mean concentrations of BOD in the Menomonee River and Milwaukee River portions of the estuary were significantly higher than the mean concentration of BOD in the Kinnickinnic River portion of the estuary. When examined on an annual basis, statistically significant decreasing trends in BOD concentration over time were detected at all stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). At several stations, these trends accounted for a substantial portion of the variation in the data. The fact that the sampling stations in the estuary are all within the area served by combined sewers suggests that the decrease over time in BOD concentrations in the estuary is being caused, at least in part, by reductions of inputs from combined sewer overflows resulting from operation of the Inline Storage System. The mean concentration of BOD over the period of record at sampling stations in the outer harbor was 1.75 mg/l. At most of those stations for which sufficient data exist, the concentration of BOD has decreased over time. These decreases represent statistically significant trends (Table 37). The mean concentration of BOD in the nearshore Lake Michigan area during the period of record was 1.53 mg/l. Individual samples varied from below the limit of detection to 8.80 mg/l. It is important to note that since data were available from only four sampling stations in the nearshore survey that are relatively close to either the outer harbor or the outfall from the South Shore WWTP, this average may not be representative of concentrations in other sections of the nearshore area. Table 37 shows that statistically significant trends toward decreasing BOD concentrations were detected at all sampling stations for which data are available.

Several factors may influence BOD concentrations in the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan area. Parts of the estuary and outer harbor act as settling basins for suspended material. Decomposition of organic material in sediment may act as a source of BOD to overlying water. BOD concentrations in the estuary are positively correlated at most stations with concentrations of fecal coliform bacteria and some nutrients such as ammonia, organic nitrogen, and total phosphorus. Some of these correlations also occurred in the outer harbor and nearshore area. These correlations may reflect the fact that these pollutants, to some extent, share common sources and modes of transport into the estuary. In addition, at some stations BOD concentrations are negatively correlated with dissolved oxygen concentrations. The declining trends in BOD concentrations over time in the estuary, outer harbor, and nearshore area represent an improvement in water quality.

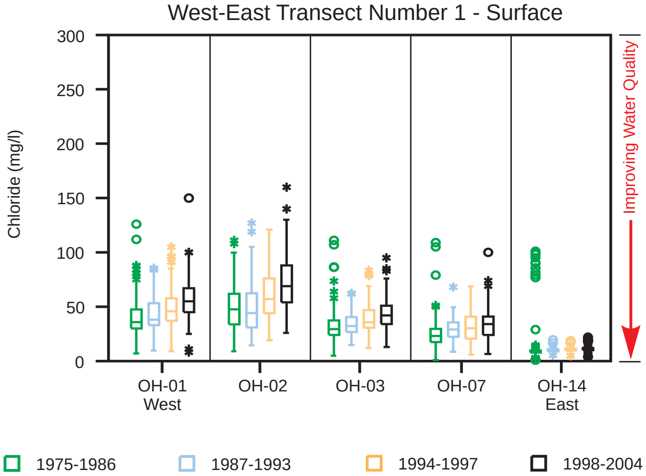
Chloride

The mean chloride concentration in the Milwaukee Harbor estuary for the period of record was 61.7 mg/l. All sites show wide variations between minimum and maximum values. Individual samples of this parameter ranged from 5.6 mg/l to 650.5 mg/l. Statistically significant trends toward increasing chloride concentration were detected at all stations in the estuary. The mean concentration of chloride in the outer harbor during the period of record was 32.5 mg/l. Concentrations in individual samples ranged between 0.3 mg/l to 250.0 mg/l. Figure 31 shows chloride concentrations at sampling stations in and around the outer harbor. Concentrations of chloride were higher at stations in the inner harbor than at stations outside the breakwall. At all stations, chloride concentrations have increased over time. Table 37 shows that statistically significant trends toward increasing chloride concentration were detected at all sampling stations within, and adjacent to, the outer harbor.

Chloride concentrations in the estuary and outer harbor show strong positive correlations with alkalinity, hardness, and specific conductance, all parameters which, like chloride, measure amounts of dissolved material in water. Chloride concentrations in the estuary are also positively correlated with TSS concentrations. This may reflect common mechanisms of entry into surface waters. In addition, chloride concentrations in the estuary are negatively correlated with temperature, reflecting the use of deicing salts on streets and highways during

Figure 31

CHLORIDE CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTES: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

The planning standard of 1,000 mg/l, the acute toxicity standard of 757 mg/l, and the chronic toxicity standard for aquatic life of 395 mg/l are not shown.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

the winter. The increase in chloride concentrations in the estuary and outer harbor represents a decline in water quality.

The mean concentration of chloride in the nearshore Lake Michigan waters over the period of record was 21.1 mg/l. Concentrations in individual samples ranged between 0.9 mg/l and 160.0 mg/l. Chloride concentrations in the nearshore area have also increased over time (Table 37). Chloride concentrations in the nearshore area show positive correlations with alkalinity and specific conductance, both parameters which, like chloride, measure amounts of dissolved material in water.

The increases in chloride concentrations in the outer harbor and nearshore area have occurred during a period when the ambient concentrations of chloride in offshore areas of the Lake have also increased. Between 1983 and 1999, the mean concentration of chloride at sampling stations in offshore areas of Lake Michigan increased from 8.68 mg/l to 10.86 mg/l.[27] Given that Lake Michigan contains approximately 1,180 cubic miles of water, it would require over 10.8 million tons of chloride, for instance in the form of over 17.8 million tons of salt, to produce an increase in chloride concentrations of this magnitude throughout the Lake. While this is a very rough estimate of the amount of chloride required to account for the observed increase in concentration, it does give a sense of the amount of material that the increase represents.

The distribution of chloride concentrations in tributaries to Lake Michigan, the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan areas indicate several sources of chloride to Lake Michigan. Chloride in water flowing into the Lake from tributaries is one source. Mean concentrations of chloride measured in streams and rivers flowing into the Lake are many times higher than the ambient concentration offshore. For example, mean concentrations of chloride in Fish Creek, Oak Creek, and the Root River were about 250 mg/l, 158 mg/l, and 143 mg/l, respectively (see SEWRPC Technical Report No. 39). The mean concentrations of chloride in the Milwaukee Harbor estuary and the outer harbor were about 62 mg/l and 32 mg/l, respectively. While these concentrations are somewhat lower than those observed in Fish Creek, Oak Creek, and the Root River, in part due to mixing with water from the Lake, they are still higher than mean ambient concentrations in offshore areas of the Lake. The mean chloride concentration of 62 mg/l in the estuary and the mean discharge at Jones Island of 448 cfs suggest that the Kinnickinnic, Menomonee, and Milwaukee Rivers contributed approximately 490,000 tons of chloride, or the equivalent of 806,000 tons of salt, to Lake Michigan over the period 1983 to 1999. This represents about 4.5 percent of the chloride required to account for the increase in chloride concentrations in the Lake. While this is a very rough estimate, the fact that discharge from the Milwaukee Harbor estuary represents about 1.5 percent of the discharge into Lake Michigan from major tributaries[28] suggests that it is not an

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[27]*Mark E. Holey and Thomas N. Trudeau, "The State of Lake Michigan in 2000,"* Great Lakes Fisheries Commission Special Publication No. 05-01, *2005.*

[28]*Clifford H. Mortimer,* Lake Michigan in Motion: Responses of an Inland Sea to Weather, Earth-spin, and Human Activities, *The University of Wisconsin Press, 2004.*

unreasonable estimate. Additional likely sources of chloride to Lake Michigan include effluent from wastewater treatment plants and direct runoff from the Lake Michigan direct drainage area.

The increase in chloride concentrations detected at stations in the nearshore Lake Michigan areas represents a decrease in water quality.

Dissolved Oxygen

Over the period of record, the mean concentration of dissolved oxygen in the Milwaukee Harbor estuary was 7.2 mg/l. The data ranged from concentrations that were undetectable to concentrations in excess of saturation. The mean concentrations of dissolved oxygen during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 6.2 mg/l, 5.8 mg/l, and 8.6 mg/l, respectively. During most periods, mean concentrations of dissolved oxygen in the Milwaukee River portion of the estuary were significantly higher than mean concentrations in the Kinnickinnic River and Menomonee River portions of the estuary. No statistically significant differences were found between mean concentrations of dissolved oxygen in the Kinnickinnic River and Menomonee River portions of the estuary. Few statistically significant time-based trends were found in dissolved oxygen concentration in the estuary. When examined on an annual basis, trends toward increasing concentration for dissolved oxygen were detected at four stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). Comparison of these trends toward increasing dissolved oxygen concentrations at some stations in the estuary to trends toward decreasing BOD and decreasing ammonia suggests that a decrease in loadings of organic pollutants may be responsible for the increase in dissolved oxygen concentration at these sites during the summer. This is a likely consequence of a reduction in loadings from combined sewer overflows since the MMSD Inline Storage System went on line.

The mean concentration of dissolved oxygen during the period of record in the outer harbor was 9.3 mg/l. The data ranged from concentrations that were undetectable to concentrations in excess of saturation. Figure 32 shows dissolved oxygen concentrations at sampling stations along transects through the outer harbor and in the nearshore Lake Michigan area. Concentrations of dissolved oxygen tend to be lower at stations in the outer harbor than at stations outside the breakwall. Figure 32 also shows changes over time in dissolved oxygen concentrations. The range of dissolved oxygen concentrations decreased at most stations after 1986, reflecting the fact that after 1986 MMSD discontinued sampling during the winter when increased dissolved oxygen concentrations would occur due to the higher solubility of oxygen in colder water. Thus, this decrease reflects changes in the sampling protocol, not changes in the range of dissolved oxygen concentrations in the River. Dissolved oxygen concentrations decreased at several stations in the outer harbor between the periods 1994-1997 and 1998-2004. Statistically significant trends toward decreasing dissolved oxygen concentration were detected at some sampling stations in and adjacent to the outer harbor (Table 37). These generally accounted for a small portion of the variation in the data.

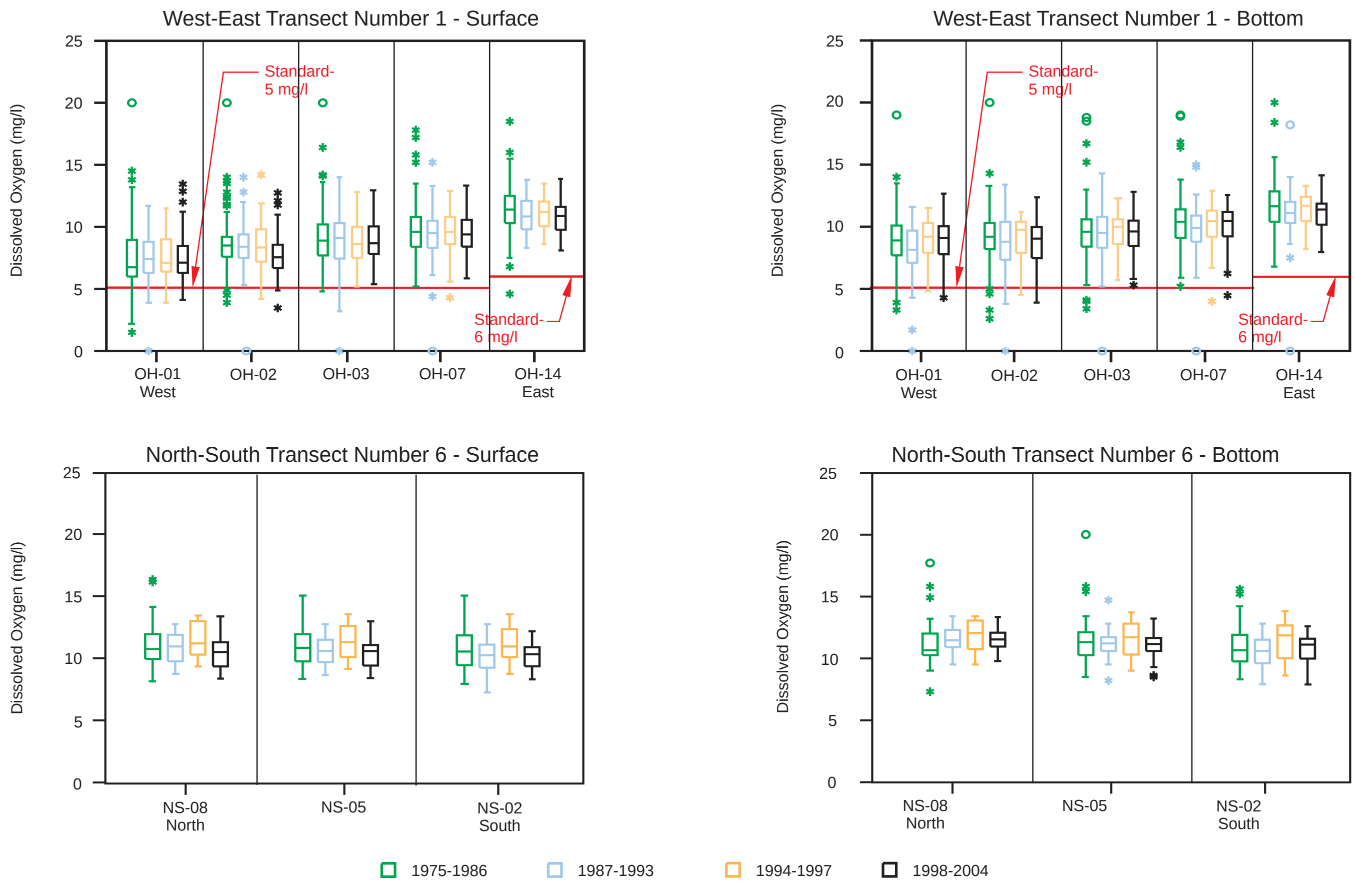
Several factors can affect dissolved oxygen concentrations in the estuary and outer harbor.

- First, decomposition of organic matter contained in the sediment, through chemical and especially biological processes, removes oxygen from the overlying water, lowering the dissolved oxygen concentration. Portions of the estuary and outer harbor act as settling basins in which material suspended in water sink and fall out into the sediment. This supplies organic material to the sediment in these sections of the estuary and outer harbor.

- Second, influxes of water from Lake Michigan and from the Rivers that flow into the estuary may influence dissolved oxygen concentrations in the estuary and outer harbor. When dissolved oxygen concentrations in these waterbodies are higher than in the estuary, mixing may act to increase dissolved oxygen concentrations in the lower estuary. Similarly, when dissolved oxygen concentrations in these waterbodies are lower than in the estuary, mixing may act to decrease dissolved oxygen concentrations in the lower estuary.

Figure 32

DISSOLVED OXYGEN CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

- Third, dissolved oxygen concentrations at some stations in the estuary and outer harbor are positively correlated with pH. This reflects the effect of photosynthesis on both of these parameters. During photosynthesis, algae and plants remove carbon dioxide from the water. This tends to raise the pH of the water. At the same time, oxygen is released as a byproduct of the photosynthetic reactions.

- Fourth, the solubility of oxygen in water is dependent upon water temperature. As temperature increases, oxygen becomes less soluble. Thus, increases in water temperature in the estuary will tend to lower the concentration of dissolved oxygen.

- Fifth, dissolved oxygen concentrations in water can be affected by numerous other factors including the presence of aquatic plants, sunlight, and the amount of and type of sediment.

The increases in dissolved oxygen concentrations at some stations in the estuary represent an improvement in water quality. The decreases in dissolved oxygen at some stations in the outer harbor represent a decline in water quality.

Over the period of record, the mean concentration of dissolved oxygen in the nearshore Lake Michigan area was 10.2 mg/l. At sampling stations in the nearshore area, dissolved oxygen concentrations during the period 1987-

1993 were lower than concentrations during the period 1975-1986 (Figure 32). This was followed by an increase in concentrations during the period 1994-1997 and another decrease during the period 1998-2004. Figure 32 also shows that the range of dissolved oxygen concentrations decreased at most stations after 1986 in the 1987 through 1993 time period. As in the outer harbor, this reflects the fact that MMSD discontinued sampling during the winter after 1986. While this at least partially accounts for the decrease in dissolved oxygen concentrations after 1986, it does not explain subsequent changes. Dissolved oxygen concentrations follow a strong seasonal pattern with highest concentrations occurring during the winter and lowest concentrations occurring during the summer. This seasonal pattern is driven by changes in water temperature. In addition, the metabolic demands and oxygen requirements of most aquatic organisms, including bacteria, tend to increase with increasing temperature. Higher rates of bacterial decomposition when the water is warm may contribute to the declines in the concentration of dissolved oxygen observed during the summer. Statistically significant trends toward decreasing dissolved oxygen concentration were detected at all sampling stations in the South Shore survey and at a few stations in the nearshore survey (Table 37). For the most part, these trends accounted for only a small portion of the variation in the data. It is important to note that data from samples collected during the winter were excluded from this analysis, so the 1987 change in MMSD's sampling schedule does not account for these trends.

Several other factors in addition to temperature can affect dissolved oxygen concentrations in the nearshore Lake Michigan area. First, thermal stratification, which separates the upper portion of the water column from the water underneath, will prevent oxygen from the atmosphere from replenishing dissolved oxygen in deeper waters. Because of this, dissolved oxygen concentrations in the nearshore area will tend to vary with depth during periods of stratification. In the upper layer, dissolved oxygen concentrations, in the absence of other process, will tend to be in equilibrium with the atmosphere. This often results in dissolved oxygen concentrations being at or near the saturation concentrations determined by water temperature. Because water temperatures in the lower layer are much cooler than water temperatures in the upper layer during stratification, in the absence of any other processes, dissolved oxygen concentrations in the lower layer may be higher than dissolved oxygen concentrations in the upper layer. In Lake Michigan, thermal stratification sets up in the spring, generally beginning in the nearshore areas and moving out into the Lake. Stratification breaks down in the fall and winter with the extension of the boundary between the two layers being pushed progressively lower by loss of heat from the upper layer and wind-driven mixing. Second, decomposition of organic material in the water and underlying sediments, through chemical and especially biological processes, removes oxygen from the water, lowering the dissolved oxygen concentration. The organic material causing this can originate in the Lake through biological production, or enter from runoff or discharges from the adjacent land. Third, dissolved oxygen concentrations at most sampling stations in the nearshore area are positively correlated with chlorophyll-*a* concentrations. This reflects the effect of photosynthesis on dissolved oxygen concentrations. During photosynthesis, algae release oxygen as a byproduct of the photosynthetic reactions. Fourth, dissolved oxygen concentrations in water can be affected by numerous other factors including the presence of aquatic plants, sunlight, and the amount and type of sediment.

The trends toward decreasing dissolved oxygen concentration at some sampling stations in the nearshore area represent a decline in water quality. It is important to note that this decline appears to be driven by changes in water temperature in Lake Michigan which, in turn, are being driven by climatic variations.

Hardness

The mean value of hardness in the Milwaukee Harbor estuary over the period of record was 254.7 mg/l as $CaCO_3$. On a commonly used scale, this is considered to be very hard water. The data show moderate variability, ranging from 18.6 to 750.1 mg/l as $CaCO_3$. During most periods, mean values of hardness in the estuary portion of the Kinnickinnic River was significantly lower than mean values of hardness in the estuary portions of the Menomonee and Milwaukee Rivers. These differences may reflect differences in the relative importance of groundwater and surface runoff on the chemistry of water in different portions of the estuary with surface runoff having a greater influence on the water chemistry of the Kinnickinnic River portion of the estuary. The mean concentration of hardness in the outer harbor was 176.7 mg/l as $CaCO_3$, indicating that water in the outer harbor is hard. The range of variation in the outer harbor was less than that seen in the estuary with values ranging from 1.7 to 617.3 mg/l as $CaCO_3$. The mean value of hardness in the nearshore Lake Michigan area was 161.9 mg/l as

$CaCO_3$, with values ranging from 1.7 to 617.3 mg/l as $CaCO_3$. Few statistically significant time-based trends were detected in hardness in the estuary, outer harbor, and nearshore area. Trends toward increasing hardness were detected at a few stations in the Milwaukee River portions of the estuary, but these accounted for a small portion of the variation in the data (see Appendix C in SEWRPC Technical Report No. 39). Hardness concentrations in the estuary and outer harbor are strongly correlated with alkalinity, pH, specific conductance, and concentrations of chloride, all parameters which, like hardness, measure amounts of dissolved material in water. In addition, hardness concentrations in the estuary are also positively correlated with TSS. Few correlations were found between hardness and other water quality parameters in the nearshore survey.

pH

The mean pH in the Milwaukee Harbor estuary over the period of record was 7.9 standard units. The mean values of pH during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 7.6 standard units, 7.8 standard units, and 8.1 standard units, respectively. These differences were statistically significant and may reflect differences among the three rivers in the relative contributions of groundwater and surface runoff to flow. The mean values of pH in the outer harbor and nearshore area were 7.8 standard units and 8.0 standard units respectively. Significant trends toward decreasing pH were detected at several stations in the estuary, mostly, but not entirely, in upstream sections (see Appendix C in SEWRPC Technical Report No. 39). At the same time, significant trends toward decreasing pH were detected at one station in the outer harbor and nearshore area (Table 37). At most of these stations these trends accounted for a small portion of the variation in the data. Positive correlations are seen between pH and alkalinity, hardness, and specific conductance at some stations in the estuary, but they are neither as common nor as strong as the correlations detected among alkalinity, hardness, and specific conductance. At some stations in the estuary, outer harbor and nearshore area, dissolved oxygen concentrations and chlorophyll-*a* concentrations are positively correlated with pH. These correlations reflect the effect of photosynthesis on these parameters. During photosynthesis, algae and plants remove carbon dioxide from the water. This tends to raise the pH of the water. At the same time, oxygen is released as a byproduct of the photosynthetic reactions.

Secchi Depth

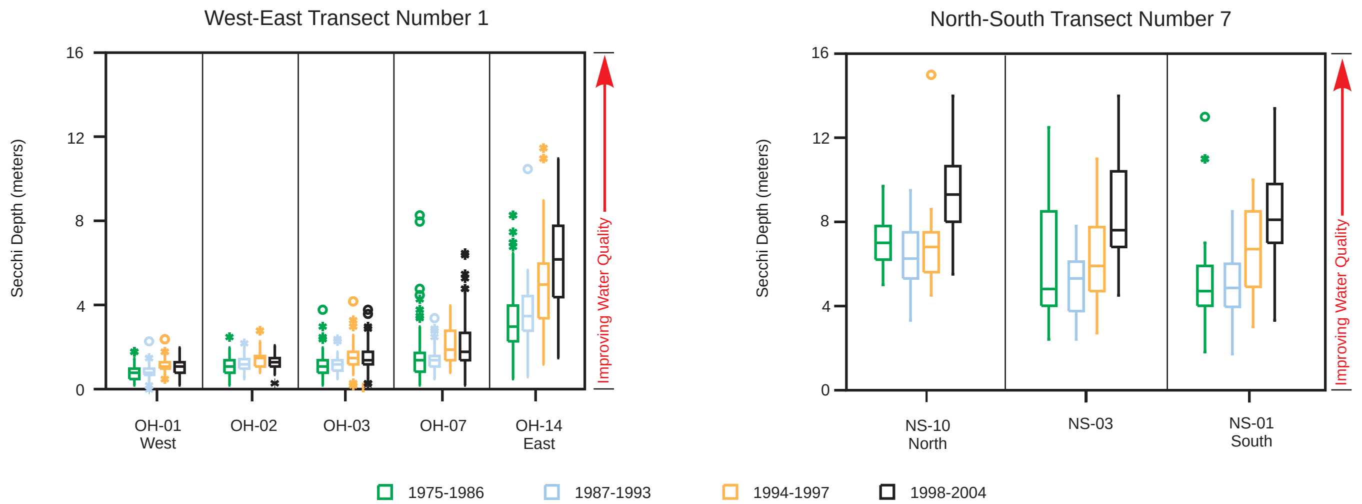
No Secchi depth data were available for the estuary. The mean Secchi depth in the outer harbor over the period of record was 1.46 meters (m). Secchi depth in the outer harbor ranged from 0.0 m to 8.50 m. The mean Secchi depth in the nearshore Lake Michigan areas over the period of record was 3.57 m. Secchi depth in the nearshore areas ranged from 0.00 m to 16.00 m. Figure 33 shows Secchi depths at stations along transects through the outer harbor and in the nearshore area. Secchi depths within the harbor and in the nearshore area have increased since 1975. There is one exception to this generalization. At stations within the harbor, Secchi depths during the period 1998-2004 were slightly lower than during the period 1994-1997. Despite this exception, statistically significant trends toward increasing Secchi depth over time were detected at all sampling stations in the outer harbor and nearshore area. Several factors may be responsible for the increase in Secchi depth. Chlorophyll-*a* concentrations have generally decreased in the outer harbor and nearshore areas of Lake Michigan. Much of this decrease appears to be the result of filtering activities of zebra mussels and quagga mussels which remove phytoplankton from the water column. Reduced nutrient loads to the outer harbor, resulting from both reductions of combined sewer overflows since the Inline Storage System came online and nonpoint source pollution control efforts, may account for the decrease in chlorophyll-*a* concentrations in both the outer harbor and nearshore area. In addition, basinwide reductions in phosphorus concentrations in open water areas of Lake Michigan beyond the nearshore area may also account for the decrease in chlorophyll-*a* concentrations in the nearshore areas and consequent increases in Secchi depth. Secchi depths in the outer harbor and nearshore area were negatively correlated with concentrations of chlorophyll-*a*, total nitrogen, and total phosphorus, suggesting that the increases in Secchi depth are being driven, at least in part, by smaller standing crops of phytoplankton. The increases in Secchi depths in the outer harbor and nearshore Lake Michigan areas represent an improvement in water quality.

Specific Conductance

The mean value for specific conductance in the Milwaukee Harbor estuary over the period of record was 625 μS/cm. Considerable variability was associated with this mean. Specific conductance in the estuary ranged from below the limit of detection to 2,350 μS/cm. Analysis of variance shows that during all periods mean

Figure 33

SECCHI DEPTH AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

specific conductance in the Menomonee River portion of the estuary was significantly higher than mean conductance in the Kinnickinnic River and Milwaukee River portions of the estuary. During the periods 1975-1986 and 1998-2002, mean specific conductance in the Milwaukee River portion of the estuary was significantly higher than mean specific conductance in the Kinnickinnic River portion of the estuary. Between 1986 and 1998, there was no statistically significant difference between mean specific conductances in these portions of the estuary. Specific conductance in the Kinnickinnic River portion of the estuary tended to be more variable than specific conductance in the Menomonee River and Milwaukee River portions of the estuary. These differences in variability are most likely related to the differences in the areas of the watersheds drained by the rivers flowing into the estuary, differences among the watersheds in relative amounts of urban land uses, and the differences in discharge among these rivers. The mean value for specific conductance in the outer harbor over the period of record was 413 μS/cm. Considerable variability was also associated with this mean. Specific conductance in the estuary ranged between 170 μS/cm and 2,350 μS/cm. The mean value of specific conductance in the nearshore Lake Michigan area over the period of record was 341 μS/cm. Values in individual samples ranged from 160 μS/cm to 2,921 μS/cm.

Some of the variability in specific conductance may reflect the discontinuous nature of inputs of dissolved material into the estuary, outer harbor, and Lake Michigan. Runoff associated with storm events can have a major influence on the concentration of dissolved material in a waterbody. The first runoff from a storm event transports a large pulse of salts and other dissolved material from the watershed into the waterbody. This will tend to raise specific conductance. Later runoff associated with the event will be relatively dilute and will tend to lower specific conductance.

Statistically significant trends toward specific conductance increasing over time were detected at most sampling stations within the estuary (see Appendix C in SEWRPC Technical Report No. 39). At several of these stations, however, these trends account for only a small portion of the variation in the data. By contrast, statistically significant trends toward specific conductance decreasing over time were detected at most sampling stations in the outer harbor and nearshore area. The data show a seasonal pattern of variation in specific conductance both in the estuary and in the outer harbor. For those years in which data were available, specific conductance was highest during the winter. It then declined during the spring to reach lower levels in the summer and early fall. The pattern also appears to be present at sampling stations adjacent to the outer harbor, though the magnitude of the seasonal differences observed at these sites is much smaller.

Specific conductance in the Milwaukee Harbor estuary show strong positive correlations with alkalinity, chloride, hardness, and pH, all parameters which, like specific conductance, measure amounts of dissolved material in water. At most stations, specific conductance also shows negative correlations with water temperature, reflecting the fact that specific conductance in the estuary tends to be lower during the summer. Specific conductance in the outer harbor shows positive correlations with alkalinity and chloride. Specific conductance in the outer harbor shows negative correlations with water temperature and Secchi depth. The latter correlation indicates that high values of specific conductance occur during periods of high turbidity and suggests that dissolved material enters the harbor at the same times and by similar mechanisms as suspended materials. Specific conductance in the nearshore area shows strong positive correlations with chloride concentration.

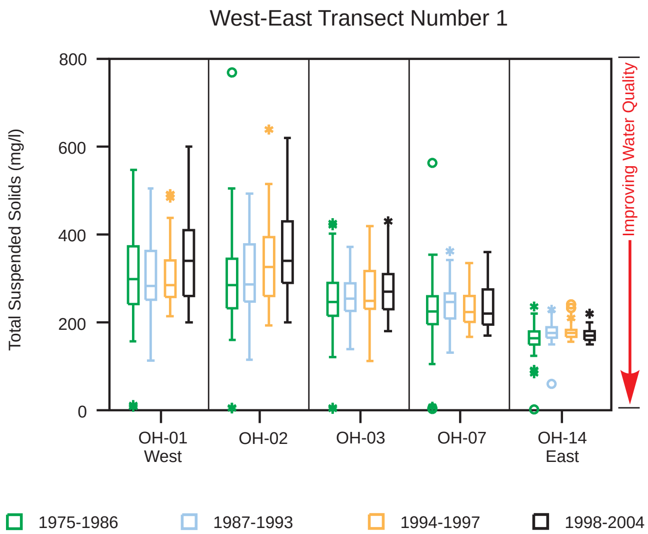
These increases in specific conductance in the estuary indicate that the concentrations of dissolved materials in the water in the estuary are increasing and represent a decline in water quality. The decreases in specific conductance in the outer harbor and nearshore area indicate that concentrations of dissolved materials in water in the outer harbor are decreasing and represent an improvement in water quality.

Suspended Material

The mean value for total suspended solids (TSS) concentration in the Milwaukee Harbor estuary over the period of record was 418 mg/l. Considerable variability was associated with this mean, with values ranging from 120 to 2,013 mg/l. The mean concentrations of TSS during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 368 mg/l, 474 mg/l, and 413 mg/l, respectively. During most periods, mean concentrations of TSS in the Menomonee River portion of the estuary were significantly higher than mean concentrations in the Milwaukee River and Kinnickinnic River portions of the estuary and the mean concentration of TSS in the Milwaukee River portion of the estuary was significantly higher than the mean concentration of TSS in the Kinnickinnic River portion of the estuary. When analyzed on an annual basis, most stations in the estuary showed trends toward increasing TSS concentration; however, these trends accounted for a small portion of the variation in the data. Mean concentrations of TSS tended to be lower at estuary stations than at stations upstream from the estuary in all periods. This reflects the fact that portions of the estuary act as a settling basin in which material suspended in water sink and fall out into the sediment. The mean concentration of TSS in the outer harbor over the period of record was 265 mg/l. Considerable variability was associated with this mean, with values ranging from one to 1,265 mg/l. Concentrations of TSS in the outer harbor were generally lower than concentrations of TSS in the estuary. Figure 34 shows concentrations of TSS at sampling stations along a transect through the outer harbor. Concentrations of TSS were highest at stations OH-01, near the mouth of the Milwaukee River, and OH-02, near the outfall from the Jones Island WWTP and decreased from west to east through the outer harbor and into the Lake. This decrease probably reflects both the effects of dilution as TSS carried by water flowing in from the estuary mixes with water in the outer harbor and settling of suspended material. Concentrations of TSS in the outer harbor were higher than concentrations of TSS outside the breakwall. Concentrations of TSS appear to have increased since the period 1975-1986 at most sampling stations in the outer harbor. Statistically significant trends toward TSS concentration increasing over time were detected at several stations in the outer harbor (Table 37). The mean value for TSS concentration in the nearshore Lake Michigan areas over the period of record was 229.8 mg/l. Considerable variability was associated with this mean, with values ranging from 1.0 to 600.0 mg/l. Data were only available from nearshore survey sampling stations that share sites with stations in either the outer harbor survey or the South Shore survey. No data were available from stations farther out in the Lake. Table 37 shows that few statistically significant time-based trends were detected in TSS concentration at stations in the nearshore area. TSS concentrations in the estuary and outer harbor were strongly correlated with concentrations of dissolved materials such as alkalinity, chloride, and specific conductance. These correlations reflect the tendency of sediment to wash into streams at the same time, and by some of the same mechanisms, as dissolved material washes in. The increases in TSS concentrations in the estuary and outer harbor represent a decline in water quality.

Figure 34

CONCENTRATIONS OF TOTAL SUSPENDED SOLIDS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTES: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Nutrients

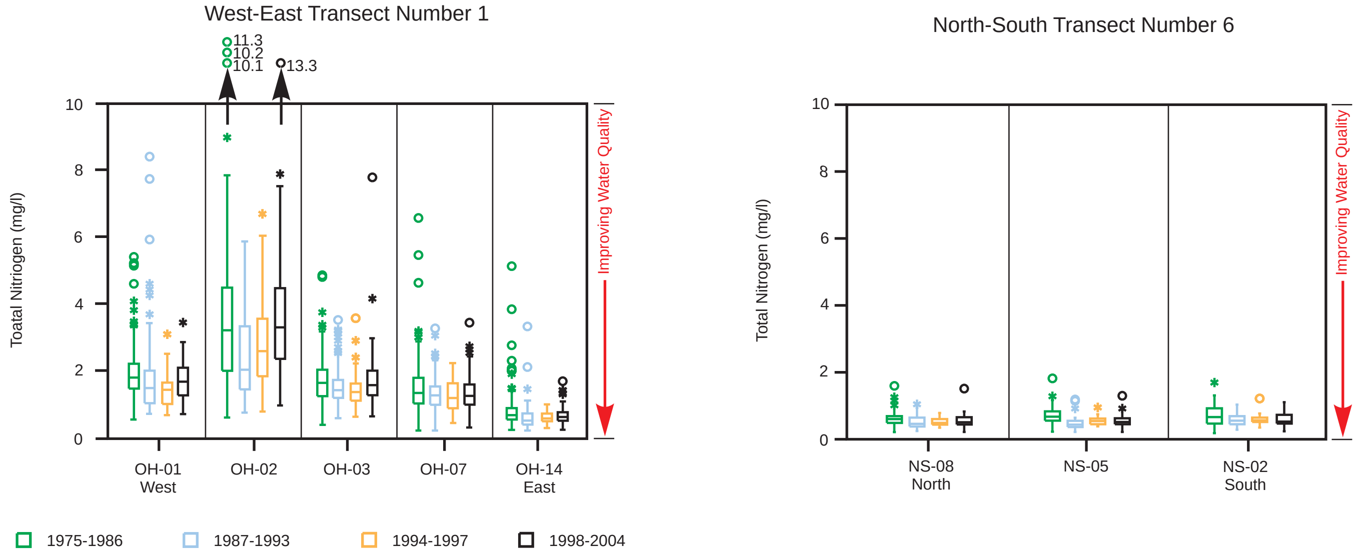
Nitrogen Compounds

The mean concentration of total nitrogen in the Milwaukee Harbor estuary over the period of record was 1.72 mg/l as N. Concentrations ranged from below the limit of detection to 17.26 mg/l as N. The mean concentrations of total nitrogen during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 1.61 mg/l as N, 1.71 mg/l as N, and 1.78 mg/l as N, respectively. At all stations, concentrations of total nitrogen during the period 1987-1993 were lower than during the period 1975-1986. In subsequent periods, concentrations of total nitrogen increased. When examined on an annual basis, statistically significant trends toward increasing total nitrogen concentrations were detected at four sampling stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). These stations were in upstream sections of the estuary. A statistically significant trend toward decreasing total nitrogen concentration was detected at one station. The concentration of total nitrogen in the estuary is positively correlated with the concentrations of nitrate and organic nitrogen, reflecting the fact that these tend to be the major forms of nitrogen compounds in the estuary. In addition, concentrations of total nitrogen were positively correlated with concentrations of total phosphorus at most stations. This probably reflects the nitrogen and phosphorus contained in particulate organic matter in the water, including detritus and live material such as plankton. Total nitrogen concentrations in the estuary are negatively correlated with Secchi depth. Finally, total nitrogen concentrations in the estuary are negatively correlated with temperature, reflecting the fact that total nitrogen concentrations tend to be highest during the winter.

The mean concentration of total nitrogen in the outer harbor during the period of record was 1.51 mg/l as N. Concentrations ranged from 0.09 mg/l as N to 13.29 mg/l as N. The mean concentration of total nitrogen in the nearshore Lake Michigan area over the period of record was 0.99 mg/l as N. Concentrations ranged from 0.04 mg/l as N to 9.88 mg/l as N. Figure 35 shows changes in total nitrogen concentrations at sampling stations along transects through the outer harbor and in the nearshore area. Concentrations of total nitrogen were higher at sampling stations in the outer harbor than at stations outside the breakwall. The highest concentration of total nitrogen was detected at station OH-02, a sampling station located near the outfall from the Jones Island WWTP. The high concentrations observed at this station probably reflect the effects of inputs of effluent from the treatment plant. With some differences in timing, a similar pattern of change in total nitrogen concentration over time was observed at most sampling stations along transects through the outer harbor and in the nearshore area. After the period 1975-1986, total nitrogen concentrations decreased through 1993 or 1997, depending on the location. After that, total nitrogen concentrations increased. At most stations, total nitrogen concentrations were lower during the period 1998-2002 than during the period 1975-1986. Statistically significant trends toward decreasing total nitrogen concentrations were detected at a few stations in the outer harbor and nearshore area (Table 37). These trends accounted for a small fraction of the variation in the data. Total nitrogen concentrations in the outer harbor and nearshore area were positively correlated with concentrations of ammonia, nitrate, and organic nitrogen, reflecting the fact that these tend to be the major forms of nitrogen compounds detected. In addition, concentrations of total nitrogen in the outer harbor were positively correlated with concentrations of total phosphorus at most stations. This probably reflects the nitrogen and phosphorus contained in particulate organic matter in the water, including live material such as plankton and detritus.

Figure 35

TOTAL NITROGEN CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

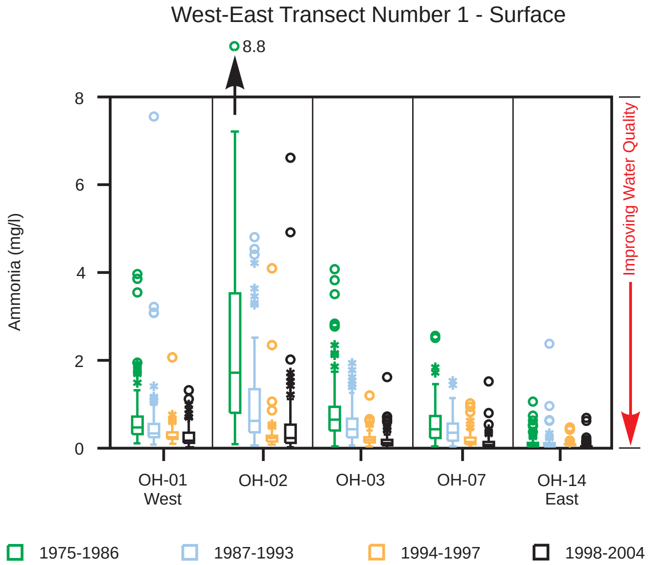
Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

Total nitrogen is a composite measure of several different compounds which vary in their availability to algae and aquatic plants and vary in their toxicity to aquatic organisms. Common constituents of total nitrogen include ammonia, nitrate, and nitrite. In addition a large number of nitrogen-containing organic compounds, such as amino acids, nucleic acids, and proteins commonly occur in natural waters. These compounds are usually reported as organic nitrogen.

The mean concentration of ammonia in the Milwaukee Harbor estuary during the period of record was 0.32 mg/l as N. Over the period of record, ammonia concentrations varied from below the limit of detection to 5.01 mg/l as N. The mean concentrations of ammonia during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.44 mg/l as N, 0.34 mg/l as N, and 0.24 mg/l as N, respectively. Analysis of variance shows that during all periods mean ammonia concentrations in the Kinnickinnic River and Menomonee River portions of the estuary were significantly higher than mean ammonia concentration in the Milwaukee River portion of the estuary. In addition, mean ammonia concentration in the Kinnickinnic River portion of the estuary was higher than mean ammonia concentration in the Menomonee River portion of the estuary in all periods except the period 1998-2002. Statistically significant trends toward decreasing ammonia concentration over time were detected at all stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). The mean concentration of ammonia in the outer harbor during the period of record was 0.42 mg/l as N. Individual samples of this parameter ranged from below the limit of detection to 8.90 mg/l as N. The mean concentration of ammonia in the nearshore Lake Michigan area over the period of record was 0.21 mg/l as N. Ammonia concentrations in individual samples varied between 0.34 mg/l as N and 7.54 mg/l as N. Figure 36 shows ammonia concentrations at sampling stations along a transect through the outer harbor. Concentrations of ammonia were higher at sampling stations in the outer harbor than at stations outside the breakwall. In addition, ammonia concentrations decreased over time at the stations in this transect. Similar decreases occurred at all stations in the outer harbor and at many stations in the nearshore area. These decreases represent statistically significant trends (Table 37). Ammonia concentrations in the estuary were positively correlated with concentrations of fecal coliform bacteria and BOD. This may reflect common sources and modes of transport into the estuary for these pollutants. At some stations, ammonia concentrations were negatively

Figure 36

AMMONIA CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTES: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

correlated with concentrations of dissolved oxygen and nitrate. These correlations may reflect a tendency toward oxidation of ammonia in aerobic environments. Ammonia concentrations in the outer harbor were positively correlated with total nitrogen and negatively correlated with Secchi depth.

The mean concentration of nitrate in the Milwaukee Harbor estuary for the period of record was 0.63 mg/l as N. During this time, concentrations in the estuary varied from below the limit of detection to 3.07 mg/l as N. The mean concentrations of nitrate during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.57 mg/l as N, 0.62 mg/l as N, and 0.68 mg/l as N, respectively. With the exception of one sampling station in the Menomonee River portion of the estuary, statistically significant trends toward increasing nitrate concentrations were detected at all sampling stations (see Appendix C in SEWRPC Technical Report No. 39). The mean concentration of nitrate in the outer harbor during the period of record was 0.57 mg/l as N. Concentrations in individual samples ranged from below the limit of detection to 8.57 mg/l as N. It is important to note that, with the exception of some outliers, the ranges of nitrate concentrations at sampling stations in the outer harbor are similar to the ranges of nitrate concentrations at sampling stations in the estuary. The mean concentration of nitrate in the nearshore Lake Michigan Area for the period of record was 0.41 mg/l as N. Concentrations in individual samples ranged from below the limit of detection to 8.57 mg/l as N. Statistically significant trends toward increasing nitrate concentrations were detected at several stations in the outer harbor and nearshore area, though at some stations the trends accounted for a small portion of the variation in the data (Table 37). Concentrations of nitrate in several stations in the outer harbor and nearshore area were positively correlated with concentrations of total nitrogen and total phosphorus. The correlation with total nitrogen reflects the fact that nitrate is a major component of total nitrogen. Nitrate concentrations in the estuary and outer harbor were negatively correlated with concentrations of chlorophyll-*a*. This correlation reflects the role of nitrate as a nutrient for algal growth. During periods of high algal productivity, algae remove nitrate from water and incorporate it into cellular material.

The mean concentration of nitrite in the Milwaukee Harbor estuary for the period of record was 0.032 mg/l as N. During this time, concentrations in the estuary varied from below the limit of detection to 4.00 mg/l as N. The mean concentrations of nitrite during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.039 mg/l as N, 0.038 mg/l as N, and 0.024 mg/l as N, respectively. Analysis of variance detected no statistically significant differences between mean nitrite concentrations in the Kinnickinnic River and Menomonee River portions of the estuary during any period. During all periods, however, mean nitrite concentration in the Kinnickinnic River and Menomonee River portions of the estuary were significantly higher than mean nitrite concentration in the Milwaukee River portion of the estuary. The mean concentration of nitrite in the outer harbor during the period of record was 0.034 mg/l as N. Concentrations in individual samples ranged from below the limit of detection to 1.100 mg/l as N. The mean concentration of nitrite in the nearshore Lake Michigan Area for the period of record was 0.020 mg/l as N. Concentrations in individual samples ranged from below the limit of detection to 1.00 mg/l as N. Nitrite concentrations at some sampling stations in the estuary and outer harbor were negatively correlated with dissolved oxygen concentration. This reflects the tendency for nitrite to be oxidized in aerobic waters.

A comparison of the nitrate and nitrite concentration data from the nearshore area to concentrations in the open waters of Lake Michigan reveals several things. The mean concentration of nitrate plus nitrite in the open waters of Lake Michigan increased from 0.262 mg/l as N in 1983 to 0.311 mg/l as N in 1999.[29] These concentrations were lower than the mean concentration of nitrate plus nitrite in the nearshore Lake Michigan area for the same period. Over the years from 1983 to 1999, the mean concentration of nitrate plus nitrite in the nearshore area was 0.45 mg/l as N. This suggests that there is a gradient in nitrate plus nitrite concentration from the nearshore area to the open waters of the Lake. The increase in nitrate plus nitrite concentration in the open waters of the Lake suggest continued loading of these nutrients.

During the period of record the mean concentration of organic nitrogen in the Milwaukee Harbor estuary was 0.75 mg/l as N. This parameter showed considerable variability with concentrations ranging from undetectable to 16.04 mg/l as N. The mean concentrations of organic nitrogen during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.58 mg/l as N, 0.74 mg/l as N, and 0.86 mg/l as N, respectively. During most periods, the mean concentration of organic nitrogen in the Milwaukee River portion of the estuary was greater than the mean concentrations of organic nitrogen in the Kinnickinnic River and Menomonee River portions of the estuary. In addition, the mean concentration of organic nitrogen in the Menomonee River portion of the estuary was greater than the mean concentration of organic nitrogen in the Kinnickinnic River portion of the estuary. During the period of record the mean concentration of organic nitrogen in the outer harbor was 0.54 mg/l as N. This parameter showed considerable variability with concentrations ranging from undetectable to 10.09 mg/l as N. During the period of record, the mean concentration of organic nitrogen in the nearshore Lake Michigan area was 0.38 mg/l as N. Concentrations in individual samples varied between the limit of detection and 7.4 mg/l as N. While few time-based trends were detected in organic nitrogen concentrations in the estuary, statistically significant trends toward increasing organic nitrogen concentrations over time were detected at several sampling stations in the outer harbor (Table 37). For the most part, only a few time-based trends in organic nitrogen concentrations were detected at stations outside the breakwall in the outer harbor survey or in the nearshore survey. Organic nitrogen concentrations at some stations in the estuary, outer harbor, and nearshore area were positively correlated with concentrations of total nitrogen and total phosphorus.

Several processes can influence the concentrations of nitrogen compounds in a waterbody. Primary production by plants and algae will result in ammonia and nitrate being removed from the water and incorporated into cellular material. This effectively converts the nitrogen to forms which are detected only as total nitrogen. Sinking of algal cells and detritus out of the epilimnion effectively makes the nitrogen in these particles unavailable for supporting algal growth. Decomposition of organic material in sediment can release nitrogen compounds to the overlying water. Bacterial action may convert some nitrogen compounds into others.

Several things emerge from this analysis of nitrogen chemistry in the Milwaukee Harbor estuary, outer harbor and nearshore Lake Michigan area:

- Concentrations of total nitrogen have increased at several stations in the estuary, outer harbor, and nearshore area. This represents a decrease in water quality.

- The relative proportions of different nitrogen compounds in the estuary, outer harbor, and nearshore area seem to be changing with time.

- Ammonia concentrations at all sampling stations in the estuary and outer harbor and several sampling stations in the nearshore area have decreased over time. This represents an improvement in water quality.

[29] *Holey and Trudeau, 2005,* op. cit.

- Concentrations of nitrate have increased at most stations in the estuary and outer harbor and several stations in the nearshore area. This appears to account for at least some of the increase in total nitrogen concentrations. This represents a decrease in water quality.

- Concentrations of organic nitrogen have increased at a few stations in the estuary and several stations in the outer harbor.

- The simultaneous increase in nitrate concentrations and decrease in ammonia concentrations may reflect an increase in the rate of microbial conversion of ammonia to nitrate in the estuary, outer harbor, and nearshore area.

- Concentrations of nitrate plus nitrite were higher in the nearshore area than in the open waters of Lake Michigan.

Total and Dissolved Phosphorus

Two forms of phosphorus are commonly sampled in surface waters: dissolved phosphorus and total phosphorus. Dissolved phosphorus represents the form that can be taken up and used for growth by algae and aquatic plants. Total phosphorus represents all the phosphorus contained in material dissolved or suspended within the water, including phosphorus contained in detritus and organisms and attached to soil and sediment.[30]

The mean concentration of total phosphorus in the Milwaukee Harbor estuary during the period of record was 0.115 mg/l, and the mean concentration of dissolved phosphorus in the estuary over the period of record was 0.041 mg/l. Total phosphorus concentrations varied over four orders of magnitude, ranging from 0.002 to 3.000 mg/l. Dissolved phosphorus concentrations varied over three orders of magnitude from 0.004 to 0.647 mg/l. The mean concentrations of total phosphorus during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.092 mg/l, 0.117 mg/l, and 0.126 mg/l, respectively. The mean concentrations of dissolved phosphorus during the period of record in the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers within the estuary were 0.033 mg/l, 0.042 mg/l, and 0.044 mg/l, respectively. It is important to note that at all stations during all periods, total phosphorus concentrations in a substantial fraction of samples exceeded the planning standard of 0.1 mg/l recommended in the initial regional water quality management plan. On an annual basis, trends toward decreasing total phosphorus concentrations over time were detected at several sampling stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). While these trends represent an improvement in water quality, they mask increases in total phosphorus concentrations at most sampling stations during the period 1998-2002. Dissolved phosphorus concentrations show a different pattern of time-based trends. Trends toward dissolved phosphorus concentrations increasing over time were detected at five stations in the estuary. These trends represent a decline in water quality. It is important to note that many of these trends account for small portions of the variation in the data.

The mean concentration of total phosphorus in the outer harbor during the period of record was 0.056 mg/l, and the mean concentration of dissolved phosphorus in the outer harbor over the period of record was 0.022 mg/l. Total phosphorus concentrations varied over four orders of magnitude, ranging from below the limit of detection to 3.880 mg/l. Dissolved phosphorus concentrations varied over four orders of magnitude from below the limit of detection to 1.330 mg/l. Figure 37 shows concentrations of total phosphorus at sampling stations along transects

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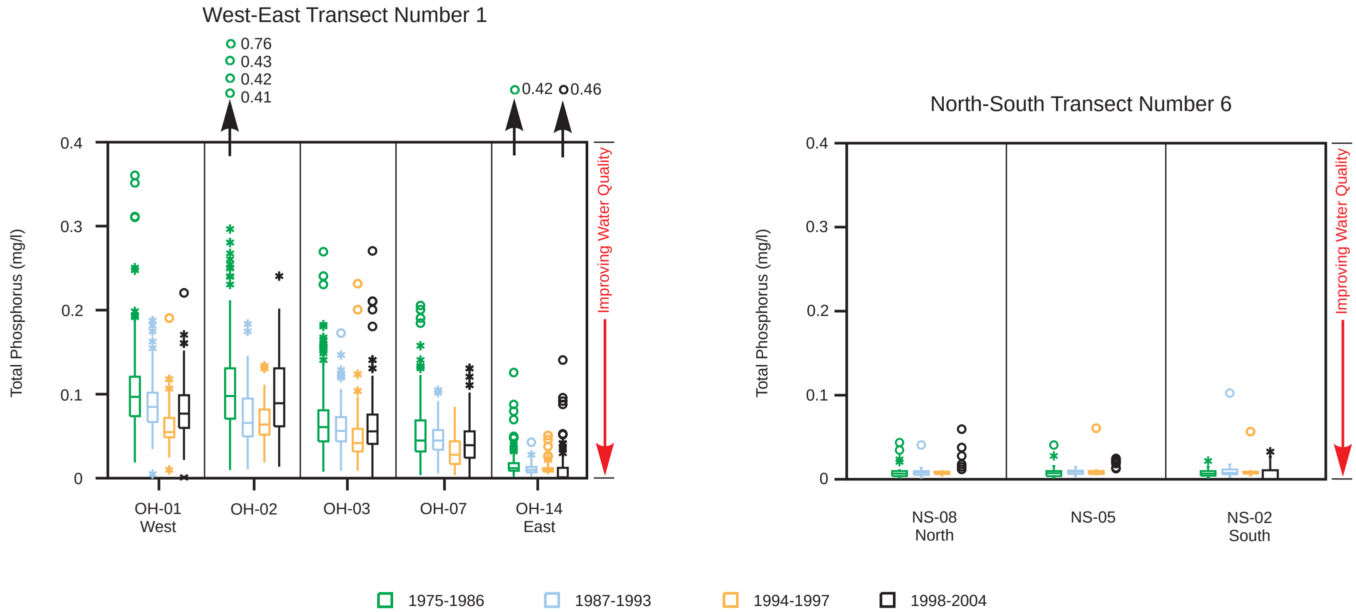
[30]*It is important to note that the data sets for dissolved phosphorus concentrations and total phosphorus concentrations do not entirely represent simultaneous sampling. While samples for both total phosphorus and dissolved phosphorus in this data set were generally collected at about the same time, on some sampling dates samples of only one or the other of these was collected. Because of this, the data sets for dissolved phosphorus concentrations and total phosphorus concentrations have a certain amount of independence from one another. This degree of independence may be reflected in the summary statistics (e.g., the minimum total phosphorus concentration during the period of record is less than the minimum dissolved phosphorus concentration although dissolved phosphorus is a component of total phosphorus).*

Figure 37

TOTAL PHOSPHORUS CONCENTRATIONS AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

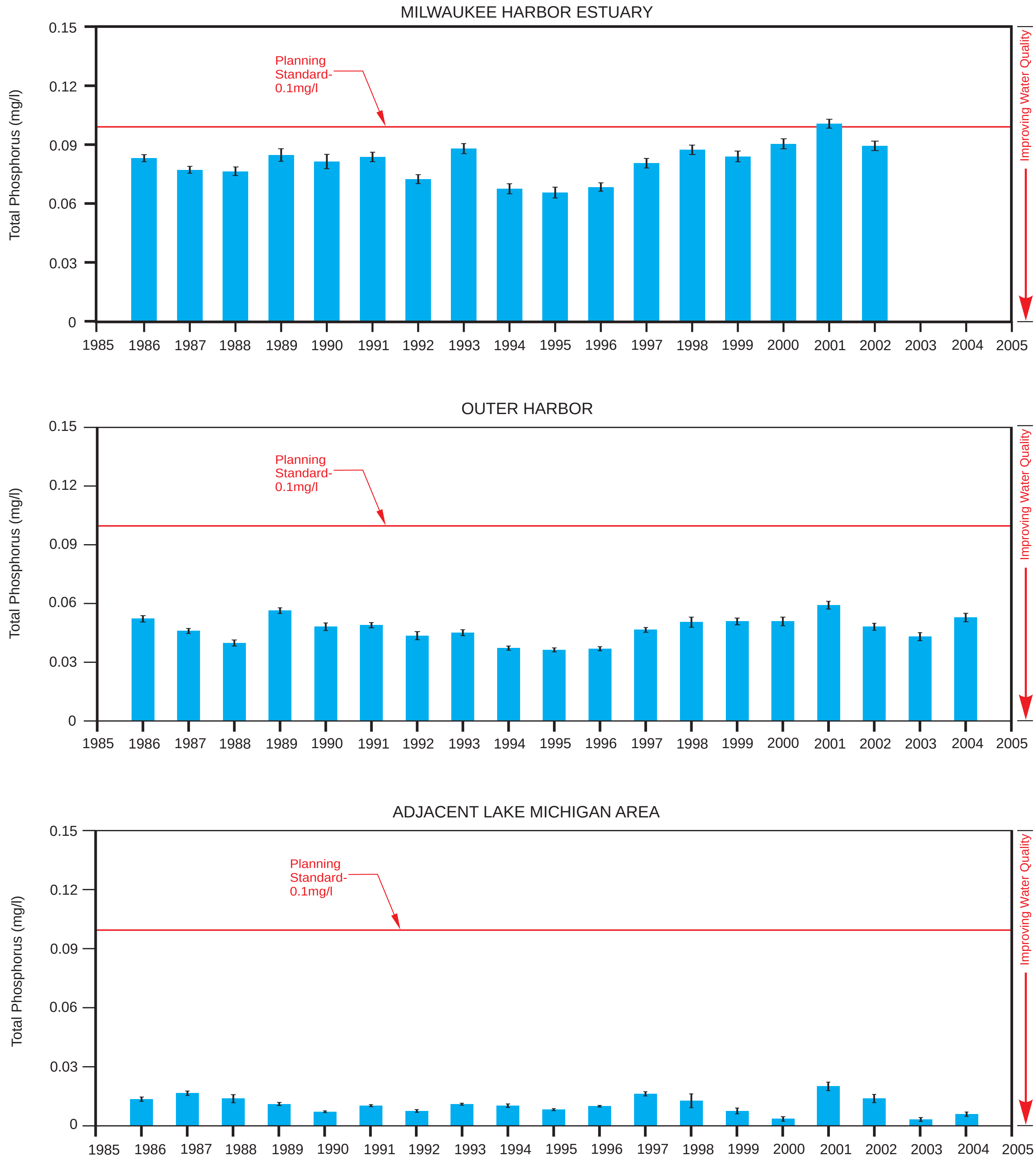
through the outer harbor and the nearshore area. Concentrations of total phosphorus were higher at sampling stations in the outer harbor than at sampling stations outside the breakwall. At all sampling stations in and adjacent to the outer harbor, concentrations of total phosphorus decreased from the 1975-1986 period through the 1994-1997 period. During the period 1998-2004, concentrations of total phosphorus at stations in the outer harbor and at stations located at gaps in the breakwall increased. Despite these recent increases, statistically significant trends toward decreasing total phosphorus concentration were detected at several sampling stations (Table 37). These trends account for only a small portion of the variation in the data. While the long-term decrease in total phosphorus indicates that water quality has improved since 1975, the recent increases indicate that water quality may currently be declining.

The mean concentration of total phosphorus in the nearshore Lake Michigan areas during the period of record was 0.0317 mg/l, and the mean concentration of dissolved phosphorus in the nearshore Lake Michigan areas over the period of record was 0.0147 mg/l. Total phosphorus concentrations ranged from below the limit of detection to 3.88 mg/l. Dissolved phosphorus concentrations ranged from below the limit of detection to 10.00 mg/l. At nearshore survey stations located in or near the outer harbor (*i.e.*, NS-12, NS-14, NS-28) and close to shore (*i.e.*, NS-04), concentrations of total phosphorus decreased over time. At stations farther out into Lake Michigan, total phosphorus concentrations increased over time. Regression analysis detected statistically significant trends toward increasing total phosphorus concentrations over time at several stations in the nearshore Lake Michigan area (see Table 37). It is likely that some of the regression results are spurious, probably due to the presence of outliers in some samples. Alternatively, these may reflect actual trends toward increasing total phosphorus concentrations in Lake Michigan.

Figure 38 shows the annual mean total phosphorus concentrations in the Milwaukee Harbor estuary for the years 1986 to 2002 and the outer harbor and adjacent areas of Lake Michigan for the years 1985-2004. While mean annual total phosphorus concentrations in the estuary and outer harbor from the years after 1996 were within the

Figure 38

MEAN ANNUAL CONCENTRATIONS OF TOTAL PHOSPHORUS CONCENTRATIONS IN THE MILWAUKEE HARBOR ESTUARY, OUTER HARBOR, AND ADJACENT LAKE MICHIGAN AREA: 1986-2004



NOTE: Error bars (I) represent one standard error of the mean.

Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, and SEWRPC.

range of variation from previous years, they increased after 1996 and remained elevated. While mean annual total phosphorus in the adjacent Lake Michigan area did increase after 1996, it has fluctuated considerably since and probably largely represents natural variation rather than a sustained increase. One possible cause of the increase in the estuary and outer harbor was phosphorus loads from facilities discharging noncontact cooling water drawn from municipal water utilities. The City of Milwaukee, for example, began treating its municipal water with orthophosphate to inhibit release of copper and lead from pipes in the water system and private residences in 1996. In 2004, for instance, concentrations of orthophosphate in plant finished water from the Milwaukee Water Works ranged between 1.46 mg/l and 2.24 mg/l,[31] considerably above average concentrations of total phosphate in the Milwaukee Harbor estuary and outer harbor. In addition, between 1992 and 2003, a number of other municipalities in the greater Milwaukee watersheds began treating their municipal water with orthophosphate or polyphosphate for corrosion control.

Dissolved phosphorus concentrations in the estuary were negatively correlated with concentrations of chlorophyll-*a*. Concentrations of total phosphorus were positively correlated with concentrations of total nitrogen and negatively correlated with concentrations of dissolved oxygen. These correlations reflect the roles of phosphorus and nitrogen as nutrients for algal growth. During periods of high algal productivity, algae remove dissolved phosphorus and nitrogen compounds from the water and incorporate them into cellular material. At the same time, respiratory demands of bacteria degrading the organic matter produced will tend to lower concentrations of dissolved oxygen. Concentrations of total phosphorus at stations in the estuary are positively correlated with concentrations of fecal coliform bacteria. This may reflect common sources and modes of transport into the estuary for these pollutants. Concentrations of total phosphorus in the outer harbor were positively correlated with dissolved phosphorus and total nitrogen and negatively correlated with Secchi depth. Concentrations of dissolved and total phosphorus can also be affected by sedimentation of particulate material and release of dissolved phosphorus from the sediment.

Metals

Arsenic

The mean concentration of arsenic in the water of the Milwaukee Harbor estuary over the period of record was 1.69 μg/l. The data ranged from below the limit of detection to 51.00 μg/l. When examined on an annual basis, statistically significant trends toward arsenic concentrations decreasing over time were detected at most stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). This may reflect changes in the amount and types of industry within the Milwaukee River watershed such as the loss of tanneries which utilized arsenic in the processing of hides. In addition, sodium arsenite has not been used as an herbicide in Wisconsin since 1969. The mean concentration of arsenic over the period of record in the outer harbor was 1.93 μg/l. Concentrations in individual samples ranged from below the limit of detection to 57.00 μg/l. Significant trends toward arsenic concentrations increasing over time were detected at several stations in the outer harbor and outside the breakwall (Table 37). The mean concentration of arsenic in the nearshore Lake Michigan waters over the period of record was 1.91 μg/l. The data ranged from below the limit of detection to 13.00 μg/l. Increasing concentrations of arsenic over time were detected at most of the stations examined in MMSD's nearshore survey (Table 37). At several stations, these trends accounted for a substantial portion of the variation in the data. These increases in the nearshore area may be influencing concentrations in the outer harbor. The reductions in arsenic concentration in the Milwaukee Harbor estuary represent an improvement in water quality. The trends toward increasing concentrations of arsenic in the outer harbor and nearshore area represent a reduction in water quality.

Cadmium

The mean concentration of cadmium in the Milwaukee Harbor estuary over the period of record was 1.62 μg/l. Concentrations in individual samples ranged from below the limit of detection to 27.0 μg/l. The mean concentration of cadmium in the outer harbor over the period of record was 1.79 μg/l. Concentrations in individual samples ranged from below the limit of detection to 82.0 μg/l. The mean concentration of cadmium in the nearshore Lake Michigan area was 2.06 μg/l. Concentrations in individual samples ranged from below the

[31]*Milwaukee Water Works, 2005,* op. cit.

limit of detection to 82.0 μg/l. Statistical analysis revealed the presence of strong decreasing trends in cadmium concentration over time at all stations in the estuary, outer harbor, and nearshore areas (Table 37, for the estuary see Appendix C in SEWRPC Technical Report No. 39). The declines in cadmium concentration may reflect changes in the number and types of industry present in the watershed, reductions due to treatment of industrial discharges, and reductions in airborne deposition of cadmium to the Great Lakes region. The reduction in cadmium concentrations in the estuary, outer harbor, and nearshore area represents an improvement in water quality.

Chromium

The mean concentration of chromium in the Milwaukee Harbor estuary over the period of record was 15.0 μg/l. Chromium concentration showed moderate variability, with individual sample concentrations ranging from below the limit of detection to 8,866.4 μg/l. No statistically significant differences were detected among the mean concentrations of chromium in the Kinnickinnic River, Menomonee River, and Milwaukee River portions of the estuary. The mean concentration of chromium in the outer harbor over the period of record was 12.0 μg/l. Concentrations in individual samples ranged from below the limit of detection to 520.0 μg/l. The mean concentration of chromium in the nearshore Lake Michigan area over the period of record was 9.7 μg/l. Concentrations in individual samples ranged from below the limit of detection to 920.0 μg/l. Statistically significant trends toward chromium concentrations decreasing over time were detected at most sampling stations in the estuary, outer harbor, and nearshore area (Table 37, for the estuary see Appendix C in SEWRPC Technical Report No. 39). These declines in chromium concentrations may reflect the loss of industry in some parts of the Kinnickinnic River, Menomonee River, and Milwaukee River watersheds and the decreasing importance of the metal plating industry in particular, as well as the treatment of discharges for the remaining and new industries since the late 1970s. There is no evidence of seasonal variation in chromium concentrations in the estuary, outer harbor, or nearshore area. The decline in chromium concentrations represents an improvement in water quality.

Copper

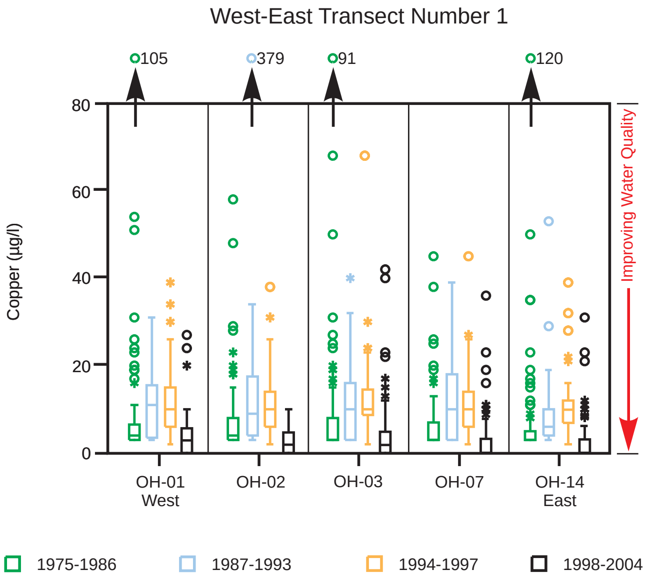
The mean concentration of copper in the Milwaukee Harbor estuary during the period of record was 10.66 μg/l. Concentrations varied from below the limit of detection to 413.00 μg/l. At all sampling stations in the estuary, copper concentrations increased over time, reaching their highest levels during the period 1994-1997. Copper concentrations were lower during the period 1998-2004 than during the period 1994-1997. Statistically significant trends toward copper concentrations increasing over time were detected at most sampling stations in the estuary. The mean concentration of copper during the period of record in the outer harbor was 8.21 μg/l. Concentrations in individual samples ranged from below the limit of detection to 379.00 μg/l. Figure 39 shows copper concentrations at sampling stations along a transect through the outer harbor. Copper concentrations at these stations followed the same pattern as copper concentrations at stations in the estuary, increasing over time and reaching their highest levels during the period 1994-1997 and then declining during the period 1998-2004. The mean concentration of copper in the nearshore Lake Michigan areas during the period of record was 7.03 μg/l. Concentrations varied from below the limit of detection to 260.00 μg/l. At most stations, median (and mean) copper concentration increased from 1975 through 1997. Copper concentrations declined during the period 1998-2004. Few statistically significant time-based trends were detected in copper concentrations in the outer harbor or nearshore area (Table 37). Where trends were detected, they tended to be trends toward increasing concentrations. Despite the overall increasing trend, the decreases in copper concentrations in the estuary, outer harbor, and nearshore area since 1997 represent improvements in water quality.

Lead

The mean concentrations of lead in the Milwaukee Harbor estuary, outer harbor, and nearshore area over the period of record were 31.25 μg/l, 34.7 μg/l, and 38.9 μg/l, respectively. These means are not representative of current conditions because lead concentrations in these surface waters have been decreasing since the late 1980s. At all sampling stations for which sufficient data exist to assess trends in lead concentrations, baseline period mean lead concentrations are quite low when compared to historical means and ranges. The mean concentration of lead in the estuary during the period 1998-2002 was 5.35 μg/l. The mean concentration of lead in the outer harbor during the period 1998-2004 was 1.88 μg/l. The mean concentration of lead in the nearshore area during the period 1998-2004 was 0.50 μg/l. These decreases in lead concentration represent statistically significant trends

Figure 39

CONCENTRATION OF COPPER AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

(Table 37, for the estuary see Appendix C in SEWRPC Technical Report No. 39). A major factor causing the decline in lead concentrations has been the phasing out of lead as a gasoline additive. From 1983 to 1986, the amount of lead in gasoline in the United States was reduced from 1.26 grams per gallon (g/gal) to 0.1 g/gal. In addition, lead was completely banned for use in fuel for on-road vehicles in 1995. The major drop in lead in water in the estuary, outer harbor, and nearshore area followed this reduction in use. In freshwater, lead has a strong tendency to adsorb to particulates suspended in water.[32] As these particles are deposited, they carry the adsorbed lead into residence in the sediment. Because of this, the lower concentrations of lead in the water probably reflect the actions of three processes: reduction of lead entering the environment, washing out of lead from the estuary and outer harbor into Lake Michigan, and deposition of adsorbed lead in the sediment. The decrease in lead concentrations over time in the estuary, outer harbor, and nearshore area represents an improvement in water quality.

Mercury

Few historical data on the concentration of mercury in the waters of the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan exist. Most sampling for mercury in water was conducted in the estuary during or after 1995 and in the outer harbor and nearshore area during or after 1997. The mean concentration of mercury in the estuary over the period of record was 0.0535 μg/l. Mercury concentrations in the estuary showed moderate variability, with a range from below the limit of detection to 2.10 μg/l. The mean concentration of mercury in the outer harbor over the period of record was 0.0156 μg/l. Concentrations of mercury in individual samples ranged from below the limit of detection to 0.220 μg/l. The mean concentration of mercury in the nearshore area over the period of record was 0.010 μg/l, with a range from below the limit of detection to 0.220 μg/l. It is important to note that the mean concentration in the nearshore area is about 30 times higher than the mean concentration for total mercury reported for offshore areas of Lake Michigan.[33] When examined on an annual basis, significant trends toward decreasing mercury concentrations were detected at all stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39) and one station in the outer harbor (Table 37). In addition, a significant trend toward decreasing mercury concentration over time was detected at a second station in the outer harbor when the data were analyzed on a seasonal basis. The concentrations of mercury in several samples in the estuary and outer harbor exceed both the State of Wisconsin's wildlife criteria for surface water of 0.0013 μg/l and Wisconsin's human threshold criteria for public health and welfare of 0.0015 μg/l. The trends toward decreasing mercury concentrations at stations in the estuary and outer harbor represent improvements in water quality.

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[32]*Windom and others, 1991,* op. cit.

[33]*U.S. Environmental Protection Agency,* Results of the Lake Michigan Mass Balance Study: Mercury Data Report, *EPA 905 R-01-012, 2004.*

Nickel

The mean concentration of nickel in the Milwaukee Harbor estuary over the period of record was 13.3 μg/l. Concentrations in individual samples ranged from below the limit of detection to 3,810.8 μg/l. No statistically significant differences were found among mean concentrations in these three sections of the estuary. The mean concentration of nickel over the period of record in the outer harbor was 6.6 μg/l. Concentrations in individual samples ranged from below the limit of detection to 97.0 μg/l. The mean concentration of nickel over the period of record in the nearshore Lake Michigan area was 6.8 μg/l. Concentrations in individual samples ranged from below the limit of detection to 97.0 μg/l. When examined on an annual basis, significant decreases over time were observed at several sampling stations in the estuary, and all stations in the outer harbor and nearshore area (Table 37, for the estuary see Appendix C in SEWRPC Technical Report No. 39). The trends toward decreasing nickel concentration in the estuary and outer harbor may reflect changes in the amount and types of industry within the Kinnickinnic River, Menomonee River, and Milwaukee River watersheds. The decreases in nickel concentrations in the estuary, outer harbor, and nearshore area represent an improvement in water quality.

Zinc

The mean concentration of zinc in the Milwaukee Harbor estuary during the period of record was 23.7 μg/l. Concentrations in individual samples ranged from 4.3 μg/l to 376.5 μg/l. Statistically significant trends toward zinc concentrations increasing over time were detected at most stations in the estuary (see Appendix C in SEWRPC Technical Report No. 39). At several stations, these trends account for a small portion of the variation in the data. The mean concentration of zinc over the period of record in the outer harbor was 14.4 μg/l. Concentrations in individual samples ranged from below the limit of detection to 160.0 μg/l. Figure 40 shows zinc concentrations at sampling stations along transects through the outer harbor and nearshore area. Zinc concentrations tended to be higher at stations in the outer harbor than at stations outside the breakwall. At most stations in the outer harbor, zinc concentrations have increased over time. At some sampling stations these increases represent statistically significant trends (Table 37). These trends account for a small portion of the variation in the data. The higher concentrations of zinc in the estuary and outer harbor may reflect higher amounts of zinc washing into the Kinnickinnic, Menomonee, and Milwaukee Rivers during snowmelt and spring rains. Wear and tear on automobile brake pads and tires are major sources of zinc in the environment. In addition, zinc can be released to stormwater by corrosion of galvanized gutters and roofing materials. Stormwater can carry zinc from these sources into streams. The mean concentration of zinc in the nearshore Lake Michigan areas during the period of record was 11.2 μg/l. Concentrations in individual samples ranged from below the limit of detection to 230.0 μg/l. At most stations, zinc concentrations increased after 1986. They then decreased either after 1993 or after 1997. Despite recent decreases in zinc concentrations, statistically significant trends toward increasing concentrations of zinc over the 1975 through 2004 time period were detected at several stations in the nearshore area (Table 37). There is no evidence of seasonal variation in the concentration of zinc in the nearshore areas. The trends toward increasing zinc concentrations in the estuary, outer harbor, and nearshore Lake Michigan areas represent a reduction in water quality.

Organic Compounds

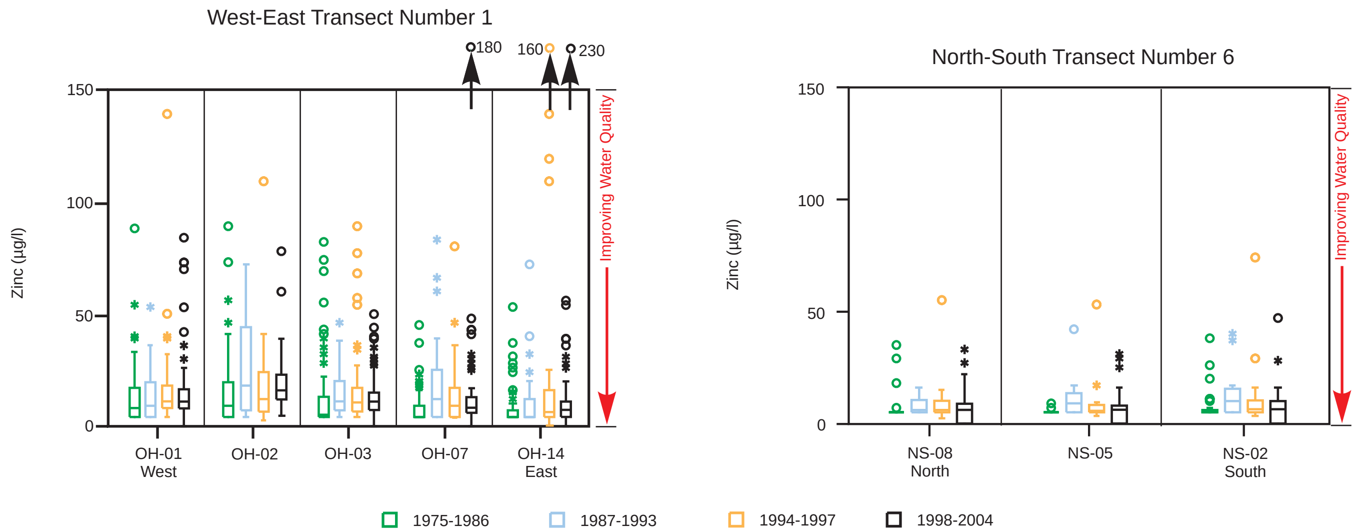
On 11 dates between February 2004 and August 2005, the USGS examined water samples collected from six sites in the Milwaukee outer harbor and adjacent areas of Lake Michigan for the presence of several organic compounds dissolved in water. The flame retardant tri(2-butylethyl) phosphate was commonly detected in these samples. Several compounds were occasionally detected including the flame retardants tri(2-chloroethyl) phosphate, tri(dichloroisopropyl) phosphate, and tributyl phosphate; the solvent isophorone; the plasticizer triphenyl phosphate; the dye component carbazole; and the nonionic detergent metabolites p-nonylphenol and diethoxynonylphenol. These last two compounds are known to be endocrine disruptors.

Pharmaceuticals and Personal Care Products

On 11 dates between February 2004 and August 2005, the USGS examined water samples collected at six sites in the Milwaukee outer harbor and adjacent areas of Lake Michigan for the presence of several compounds found in pharmaceuticals and personal care products. Commonly detected compounds included the stimulant caffeine, the insect repellant DEET, and the nicotine metabolite cotinine. Compounds occasionally detected included the fragrances and flavoring agents acetophenone; AHTN, camphor, HHCB, and menthol; the perfume fixative

Figure 40

CONCENTRATION OF ZINC AT SITES IN THE MILWAUKEE OUTER HARBOR AND ADJACENT LAKE MICHIGAN AREA: 1975-2004



NOTE: See Figure 11 for description of symbols and Map 27 for locations of monitoring stations relative to the outer harbor and the adjacent Lake Michigan area.

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

benzophenone; the cosmetic component triethyl citrate; the deodorizer 1,4-dichlorobenzene; and the sterol cholesterol. The sources of these compounds to the outer harbor and Lake Michigan are not known. A recent study also detected the presence of several synthetic musk compounds in water samples collected from Lake Michigan offshore from Milwaukee.[34] A lakewide mass budget indicated that wastewater treatment plants were the major source of these compounds to the Lake.

Water Quality at Lake Michigan Beaches

While Wisconsin does not have a statewide mandatory monitoring program for Great Lakes public beaches, a number of Lake Michigan communities, including the Cities of Milwaukee and Racine, have monitored the water quality of their beaches for decades. In 2003, with annual grants available through the Federal Beach Act of 2000, the WDNR began the implementation of the Wisconsin Beach Monitoring Program, a collaborative effort between State and local environmental and health agencies to monitor recreational waters for health risks. The WDNR coordinates the program, but the local health departments have authority over public beaches within their jurisdictions. In 2005, the City of Milwaukee Health Department, the City of Racine Health Department, the Shorewood/Whitefish Bay Health Department, the South Milwaukee Health Department, and the North Shore Health Department participated in the program. The latter agency serves the City of Glendale and the Villages of Brown Deer, Fox Point, and River Hills. In addition, the Ozaukee County Health Department also participated, though they did not monitor any public beaches within the Lake Michigan direct drainage area. More information on the Wisconsin Beach Monitoring Program is given in SEWRPC Technical Report No. 39.

Agencies participating in the Wisconsin Beach Monitoring Program use *E. coli* as an indicator of fecal pollution in recreational waters. All warm-blooded animals have *E. coli* in their feces. Because of this, the presence of high concentrations of *E. coli* indicates a high probability of the presence of fecal contamination and the possible presence of pathogens related to fecal contamination. While the presence of high concentrations of *E. coli* does

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[34]*Aaron M. Peck and Keri C. Hornbuckle, "Synthetic Musk Fragrances in Lake Michigan,"* Environmental Science and Technology, *Volume 38, 2004.*

not necessarily indicate the presence of pathogenic agents, *E. coli* is generally found when the pathogenic agents are found.

For beaches monitored under the Wisconsin Beach Monitoring Program, advisories are issued and beaches are closed when standards developed by the USEPA in the late 1970s are exceeded.[35] Water quality advisories are issued for beaches whenever the concentration of *E. coli* in a single sample exceeds 235 cells per 100 ml or when the geometric mean of at least five samples taken over a 30-day period exceeds 126 cells per 100 ml. Beaches are closed whenever the concentration of *E. coli* in water exceeds 1,000 cells per 100 ml. Beaches are also closed after a significant rainfall event that is determined to impact the beach area, after a major pollution event where there is the potential for *E. coli* to exceed the standard, or whenever a human health hazard exists as determined by the local health department.

The Wisconsin Beach Monitoring Program has implemented a tiered monitoring approach to sampling requirements for monitored beaches. Monitoring requirements vary depending on whether a beach is considered high, medium, or low priority. In 2005, high priority beaches were required to be sampled at least four times per week during the swimming season. This requirement was increased to five times per week in 2006. In both of these years, medium priority beaches were required to be sampled at least two times per week. The sampling frequency at low priority beaches is determined on a case-by-case basis by State and local authorities, taking into account resource constraints and risk factors at each low priority beach.

Map 28 shows the public beaches along Lake Michigan in the Lake Michigan direct drainage area. In 2000, concentrations of *E. coli* were monitored at seven out of 20 beaches in this area. By 2005, the number of monitored beaches in the area increased to 12. Six of the beaches monitored in 2005 were considered high priority beaches. The other monitored beaches in the area were considered medium priority.

Beach Closures and Water Quality Advisories

Figure 41 shows the number of days that Lake Michigan beaches were closed or under water quality advisories during the years 1999-2005. Combining closings and advisories into one measure gives a more representative measure of beach water quality because, prior to the standardization that accompanied implementation of the Wisconsin Beach Monitoring Program in 2003, different jurisdictions used different standards and criteria for closing beaches. The mean number of days per beach season that individual beaches were closed or under a water quality advisory was 21.7. There was considerable variation among beaches as to how often they were closed or under a water quality advisory. For example, Bay View Park Beach had a mean number of days per beach season of closure or advisory of 4.0 over the years 2004-2005. Similarly, Bender Park Beach had a mean number of days per beach season of closure or advisory of 7.7 over the years 2003-2005. By contrast, South Shore Beach had a mean number of days per beach season of closure or advisory of 54.2 over the years 2000-2005. Three beaches, Bradford Beach, McKinley Beach, and South Shore Beach, showed marked increases in the number of days of closure or advisory after 2003. By contrast, Atwater Beach and Klode Park Beach showed decreases in the number of days of closure or advisory after 2002. After 2002, decreases were also seen at Watercraft and Grant Park Beaches, although the numbers of closings in 2005 at these beaches were similar to the numbers in 2001.

Figure 42 shows *E. coli* concentrations at 12 Lake Michigan beaches and the rocky site at South Shore Beach. At every monitored beach, the single sample standard for issuing advisories of 235 cells per 100 ml was exceeded in each year for which data exist. At some beaches, the proportion of samples exceeding this standard was quite high. For example, in every year except 2003, *E. coli* concentrations at South Shore Beach exceeded this standard in 50 percent or more of the samples collected. The single sample standard for beach closure of 1,000 cells per 100 ml was also often exceeded. At most beaches, it was exceeded at least once in most years for which data are

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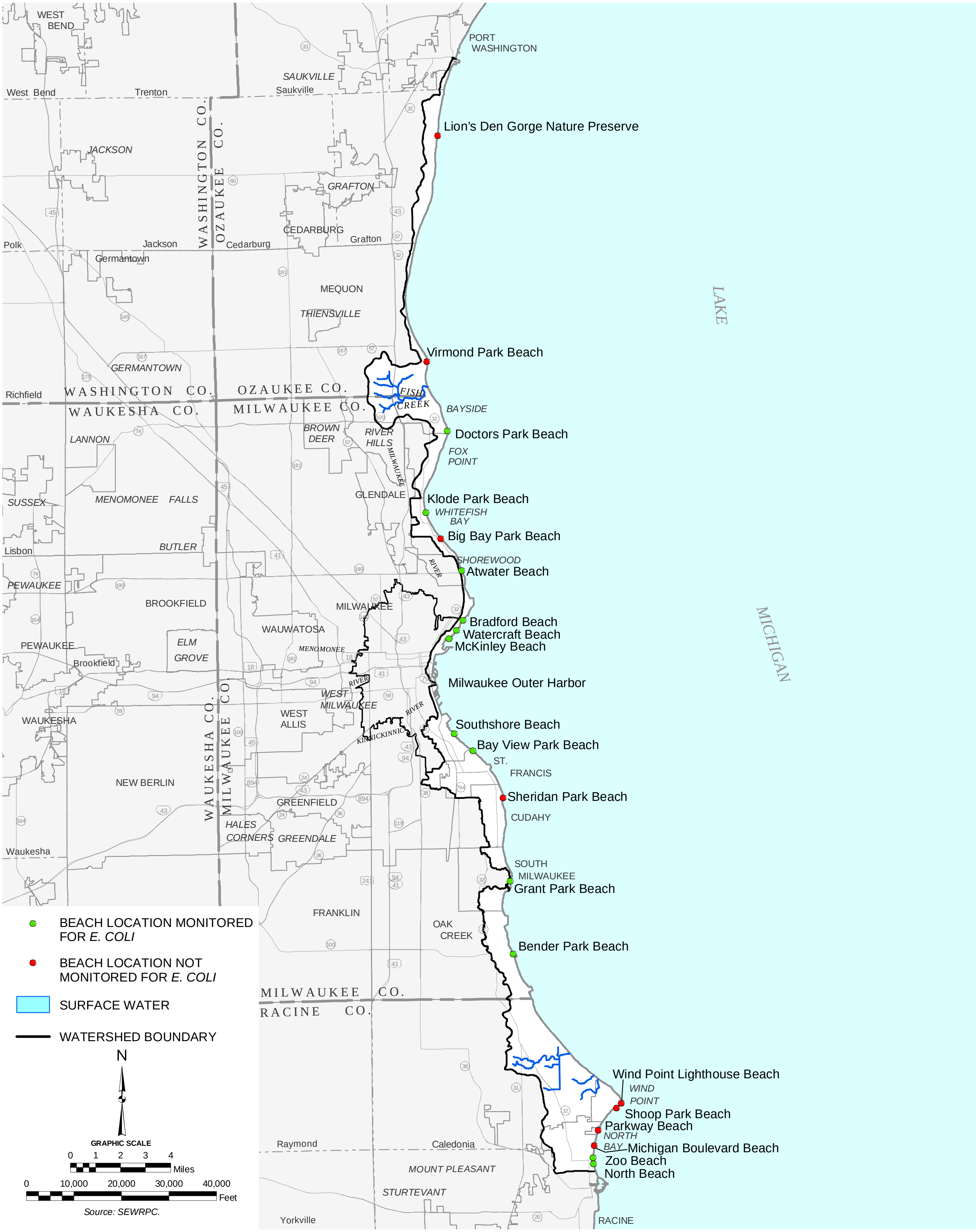
[35]*V.J. Cabelli,* Health Effects Criteria for Marine Recreational Waters*, USEPA EPA-600/1-80-031, 1983; USEPA,* Health Effects Criteria for Fresh Recreational Waters*, EPA-600/1-84-002, 1984; USEPA,* Ambient Water Quality Criteria for Bacteria-1986*, EPA-440/5-84-002, 1986.*

Map 28

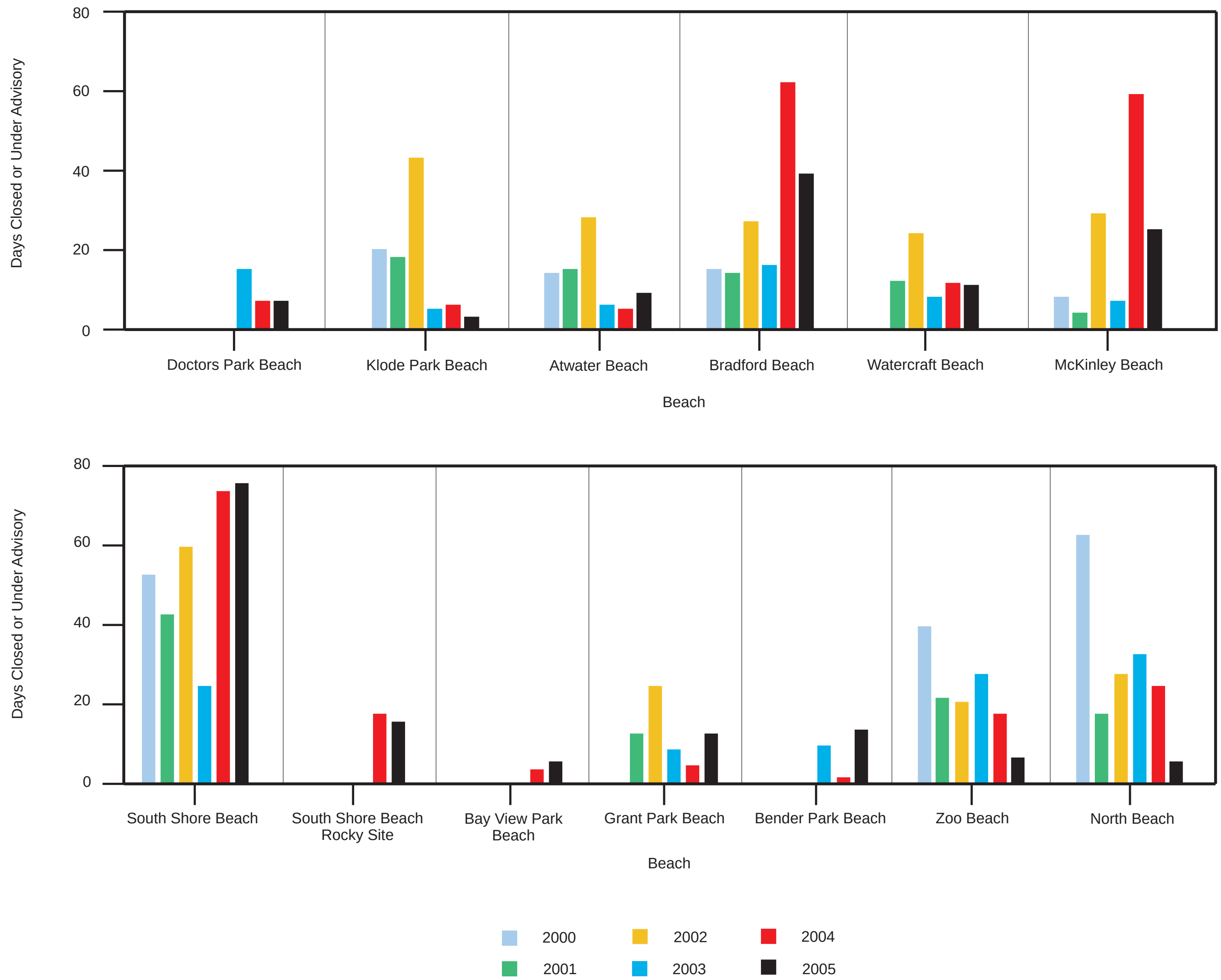
MONITORING OF BEACHES WITHIN THE AREA DIRECTLY TRIBUTARY TO LAKE MICHIGAN: 2000-2005



Source: SEWRPC.

Figure 41

CLOSINGS AND ADVISORIES AT LAKE MICHIGAN BEACHES: 2000-2005



Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, City of Milwaukee Health Department, City of Racine Health Department, and SEWRPC.

available. A few trends were apparent in the data. At most beaches, median *E. coli* concentrations were lower in 2005 than in 2004. There were three exceptions to this generalization. Median *E. coli* concentrations at Doctors Park Beach, the rocky site at South Shore beach, and Bender Park Beach in 2005 were similar to, or higher than, median concentrations in 2004. At four beaches, Atwater Beach, Bradford Beach, McKinley Beach, and Bender Park Beach, concentrations of *E. coli* have increased over time. By contrast concentrations of *E. coli* at Klode Park Beach appear to have decreased. No trends over time were apparent at Doctors Park Beach, South Shore Beach, Grant Park Beach, Zoo Beach, or North Beach. At South Shore Beach, concentrations of *E. coli* at the shoreline were compared to concentrations 10 meters and 150 meters offshore. On both dry and rainy days, concentrations at the shoreline were higher than concentrations offshore.[36]

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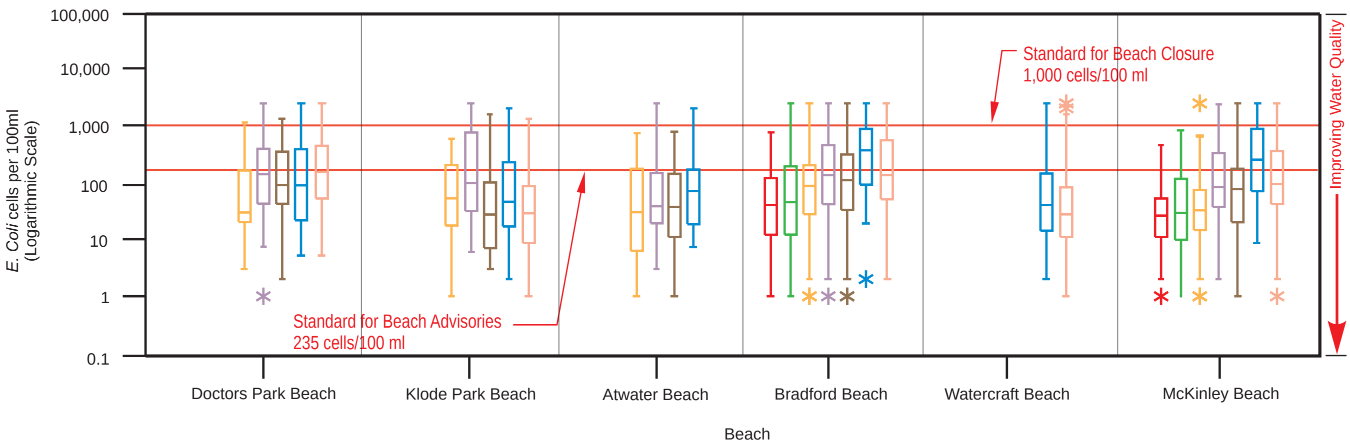
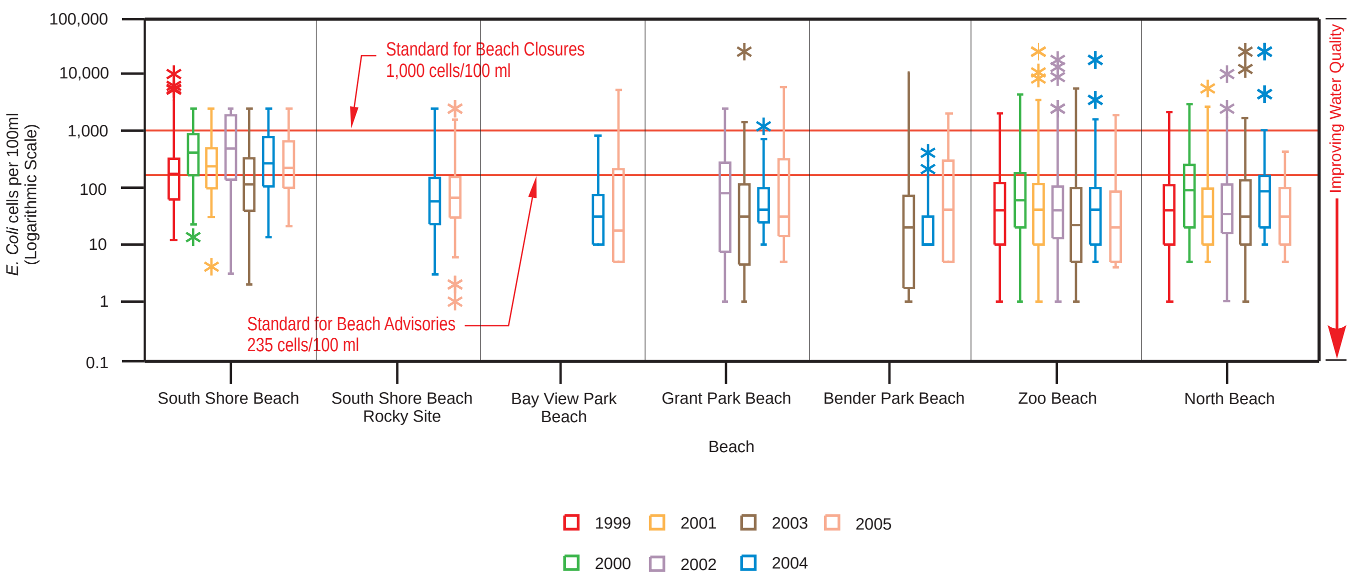
[36]*S.L. McLellan and A.K. Salmore, "Evidence for Localized Bacteria Loadings as the Cause of Chronic Beach Closings in a Freshwater Marina,"* Water Research, *Volume 37, 2003.*

Figure 42

CONCENTRATIONS OF *E. COLI* AT LAKE MICHIGAN BEACHES: 1999-2005





NOTE: See Figure 11 for description of symbols.

Source: U.S. Geological Survey, U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, City of Milwaukee Health Department, City of Racine Health Department, and SEWRPC.

Sources of Bacterial Contamination to Lake Michigan Beaches

Several potential sources of contamination have been suggested as contributing to the high concentrations of *E. coli* detected at Lake Michigan beaches. The potential sources of contamination cited include overflows from combined and sanitary sewers, discharges of stormwater from outfalls near beaches, runoff from parking lots and other impervious areas adjacent to beaches, mobilization of *E. coli* from reservoirs in sand and sediment, contributions of *E. coli* from wildlife visiting or residing at beaches or in adjacent areas, and mobilization from reservoirs in algal mats on beaches or in nearshore waters. It is important to note that beach closings and advisories are not always related to elevated bacteria concentrations. When they are, the source of the bacteria causing the closing or advisory is not always obvious. More-detailed information about sources of bacterial contamination to Lake Michigan beaches is given in SEWRPC Technical Report No. 39.

High concentrations of *E. coli* and the resulting water quality advisories and beach closures have popularly been attributed to overflows from combined and separate sanitary sewers. Several lines of evidence suggest that while sewer overflows can affect water quality at some of the Lake Michigan beaches, they may not currently be the major factor driving trends in beach water quality. First, there was not a strong correspondence between timing of overflows and timing of beach closings and advisories. Figure 43 compares the timing of beach advisories at three Milwaukee beaches during 2000 to rainfall and combined sewer overflow events. In the figure, overflow events are indicated by gray shading, rainfall is indicated by blue bars, and the number of beaches closed or under water quality advisory is indicated by green dots. The timing of most beach water quality advisories in 2000 did not correspond to the timing of overflow events. Beach advisories occurred consistently throughout the season. In addition, some periods with high numbers of advisories occurred several weeks after the most recent overflow event. Given that *E. coli* die off fairly rapidly in Lake Michigan water, it is unlikely that the bacteria triggering these closures were contributed by overflows. Second, while surveys of *E. coli* taken in the inner and outer harbors and adjacent areas of Lake Michigan during CSO events did indicate some impact of those events on South Shore Beach, they showed little impact of CSO on *E. coli* concentrations at Bradford, McKinley, and Watercraft Beaches.[37] These surveys also found that *E. coli* during overflow events could not be detected at concentrations above 10 cells per 100 ml at distances greater than 3.1 miles from the harbor breakwall, suggesting that the impact of inputs from the harbor, including the impacts of CSOs and SSOs may be limited to those beaches that are relatively close to the harbor. Third, the results of a modeling study suggest that many of closures and advisories at Bradford, McKinley, and South Shore Beaches derived from other causes than inputs from the Rivers and overflow events.[38] In several instances the study found that the concentrations of bacteria predicted by the model based inputs of bacteria from the Kinnickinnic, Menomonee, and Milwaukee Rivers, CSOs, SSOs, and wastewater treatment plants were less than the observed concentrations, suggesting that the observed concentrations were strongly influenced by locally derived sources not accounted for in the model. The study concluded that bacterial loads from the Rivers and from overflows can have impacts at Bradford, McKinley, and South Shore Beaches; however, these impacts are related to short-duration storm and overflow events and have a time period on the order of five days.

Inputs of stormwater from outfalls discharging over or near beaches can affect water quality at beaches. High concentrations of *E. coli* have been detected in discharges from stormwater outfalls over or near some Lake Michigan beaches.[39] Similarly, runoff from parking lots and other paved surfaces near beaches can contribute bacteria and other pollutants that affect water quality at beaches. High concentrations of *E. coli* have been detected in samples of runoff collected from parking lots at some Lake Michigan Beaches.[40]

Reservoirs of bacteria in beach sand and sediment may also act as sources of bacteria to water at swimming beaches. Concentrations of *E. coli* detected in foreshore sands at beaches have been reported to be 10 to 1,000

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[37]*McLellan and Hollis, 2005,* op. cit.

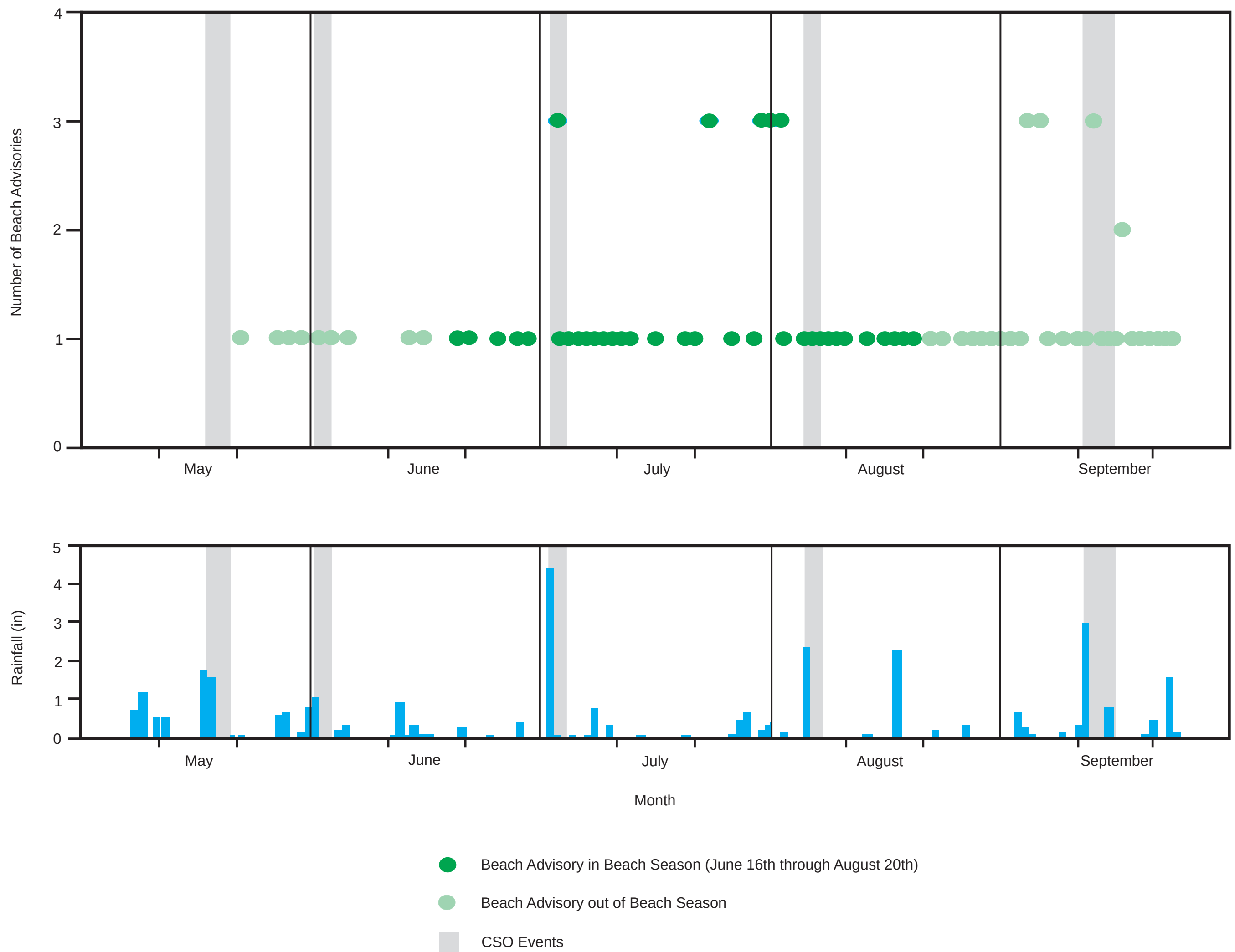
[38]*HydroQual, Inc. and Camp Dresser McKee,* Milwaukee Harbor Estuary Hydrodynamic & Bacteria Modeling Report, *Bacteria Source, Transport and Fate Study—Phase 1, August, 2005.*

[39]*Sandra L. McLellan and Erika T. Jensen,* Identification and Quantification of Bacterial Pollution at Milwaukee County Beaches, *Great Lakes WATER Institute Technical Report, September 2005; Julie Kinzelman, Sandra L. McLellan, Annette D. Daniels, Susan Cashin, Ajaib Singh, Stephen Gradus, and Robert Bagley, "Non-point Source Pollution: Determination of Replication Versus Persistence of* Escherichia coli *in Surface Water and Sediment with Correlation of Levels to Readily Measurable Environmental Parameters,"* Journal of Water and Health, *Volume 2, 2004.*

[40]*McLellan and Salmore, 2003,* op. cit.

Figure 43

MILWAUKEE AREA BEACH ADVISORIES: 2000



NOTES: Milwaukee area beaches include South Shore, Bradford, and McKinley Beaches.

There were a total of 55 in-season beach advisories and 50 out-of-season beach advisories.

Rainfall amounts are recorded at General Mitchell International Airport.

Source: Milwaukee Metropolitan Sewerage District and CDM/HydroQual, Inc.

times higher than concentrations in beach waters.[41] High concentrations of *E. coli* in sand are associated with several factors including the amount of moisture in the sand, the presence of stormwater discharge over the beach,[42] and the particular beach grooming techniques used.[43] Altering mechanical grooming techniques to

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[41]*Richard L. Whitman and Meredith B. Nevers, "Foreshore Sand as a Source of* Escherichia coli *in Nearshore Water of a Lake Michigan Beach,"* Applied and Environmental Microbiology, *Volume 69, 2003.*

[42]*McLellan and Jensen, 2005,* op. cit.

[43]*Julie L. Kinzelman, Richard L. Whitman, Muruleedhara Byappanalalli, Emma Jackson, and Robert C. Bagley, "Evaluation of Beach Grooming Techniques on* Escherichia coli *Density in Foreshore Sand at North Beach, Racine, WI,"* Lake and Reservoir Management, *Volume 19, 2003.*

provide deeper grooming and omitting the finishing process can reduce concentrations in foreshore sand.[44] When reservoirs of bacteria are present in beach sand, wave action can draw these microorganisms out into the water.[45] It is important to note that bathers at beaches spend considerable time directly exposed to beach sand. Even if beach sands contribute relatively small amounts of bacteria to beach waters, concentrations of bacteria in the sand may pose a risk of infection to bathers.

Fecal material from waterfowl may be a source of bacterial contamination to beach sand and water. While several species have been suggested as potentially contributing to decreases in beach water quality, ring-billed gulls are a particular species of concern. Several beaches in the study area serve as roosting areas for ring-billed gulls. Ring-billed gull feces have been shown to contain high concentrations of bacteria species used as water quality indicators.[46] Studies have shown correlations between gull counts at beaches and concentrations of *E. coli* in beach water and sand.[47] Finally, ring-billed gull feces have been shown to contain species and strains of bacteria known to be pathogenic to humans.[48]

The presence of mats of filamentous algae may also contribute bacterial contamination to Lake Michigan beaches. High concentrations of bacterial indicators of fecal contamination in swimming waters and beach sand have been associated with the presence of algal mats, particularly *Cladophora*.[49] In addition, some studies suggest that water quality indicator bacteria are able to persist for long periods and perhaps multiply in algal mats.[50]

Synthesis

There is continuing public concern about water quality at public beaches along Lake Michigan. Conditions as measured by the number of closings and advisories improved at some beaches, such as North Beach and Zoo Beach (Figure 41). By contrast, at some other beaches, such as Bradford Beach, McKinley Beach, and South

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[44]*J.L Kinzelman, K.R. Pond, K.D. Longmaid, and R.C. Bagley, "The Effects of Two Mechanical Beach Grooming Strategies on* Escherichia coli *Density in Beach Sand at a Southwestern Lake Michigan Beach,"* Aquatic Ecosystem Health & Management, *Volume 7, 2004.*

[45]*Kinzelman and others,* Journal of Water and Health, *2004,* op. cit.

[46]*K.A. Alderisio and N. DeLuca, "Seasonal Enumeration of Fecal Coliform Bacteria from the Feces of Ring-Billed Gulls (*Larus delawarensis*) and Canada Geese (*Branta Canadensis*),"* Applied and Environmental Microbiology, *Volume 65, 1999; L.R. Fogarty, S.K. Haack, M.J. Wolcott, and R.L. Whitman, "Abundance and Characteristics of the Recreational Water Quality Indicator Bacteria* Escherichia coli *and Enterococci in Gull Faeces,"* Journal of Applied Microbiology, *Volume 94, 2003.*

[47]*Benoît Lévesque, Pierre Bousseau, Pierre Simard, Eric Dewailly, Monica Meisel, DanièRamsay, and Jean Joly, "Impact of the Ring-Billed Gull (*Larus delawarensis*) on the Microbiological Quality of Recreational Water,"* Applied and Environmental Microbiology, *Volume 59, 1993; Whitman and Nevers, 2003,* op. cit.

[48]*Sylvain Quessy and Serge Messier, "Prevalence of* Salmonella *spp.,* Campylobacter *spp. and* Listeria *spp. in Ring-Billed Gulls (*Larus delawarensis*),"* Journal of Wildlife Diseases, *Volume 28, 1992; Lévesque and others, 1993,* op. cit.

[49]*Richard L. Whitman, Dawn A. Shively, Heather Pawlik, Meredith B. Nevers, and Muruleedhara N. Myappanahalli, "Occurrence of* Escherichia coli *and Enterococci in* Cladophora *(Chlorophyta) in Nearshore Water and Beach Sand of Lake Michigan,* Applied and Environmental Microbiology, *Volume 69, 2003; Ola A. Olapade, Morgan M. Depas, Erika T. Jensen, and Sandra L. McLellan, "Microbial Communities and Fecal Indicator Bacteria Associated with* Cladophora *Mats on Beach Sites along Lake Michigan Shores,"* Applied and Environmental Microbiology, *Volume 72, 2006.*

[50]*Whitman and others, 2003,* op. cit.; *Olapade and others, 2006,* op. cit.

Shore Beach, water quality is declining or remains poor. Local sources of contamination appear to be important determining factors of water quality at Lake Michigan beaches. Factors such as the placement of stormwater outfalls relative to beaches and swimming areas, locations of impervious surfaces such as parking lots, and the presence of wildlife can exert a strong influence on beach water quality and appear to be contributing to the number of water quality advisories and beach closings at some beaches in the Lake Michigan direct drainage area. It is important to note that water quality indicator organisms, such as *E. coli*, contributed by these and other sources can persist in beach sand and mats of *Cladophora* present on or adjacent to beaches. The presence, concentration, and persistence of indicator bacteria in beach sand can be affected by the particular methods of beach grooming used. In any case, precipitation and wave action may mobilize indicator bacteria present in sand or algal mats to beach water. The persistence of pathogens in beach sand and *Cladophora* mats is poorly understood. To the extent that persistence of indicator bacteria in sand and *Cladophora* mats does not reflect persistence of pathogens, the persistence of indicator bacteria in these places may reduce the strength of the relationship between indicator organisms, such as *E. coli,* and actual pollution, potentially complicating beach-monitoring efforts through releases of *E. coli* that elevate concentrations in water at times when fecal contamination is not present. It is important to note, however, that issuance of beach advisories and closings under these circumstances errs on the side of being protective of human health.

TOXICITY CONDITIONS OF THE GREATER MILWAUKEE WATERSHEDS

Much, though not all, of the data on toxic contaminants in the greater Milwaukee watersheds is related to four sites with contaminated sediments: the Moss-American USEPA Superfund site on the Little Menomonee River in the Menomonee River watershed, the Cedar Creek USEPA Superfund site in the Milwaukee River watershed, Estabrook Impoundment on the Milwaukee River in the Milwaukee River watershed, and the Milwaukee Estuary Area of Concern (AOC) in the Milwaukee River estuary, outer harbor, and adjacent Lake Michigan area.

The Moss-American USEPA Superfund site is located on Granville Road, west of the Little Menomonee River. It was formerly the location of a wood preserving facility. From 1921 to 1976, the facility treated railroad ties with creosote for preservation. Until 1971, wastes from this operation were discharged into settling ponds which ultimately drained to the Little Menomonee River. Remediation efforts at the Moss-American site and along the Little Menomonee River are ongoing. Between 1995 and 2002, about 3,100 gallons of creosote were removed from ground water associated with the site and about 137,000 tons of soil from the site were treated to remove contaminants. From 2003 to 2005, sections of channel of the Little Menomonee River between W. Brown Deer Road and Leon Terrace were relocated. Current plans call for five sections totaling six miles of the Little Menomonee River to be treated by rerouting the channel, removing and treating the contaminated sediment, filling the old channel, and revegetating the new channel. These remedial efforts represent implementation of recommendations first made in the Commission's comprehensive plan for the Menomonee River watershed.[51]

The Cedar Creek Superfund site consists of the Mercury Marine Plant 2 on St. John Avenue, the Amcast Facility on Hamilton Road, and Zeunert Pond, all in the City of Cedarburg, and a 5.1 mile segment of Cedar Creek from below the Ruck Pond dam in the City of Cedarburg downstream to the confluence with the Milwaukee River in the Town of Grafton. PCBs from two sources have contaminated Cedar Creek. Mercury Marine, a boat engine manufacturer, operated a plant on St. John Avenue from 1951 to 1982. Fluids containing PCBs leaked from equipment in this plant and were washed into floor drains, which emptied into storm sewers. Those sewers emptied into Ruck Pond and ultimately flowed into the Milwaukee River. Amcast, an automotive industry supplier, operated an aluminum and magnesium die-cast plant on Hamilton Road that discharged PCBs into the Creek via storm sewers. One of those sewers emptied into Hamilton Pond, an impoundment on Cedar Creek. In 1996, as a result of heavy rains and high streamflow, the Hamilton dam failed and was removed. The pond was drained, leaving behind several acres of mud flats containing PCBs. Several remediation efforts have been undertaken at this site. Among these was the removal of about 7,700 cubic yards of contaminated sediment and

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[51]*SEWRPC Planning Report No. 26,* A Comprehensive Plan for the Menomonee River Watershed, *Volume Two,* Alternative Plans and Recommended Plan, *October 1976.*

soil from Ruck Pond. While this removed about 96 percent of the PCB mass from the pond, samples from residual sediment remaining in the pond exhibited an average PCB concentration of 76 mg/kg.[52] In addition, about 14,000 tons of contaminated soils were removed from the banks of the former Hamilton Pond.

Estabrook Impoundment is formed by the Estabrook dam on the Milwaukee River. This site contains about 100,000 cubic yards of sediment contaminated with about 5,200 kg of PCBs.[53] The site includes the western channel of the Milwaukee River, sections of the mainstem of the Milwaukee River from the confluence with the western channel downstream to Estabrook dam, and Lincoln Creek from Green Bay Road to the confluence with the Milwaukee River. A study of PCB transport in the Milwaukee River watershed estimated that, through resuspension of sediment and dissolution of PCBs stored in sediment, this impoundment increases annual mass transport of PCBs in the Milwaukee River from about 5 kg to about 15 kg.[54] The source of the PCBs in this impoundment is not known; however, the mixture of PCB congeners found at this site contains a greater proportion of lighter, less chlorinated congeners than those found at sites along Cedar Creek or at upstream sites along the mainstem of the Milwaukee River, suggesting that these contaminants may have entered the watershed through Lincoln Creek.

The Milwaukee Estuary Area of Concern (AOC) includes the Milwaukee River downstream from the site of the former North Avenue dam, the Menomonee River downstream from S. 35th Street, the Kinnickinnic River downstream from S. Chase Avenue, the inner and outer harbors, and the nearshore waters of Lake Michigan bounded by a line extending north from Sheridan Park to the intake from the City of Milwaukee's Linnwood water treatment plant. It is one of 43 sites in the Great Lakes area targeted for priority attention under the U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) due to impairment of beneficial use of the area's ability to support aquatic life. Eleven beneficial use impairments have been identified in the Milwaukee Estuary AOC including restrictions of fish and wildlife consumption, degradation of fish and wildlife populations, fish tumors or other deformities, bird or animal deformities or reproductive problems, degradation of benthos, restrictions on dredging activities, eutrophication or undesirable algae, beach closings, degradation of aesthetics, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat.[55] While these impairments are the result of many causes, many are related, at least in part, to the presence of toxic substances in water, sediment, and the tissue of organisms.

Toxic Substances in Water

Pesticides

Since the 1970s, streams in the greater Milwaukee watersheds have been sampled for the presence of pesticides in water on several occasions. Most of the sampling was conducted on the mainstems of the major rivers and streams. Few tributaries have been sampled. It is important to note that the results from the samples taken during 2004 in all watersheds and during 1993-2002 in the Milwaukee River watershed are not directly comparable to those from earlier periods. The data from the earlier periods were derived from unfiltered samples which included both pesticides dissolved in water and pesticides contained in and adsorbed to particulates suspended in the water. The data from the later samples were derived from filtered samples and measure only the fraction of pesticides dissolved in water. Since most pesticides are poorly soluble in water, these data may give an underestimate of ambient pesticide concentrations relative to the earlier data.

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[52]*Baird and Associates,* Final Report, Milwaukee PCB Mass Balance Project, *September 1997.*

[53]Ibid.

[54]*Jeffrey S. Steuer, Sharon A. Fitzgerald, and David W. Hall,* Distribution and Transport of Polychlorinated Biphenyls and Associated Particulates in the Milwaukee River System, Wisconsin, 1993-1995, *U.S. Geological Survey Water-Resources Investigations Report 99-4100, 1999.*

[55]*Wisconsin Department of Natural Resources,* Milwaukee Estuary Remedial Action Plan Progress through January 1994, *1995.*

Since the 1970s, the Kinnickinnic River watershed has been sampled for the presence of pesticides in water on several occasions. There have been four sampling years: 1975, 1984, 1993 and 2004. Sampling during 1975 focused heavily on the insecticides dieldrin, lindane, and DDT and on the metabolites of DDT. In general, the concentrations of these substances were below the limits of detection. In 1984 samples were tested for chlordane, dieldrin, DDT and its metabolites, endosulfan, lindane, and toxaphene. While the concentrations of most of these were below the limit of detection, lindane and toxaphene were each detected in one sample. In 1993, four sites in the estuary were sampled for chlordane isomers. In one sample, measurable concentrations of γ-chlordane were detected. During the 2004 sampling, the insecticides carbaryl and diazinon were occasionally detected as were the herbicide atrazine and its metabolite deethylatrazine. Where detectable concentrations of diazinon and atrazine were reported, they were below the USEPA draft aquatic life criteria.

Since the 1970s, the Menomonee River watershed has been sampled for the presence of pesticides in water on several occasions. There have been three sampling periods: the mid-1970s, the early-1990s, and 2004. Sampling during the 1970s focused heavily on the insecticide DDT and its metabolites. In general, the concentrations of these substances were below the limits of detection. Several pesticides were detected in the sampling conducted during the 1990s including the insecticides DDT, chlordane, endosulfan, lindane, and toxaphene and the herbicides 2,4-D and atrazine. DDT metabolites were also detected. During the 2004 sampling, the insecticides carbaryl and diazinon were occasionally detected as were the herbicide atrazine and its metabolite deethylatrazine. Where detectable concentrations of diazinon and atrazine were reported, they were below the USEPA draft aquatic life criteria. Detectable concentrations of some herbicides were present mostly in May and June, corresponding to the periods during which these pesticides were normally applied.

Since the 1970s, the Milwaukee River has been sampled for the presence of pesticides in water on several occasions. There have been four periods of sampling: 1975-1976, 1982, 1993-2002, and 2004. During 1975 and 1976, water samples from six sites along the mainstem of the Milwaukee River in Milwaukee County were examined for the presence of the insecticides DDT, dieldrin, and lindane and for the DDT metabolites DDD and DDE. In all samples the concentrations of these substances were below the limit of detection. In 1982, three samples collected from the Milwaukee River at Estabrook Park were examined for presence of the herbicide atrazine. Atrazine was detected in all samples at a mean concentration of 0.33 μg/l. During the period 1993-2002, samples collected from the Milwaukee River at Estabrook Park were examined for the presence of several pesticides. The herbicide atrazine and its metabolite deethylatrazine were detected in all samples at mean concentrations of 0.10 μg/l and 0.03 μg/l, respectively. In addition, the atrazine metabolite deisopropylatrazine was detected in all samples that were screened for it. The mean concentration of this compound was 0.02 μg/l. The insecticides carbaryl and diazinon were frequently detected at mean concentrations of 0.014 μg/l and 0.010 μg/l, respectively. The insecticides dieldrin, lindane, and malathion and the DDT metabolite DDE were detected in a few samples at concentrations of 0.011 μg/l, 0.06 μg/l, 0.018 μg/l, and 0.014 μg/l, respectively. In 2004, samples were collected from the mainstem of the Milwaukee River at Pioneer Road, Estabrook Park, and the Jones Island WWTP and examined for the presence of several pesticides. Atrazine and deethylatrazine were detected in all samples that were screened for these compounds at mean concentrations of 0.190 μg/l and 0.055 μg/l, respectively. Carbaryl and diazinon were occasionally detected with mean concentrations of 0.008 μg/l and 0.007 μg/l, respectively. When they were detected in the Milwaukee River, the concentrations of atrazine and diazinon reported were below the USEPA draft aquatic life criteria. The USEPA has not promulgated criteria for the other pesticides that were detected.

Since the 1970s, Lincoln Creek in the Milwaukee River watershed has been sampled for the presence of pesticides in water on several occasions. There have been four periods of sampling: 1975, 1993-1994, 2001 and 2004. The results from the samples taken during 2001 and 2004 are not directly comparable to those from the earlier periods for the reasons given above. During 1975, water samples from three sites along Lincoln Creek were examined for the presence of the insecticides DDT, dieldrin, and lindane and for the DDT metabolites DDD and DDE. In all samples the concentrations of these substances were below the limit of detection. During the period 1993-1994, water samples were collected from Lincoln Creek at N. 47th Street and examined for the presence of several pesticides. Atrazine was occasionally detected with a mean concentration of 0.20 μg/l. The insecticide chlordane was detected in one sample at a concentration of 0.08 μg/l. In 2001, water samples collected from Lincoln Creek at N. 47th Street were examined for the presence of several pesticides. Atrazine was detected in most of the samples, with a mean concentrations of 0.040 μg/l. Deethylatrazine was detected in all samples with a mean concentration of 0.016 μg/l. Diazinon was frequently detected and had a mean concentration of 0.203 μg/l. Carbaryl, deisopropylatrazine, and malathion were each detected in one sample at concentrations of 0.035 μg/l, 0.008 μg/l, and 0.127 μg/l, respectively. In 2004, water samples collected from Lincoln Creek at N. 47th Street were examined for the presence of several pesticides. Atrazine, carbaryl, deethylatrazine, and diazinon were each detected in one sample at concentrations of 0.148 μg/l, 0.004 μg/l, 0.046 μg/l, and 0.009 μg/l. When they were detected in Lincoln Creek, the concentrations of atrazine and diazinon reported were below the USEPA draft aquatic life criteria. The USEPA has not promulgated criteria for the other pesticides that were detected.

Relatively few data are available on concentrations of pesticides in water in other tributaries to the Milwaukee River. In 1993, samples were collected from Batavia Creek, Chambers Creek, Gooseville Creek, the Lake Ellen Outlet, Melius Creek, Nichols Creek, and the North Branch of the Milwaukee River and examined for the presence of atrazine and deethylatrazine. Both of these compounds were found in all of the samples. Concentrations of atrazine in these streams ranged between 0.007 μg/l and 0.043 μg/l, with a mean of 0.023 μg/l. Concentrations of deethylatrazine ranged between 0.011 μg/l and 0.041 μg/l, with a mean of 0.022 μg/l. During the period 1993-1994, the North Branch of the Milwaukee River was sampled extensively at a site near Random Lake for the presence of several pesticides. Atrazine and deethylatrazine were found in all samples with mean concentrations of 0.060 μg/l and 0.031 μg/l, respectively. Carbaryl, diazinon, and malathion were also occasionally detected. In 2001, additional sampling was conducted at this site. Atrazine and deethylatrazine were found in all samples with mean concentrations of 0.080 μg/l and 0.021 μg/l, respectively. The concentrations of atrazine and diazinon reported in tributary streams in the Milwaukee River watershed were below the USEPA draft aquatic life criteria. The USEPA has not promulgated criteria for the other pesticides that were detected.

Since the 1970s, the Oak Creek watershed has been sampled for the presence of pesticides in water on several occasions. There have been four sampling years: 1975, 1982, 1993 and 2004. Sampling during 1975 focused heavily on the insecticides dieldrin, lindane, and DDT and on the metabolites of DDT. The concentrations of these substances were below the limits of detection. Single samples from sites on the mainstem of Oak Creek were taken in 1982 and 1993 and tested for toxaphene. In both cases, the concentration of this insecticide was below the limit of detection. During the 2004 sampling, the insecticides diazinon, dieldrin, and malathion were below the limit of detection. The insecticide carbaryl was detected in one sample as were the herbicide atrazine and its metabolite deethylatrazine. The concentration of atrazine reported was below the USEPA draft aquatic life criteria.

The Root River watershed has been sampled for the presence of pesticides in water on several occasions. The site below the Horlick dam on the mainstem of the River in Racine was sampled in 1995, 1998, and 2002. Three additional sites along the mainstem, W. Layton Avenue, W. Grange Avenue, and upstream of W. Ryan Road, were sampled in 2004. The insecticides carbaryl and diazinon were detected in some samples from each site. The herbicide atrazine was detected in most of the samples. The atrazine metabolite deethylatrazine was detected at two upstream sites. The herbicide glyphosate was detected in samples from the station below the Horlick dam. Concentrations of the insecticides dieldrin, lindane, and malathion were below the limit of detection. The concentrations of atrazine and diazinon reported were below the USEPA draft aquatic life criteria.

Relatively few data are available on concentrations of pesticides in water in the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan area. In 1993, four sites in the estuary portion of the Kinnickinnic River were sampled for chlordane isomers. Measurable concentrations of γ-chlordane were detected in one sample. In 2004, samples were collected from the Milwaukee River section of the estuary at the Jones Island WWTP and examined for the presence of several pesticides. Atrazine and deethylatrazine were detected in one sample that was screened for these compounds at concentrations of 0.195 μg/l. and 0.060 μg/l, respectively. Carbaryl and diazinon were detected in one sample each with concentrations of 0.011 μg/l and 0.011 μg/l, respectively. The concentrations of atrazine and diazinon reported were below the USEPA draft aquatic life criteria. The USEPA has not promulgated criteria for the other pesticides that were detected.

While no data were available on pesticide concentrations in water from the outer harbor or nearshore Lake Michigan area, data were available for Lake Michigan as a whole. These data should give some indications of conditions in the nearshore area. The Lake Michigan Mass Balance Study examined concentrations of the pesticide atrazine and two of its metabolites, deethylatrazine and deisopropylatrazine, in tributaries draining into Lake Michigan and the open waters of Lake Michigan.[56] Loadings from tributaries represent the major source of atrazine to the Lake, accounting for about 68 percent of contributions. Concentrations of atrazine in 16 samples collected from near the mouth of the Milwaukee River in 1994 and 1995 ranged between 0.011 μg/l and 0.058 μg/l, with a mean concentration of 0.030 μg/l. Concentrations of deethylatrazine ranged between 0.017 μg/l and 0.060 μg/l, with a mean concentration of 0.029 μg/l. Concentrations of deisopropylatrazine ranged between 0.015 μg/l and 0.056 μg/l, with a mean concentration of 0.028 μg/l. Concentrations of atrazine in the open waters of Lake Michigan ranged between 0.022 μg/l and 0.058 μg/l, with a mean concentration of 0.038 μg/l. Concentrations of deethylatrazine in the open waters of Lake Michigan ranged between 0.014 μg/l and 0.036 μg/l, with a mean concentration of 0.026 μg/l. Concentrations of deisopropylatrazine in the open waters of Lake Michigan ranged from below the limit of detection to 0.030 μg/l with a mean concentration of 0.015 μg/l. These observed concentrations are well below the USEPA biological effects threshold. The study estimated that in 1994 the Milwaukee River basin contributed 87 kg of atrazine to Lake Michigan. This represents less than 2 percent of the estimated tributary loading of 5,264 kg to the Lake.

The Lake Michigan Mass Balance Study also examined concentrations of the pesticide trans-nonachlor, an isomer and constituent of the insecticide chlordane in tributaries draining into Lake Michigan and the open waters of Lake Michigan.[57] Concentrations of dissolved trans-nonachlor in 36 samples collected from near the mouth of the Milwaukee River in 1994 and 1995 ranged from below the limit of detection to 0.044 nanograms per liter (ng/l) with a mean concentration of 0.023 ng/l. Concentrations of particulate trans-nonachlor ranged between 0.011 ng/l and 0.22 ng/l with a mean concentration of 0.037 ng/l.

Polycyclic Aromatic Hydrocarbons (PAHs)

Since 1995, sampling has been conducted for PAHs in the mainstems of most of the major streams and rivers of the greater Milwaukee watershed. The samples collected fall into two groups. MMSD conducted extensive sampling for 16 PAH compounds in whole water at stations along the mainstems of the Menomonee, Kinnickinnic, and Milwaukee Rivers during the period 1995-2001 and at stations along the Root River in Milwaukee County during the period 1999-2001. In 2004 the USGS sampled at sites along the Menomonee, Kinnickinnic, Milwaukee, and Root Rivers and Oak Creek for six PAH compounds dissolved in water. It is important to note that the results of the 2004 sampling are not directly comparable to the results of the earlier sampling. The 2004 sampling examined fewer compounds than the earlier sampling. In addition, the data from 1995-2001 were derived from unfiltered samples which included both PAHs dissolved in water and PAHs contained in and adsorbed to particulates suspended in the water. The data from 2004 were derived from filtered samples and measure only the fraction of PAHs dissolved in water. Since most PAHs are poorly soluble in water, the data from the 2004 samples may give an underestimate of concentrations relative to the earlier data.

Measurable concentrations of PAHs were detected at all of the sampling stations surveyed. Concentrations of total PAHs in whole water samples ranged from below the limit of detection to 12.8 μg/l. Between the periods 1995-1997 and 1998-2001, mean total PAH concentrations in the Milwaukee Harbor estuary decreased slightly from 1.06 μg/l to 0.97 μg/l. This decrease was not statistically significant. At the same time, mean concentrations of total PAHs in the estuary portions of the Kinnickinnic and Menomonee Rivers increased. Between the periods 1995-1997 and 1998-2001, the mean concentration of total PAHs in the estuary portion of the Kinnickinnic River increased from 0.98 μg/l to 1.15 μg/l and the mean concentration of total PAHs in the estuary portion of the

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[56]*U.S. Environmental Protection Agency,* Results of the Lake Michigan Mass Balance Study: Atrazine Data Report, *EPA 905R-01-010, December 2001.*

[57]*U.S. Environmental Protection Agency,* Results of the Lake Michigan Mass Balance Study: Polychlorinated Biphenyls and Trans-nonachlor Data Report, *EPA 905R-01-011, April 2004.*

Menomonee River increased from 0.51 μg/l to 1.01 μg/l. These increases in mean PAH concentration the estuary portions of these Rivers were accompanied by decreases in the portions of the Rivers upstream from the estuary. Between the periods 1995-1997 and 1998-2001, the mean concentration of total PAHs in the portion of the Kinnickinnic River upstream from the estuary decreased from 1.70 μg/l to 1.04 μg/l. Similarly, the mean concentration of PAHs in the portion of the Menomonee River decreased from 1.76 μg/l to 0.72 μg/l between the same two periods. The mean concentration of PAHs in whole water samples from the Milwaukee River was 0.85 μg/l. In the Milwaukee River, the concentration and frequency of detection of PAHs tended to increase from upstream to downstream. The mean concentration of PAHs in whole water samples collected from the Root River was 0.47 μg/l. It is important to note that these samples were all collected from MMSD's sampling stations in Milwaukee County.

In general, mean concentrations of PAHs in samples collected in 2004 were lower than those collected in previous years, but as noted above, fewer compounds were examined in these samples and these samples were examined only for dissolved concentrations.

Polychlorinated Biphenyls (PCBs)

Between 1995 and 2001 the MMSD long-term sampling sites along the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Lincoln and Southbranch Creeks were sampled for the presence and concentrations of 14 PCB congeners in water. Concentrations of only 14 out of 209 congeners from this family of compounds were examined. Thus, the total PCB concentration may be underestimated since only some congeners were examined. In all of the samples collected from the Root River and Southbranch Creek, the concentrations of these PCB congeners were below the limit of detection. While in the majority of samples collected from the Kinnickinnic, Menomonee, and Milwaukee Rivers and Lincoln Creek, the concentrations of these PCB congeners were below the limit of detection, when PCBs were detected they were at concentrations that exceeded Wisconsin's wildlife criterion for surface water quality of 0.12 nanograms per liter (ng/l). While the congeners that were most commonly detected in these samples are known to exhibit toxicological activity, they are not considered to be among the most highly toxic PCB congeners. It is important to note that concentrations of several of the congeners considered to be most highly toxic were not examined by MMSD in this sampling.

More extensive sampling for PCB concentrations in water was conducted by the U.S. Geological Survey in the Milwaukee River and Cedar Creek, both in the Milwaukee River watershed. These samples were examined for both concentrations of the PCB fractions dissolved in water and concentrations associated with suspended sediment. For both streams sampled, the total PCB concentration may be underestimated since only some congeners were examined. Between 1993 and 1995 concentrations of 62 PCB fractions representing 85 PCB congeners out of 209 congeners from this family of compounds were examined at five locations along the mainstem of the Milwaukee River. Also, between 1991 and 2001 concentrations of 62 PCB fractions representing 85 PCB congeners were examined at four locations along Cedar Creek. In all of the samples collected from both streams, PCB concentrations exceeded Wisconsin's wildlife criterion for surface water quality of 0.12 nanograms per liter (ng/l). In both streams, several of the congeners that are regarded as most highly toxic were detected, usually being found in the majority of samples.

Because of both the limited time frame over which sampling for PCB concentrations in water was conducted and differences among the congener suites examined, the data are not adequate to assess trends in PCB concentrations in water over time.

Toxic Contaminants in Aquatic Organisms

The WDNR periodically surveys tissue from fish and other aquatic organisms for the presence of toxic and hazardous contaminants. Several surveys were conducted at sites within the greater Milwaukee watersheds between 1976 and 2002. These surveys screened for the presence and concentrations of several contaminants including metals, PCBs, and organochloride pesticides. Because of potential risks posed to humans by consumption of fish containing contaminants, the WDNR has issued a general fish consumption advisory for fish caught from most of the surface waters of the State. The details of this advisory are shown in Table 38. In

Table 38

GENERAL FISH CONSUMPTION ADVISORY FOR MOST WATERS IN WISCONSIN[a]

Advisory	Sensitive Group[b]	All others
Unlimited Consumption	- -	Bluegill, sunfish, black crappie, white crappie, yellow perch, or bullheads
One Meal per Week	Bluegill, sunfish, black crappie, white crappie, yellow perch, or bullheads	Walleyed pike, northern pike, smallmouth bass, largemouth bass, channel catfish, flathead catfish, or other species
One Meal per Month	Walleyed pike, northern pike, smallmouth bass, largemouth bass, channel catfish, flathead catfish, white sucker, drum, burbot, sauger, sturgeon, carp, white bass, rock bass, or other species	- -
Do Not Eat	Muskellunge	- -

[a]*On certain waters, the Wisconsin Department of Natural Resources issues more restrictive consumption advice due to higher levels of mercury or PCBs in fish.*

[b]*Sensitive group includes pregnant women, nursing mothers, women of childbearing age, and children under 15 years of age.*

Source: Wisconsin Department of Natural Resources.

addition, when tissue from fish caught in a particular waterbody is found to contain higher levels of mercury, PCBs, or dioxins, the WDNR issues more restrictive consumption recommendations. The WDNR has issued fish consumption advisories for several species of fish taken from several waterbodies in the greater Milwaukee watersheds. These waterbodies include Cedar Creek, Jackson Park Pond in Milwaukee County, the Kinnickinnic River, Lake Michigan and tributaries of Lake Michigan up to the first dam, Lincoln Creek, Mauthe Lake, the Menomonee River, the Milwaukee Harbor Estuary, the Milwaukee River downstream from the City of Grafton, the Root River downstream from the Horlick dam, and Zeunert Pond in the City of Cedarburg. Table 39 shows the details of these consumption advisories. In addition due to tissue concentrations of PCBs in excess of the U.S. Food and Drug Administration's standard, the Wisconsin Division of Health has issued a do not eat consumption advisory for black ducks, mallard ducks, ruddy ducks, and scaup using the Milwaukee Harbor.

Mercury

Between 1976 and 2002, the WDNR sampled tissue from several species of aquatic organisms for mercury contamination. The concentration of mercury reported in fish tissue ranged between 0.03 micrograms mercury per gram tissue (μg Hg per g tissue) and 1.40 μg Hg per g tissue. Tissue concentrations of mercury in fish collected from the Kinnickinnic River and Menomonee River watersheds were generally below 0.05 μg Hg per g tissue. No apparent trends were detected in tissue concentrations from these watersheds. Tissue concentrations of mercury in fish collected from the Milwaukee River watershed ranged between 0.05 μg Hg per g tissue and 0.36 μg Hg per g tissue. No apparent trends were detected in tissue concentrations from this watershed. It is important to note that Mauthe Lake in the Milwaukee River watershed is subject to a special fish consumption advisory due to high tissue concentrations of mercury detected in fish from this Lake (Table 39). Few data were available from the Oak Creek watershed. The tissue concentration of mercury in two fish collected from this watershed was 0.38 μg Hg per g tissue. Tissue concentrations of mercury in fish collected from the Root River watershed ranged between 0.03 μg Hg per g tissue and 1.40 μg Hg per g tissue. Tissue concentrations of mercury in fish collected from the Milwaukee Harbor ranged between 0.11 μg Hg per g tissue and 0.28 μg Hg per g tissue. While no data were available for the nearshore Lake Michigan area, the Lake Michigan Mass Balance Study found that tissue concentrations of mercury in adult lake trout collected from Lake Michigan ranged between 0.019 μg Hg per g

Table 39

FISH CONSUMPTION ADVISORIES FOR THE GREATER MILWAUKEE WATERSHEDS[a]

Species	Consumption Advisory Level			
	One Meal per Week	One Meal per Month	One Meal per Two Months	Do Not Eat
Cedar Creek				
All Species	- -	- -	- -	All sizes
Jackson Park Pond				
Black Crappie	- -	- -	All sizes	- -
Bluegill	- -	- -	All sizes	- -
Carp	- -	- -	All sizes	- -
Largemouth Bass	- -	- -	All sizes	- -
Pumpkinseed	- -	- -	All sizes	- -
Lake Michigan and Its Tributaries Up to First Dam[b]				
Chubs	- -	All sizes	- -	- -
Chinook Salmon	- -	Less than 32 inches	Larger than 32 inches	- -
Coho Salmon	- -	All sizes	- -	- -
Brown Trout	- -	Less than 22 inches	Larger than 22 inches	- -
Lake Trout	- -	Less than 23 inches	23-27 inches	Larger than 27 inches
Rainbow Trout	Less than 22 inches	Larger than 22 inches	- -	- -
Smelt	All sizes	- -	- -	- -
Whitefish	- -	All sizes	- -	- -
Yellow Perch	All sizes	- -	- -	- -
Mauthe Lake				
Yellow Perch	- -	All sizes[c]	- -	All sizes[c]
Milwaukee River from the City of Grafton Downstream to Estabrook Falls				
Black Crappie	- -	All sizes	- -	- -
Brown Trout	- -	Less than 22 inches	Larger than 22 inches	- -
Carp	- -	- -	- -	All sizes
Chinook Salmon	- -	Less than 32 inches	Larger than 32 inches	- -
Coho Salmon	- -	All sizes	- -	- -
Lake Trout	- -	Less than 23 inches	23-27 inches	Larger than 27 inches
Largemouth Bass	- -	All sizes	- -	- -
Northern Pike	- -	- -	All sizes	- -
Rainbow Trout	Less than 22 inches	Larger than 22 inches	- -	- -
Redhorse	- -	All sizes	- -	- -
Rock Bass	- -	All sizes	- -	- -
Smallmouth Bass	- -	All sizes	- -	- -
Milwaukee River from Estabrook Falls to the Estuary[d]				
Black Crappie	- -	- -	All sizes	- -
Brown Trout	- -	Less than 22 inches	Larger than 22 inches	- -
Carp	- -	- -	- -	All sizes
Chinook Salmon	- -	Less than 32 inches	Larger than 32 inches	- -
Coho Salmon	- -	All sizes	- -	- -
Lake Trout	- -	Less than 23 inches	23-27 inches	Larger than 27 inches
Northern Pike	- -	- -	All sizes	- -
Rainbow Trout	Less than 22 inches	Larger than 22 inches	- -	- -
Redhorse	- -	- -	All sizes	- -
Rock Bass	- -	All sizes	- -	- -
Smallmouth Bass	- -	All sizes	- -	- -
Walleye	- -	Less than 18 inches	Larger than 18 inches	- -
White Sucker	- -	- -	All sizes	- -
Yellow Perch	All sizes	- -	- -	- -
Root River from the Horlick Dam Downstream to the Mouth				
Carp	- -	- -	- -	All sizes
Chinook Salmon	- -	Less than 32 inches	Larger than 32 inches	- -
Coho Salmon	- -	All sizes	- -	- -
Brown Trout	- -	Less than 22 inches	Larger than 22 inches	- -
Lake Trout	- -	Less than 23 inches	23-27 inches	Larger than 27 inches
Rainbow Trout	Less than 22 inches	Larger than 22 inches	- -	- -

Table 39 Footnotes

[a]*The statewide general fish consumption advisory applies to fish species not listed in this table.*

[b]*This includes the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek.*

[c]*This advisory is for women of childbearing age and children under 15. Women beyond their childbearing age and men are advised to eat no more than one meal per week.*

[d]*This includes the Kinnickinnic and Menomonee Rivers and Lincoln Creek.*

Source: Wisconsin Department of Natural Resources.

tissue and 0.396 μg Hg per g tissue.[58] This study also found that tissue concentrations of mercury in adult coho salmon collected from Lake Michigan ranged between 0.023 μg Hg per g tissue and 0.127 μg Hg per g tissue.

It is important to recognize that the number of individual organisms and the range of species taken from these watersheds that have been screened for the presence of mercury contamination are quite small. Because of this, these data may not be completely representative of body burdens of mercury carried by aquatic organisms in the greater Milwaukee watersheds.

PCBs

Between 1977 and 2002, the WDNR sampled tissue from several species of aquatic organisms for PCB contamination. High tissue concentrations of PCBs were found in several species, especially carp, in samples collected from the Kinnickinnic and Menomonee River watersheds. High tissue concentrations of PCBs were found in several species of fish collected from the Milwaukee River watershed, especially from sites along the mainstem of the Milwaukee River downstream from the Village of Grafton, Cedar Creek, Lincoln Creek, Jackson Park Pond, and Zeunert Pond. Tissue concentrations in fish collected from sites along the mainstem of the Milwaukee River above Grafton and from sites along several upstream tributaries were lower. High tissue concentrations of PCBs were also detected in several species of fish collected from the Root River, especially from sites below the Horlick dam. While no data were available on tissue concentrations of PCBs in organisms collected from sites in the Milwaukee outer harbor or nearshore Lake Michigan area, data were available for Lake Michigan as a whole. The Lake Michigan Mass Balance study found high tissue concentrations in both forage fish and piscivorous fish collected from the Lake.[59]

Comparisons of tissue concentrations of PCBs in recent samples to concentrations in samples from the 1970s suggest that at some locations, including Lake Michigan, tissue concentrations of PCBs in fish have decreased. Time comparisons in many of these locations are complicated by the fact that different species were collected on different dates.

It is important to note that several waterbodies and stream reaches in the greater Milwaukee watersheds are subject to special fish consumption advisories due to high tissue concentrations of PCBs detected in fish. These advisories are given in Table 39.

It is important to recognize that the number of individual organisms and the range of species taken from these watersheds that have been screened for the presence of PCB contamination are quite small. Because of this, these

[58]*U.S. Environmental Protection Agency,* Results of the Lake Michigan Mass Balance Study: Mercury Data Report, *EPA 905 R-01-012, 2004.*

[59]*U.S. Environmental Protection Agency,* Results of the Lake Michigan Mass Balance Study: Polychlorinated Biphenyl and Trans-nonachlor Data Report, *EPA 905R-01-011, 2004.*

data may not be completely representative of body burdens of PCBs carried by aquatic organisms in the greater Milwaukee watersheds.

Pesticides

Between 1977 and 2002, the WDNR sampled several species of aquatic organisms from the greater Milwaukee watersheds for contamination by historically used, bioaccumulative pesticides and their breakdown products. Many of these compounds are no longer in use. For example, crop uses of most of these compounds were banned in the United States between 1972 and 1983. While limited uses were allowed after this for some of these substances, by 1988 the uses of most had been phased out. To some extent, the data on pesticides detected in the tissue of aquatic organisms reflect these changes in pesticide use.

During the late 1970s and early 1980s, isomers of the insecticide DDT and the DDT breakdown products DDD and DDE were detected in the tissue of several species of fish collected from the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers. DDD and DDE were also detected in the tissue of carp collected from Oak Creek. The insecticide dieldrin and isomers of the insecticide chlordane were detected in tissue of fish collected from the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers. Several other pesticides, including aldrin, hexachlorobenzene, and methoxychlor, were detected in the tissue of fish collected from some locations in the greater Milwaukee watersheds.

Since the mid 1980s and early 1990s, concentrations of DDT isomers in fish tissue in samples collected from the Menomonee River and Milwaukee River and Oak Creek have been below the limit of detection. DDT has been detected in fish tissue in samples collected from the Root River, Oak Creek Parkway Pond, and some tributaries from the Milwaukee River. While DDD and DDE were still detected in fish tissue at most locations that were sampled, concentrations found in some streams were lower than those detected during the late 1970s and early 1980s. Concentrations of dieldrin in fish tissue were below the limit of detection in many streams, though measurable concentrations were still being detected in some fish collected from the Root River. Concentrations of chlordane isomers in fish tissue were below the limit of detection in many streams, though measurable concentrations were still being detected in some fish collected from Cedar Creek and the Root River.

While no data were available on tissue concentrations of pesticides in organisms collected from the outer harbor or nearshore Lake Michigan area, data were available for one pesticide for Lake Michigan as a whole. These data give some indication of likely conditions in the nearshore area. The Lake Michigan Mass Balance Study examined concentrations of the chlordane isomer trans-nonachlor in tissue of phytoplankton, zooplankton, aquatic invertebrates, and fish collected in the open waters of Lake Michigan.[60] This insecticide was detected in tissue from these organisms. The relative concentrations detected in these groups indicate that trans-nonachlor is being biomagnified through the Lake Michigan food web.

It is important to recognize that the number of individual organisms and the range of species taken from these watersheds that have been screened for the presence of pesticide contamination are quite small. Because of this, these data may not be completely representative of body burdens of pesticides carried by aquatic organisms in the greater Milwaukee watersheds.

Toxic Contaminants in Sediment

Since 1973, sediment samples from streams in the greater Milwaukee watersheds have been examined for the presence and concentrations of toxic substances on several occasions. Toxicants that have been sampled for include metals, PAHs, PCBs, and pesticides. Most of the sites sampled in the Kinnickinnic River watershed are from the mainstem of the Kinnickinnic River within the estuary. Most of the sites sampled in the Menomonee River watershed are from the Little Menomonee River and are related to the Moss-American USEPA Superfund site. A variety of sites were sampled in the Milwaukee River watershed. Sampling has been especially intensive along Cedar Creek and Lincoln Creek, and in Estabrook Impoundment. The sites sampled in the Oak Creek

[60]*U.S. Environmental Protection Agency, EPA 905R-01-011,* op. cit.

watershed are from the mainstem of Oak Creek and Oak Creek Parkway Pond. The sites sampled in the Root River watershed include sites along the mainstem of the Root River, Crayfish Creek, Whitnall Park Creek, and an unnamed tributary to Crayfish Creek. Considerable sampling has been conducted within the Milwaukee River estuary and outer harbor.

The potential for contaminants present in the sediment at particular sites to create biological impacts was evaluated based upon proposed consensus-based sediment quality guidelines developed by the WDNR.[61] These guidelines apply average effect-level concentrations from several guidelines of similar intent and are used to predict the presence or absence of toxicity. Three criteria based on likely effects to benthic-dwelling organisms are proposed: threshold effect concentration (TEC), probable effect concentration (PEC), and midpoint effect concentration (MEC). TECs indicate contaminant concentrations below which adverse effects to benthic organisms are considered to be unlikely. PECs indicate contaminant concentrations at which adverse effects to the benthic organisms are highly probable or will be frequently seen. MECs are derived from TEC and PEC values for the purpose of interpreting the effects of contaminant concentrations that fall between the TEC and the PEC. The WDNR recommends that their criteria be used to establish levels of concern for prioritizing sites for additional study.[62] The threshold, midpoint, and probable effect concentrations for metals and for nonpolar organic compounds are presented in Chapter III of SEWRPC Technical Report No. 39.

The probable effect concentrations can also be used to derive mean PEC quotients (mean PEC-Q) for evaluating the toxicity of mixtures of contaminants in sediment to benthic organisms. This normalizes the value to provide comparable indices of contamination among samples for which different numbers of contaminants were analyzed. Results of evaluation of this method show that mean PEC quotients that represent mixtures of contaminants are highly correlated with incidences of toxicity to benthic organisms in the same sediments. The reliability of predictions of toxicity is greatest for mean PEC quotients calculated from total PAHs, total PCBs, and the metals arsenic, cadmium, chromium, copper, lead, nickel, and zinc.

Several toxic metals have been detected in sediment samples collected in the greater Milwaukee watersheds. Detectable concentrations of arsenic, cadmium, copper, lead, and zinc have been frequently reported in sediment samples collected from most of the watersheds and the estuary and outer harbor. Chromium, iron, mercury, and nickel have also been detected in sediment samples from several watersheds. The mean concentrations of cadmium, chromium, copper, lead, mercury, and zinc reported for the watersheds in which they have been detected are generally above their respective TECs indicating that these toxicants are likely to be producing some level of toxic effect in benthic organisms. In some watersheds, concentrations of cadmium, copper, lead, and zinc are also above their respective PECs, suggesting that toxic effects to benthic organisms are highly probable.

The amount of organic carbon in sediment can exert considerable influence on the toxicity of nonpolar organic compounds such as PAHs, PCBs, and certain pesticides to benthic organisms. While the biological responses of benthic organisms to nonionic organic compounds has been found to differ across sediments when the concentrations are expressed on a dry weight basis, they have been found to be similar when the concentrations

[61]*Wisconsin Department of Natural Resources,* Consensus-Based Sediment Quality Guidelines: Recommendations for Use and Application—Interim Guidance, *WT-732 2003, December 2003.*

[62]*It is important to note that these guidelines estimate only the effects of contaminants on benthic macroinvertebrate species. Where noncarcinogenic and nonbioaccumulative compounds are concerned, these guidelines should be protective of human health and wildlife concerns. For bioaccumulative compounds, considerations of the protection of human health or wildlife may necessitate the use of more restrictive concentration levels.*

have been normalized to a standard percentage of organic carbon.[63] Because of this, the concentrations of PAHs, PCBs, and pesticides were normalized to 1 percent organic carbon prior to analysis.

Concentrations of PAHs in sediment samples ranged from below the limit of detection to 11,424,000 micrograms PAH per kilogram sediment (μg PAH/kg sediment). While PAHs were detected in sediment from all of the watersheds, particularly high concentrations were found in sediment from sites in the Little Menomonee River in the Menomonee River watershed, the mainstem of the Kinnickinnic River in the estuary, and Estabrook Impoundment and Lincoln Creek in the Milwaukee River watershed. Concentrations of PAHs exceeded the PEC for total PAHs at sites along the Little Menomonee River, the Kinnickinnic River, Lincoln Creek, the Root River, and in the estuary and outer harbor, suggesting that benthic organisms at these sites may be experiencing substantial incidences of toxic effects. At other sampling locations, concentrations of PAHs were between the TEC and the PEC, indicating that these toxicants are likely to be producing some level of toxic effect in benthic organisms.

Concentrations of PCBs in sediment samples ranged from below the limit of detection to 11 million micrograms PCB per kilogram sediment (μg PCB/kg sediment). While PCBs were detected in sediment from a number of locations, particularly high concentrations were found in sediment from sites in Cedar Creek and Zeunert Pond in Cedarburg, Estabrook Impoundment and Lincoln Creek in the Milwaukee River watershed, and the Milwaukee Harbor estuary. Concentrations of PCBs exceeded the PEC for total PCBs at several sites in the Milwaukee River watershed, including sites in Cedar Creek, Estabrook Impoundment, and Zeunert Pond, and some sites in the estuary and outer harbor, suggesting that benthic organisms at these sites may be experiencing substantial incidences of toxic effects. At other sampling locations, concentrations of PCBs were between the TEC and the PEC, indicating that these toxicants are likely to be producing some level of toxic effect in benthic organisms. These sites include many sites in the estuary and outer harbor, a substantial number of sites in the Milwaukee River watershed, and a few sites in the Root River watershed.

The combined effects of several toxicants in sediment from waterbodies within the greater Milwaukee watersheds were evaluated by computing mean PEC-Q values as described above and calculating the associated estimated incidence of toxicity to benthic organisms. In sediment samples from the Kinnickinnic River, the estimated incidence of toxicity ranged from 25 percent to 100 percent. Estimated incidences of toxicity to benthic organisms in sediment samples from the Little Menomonee River in the Menomonee River watershed ranged from 25 percent to 100 percent. Along the mainstem of the Milwaukee River, estimated incidences of toxicity ranged from less than 1 percent to 100 percent. Higher estimated incidences occurred downstream from the confluence with Cedar Creek, with the highest estimated incidences being found in Estabrook Impoundment. For two Milwaukee River tributaries, Cedar Creek and Lincoln Creek, the ranges of the estimated incidences of toxicity were 9 percent to 100 percent and 20 percent to 100 percent, respectively. Estimated incidences of toxicity to benthic organisms in Oak Creek and its tributaries the North Branch of Oak Creek and the Mitchell Field Drainage Ditch ranged between 17 percent and 58 percent. The estimated incidences of toxicity to benthic organisms from sediment samples in the Root River ranged between 8 percent and 67 percent. Higher estimated incidences were found at sites near the confluence with Lake Michigan. Sampling of Crayfish Creek, Whitnall Park Creek, and an unnamed tributary in the Crayfish Creek subwatershed suggest that benthic organisms in these streams are experiencing similar incidences of toxicity, with estimated incidences ranging between 20 and 72 percent. Estimated incidences of toxicity to benthic organisms in the Milwaukee harbor estuary ranged between 2 percent and 94 percent. The highest estimated incidences of toxicity occurred in the Kinnickinnic River portion of the estuary. The estimated incidences of toxicity were lower in the outer harbor, ranging between 2 percent and 62 percent.

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[63]*U.S. Environmental Protection Agency,* Technical Basis for the Derivation of Equilibrium Partitioning Sediment Guidelines (ESGs) for the Protection of Benthic Organisms: Nonionic Organics, *USEPA Office of Science and Technology, Washington, D.C., 2000.*

BIOLOGICAL CONDITIONS OF THE GREATER MILWAUKEE WATERSHEDS

Aquatic and terrestrial wildlife communities have educational and aesthetic values, perform important functions in the ecological system, and are the basis for certain recreational activities. The location, extent, and quality of fishery and wildlife areas and the type of fish and wildlife characteristic of those areas are, therefore, important determinants of the overall quality of the environment in the greater Milwaukee watersheds.

Streams and Rivers

Review of fishery data collected in the greater Milwaukee watersheds since the beginning of the twentieth century show apparent net losses of species in the Kinnickinnic River, Milwaukee River, and Oak Creek watersheds, no apparent net loss in the Root River watershed, and an apparent net gain in the Menomonee River watershed. Some, though not all, of these apparent changes appear to be due to decreased sampling effort.

Historically, low numbers of fish species were detected in samples from the Kinnickinnic River and Oak Creek watersheds, with 24 species having been reported in the Kinnickinnic River watershed and 29 species having been reported in the Oak Creek watershed over the past century. Current species diversity remains low in these watersheds. During the period 1998-2004, only one species was reported as being present in samples collected from the Kinnickinnic River and its tributaries and 20 species were reported as being present in samples collected from Oak Creek and its tributaries. It is important to note that during the period 1998-2004, only one sample was collected from the Kinnickinnic River. It is likely that a greater sampling effort would have resulted in the detection of more species. For the Kinnickinnic River watershed, this total represents a decrease from the number of species collected during 1994-1997. For the Oak Creek watershed, this total represents an increase from the number detected during 1994-1997.

By contrast, higher numbers of fish species were historically detected in the Milwaukee River and Root River watersheds, with 81 species having been reported in the Milwaukee River watershed and 64 species having been reported in the Root River watershed over the past century. Current species diversity is also higher in these watersheds. During the period 1998-2004, 63 species were reported as being present in samples collected from Milwaukee River and its tributaries and 46 species were reported as being present in samples collected from the Root River and its tributaries. For both these watersheds, these totals represent increases from the numbers detected during 1994-1997.

Historically, an intermediate number of fish species was detected in the Menomonee River watershed, with 46 species having been reported as being present in samples collected over the last century. During the period 1998-2004, 31 species were reported in this watershed. This total represents an increase over the number of species detected during 1994-1997.

In each watershed, the composition of the fish community appears to be changing.

- In the Kinnickinnic River watershed, four species have not been observed since 1986.
- In the Menomonee River watershed, three species have not been observed since 1986.
- In the Milwaukee River watershed, 12 species have not been observed since 1986.
- In the Oak Creek watershed, seven species have not been observed since 1986.
- In the Root River watershed, 10 species have not been observed since 1986.

There have also been new fish species observations in recent years in most of the watersheds. Since 1986, 10 new species have been observed in the Menomonee River watershed, two new species have been observed in the Milwaukee River watershed, seven new species have been observed in the Oak Creek watershed, and 10 new species have been observed in the Root River watershed. In the Oak Creek and Root River watersheds, some of the new observations have occurred in reaches of the mainstems between the confluence with Lake Michigan and the first dam, suggesting that some of these observations reflect the influence of Lake Michigan's fish community on the fish communities in the lower reaches of these Rivers.

Most of the streams of the greater Milwaukee watersheds are warmwater streams; however, some coldwater streams are present, mostly in upstream areas of the Milwaukee River watershed. In Wisconsin, high-quality warmwater streams are characterized by many native species, darters, suckers, sunfish, and intolerant species (species that are particularly sensitive to water pollution and habitat degradation). Within such environments, tolerant fish species also occur that are capable of persisting under a wide range of degraded conditions and are also typically present within high-quality warmwater streams, but they do not dominate.

In contrast to warmwater streams, coldwater systems are characterized by a smaller number of species, with salmonids (trout) and cottids (sculpin) dominating, and they lack many of the taxonomic groups that are important in high-quality warmwater streams. An increase in fish species richness in coldwater fish assemblages often indicates environmental degradation. When degradation occurs, the small number of coldwater species is replaced by a larger number of more physiologically tolerant cool and warmwater species, which is the opposite of what tends to occur in warmwater fish assemblages.

Figure 44 shows the number of fish species by tolerance class in each of the watersheds of the study area. All of the watersheds contain high proportions of species that are tolerant of low dissolved oxygen conditions. These tolerant species tend to be present at high prevalence in the fish communities in the Kinnickinnic River, Menomonee River, and Oak Creek watersheds. Low numbers of native species and species that are intolerant of low dissolved oxygen conditions are also present in these watersheds. This is indicative of a poor-quality fishery. The proportion of tolerant species has increased in many parts of the study area. For example, the proportion of tolerant fish collected from the Menomonee River watershed represented by common carp increased from about 2 percent in 1975, to 40 percent in 2004. Carp are likely to be having a negative effect on the fisheries in many stream reaches by destroying habitat and competing for food and spawning areas of native fish species.

Because of its size, the situation is more complicated in the Milwaukee River watershed. Some stream reaches in this watershed are dominated by low dissolved oxygen tolerant fish, especially in the North Branch Milwaukee River, Lincoln Creek, and Lower Milwaukee River subwatersheds. Other stream reaches sustain good proportions of top carnivore species and good balances of predatory fishes to forage fishes, indicating a high-quality fishery. Although the fisheries in portions of the watershed are high quality, most notably in the northern part of the watershed and in the portions of the mainstem that is directly connected to Lake Michigan, there are many areas where the fishery quality is poor to fair or where the quality of the fishery has declined.

The apparent stagnation of the fishery communities within much of the greater Milwaukee watersheds can be attributed to habitat loss and degradation as a consequence of human activities primarily related to the historic and current agricultural and urban land use development that has occurred within this the watershed. Agricultural and/or urban development can cause numerous changes to streams that have the potential to alter aquatic biodiversity that include but are not limited to the following factors which have been observed to varying degrees in the greater Milwaukee watersheds:[64]

- Increased flow volumes and channel-forming storms—These alter habitat complexity, change availability of food organisms related to timing of emergence and recovery after disturbance, reduce prey availability, increase scour related mortality, deplete large woody debris for cover in the channel, and accelerate streambank erosion;

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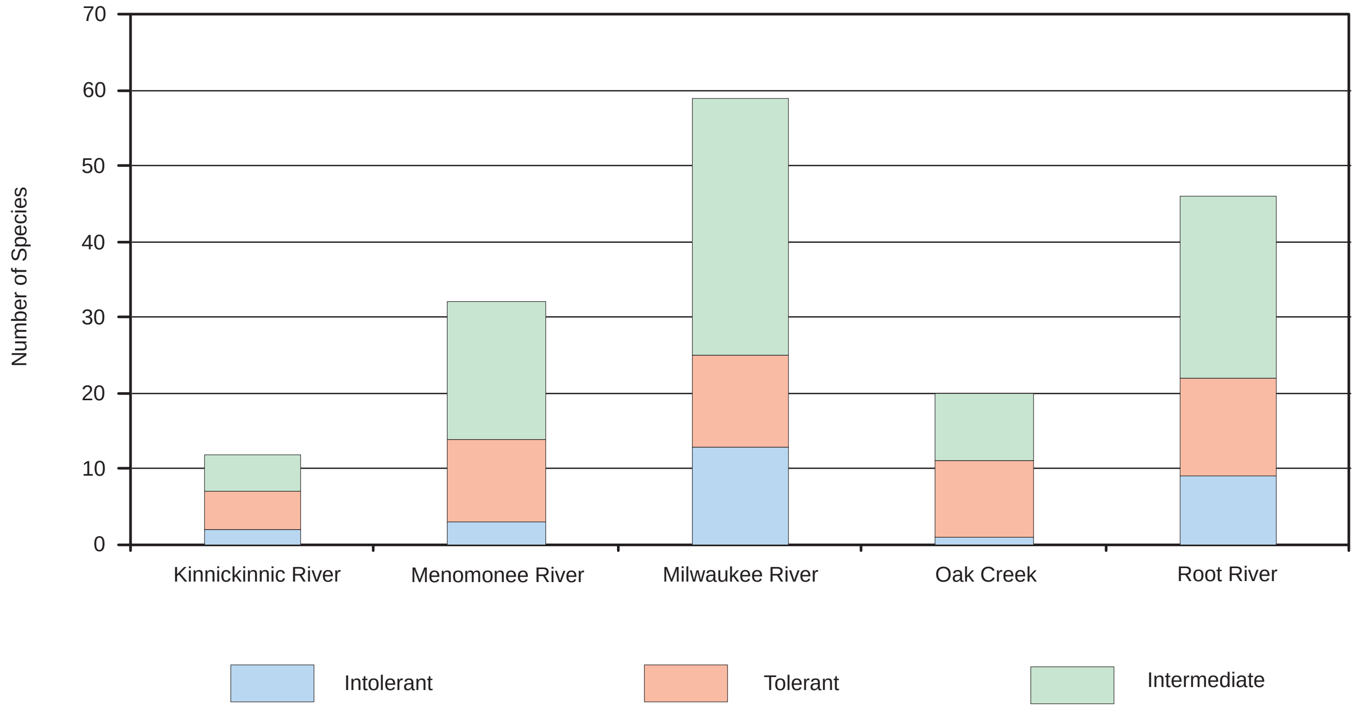
[64]*Center for Watershed Protection*, Impacts of Impervious Cover on Aquatic Systems, *Watershed Protection Research Monograph No. 1, March 2003.*

Figure 44

NUMBER OF FISH SPECIES BY TOLERANCE CLASS IN THE GREATER MILWAUKEE WATERSHEDS: 1998-2004



Source: SEWRPC.

- Decreased base flows—These lead to increased crowding and competition for food and space, increased vulnerability to predation, decreased in habitat quality, and increased sediment deposition;

- Increased sediment load from cultivated agricultural lands and urban lands during and after construction of urban facilities, resulting in sediment transport and deposition in streams—This leads to reduced survival of eggs, loss of habitat due to deposition, siltation of pool areas, and reduced macroinvertebrate reproduction;

- Loss of pools and riffles—This leads to a loss of deep water cover and feeding areas causing a shift in the balance of species due to habitat changes;

- Changed substrate composition—This leads to reduced survival of eggs, loss of inter-gravel cover refuges for early life stages for fishes, and reduced macroinvertebrate production;

- Loss of large woody debris—This leads to loss of cover from large predators and high flows, reduced sediment and organic matter storage, reduced pool formation, and reduced organic substrate for macroinvertebrates;

- Increased temperatures due to loss of riparian buffers as well as runoff from pavement—This leads to changes in migration patterns, increased metabolic activity, increased disease and parasite susceptibility, and increased mortality of sensitive fishes and macroinvertebrates;

- Creation of fish blockages by road crossings, culverts, drop structures, and dams—This leads to loss of spawning habitat, inability to reach feeding areas and/or overwintering sites, loss of summer rearing habitat, and increased vulnerability to predation;

- Loss of vegetative rooting systems—This leads to decreased channel stability, loss of undercut banks, and reduced streambank integrity;

- Channel straightening or hardening—This leads to increased stream scour and loss of habitat quality and complexity (i.e. width, depth, velocity, and substrate diversity) through disruption of sediment transport ability;

- Reduced water quality—This leads to reduced survival of eggs and juvenile fishes, acute and chronic toxicity to juveniles and adult fishes, and increased physiological stress;

- Increased turbidity—This leads to reduced survival of eggs, reduced plant productivity, and increased physiological stress on aquatic organisms;

- Increased algae blooms due to increased nutrient loading—Chronic algae blooms, resulting from increased nutrient loading, lead to oxygen depletion, causing fish kills, and to increased eutrophication of standing waters. These effects can be worsened through encroachment into the riparian buffer adjacent to the waterbody and loss of riparian canopy which increases light penetration.

Chapter II of SEWRPC Technical Report No. 39 includes a description of the correlation between urbanization in a watershed and the quality of the aquatic biological resources. The amount of imperviousness in a watershed that is directly connected to the stormwater drainage system can be used as a surrogate for the combined impacts of urbanization in the absence of mitigation. The overall percentages of urban land in the watersheds in 2000 ranged from about 21 percent in the Milwaukee River watershed to about 93 percent in the Kinnickinnic River watershed, corresponding to levels of imperviousness that range between 5 percent and 40 percent. Some portions of the study area have even higher percentages of imperviousness, with the amounts in the lower reaches of the Milwaukee River, for example approaching 50 to 60 percent. Many areas have levels of imperviousness above the threshold level of 10 percent at which previously cited studies indicate that negative biological impacts have been observed. The Milwaukee River, Root River and Oak Creek watersheds still have high proportions of agricultural land use. Based upon the amounts of agricultural and urban lands in these watersheds and, in the past, a lack of measures to mitigate the adverse effects of those land uses, it is not surprising that indices of fish community quality in many areas of these watersheds indicate poor to fair quality fisheries.[65]

Habitat data for sites in the greater Milwaukee watersheds have been collected as part of the WDNR baseline monitoring program and by the WDNR Fish and Habitat Research Section in the Milwaukee River watershed. The baseline monitoring program data were analyzed using the Qualitative Habitat Evaluation Index (QHEI),[66] which integrates the physical parameters of the stream and adjacent riparian features to assess potential habitat quality. This index is designed to provide a measure of habitat that generally corresponds to those physical factors that affect fish communities and which are important to other aquatic life (i.e. macroinvertebrates). This index has been shown to correlate well with fishery IBI scores, which measure fish community quality. The habitat data from the WDNR Research Section evaluated the quality of fish habitat at sites based upon the guidelines

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[65]*The standards and requirements of Chapter NR 151, "Runoff Management," and Chapter NR 216, "Storm Water Discharge Permits," of the* Wisconsin Administrative Code *are intended to mitigate the impacts of existing and new urban development and agricultural activities on surface water resources through control of peak flows in the channel-forming range, promotion of increased baseflow through infiltration of stormwater runoff, and reduction in sediment loads to streams and lakes. The implementation of those rules is intended to mitigate, or improve, water quality and instream/inlake habitat conditions.*

[66]*Edward T. Rankin, The Quality Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application, State of Ohio Environmental Protection Agency, November 1989.*

developed from several publications.[67] Based on limited habitat data, habitat conditions in the Kinnickinnic River watershed have generally been described as being degraded due, in large part, to more than 60 percent of the entire river network either being comprised of enclosed conduit or concrete-lined channel. A small data set suggests that habitat conditions in the Menomonee River watershed are fair to good. Based upon the data collected, the results suggest that fisheries habitat is generally fair to good throughout the Milwaukee River watershed. Limited data suggest habitat conditions in the Oak Creek watershed are poor to fair. Limited data suggest habitat conditions in the Root River watershed may be fair to good. It is important to note that many of the streams have been channelized within the greater Milwaukee watersheds. Such channelization impacts habitat quality by reducing instream and riparian vegetation cover, increasing sedimentation, decreasing diversity of flow, decreasing water depths, and decreasing substrate diversity, among others.

Despite the habitat classification of fair to good, the WDNR has recently concluded that instream habitat is impaired in many stream reaches in the greater Milwaukee watersheds, primarily due to the impacts of hydrologic modification, streamflow fluctuations caused by unnatural conditions, stream bank erosion, urban storm water runoff, cropland erosion, and roadside erosion emanating from both agricultural and urban land use areas of this watershed.[68]

The Hilsenhoff Biotic Index[69] (HBI) and percent EPT (percent of families comprised of Ephemeroptera, Plecoptera, and Trichoptera) were used to classify the historic and existing macroinvertebrate and environmental quality in this stream system using survey data from various sampling locations in the greater Milwaukee watersheds. The macroinvertebrate communities in the Kinnickinnic River, Oak Creek, and Root River watersheds were found to be depauperate and dominated by tolerant taxa. The macroinvertebrate communities in the Menomonee River watershed were found to have improved substantially since 1993, especially in the Lower Milwaukee River subwatershed. Results from the Milwaukee River watershed show that current macroinvertebrate diversity and abundances are indicative of fair to good-very good water quality. They also indicate long-term improvement in the abundance and diversity of macroinvertebrates.

Lakes and Ponds

There are 20 major lakes (i.e. lakes greater than 50 acres in size) within the greater Milwaukee watersheds. All of them are located within the Milwaukee River watershed. In addition, there are more than 130 lakes and ponds of less than 50 acres in size in the greater Milwaukee watersheds. The lakes and ponds in the study area are listed in Table 35.

The last recorded fishery surveys for many of the lakes and ponds were completed in the late 1970s and early 1980s. The surveys indicate that that these waterbodies contained a typical urban fish species mixture mostly dominated by tolerant species of green sunfish, black bullhead, carp, and white sucker. However, largemouth bass, northern pike, and yellow perch were also found in several of these waterbodies. Information from WDNR staff indicates that many of the lakes and ponds listed in Table 35 provide various recreational fishing opportunities for gamefish and/or panfish species; however, some of these waterbodies are stocked to supplement these fisheries.

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[67]*Timothy Simonson, John Lyons, and Paul Kanehl, "Guidelines for Evaluating Fish Habitat in Wisconsin Streams,"* General Technical Report NC-164, *1995; and Lihzu Wang, "Development and Evaluation of a Habitat Rating System for Low-Gradient Wisconsin Streams,"* North American Journal of Fisheries Management, *Volume 18, 1998.*

[68]*Wisconsin Department of Natural Resources,* The State of the Milwaukee River Basin, *WT-704-2001, August 2001; Wisconsin Department of Natural Resources,* The State of the Root-Pike River Basin, *WT-700-2002, May 2002.*

[69]*William L. Hilsenhoff, "Using a Biotic Index to Evaluate Water Quality in Streams,"* Wisconsin Department of Natural Resource Technical Bulletin No. 132, *1982.*

More-recent comprehensive fisheries surveys have been completed by the WDNR for Erler, Little Cedar, Long (Fond du Lac County), and Random Lakes.[70] In 2003, a fish community survey of Erler Lake found 11 fish species including bluegills, carp, largemouth bass, and yellow perch. More restrictive fishing regulations on panfish and bass were proposed for this lake to protect the populations from collapse when public access is developed. A fish community survey conducted in Little Cedar Lake during 1999 found that fish habitat conditions in this lake were good to very good. The species found in this lake included bluegills, bluntnose minnows, crappies, largemouth bass, northern pike, and yellow perch. While some populations, such as those of bluegills and northern pike consisted mostly of small individuals, other populations, such as largemouth bass had good size structure. A comprehensive fish community survey of Long Lake in eastern Fond du Lac County conducted during 2004 found 15 native species of fish, including bluegill, northern pike, walleye, yellow bullhead, and yellow perch. The Long Lake largemouth bass population was in exceptional condition and was likely the best overall population in Fond du Lac and surrounding counties. An electrofishing survey of the shoreline of Random Lake conducted during the fall of 2004 found several species, including black crappies, bluegills, largemouth bass, muskellunge, walleye, and yellow perch. While panfish were abundant, they were generally small in size and appeared to be growing slowly. By contrast, the walleye in the lake were generally plump, an indication that they were feeding well.

Exotic invasive species have been recorded in several of the lakes and ponds within the greater Milwaukee watersheds. Carp are found in Barton Pond, Big Cedar Lake, Birchwood Lake, Crooked Lake, Dineen Park Pond, Estabrook Park Pond, Forest Lake, Gilbert Lake, Green Lake, Grafton Millpond, Hasmer Lake, Kettle Moraine Lake, Kewaskum Millpond, Lake Bernice, Lake Ellen, Long Lake (Fond du Lac County), Mauthe Lake, McGovern Park Pond, Random Lake, Root River Parkway Pond, Smith Lake, Thiensville Millpond, Tily Lake, West Bend Pond, and Whitnall Park Pond. Zebra mussels have been recorded in Auburn Lake, Big Cedar Lake, Lake Ellen, Little Cedar Lake, Long Lake (Fond du Lac County), Mauthe Lake, and Quarry Lake. While data on aquatic plant communities are limited, Eurasian water milfoil is known to exist in Beechwood Lake, Big Cedar Lake, Crooked Lake, Erler Lake, Estabrook Park Pond, Forest Lake, Gilbert Lake, Green Lake, Juneau Park Lagoon, Kettle Moraine Lake, Little Cedar Lake, Long Lake (Fond du Lac County), Lower Kelly Lake, Lucas Lake, Mauthe Lake, Pit Lake, Random Lake, Scout Lake, Silver Lake, and Upper Kelly Lake. Curly-leaf pondweed is known to exist in each of the Counties within the greater Milwaukee watersheds.

Twenty-three lakes and ponds in the greater Milwaukee watersheds are enrolled in the Wisconsin Department of Natural Resources Urban Fishing Program in partnership with local counties and municipalities. That program was initiated in 1983 for the metropolitan Milwaukee area and is still active today. The program provides fishing in urban ponds for anglers who do not have opportunities to leave the urban environment. The program stocks rainbow trout and other species to provide seasonal and year-round fishing.

Lake Michigan

Biological conditions in the estuary, outer harbor and nearshore areas are strongly linked to the conditions in Lake Michigan.

Lake Michigan Fishery

Lake Michigan has undergone well-documented, significant changes in its fishery since the 1880s.[71] These changes have been linked to various factors that include eutrophication, fishery exploitation, and the invasions of exotic or nonnative species among several trophic levels of fishes, mussels, plankton, and aquatic plants.

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[70] *John Nelson, Senior Fisheries Biologist, Wisconsin Department of Natural Resources, Long Lake Comprehensive Fish Community Survey, Fond du Lac County, 2004; Random Lake Electrofishing Report, 2004; Comprehensive Fish Community Survey, Little Cedar Lake, Washington County, 1999, and; Erler Lake Fish Community Survey, Washington County, 2003.*

[71] *L. Wells and A.L. McClain, Lake Michigan: Effects of Exploitation, Introductions, and Eutrophication on the Salmonid Community,* Journal of the Fisheries and Natural Resources Board of Canada, *Volume 34, 1972; L. Wells and A.L. McClain, Lake Michigan-Man's Effect on Native Fish Stocks and Other Biota,* Great Lakes

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Most recently, there are several major trends throughout Lake Michigan that are important to note in order to understand the context of the estuary and nearshore fisheries. The findings summarized below are based upon some of the recent major studies and stock assessment activities carried out by the WDNR on Lake Michigan.[72]

While sport harvests of chinook salmon have been good in recent years, size-at-age of these fish has continued to decline. In response to this, lakewide chinook stocking levels were reduced by 25 percent in 2006. As of 2005, the yellow perch population in southern Lake Michigan was still dominated by the 1998 year class. The sport harvest of this year class is decreasing. Effective May 2002, the sport fishery for Lake Michigan yellow perch was closed between May 1 and June 15 to reduce fishing impacts on spawning stocks. While the reported commercial harvest of lake whitefish from Wisconsin waters of Lake Michigan has increased slightly, the size-at-age of these fish has continued to decrease. This may be related to lakewide declines in the abundance of the amphipod *Diporeia* and increases in the abundance of quagga mussels, which form the major food source and major competitor for the food source respectively.

Nuisance Algae (Cladophora) in Lake Michigan

In recent years large quantities of decaying algae, mostly from the genus *Cladophora*, have been fouling Wisconsin's Lake Michigan shoreline. As the bacteria and organisms trapped in the alga rot, they generate a pungent septic odor that many people confuse with sewage. While the presence of rotting *Cladophora* on Lake Michigan beaches does not present a risk to human health, the rotting algal mats may provide adequate conditions for bacterial growth, and microcrustaceans deposited on the beach with the decaying *Cladophora* may attract large flocks of gulls resulting in increased bacteria concentrations from gull fecal material.

Cladophora is found naturally along the Great Lakes coastlines. It grows on submerged rocks, logs or other hard surfaces. Because of Lake Michigan's water clarity it has been observed growing at depths below 30 feet. Wind and wave action cause the algae to break free from the lake bottom and wash up on shore. Nuisance levels of *Cladophora* were previously a problem during the mid-1950s and during the 1960s and 1970s. The causes of the *Cladophora* resurgence in the Great Lakes are not known for certain, but probably include changes in water clarity and changes in phosphorus availability related to the presence of zebra mussels and quagga mussels in the nearshore area.

Declines in Lake Michigan Diporeia

Populations of shrimp-like organisms called amphipods (i.e., *Diporeia*) that are normally found in bottom mud of the Great Lakes are declining in southern Lake Michigan. During the 1980s researchers at the NOAA Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan were able to collect up to 20,000 amphipods per square meter of Lake Michigan bottom. Data collected in the early 1990s indicated that, in the far southern end of the lake, amphipod populations had declined by 60 to 90 percent. Since then, the average abundance of *Diporeia* dropped from about 5,200 per square meter in 1994 and 1995 to about 1,800 per square meter by 2000. The average abundance in 2005 was only 300 per square meter. *Diporeia* has declined in deeper waters, and the areas of the Lake with no *Diporeia* have expanded greatly. Since amphipods normally make up to 70 percent of the living biomass in a given area of a healthy lake bottom and have high food value to fish, their decline in Lake Michigan may impact a variety of fish species that depend heavily on them for food.

Milwaukee Harbor Estuary and Nearshore Lake Michigan Fisheries

The Lower Milwaukee River and Milwaukee Harbor estuary habitat and water quality have been heavily altered due to damming, channelization, streambank modification by installation of riprap and sheet piling, and urban stormwater discharges. The International Joint Commission (IJC) identified the Milwaukee Harbor estuary as one

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(Footnote Continued from Previous Page)

Fishery Commission Technical Report No. 20, *1973; Charles P. Madenjian and others, Dynamics of the Lake Michigan Food Web: 1970-2000,* Canadian Journal of Fisheries and Aquatic Sciences, *Volume 59, 2002.*

[72]*Additional information on the Lake Michigan fishery can be obtained from the WDNR Lake Michigan web page at http://dnr.wi.gov/org/water/fhp/fish/lakemich/index.htm.*

of 43 Areas of Concern (AOC) requiring clean up of toxic wastes and remedial action.[73] While the beneficial use impairments identified in the Milwaukee Harbor estuary AOC are the result of many causes, many are related, at least in part, to the presence of toxic substances in water, sediment, and the tissue of organisms. It is also important to note that the habitat in the lower reaches of each of the watersheds draining into the Milwaukee Harbor estuary is typical of that found in a highly urbanized environment, with extensive channelization and placement of sheet piling for bank stabilization. More natural habitat can be generally found in upstream areas of each of the major rivers.

Despite extensive habitat, water quality, and toxicity impacts, the Milwaukee Harbor estuary contains a fairly high abundance and diversity of fish species. The quality of the fishery in the Milwaukee Harbor estuary is largely dependent upon the influx of fishes from the higher-quality waters in the upstream areas of the Menomonee, Kinnickinnic, and Milwaukee Rivers that have been documented to support a full range of fish and aquatic life, influx of fishes from Lake Michigan, and continued habitat improvement and species restoration projects

The 1997 removal of the 150-year-old North Avenue dam on the Milwaukee River 3.2 miles upstream from the confluence with Lake Michigan reconnected the Milwaukee Harbor estuary with the Milwaukee River system. With the removal of the dam, improvements in wastewater treatment, and abatement of combined sewer overflows, riverine conditions quickly began to reestablish in the formerly impounded area. The removal of the dam not only provided an opportunity for migratory fish species to move further upstream, but also opened up opportunities for the rehabilitation of some of the native species that were extirpated or reduced to remnant populations. Many habitat improvement measures have been implemented including streambank stabilization, revegetation of mud flats, and reestablishment of meanders within the former impounded area. As a result of these efforts, several miles of stream channel were made available to migratory as well as resident species whose movements were restricted prior to dam removal. This increase in migration along with the improvements in water quality and habitat allowed WDNR staff to initiate native walleye and lake sturgeon restoration projects in the Lower Milwaukee River and the Milwaukee Harbor estuary. For example, since 1995, approximately 10,000 extended growth walleye fingerlings have been stocked annually into the Lower Milwaukee River downstream of the former North Avenue dam. These fishes are reported to be surviving and growing well, supporting a limited nearshore fishery. Mature and spent walleye were recorded during spring spawning assessments beginning in 1998; however, as yet, no successful natural reproduction of walleye has been documented in the system.

Exotic Invasive Species

The food web of Lake Michigan and of the Great Lakes in general, is defined by, and complicated by, historical and continued additions of exotic invasive species. The entry and dispersal mechanisms which have acted singly or jointly in the movement of organisms into the Great Lakes basin include unintentional release (shipping traffic via discharge of ballast water; escape from cultivation, aquaculture and aquaria, and accidental releases due to fish stocking and from unused bait), deliberate releases (for example, the deliberate introduction of salmon species to enhance fisheries), canals, and disturbance linked to the construction of railroads and highways.[74] Scientists have identified 145 nonindigenous fishes, invertebrates, fish disease pathogens, plants, and algae established in the Great Lakes basin since the early 1800s.[75] Some taxonomic groups have not been studied as well as others;

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[73]*Wisconsin Department of Natural Resources,* Milwaukee Estuary Remedial Action Plan Progress through January 1994, 1995.

[74]*Edward L. Mills and Kristen T. Holeck, "Biological Pollutants in the Great Lakes,"* Clearwaters, *Volume 31, Spring 2001.*

[75]*E.L. Mills, J.H. Leach, J.T. Carlton, and C.L. Secor, "Exotic Species in the Great Lakes: A History of Biotic Crises and Anthropogenic Introductions,"* Journal of Great Lakes Research, *Volume 19, 1993; J.H. Leach, E.L. Mills, and M.A. Dochoda, "Non-indigenous Species in the Great Lakes: Ecosystems Impacts, Binational Policies, and Management," In* Great Lakes Fishery Policy and Management: A Binational Perspective, *Edited by W.W. Taylor, Michigan State University Press, 1998.*

however, plants, algae, disease pathogens and parasites account for about 60 percent of new species established in the Great Lakes basin since 1810, followed by invertebrates that account for 22 percent, and fish that make up about 18 percent.

It is difficult if not impossible to predict how these species introductions will affect the existing or future food web dynamics in Lake Michigan. However, similar patterns of invasion and system responses have occurred among several of the Great Lakes. Sea lampreys, for example, have caused great damage to the lake trout, whitefish, and burbot populations in all the Great Lakes and similar impacts of zebra mussels have also been documented.

Lake Erie, like all of the Great Lakes, has had similar changes in food web dynamics, but because it is the shallowest and warmest of the Great Lakes, Erie is usually the first to show signs of stress. In other words, recent food web changes in Lake Erie may provide insight into trends that may also occur in Lake Michigan. In Lake Erie, zebra mussels have directly led to increased water clarity, clogging of municipal intakes, reduced recreation on beaches, and disappearance of many native mussel species. Indirect effects of zebra mussels in Lake Erie include creation of algal blooms and dead zones, disappearance of *Diporeia*, deaths of fish-eating birds, and accelerated bioaccumulation of toxicants to predatory fishes and birds. Except for indirect bird or fish deaths, the above consequences associated with the invasion of zebra mussels in Lake Erie have also occurred in Lake Michigan.

Other Wildlife

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of this study, it is possible, by polling naturalists and wildlife managers familiar with the area, to compile lists of amphibians, reptiles, birds, and mammals which may be expected to be found in the area under existing conditions. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed, in the greater Milwaukee watersheds area, associating these lists with the historic and remaining habitat areas in the area as inventoried, and projecting the appropriate amphibian, reptile, bird, and mammal species into the watershed area. The net result of the application of this technique is a listing of those species which were probably once present in the watershed area, those species which may be expected to still be present under currently prevailing conditions, and those species which may be expected to be lost or gained as a result of urbanization within the area. Table 40 summarizes the results of this inventory. More-detailed results are given in SEWRPC Technical Report No. 39. It is important to note that this inventory was conducted on a countywide basis for each of the aforementioned major groups of organisms. Some of the organisms listed as occurring in Dodge, Fond du Lac, Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha Counties may only infrequently occur within the greater Milwaukee watersheds.

Table 40 shows that 57 species of mammals, ranging in size from large animals like the white-tailed deer, to small animals like the meadow vole, are likely to be found within the greater Milwaukee watersheds. At least 180 species of birds have been reported to breed in this area. Some of these species are resident throughout the year. An additional 108 bird species visit the area only during the annual migration periods, or winter in the area. Species reported include game birds, songbirds, waders, and raptors. Amphibians and reptiles are vital components of the ecosystem within an environmental unit like that of the greater Milwaukee River watersheds area. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the area. Table 40 shows that 18 species of amphibians and 24 species of reptiles have been reported in the greater Milwaukee watersheds area. One amphibian species and two reptile species are likely to have been extirpated from the area.

Endangered and threatened species and species of special concern present within the greater Milwaukee watersheds area include 74 species of plants, 16 species of birds, 13 species of fish, five species of herptiles, and 21 species of invertebrates from Wisconsin Department of Natural Resources records dating back to the late 1800s. These are summarized in Table 41.

Table 40

NUMBERS OF AMPHIBIAN, REPTILE, BIRD, AND MAMMAL SPECIES KNOWN OR LIKELY TO OCCUR IN THE SOUTHEASTERN WISCONSIN AREA

Group	Fond du Lac County	Sheboygan County	Washington County	Ozaukee County	Dodge County
Amphibians	18[a]	17	17[a]	16	16
Reptiles	18	14	19	15[b]	16
All Bird Species[c]	256	249	245	256	239
Resident or Breeding Bird Species	157	134	142	142	184
Mammals	27	27	18	22	38

Group	Waukesha County	Milwaukee County	Racine County	Kenosha County	Southeastern Wisconsin
Amphibians	17[a]	17[a]	16[a]	16[a]	18[a]
Reptiles	21[b]	22[b,d]	20[b]	17	24[b,d]
All Bird Species[c]	248	275	219	214	288
Resident or Breeding Bird Species	129	129	129	109	180
Mammals	35	44	39	24	57

[a]*Total includes Blanchard's cricket frog, which has likely been extirpated.*

[b]*Total includes the queen snake, which has likely been extirpated.*

[c]*Includes resident, breeding, wintering, and migrant species.*

[d]*Total includes the northern ribbon snake and the northern ringneck snake, which have likely been extirpated.*

Source: SEWRPC.

The complete spectrum of wildlife species originally native to the watershed, along with their habitat, has undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of urban land in some areas. Successive cultural uses and attendant management practices, primarily urban, have been superimposed on the land use changes and have also affected the wildlife and wildlife habitat. In urban areas, cultural management practices that affect wildlife and their habitat include the use of fertilizers, herbicides, and pesticides; road salting for snow and ice control; heavy motor vehicle traffic that produces disruptive noise levels and air pollution and nonpoint source water pollution; and the introduction of domestic pets.

CHANNEL CONDITIONS AND STRUCTURES

The conditions of the bed and bank of a stream are greatly affected by the flow of water through the channel. The great amount of energy possessed by flowing water in a stream channel is dissipated along the stream length by turbulence, streambank and streambed erosion, and sediment resuspension. Sediments and associated substances delivered to a stream may be stored, at least temporarily, on the streambed, particularly where obstructions or irregularities in the channel decrease the flow velocity or act as a particle trap or filter. On an annual basis or a long-term basis, streams may exhibit a net deposition, net erosion, or no net change in internal sediment transport, depending on tributary land uses, watershed hydrology, precipitation, and geology. From 3 to 11 percent of the

Table 41

ENDANGERED AND THREATENED SPECIES IN THE GREATER MILWAUKEE WATERSHEDS

Group	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Study Area
Mollusks						
Endangered	0	0	0	0	0	0
Threatened	0	0	1	0	0	1
Special Concern	0	0	0	0	0	0
Crustaceans						
Endangered	0	0	0	0	0	0
Threatened	0	0	0	0	0	0
Special Concern	1	1	1	1	1	1
Butterflies and Moths						
Endangered	0	0	1	0	0	1
Threatened	0	0	0	0	0	0
Special Concern	0	2	3	0	0	5
Dragonflies and Damselflies						
Endangered	0	0	0	0	0	0
Threatened	0	0	0	0	0	0
Special Concern	0	1	8	1	0	10
Other Insects						
Endangered	0	0	0	0	0	0
Threatened	0	0	0	0	0	0
Special Concern	0	2	1	0	0	3
Fish						
Endangered	1	1	1	0	0	1
Threatened	3	3	4	1	2	4
Special Concern	2	2	6	1	4	8
Reptiles and Amphibians						
Endangered	0	1	2	0	2	2
Threatened	1	2	2	1	2	2
Special Concern	0	1	0	0	1	1
Birds						
Endangered	0	0	1	0	0	1
Threatened	0	0	5	1	1	5
Special Concern	1	4	4	1	7	10
Plants						
Endangered	4	8	2	4	8	16
Threatened	2	5	10	2	12	15
Special Concern	16	19	32	9	26	43

Source: SEWRPC.

annual sediment yield in a watershed in southeastern Wisconsin may by contributed by streambank erosion.[76] In the absence of mitigative measures, increased urbanization in a watershed may be expected to result in increased streamflow rates and volumes, with potential increases in streambank erosion and bottom scour, and flooding problems. In the communities within the MMSD service area, the requirements of MMSD Chapter 13, "Surface Water and Storm Water," are applied to mitigate instream increases in peak rates of flow that could occur due to new urban development without runoff controls. In communities outside of the MMSD service area, local ordinances provide for varying degrees of control of runoff from new development. Also, where soil conditions allow, the infiltration standards of Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* are applied to limit increases in runoff volume from new development.

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[76]*SEWRPC Technical Report No. 21,* Sources of Water Pollution in Southeastern Wisconsin: 1975. *September 1978.*

While a comprehensive evaluation of channel conditions within the greater Milwaukee watersheds has not been conducted, several studies provide data on channel conditions in portions of the study area.

Milwaukee County commissioned an assessment of stability and fluvial geomorphic character of streams within four watersheds in the County including the Milwaukee River watershed.[77] This study, conducted in fall 2003, examined channel stability in about 60 miles of stream channel along the mainstems of the Kinnickinnic, Milwaukee, and Root Rivers; Oak Creek; and several tributary streams. A major goal of this study was to create a prioritized list of potential project sites related to mitigation of streambank erosion and channel incision, responses to channelization, and maintenance of infrastructure integrity.

The Milwaukee Metropolitan Sewerage District commissioned a study of sediment transport in the Menomonee River watershed.[78] This study, conducted in 2000, examined sediment transport in about 63 miles of stream channel along the mainstem of the Menomonee River and several of its tributaries. Included among the factors assessed in this study were the characterization of channel bed and bank material composition, the evaluation of bed and bank stability, the examination of the integrity of the Works Progress Administration (WPA) walls lining portions of the channel, and the examination of bed and bank stability at road crossings.

The City of Racine commissioned a study to evaluate the condition of storm sewer outfalls and streambanks and associated erosion and erosion potential along the Root River within the City.[79] A goal of this study was to develop baseline data identifying, characterizing, and mapping erosion problems associated with stormwater outfalls and hydromodifications such as riprap, concrete, and retaining walls.

MMSD commissioned an assessment of geomorphic, hydrologic, and hydraulic conditions for Fish Creek and its watershed.[80] This study, conducted in 2000 to 2001, examined geomorphic and sediment characteristics and hydrologic and hydraulic conditions for about 3.5 miles of stream channel along Fish Creek. Major goals of this study were to evaluate the mechanisms driving flood control, erosion, valley stability, and environmental management for the Creek and to identify engineering and management options to be considered in future studies.

In addition, the SEWRPC staff has evaluated the condition of the streambanks and associated erosion 1) along an unnamed Tributary to the Milwaukee River as part of the reconstruction of the USH 45 roadway improvement project in cooperation with the Wisconsin Department of Transportation and 2) in the Quaas Creek subwatershed as part of the development of a watershed protection plan in cooperation with Washington County Land Conservation Department.[81]

Some streams of the greater Milwaukee watersheds show substantial modification of streambeds and banks. The percentages of streambed and bank modification tend to differ among the watersheds. The Kinnickinnic River watershed has a high proportion of bed and bank modifications with about 58 percent of the stream channel examined being lined with concrete or enclosed in conduit. The Menomonee River watershed also has a high proportion of this sort of modification with about 22 percent of the stream channel examined being lined with

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[77]*Inter-Fluve, Inc.,* Milwaukee County Stream Assessment, Final Report, *September 2004.*

[78]*Inter-Fluve, Inc.,* Menomonee River Watershed Transport Study Summary Report, *MMSD Contract No. W021-PE001, February 2001.*

[79]*Earth Tech, Inc.,* Root River Outfall and Streambank Erosion Assessment, *January 2005.*

[80]*W.F. Baird & Associates,* Fish Creek Geomorphic Study: Final Study Report, *January 2002.*

[81]*Wisconsin Department of Transportation and SEWRPC Letter Agreement, USH 45—Stream Relocation Project (Project ID#4070-01-02), August 2001; SEWRPC Memorandum Report No. 151,* Stream Channel Stability and Biological Assessment of Quaas Creek: 2002, Washington County, Wisconsin, *July 2002.*

concrete or riprap, or enclosed in conduit. Lower proportions of stream channel show these sorts of modifications in the other watersheds. About 7 percent of the stream channel examined in the Oak Creek watershed is lined with concrete or enclosed in conduit. Less than 1 percent of the stream channel examined in the Root River watershed is enclosed in conduit and none is concrete-lined. About seven miles of stream channel in the Milwaukee River watershed are lined with concrete or enclosed in conduit, representing about 2 percent of the perennial stream length in this watershed.

There are some areas where stream channel modification has not been as significant. Examples of this include the designated exceptional water resources areas in the East Branch of the Milwaukee River and Lake Fifteen Creek subwatersheds in the upper portions of the Milwaukee River watershed.

Bed and Bank Stability

Alluvial streams within urbanizing watersheds often experience rapid channel enlargement. As urbanization occurs, the fraction of the watershed covered by impervious surfaces increases. This can result in profound changes in the hydrology in the watershed. As a result of runoff being conveyed over impervious surfaces to storm sewers which discharge directly to streams, peak flows become higher and more frequent and streams become "flashier," with flows increasing rapidly in response to rainfall events. The amount of sediment reaching the channel often declines. Under these circumstances and in the absence of armoring, the channel may respond by incising. This leads to an increase in the height of the streambank, which continues until a critical threshold for stability is exceeded. When that condition is reached, mass failure of the bank occurs, leading to channel widening. Typically, incision in an urbanizing watershed proceeds from the mouth to the headwaters.[82] Lowering of the downstream channel bed increases the energy gradient upstream and in the tributaries. This contributes to further destabilization. Once it begins, incision typically follows a sequence of channel bed lowering, channel widening, and deposition of sediment within the widened channel. Eventually, the channel returns to a stable condition in equilibrium with the altered watershed hydrology characteristic of the altered channel geometry.

It is also important to note that most of the agricultural lands in the study area contain drain tiles that are designed specifically to convey water out of the soils and into the adjacent streams that have generally been channelized. As a result of runoff being conveyed via drain tiles, relative to undrained conditions, peak flows become somewhat higher and more frequent with flows increasing more rapidly in response to rainfall events. Similar to urban development conditions, agricultural activities in a watershed can also lead to localized bank scour, channel incision, and bank failure.

Degrading channels and eroding banks are common along streams in some portions of the greater Milwaukee watersheds. Locations of aggrading, degrading, and stable stream reaches are inventoried in SEWRPC Technical Report No. 39.

Since a large portion of the Kinnickinnic River watershed contains channels which are enclosed in conduit or concrete-lined, only about six miles of channel were inventoried for stability. Most alluvial reaches that were examined appeared to be degrading and actively eroding. Less than 5 percent of the total 6.1 miles assessed were observed to be stable.

About 63 miles of channel in the Menomonee River watershed were inventoried for stability. Lateral erosion is relatively uncommon in this watershed, comprising about 5 percent of total bank conditions. Streambeds in this watershed showed similar trends toward stability. Only about 5 percent of alluvial reaches were observed to be unstable. In particular, the lower portions of the Menomonee River have experienced relatively little bed and bank degradation. This appears to be the result of armoring of the channel by bedrock, large bed materials, and manmade structures. Aggrading alluvial reaches are uncommon in the portions of this watershed which were assessed.

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[82]*S A. Schumm, "Causes and Controls of Channel Incision," In: S.E. Darby and A. Simon (eds.),* Incised River Channels: Processes, Forms, Engineering and Management, *John Wiley & Sons, New York, 1999.*

About 43 miles of channel in the Milwaukee River watershed were inventoried for stability including about 31 miles of channel in Milwaukee County and about 2.4 miles of channel in the unnamed tributary to the Milwaukee River and Quaas Creek systems. Approximately half of the alluvial reaches that were examined appeared to be degrading and actively eroding. About 9.5 percent of the stream length assessed was observed to be stable.

About 24 miles of channel in the Oak Creek watershed were inventoried for stability. Most alluvial reaches that were examined appeared to be degrading and actively eroding. Less than 8 percent of the lengths of bank assessed were observed to be stable.

About 55.4 miles of channel in the Root River watershed were inventoried for stability, about 48 miles of channel in Milwaukee County and about 7.4 miles of channel in the City of Racine. Most alluvial reaches that were examined appeared to be degrading and actively eroding. About 34 percent of the stream length assessed was observed to be stable. Less than 2 percent of the assessed channel was observed to be aggrading.

About 3.6 miles of channel of Fish Creek in the Lake Michigan direct drainage area were inventoried for stability. Most alluvial reaches that were examined appeared to be degrading and actively eroding. Beds along approximately 61 percent of the examined sections of the stream appeared to be degrading and actively eroding. Degradation was also observed along streambanks. Approximately 39 percent of the length of banks that were examined appeared to be actively eroding. Aggradation was occurring in about 19 percent of the stream.

Works Progress Administration Walls

The WPA walls were constructed as flood management structures in the 1920s and 1930s along several streams in the Milwaukee metropolitan area. Depending on location, these walls either form the active channel margin or are located within the active floodplain. They serve as channel boundaries and act to inhibit lateral channel migration and associated erosion. They are made from mortared limestone blocks and are generally about two feet thick. They vary in height from five to 12 feet depending on local channel bed, bank, and floodplain elevations. These walls are about 70 years old. As they degrade over time, increases in lateral bank instability and flooding are likely results.

Relatively stable WPA walls are present in the upper portion of the Kinnickinnic River.

WPA walls are present along three streams within the Menomonee River watershed: Honey Creek, Woods Creek, and the mainstem of the Menomonee River are lined by these walls. In many places, the walls contain the river as originally designed. In isolated segments, the walls are flanked, degraded, or crumbling and no longer provide proper flood conveyance or adequate protection to infrastructure. At some other isolated sites, the stream channel has migrated away from the walls.

Dams

Dams and drop structures can disrupt sediment transport and limit aquatic organism passage, fragmenting populations. Those factors can lead to a reduction in overall abundance and diversity of aquatic organisms. As shown in Table 42, in 2005 there were about 88 dams and 64 drop structures located within the greater Milwaukee watersheds.

In 2005, there was one dam within the Kinnickinnic River watershed. It is a low sill located on Cherokee Park Creek. In addition, numerous drop structures are located in Lyons Park Creek and Villa Mann Creek.

In 2005, there were seven dams within the Menomonee River watershed. One is located in the headwaters of Dousman Ditch, two are located on the mainstem of the Menomonee River, and four are located on Underwood Creek. The Falk dam, which was located in the Lower Menomonee watershed was physically removed in February 2001. In addition, numerous drop structures were located in the watershed, mostly along Honey and Underwood Creeks.

Table 42

DAMS AND DROP STRUCTURES WITHIN THE GREATER MILWAUKEE WATERSHEDS: 2005

Watershed	Dams	Drop Structures	Dams Removed from 1988 through 2005
Kinnickinnic River	1	14	0
Menomonee River	7	28	1
Milwaukee River	70	6	8[a]
Oak Creek	1	8	0
Root River	8	6	0
Lake Michigan Direct Drainage Area	1	2	0
Total	88	64	9

[a]*The dam on Pigeon Creek at the Lutheran Seminary was breached after 2005 and was intended to be removed. That dam is not included in this number.*

Source: Wisconsin Department of Natural Resources, Inter-Fluve, Inc., River Alliance of Wisconsin, and SEWRPC.

In 2005, there were about 70 dams and about 6 drop structures within the Milwaukee River watershed. The dams are located throughout the watershed, along the mainstem and tributaries of the Milwaukee River. Most of these dams form impoundments. In addition, a small number of drop structures are located in Beaver Creek and Brown Deer Park Creek.

The one dam within the Oak Creek watershed is located on Oak Creek in the Oak Creek Parkway. In addition, a total of six drop structures are located in Oak Creek and the North Branch of Oak Creek. Three other drop structures in Oak Creek and the North Branch were removed by MMSD in 2004.

In 2005, eight dams were located within the Root River watershed. Four are located on Whitnall Park Creek, one is located on Dale Creek, one is located on Tess Corners Creek, one is located on an unnamed tributary to the West Branch of the Root River Canal, and one is located on the mainstem of the River in the City of Racine (Horlick dam). Most of these dams form impoundments. In addition, a small number of drop structures are located in Dale Creek and Whitnall Park Creek.

In 2005, there were two drop structures and one dam located within the Lake Michigan direct drainage area. These structures are located on Fish Creek. A recent assessment reported that the low-head dam is failing.[83]

HABITAT AND RIPARIAN CORRIDOR CONDITIONS

One of the most important tasks undertaken by the Commission as part of its regional planning effort was the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources and which, therefore, should be preserved and protected in order to maintain the overall quality of the environment. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and the natural beauty of the Region: 1) lakes, rivers, and streams and the associated undeveloped shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and 7) rugged terrain and high-relief topography. While the foregoing seven elements constitute integral parts of the natural resource base, there are five additional elements which, although not a part of the natural resource base per se, are closely related to or centered on that base and therefore are important considerations in identifying and delineating areas with scenic, recreational, and educational value. These additional elements are:

[83]*W.F. Baird & Associates, 2002,* op. cit.

1) existing outdoor recreation sites; 2) potential outdoor recreation and related open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and 5) natural and scientific areas.

The delineation of these 12 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed “environmental corridors” by the Commission. Primary environmental corridors include a wide variety of the abovementioned important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors generally connect with the primary environmental corridors and are at the least 100 acres in size and one mile long. In addition, smaller concentrations of natural resource features that have been separated physically from the environmental corridors by intensive urban or agricultural land uses have also been identified. These areas, which are at least five acres in size, are referred to as isolated natural resource areas.

It is important to point out that, because of the many interlocking and interacting relationships between living organisms and their environment, the destruction or deterioration of any one element of the total environment may lead to a chain reaction of deterioration and destruction among the others. The drainage of wetlands, for example, may have far-reaching effects, since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting lake and stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides a basis for low flows in rivers and streams. Similarly, the destruction of woodland cover, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the greater Milwaukee watersheds thus becomes apparent.

Primary Environmental Corridors

The primary environmental corridors in the regional water quality management plan update study area are primarily located along major stream valleys, around major lakes, and along the northern Kettle Moraine. As indicated in Table 29 in Chapter II of this report, primary environmental corridors encompassed about 185 square miles, or about 16 percent of the study area, in 2000. These primary environmental corridors contain almost all of the best remaining woodlands, wetlands, and wildlife habitat areas in the study area, and represent a composite of the best remaining elements of the natural resource base. Primary environmental corridors in the regional water quality management plan update study area are shown on Map 19 in Chapter II of this report.

Secondary Environmental Corridors

Secondary environmental corridors are generally located along the small perennial and intermittent streams within the regional water quality management plan update study area. In 2000, secondary environmental corridors encompassed about 27 square miles, or about 2 percent of the total area of the study area (Table 29 in Chapter II of this report). Secondary environmental corridors also contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive urban or agricultural purposes. Secondary environmental corridors facilitate surface water drainage, maintain pockets of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. Secondary environmental corridors in the regional water quality management plan update study area are shown on Map 19 in Chapter II of this report.

Isolated Natural Resource Areas

Widely scattered throughout the study area, isolated natural resource areas encompassed about 28 square miles, or about 3 percent of the total study area, in 2000 (Table 29 in Chapter II of this report). These smaller pockets of wetlands, woodlands, surface water, or wildlife habitat exist within the study area. Isolated natural resource areas may provide the only available wildlife habitat in an area, provide good locations for local parks and nature study areas, and lend unique aesthetic character or natural diversity to an area. These isolated natural resource areas should also be protected and preserved in their natural state whenever possible. Isolated natural resource areas in the regional water quality management plan update study area are shown on Map 19 in Chapter II of this report.

Natural Areas and Critical Species Habitat

The regional natural areas and critical species habitat protection and management plan[84] ranked natural resource features based upon a system that considered areas to be of statewide or greater significance, NA-1; countywide or regional significance, NA-2; or local significance, NA-3. In addition, certain other areas were identified as critical species habitat sites. It is important to note that the inventories in this plan did not specifically include areas within Sheboygan, Fond du Lac, and Dodge Counties, except for areas that are immediately adjacent to or shared by the northern boundaries of Ozaukee and Washington Counties. However, as shown in Table 30 in Chapter II of this report and Map 20 in Chapter II of this report, there are a total of five and three State natural areas identified by the WDNR Bureau of Endangered Resources within Fond du Lac and Sheboygan Counties, respectively. As indicated in Table 30 in Chapter II of this report, and illustrated on Map 20 in Chapter II of this report, there were 227 natural area sites inventoried in the study area that encompassed a total of about 20,700 acres, or approximately 3 percent of the study area. In addition, the regional natural areas and critical species habitat protection and management plan also included an inventory of critical species habitat sites located in the study area, except for areas within Sheboygan, Fond du Lac, and Dodge Counties. Critical species are those species of plants and animals that are considered endangered, threatened, or of special concern. The majority of critical species habitat sites are located within identified natural areas of the study area; however, a few are located outside of the known natural areas. Table 30 in Chapter II of this report identifies 47 critical species habitat sites that are outside of the abovementioned natural area sites.

Measures for Habitat Protection

Varying approaches to the protection of stream corridors have been adopted within the greater Milwaukee watersheds. In Milwaukee County, stream corridor protection has been focused on public acquisition of the lands adjacent to the stream banks and their preservation as river parkways. These lands are frequently incorporated into public parks and other natural areas. Racine County has acquired some lands adjacent to the mainstem of the Root River and preserved it as river parkway. In Washington County, the City of West Bend has also acquired some lands adjacent to the mainstem of the Milwaukee River, at the site of the former Woolen Mills dam, and has preserved it as a park. The Washington County comprehensive shoreland and floodland protection ordinance requires setbacks of principal structures and places limits upon removal of shoreland vegetative cover, excavation of shoreland, and encroachment into shorelands by structures based upon a lake and stream classification system designed to protect those waters most sensitive to human encroachment. While most of the Milwaukee River and Menomonee River systems within the County are classified as Class III waters, which are subject to statewide minima with respect to these parameters, the East and West Branch of the Milwaukee River, Silver Creek (West Bend), Stony Creek, and Willow Creek within Washington County are classified as a Class I streams, and Kewaskum Creek and the West Branch of the Menomonee River within the County are classified as Class II streams. These waterways are subjected to greater setbacks and other more stringent performance standards designed to protect and preserve sensitive instream habitat and water quality. Of the lakes within the Milwaukee River watershed in Washington County, most of the larger, historically developed lakes are classified as Class III waters, subject to statewide minimum standards for shoreland protection. Erler, Hasmer, Lucas, Mud, and Smith Lakes are classified as Class II waters and are subject to greater setbacks and other more stringent performance standards designed to protect and preserve sensitive habitat and water quality. In Waukesha County, a comprehensive shoreland and floodland protection ordinance requires setbacks of principal structures and places limits upon removal of shoreland vegetative cover, excavation of shoreland, and encroachment into shorelands by structures.

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[84]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

The provision of buffer strips along waterways represents an important intervention that addresses anthropogenic sources of contaminants, with even the smallest buffer strip providing environmental benefit.[85] Figure 45 shows the current status of buffer widths around streams among each of the greater Milwaukee watersheds, ranging from less than 25 feet, 25 to 50 feet, 50 to 75 feet, and greater than 75 feet. Buffers of greater than 75 feet in width were the most common category of buffer, accounting for about 56 percent of the buffer widths observed in the study area. Buffer widths less than 25 feet were the next most common category of buffer, accounting for about 25 percent of the buffer widths observed in the study area. Figure 45 also shows that the status of buffer widths along streams differs among the watersheds in the study area. Depending on the watershed, buffers of greater than 75 feet in width accounted for between about 10 and 67 percent of buffers in the watershed, with the greatest percentage of buffers in this width category being found in the Milwaukee River watershed and the smallest percentage of buffers in this width category being found in the Kinnickinnic River watershed. Enclosed conduits, which comprise about 34 miles of the greater Milwaukee watersheds stream system, essentially eliminate opportunities for installation of buffers. These enclosures are located largely within Wilson Park Creek and the S. 43rd Street Ditch subwatersheds in the Kinnickinnic River watershed, Honey Creek, Underwood Creek, the South Branch of Underwood Creek, and Grantosa Creek in the Menomonee River watershed, Beaver Creek, Brown Deer Park Creek, Southbranch Creek, an unnamed tributary to Southbranch Creek, and an unnamed tributary to Indian Creek, in the Milwaukee River watershed, the Mitchell Field Drainage Ditch subwatershed in the Oak Creek watershed, and Crayfish, Legend, and Tess Corners Creeks and an unnamed tributary to the Root River in the Root River watershed. Maps showing buffer widths along streams in the greater Milwaukee watersheds area are presented in Chapters V through IX of SEWRPC Technical Report No. 39.

ACHIEVEMENT OF WATER USE OBJECTIVES

The water use objectives and the supporting water quality standards and criteria for the greater Milwaukee watersheds are documented in Chapter VII of this report. Most of the stream reaches in these watersheds are designated for fish and aquatic life and full recreational uses. A few are designated for coldwater uses. Auburn Lake Creek upstream from Auburn Lake, Chambers Creek, Gooseville Creek, Melius Creek, Nichols Creek, and Watercress Creek are all considered coldwater streams and subject to standards under which dissolved oxygen concentrations are not to be less than 7.0 mg/l during spawning and 6.0 mg/l during the rest of the year. These streams are all in the Milwaukee River watershed. The other exceptions to the fish and aquatic life and full recreational use designations are subject to variances under Chapter NR 104 of the *Wisconsin Administrative Code*. The mainstem of the Kinnickinnic River in the Kinnickinnic River watershed; Honey Creek, Underwood Creek from Juneau Boulevard in the Village of Elm Grove downstream to the confluence with the Menomonee River, and the mainstem of the Menomonee River downstream from the confluence with Honey Creek in the Menomonee River watershed; and Indian Creek, Lincoln Creek, and the mainstem of the Milwaukee River downstream from the site of the former North Avenue dam in the Milwaukee River watershed are subject to a special variance under which dissolved oxygen is not to be less than 2.0 mg/l and counts of fecal coliform bacteria are not to exceed 1,000 per 100 ml. Burnham Canal and South Menomonee Canal in the Menomonee River watershed are subject to special variances that impose the same requirements with the additional requirement that the water temperature shall not exceed 31.7ºC. In the Milwaukee River watershed, Silver Creek (Sheboygan County) downstream from the Random Lake wastewater treatment plant to the first crossing of Creek Road is designated for limited forage fish and is subject to a variance under which dissolved oxygen concentrations are not to be less than 3.0 mg/l. The East Branch of the Root River Canal from STH 20 to the confluence with the West Branch of the Root River Canal, Hoods Creek, Tess Corners Creek, the West Branch of the Root River Canal between STH 20 and CTH C, and Whitnall Park Creek downstream from the site of the former Hales Corners wastewater treatment plant to Whitnall Park Pond in the Root River watershed are designated for limited forage fish and subject to variances under which dissolved oxygen concentrations are not to be less than 3.0 mg/l.

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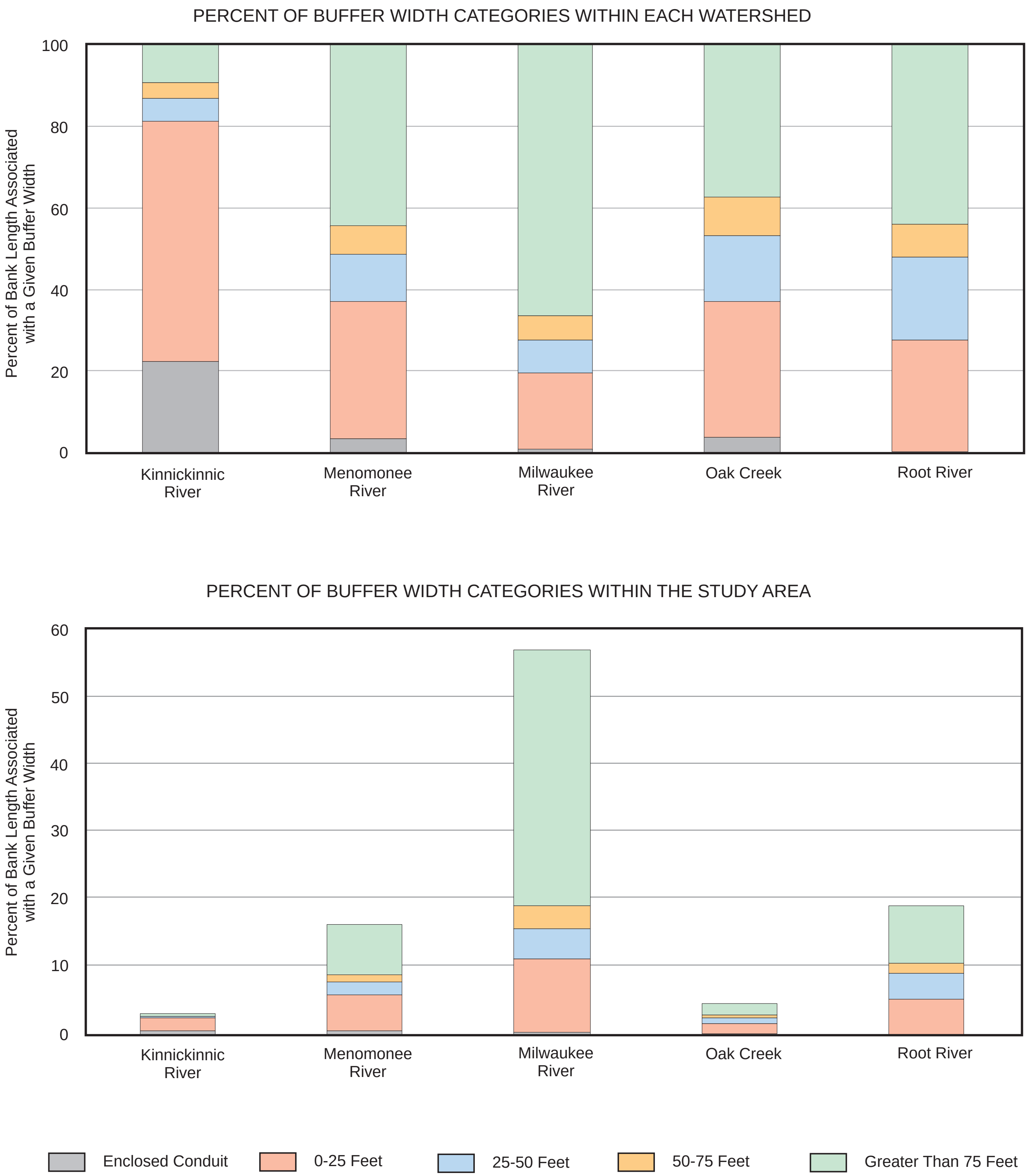
[85]*See Chapter II of SEWRPC Technical Report No. 39. Data were drawn from A. Desbonnet, P. Pogue, V. Lee, and N. Wolff, "Vegetated Buffers in the Coastal Zone—a Summary Review and Bibliography,"* CRC Technical Report No. 2064. *Coastal Resources Center, University of Rhode Island, 1994.*

Figure 45

RIPARIAN CORRIDOR BUFFER WIDTHS IN THE GREATER MILWAUKEE WATERSHEDS: 2005



Source: SEWRPC.

The East Branch of the Root River, the East Branch of the Root River Canal upstream from STH 20, Ives Grove Ditch, the West Branch of the Root River Canal upstream from CTH C, Whitnall Park Creek upstream from the site of the former Hales Corners wastewater treatment plant, and an unnamed tributary of the Root River from downstream from the site of the former New Berlin Memorial Hospital wastewater treatment plant in the Root River watershed are designated for limited aquatic life and are subject to variances under which dissolved oxygen concentrations are not to be less than 1.0 mg/l.

For the most part, the standards that apply to the Milwaukee outer harbor and adjacent nearshore Lake Michigan area are less clear cut. The Beach Act of 2000 requires that water quality advisories be issued at designated bathing beaches when concentrations of *E. coli* in a single sample exceed 235 cells per 100 ml. This standard was used to assess whether water quality at beaches and in the nearshore Lake Michigan area was suitable for full recreational use. For other water quality parameters, it was decided to compare water quality in the outer harbor to the standards for fish and aquatic life.

Fairly large data sets for the assessment of achievement of water use objectives were available from multiple sampling stations along the mainstems of the Menomonee and Kinnickinnic Rivers and Oak Creek and from large portions of the mainstems of the Milwaukee and Root Rivers. Far fewer data are available from tributary streams. In the inventories contained in Chapters V through X of SEWRPC Technical Report No. 39, 119 tributary steams were identified in the Kinnickinnic River, Menomonee River, Milwaukee River, Oak Creek, and Root River watersheds and in the Lake Michigan direct drainage area for assessing compliance with water quality standards and criteria related to five water quality parameters during the baseline period.[86] Observed data were available to assess compliance with standards or criteria for all five parameters for only eight tributary streams. Data were available for assessing compliance with standards or criteria for at least one of these parameters for another 20 tributary streams. It is important to note that these numbers reflect the tributaries for which any data were available. For many tributaries, these assessments were based upon small numbers of samples. For about half the tributaries assessed, the assessment of compliance was based on 15 or fewer samples. In some cases, the assessments were based on five or fewer samples.

Streams

Based upon the available data for sampling stations in the greater Milwaukee watersheds, the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers, Oak Creek, and the major tributaries of these streams did not fully meet the water quality standards associated with the designated water use objectives during and prior to 1975, the base year of the initial plan. Review of subsequent data indicated that as of 1995, the designated water use objectives were only being partially achieved in the majority of the streams in the watershed.[87] For streams in the Lake Michigan direct drainage area, data for assessing achievement of water use objectives were available only for Fish Creek. Data were not available to assess whether Fish Creek met water quality standards associated with the designated water use objectives during and prior to 1975, the base year of the initial regional water quality management plan, or during review of subsequent data that examined conditions as of 1995.[88]

During the baseline period, the designated water use objectives were only being partially achieved in much of the greater Milwaukee watersheds. Table 43 shows the results of comparisons of water quality data from the baseline period to supporting water quality standards for the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and

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[86]*The baseline was initially set as 1998-2001. During the course of the study, more recent data were incorporated into analyses as they became available. Thus, the baseline period used for these assessments in the Menomonee River, Kinnickinnic River, and Oak Creek watersheds was 1998-2001. Because more recent data were available when the analyses were conducted, the baseline period used for these assessments in the Milwaukee River and Root River watersheds and the Lake Michigan direct drainage area was 1998-2004.*

[87]*SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[88]Ibid.

Table 43

CHARACTERISTICS OF STREAMS IN THE GREATER MILWAUKEE WATERSHEDS: 1998-2004

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a]					Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
		Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria			
Kinnickinnic River Mainstem									
Kinnickinnic River above S. 27th Street[f]	3.1	100.0 (67)[g]	100.0 (67)	100.0 (55)	29.9 (67)	30.3 (66)[h]	Very poor (1)	- -	
Kinnickinnic River between S. 7th Street and S. 27th Street[f]	2.1	98.4 (63)[g]	98.4 (63)	100.0 (46)	56.2 (64)	50.8 (63)[h]	- -	Fair (1)	
Kinnickinnic River between S. 1st Street and S. 7th Street[f]	1.4	94.1 (68)[g]	100.0 (68)	100.0 (64)	58.8 (68)	58.2 (67)[h]	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Kinnickinnic River between Greenfield Avenue (extended) and S. 1st Street[f]	0.8	100.0 (58)[g]	100.0 (58)	100.0 (56)	74.1 (58)	75.4 (57)[h]	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Kinnickinnic River between Jones Island Ferry and Greenfield Avenue (extended)[f]	0.4	100.0 (58)[g]	100.0 (58)	100.0 (57)	74.1 (58)	77.2 (57)[h]	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Wilson Park Creek Subwatershed									
Wilson Park Creek Tributary Upstream of Conduit[f]		- -	- -	100.0 (22)	78.6 (42)	- -	- -	- -	- -
Wilson Park Creek Tributary Downstream of Conduit[f]		- -	- -	96.0 (25)	70.5 (44)	- -	- -	- -	- -
Wilson Park Creek[f]	5.5	- -	- -	100.0 (22)	70.5 (44)	- -	- -	- -	- -
Menomonee River Mainstem									
Menomonee River above County Line Road[f]	4.5	87.9 (58)	100.0 (58)	100.0 (16)	66.7 (57)	36.2 (58)	- -	- -	- -
Menomonee River between N. 124th Street and County Line Road[f]	10.0	100.0 (89)	100.0 (63)	100.0 (28)	67.4 (89)	24.4 (90)	Poor (4)	Fair (1)	- -
Menomonee River between W. Hampton Avenue and N. 124th Street[f]	1.0	98.7 (76)	100.0 (61)	100.0 (21)	59.1 (77)	26.0 (77)	- -	- -	- -
Menomonee River between N. 70th Street and W. Hampton Avenue[f]	4.5	100.0 (117)	100.0 (71)	100.0 (44)	43.1 (102)	39.3 (117)	Very poor (9)[i]	Good-very good (3)[i]	- -
Menomonee River between N. 25th Street and N. 70th Street[f]	6.2	100.0 (64)[g]	100.0 (64)	100.0 (18)	31.7 (63)	62.5 (64)[j]	Very poor (9)[i]	Good-very good (3)[i]	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory[k]
Menomonee River between Muskego Avenue and N. 25th Street[f]	0.9	100.0 (66)[g]	100.0 (60)	100.0 (21)	36.9 (65)	71.8 (64)[j]	Very poor (1)[l]	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Menomonee River between Burnham Canal and Muskego Avenue[f]	0.1	100.0 (62)[g]	93.5 (62)	100.0 (16)	63.7 (61)	85.2 (61)[j]	Very poor (1)[l]	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory

Table 43 (continued)

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a]					Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
		Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria			
Menomonee River Mainstem (continued)									
Menomonee River between S. 2nd Street and Burnham Canal[f]	0.8	100.0 (114)[g]	100.0 (67)	100.0 (30)	32.7 (113)	59.6 (111)[j]	Very poor (1)[l]	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
West Branch of the Menomonee River[f]	4.2	- -	- -	- -	- -	- -	Poor (1)	Fair (4)	- -
Willow Creek Subwatershed									
Willow Creek[f]	2.8	100.0 (5)	100.0 (6)	100.0 (10)	81.8 (11)	- -	Very poor (1)	Good-very good (5)	- -
Butler Ditch Subwatershed									
Butler Ditch[m]	2.9	100.0 (3)	100.0 (3)	- -	- -	- -	Very poor (4)	- -	- -
Little Menomonee River Subwatershed									
Little Menomonee River[f]	11.2	100.0 (5)	100.0 (6)	100.0 (6)	83.3 (6)	100.0 (1)	Very poor (5)	Good-very good (1)	Aquatic toxicity
South Branch Underwood Creek Subwatershed									
South Branch of Underwood Creek[n]	1.0	71.9 (32)	100.0 (32)`	100.0 (32)	43.3 (30)	21.9 (32)	- -	- -	- -
Underwood Creek Subwatershed									
Underwood Creek from Juneau Boulevard to Headwaters[n]	7.4	68.8 (32)	100.0 (32)	100.0 (32)	77.4 (31)	43.8 (32)	Very poor (3)	- -	- -
Underwood Creek from confluence with the Menomonee River to Juneau Boulevard[n]	1.5	100.0 (48)[g]	100.0 (48)	100.0 (48)	68.2 (44)	70.8 (48)[j]	- -	Poor-fairly poor (1)	- -
Honey Creek Subwatershed									
Honey Creek[f]	10.0	94.6 (92)[g]	100.0 (80)	100.0 (92)	33.8 (77)	32.6 (92)[j]	- -	- -	- -
Mainstem Milwaukee River									
Milwaukee River above Dam at Kewaskum	22.9	84.0 (144)	100.0 (191)	- -	63.8 (58)	60.0 (10)	Very poor to excellent (3)	Poor to good (12)	Fish consumption advisory
Milwaukee River between Dam at Kewaskum and CTH M near Newburg	20.5	100.0 (117)	100.0 (121)	- -	74.5 (51)	72.7 (11)	Fair to excellent (4)	Fair to good (4)	Fish consumption advisory
Milwaukee River between CTH M near Newburg and Waubeka	12.3	100.0 (95)	100.0 (110)	- -	78.6 (42)	100.0 (9)	Fair to excellent (5)	Poor to good (10)	Fish consumption advisory
Milwaukee River between Waubeka and Pioneer Road near Cedarburg	19.2	100.0 (95)	100.0 (95)	98.9 (90)	38.4 (112)	41.1 (90)	Good to excellent (5)	Fair to good (3)	Bacteria, fish consumption advisory
Milwaukee River between Pioneer Road near Cedarburg and W. Brown Deer Road	11.3	100.0 (87)	100.0 (88)	100.0 (70)	44.8 (87)	30.7 (88)	- -	- -	Bacteria, fish consumption advisory
Milwaukee River between W. Brown Deer Road and E. Silver Spring Drive	6.5	100.0 (81)	100.0 (81)	100.0 (64)	42.5 (80)	38.3 (81)	Excellent (4)	Fair to good (3)	Bacteria, fish consumption advisory
Milwaukee River between E. Silver Spring Drive and N. Port Washington Road	1.6	94.1 (85)	100.0 (85)	100.0 (69)	42.9 (84)	30.6 (85)	- -	- -	Bacteria, fish consumption advisory

Table 43 (continued)

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a]					Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
		Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria			
Mainstem Milwaukee River (continued)									
Milwaukee River between N. Port Washington Road and Estabrook Park	0.3	100.0 (75)	100.0 (76)	100.0 (76)	42.4 (92)	54.5 (11)	- -	Poor to good (3)	Bacteria, fish consumption advisory
Milwaukee River between Estabrook Park and former North Avenue Dam	3.6	98.6 (71)	100.0 (71)	100.0 (62)	37.1 (70)	19.7 (71)	Good to excellent (5)	Fair to good (9)	Bacteria, fish consumption advisory
Milwaukee River between former North Avenue Dam and Walnut Street	0.9	100.0 (87)	100.0 (87)	100.0 (74)	39.5 (86)	65.1 (83)	Very poor (1)	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Milwaukee River between Walnut Street and Wells Street	0.8	100.0 (84)	100.0 (84)	100.0 (75)	38.6 (83)	69.9 (83)	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Milwaukee River between Wells Street and Water Street	0.6	100.0 (88)	100.0 (88)	100.0 (86)	37.5 (88)	68.2 (88)	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Milwaukee River between Water Street and Union Pacific Railroad	0.3	100.0 (76)	100.0 (76)	100.0 (73)	64.5 (76)	77.3 (75)	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen, fish consumption advisory
Milwaukee River between Union Pacific Railroad and confluence with Lake Michigan	0.4	100.0 (2)	100.0 (2)	100.0 (2)	75.0 (4)	100.0 (3)	- -	- -	Aquatic toxicity, bacteria, dissolved oxygen consumption advisory
West Branch Milwaukee River Subwatershed									
West Branch Milwaukee River	20.1	60.0 (5)	100.0 (6)	100.0 (5)	61.5 (39)	- -	Poor to excellent (4)	Poor to good (10)	- -
Kewaskum Creek Subwatershed									
Kewaskum Creek	6.4	- -	- -	- -	70.6 (34)	- -	Fair (1)	Fair to good (5)	- -
East Branch Milwaukee River Subwatershed									
East Branch Milwaukee River from Long Lake to STH 28	15.9	100.0 (125)	100.0 (139)	100.0 (6)	98.4 (62)	100.0 (10)	Fair to excellent (11)	Poor to excellent (17)	- -
Unnamed Creek (T14N R19E SE NW 36) (Parnell Creek)	7.8	100.0 (6)	100.0 (6)	100.0 (7)	66.7 (6)	- -	- -	Good (5)	- -
Crooked Lake Creek	5.1	100.0 (6)	100.0 (6)	100.0 (6)	100.0 (6)	- -	Poor to very poor (2)	Fair to good (7)	- -
Middle Milwaukee River Subwatershed									
Quaas Creek	5.9	99.1 (856)	100.0 (856)	- -	79.4 (34)	- -	Fair to very poor (5)	Fair to good (4)	- -
Riveredge Creek	2.2	- -	100.0 (131)	- -	- -	- -	- -	- -	- -

Table 43 (continued)

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a]					Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
		Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria			
North Branch Milwaukee River Subwatershed									
North Branch Milwaukee River	30.0	83.6 (140)	100.0 (197)	100.0 (12)	56.3 (64)	44.4 (9)	Fair (1)	Poor to good (3)	- -
Adell Tributary	5.1	- -	- -	- -	- -	- -	- -	Poor to fair (4)	Degraded habitat
Wallace Creek	8.6	100.0 (5)	100.0 (6)	100.0 (5)	33.3 (6)	- -	Poor to fair (2)	Good (7)	- -
Batavia Creek Subwatershed									
Batavia Creek	5.0	- -	- -	- -	65.8 (32)	- -	- -	- -	- -
Stony Creek Subwatershed									
Stony Creek	10.0	100.0 (6)	100.0 (6)	100.0 (6)	100.0 (6)	- -	Poor to fair (3)	Good (6)	- -
Upper Lower Milwaukee River Subwatershed									
Mole Creek	4.0	100.0 (5)	100.0 (6)	100.0 (5)	100.0 (6)	- -	Very poor to fair (9)	Poor to good (11)	- -
Cedar Creek Subwatershed									
Cedar Creek	31.5	100.0 (124)	99.2 (127)	100.0 (6)	94.9 (59)	92.9 (14)	Good (3)	Fair to good (4)	Fish consumption advisory
Lehner Creek	0.3	- -	- -	- -	- -	- -	Very poor (2)	Good (1)	Degraded habitat, temperature
Unnamed Creek (T10N R20E SW SE 19) (Jackson Creek)	1.3	- -	- -	- -	- -	- -	- -	- -	Degraded habitat
Polk Springs Creek	1.9	100.0 (161)	100.0 (167)	100.0 (89)	48.7 (39)	- -	Very poor to poor (3)	Poor to good (6)	- -
Friedens Creek	3.8	100.0 (5)	100.0 (6)	100.0 (5)	83.3 (6)	- -	Very poor (2)	Fair to good (6)	- -
Evergreen Creek	4.9	- -	- -	- -	- -	- -	- -	- -	Degraded habitat
Lower Cedar Creek Subwatershed									
North Branch Cedar Creek	7.3	- -	- -	- -	- -	- -	Very poor to poor (2)	Poor to good (4)	- -
Lower Milwaukee River Subwatershed									
Pigeon Creek	2.4	100.0 (5)	100.0 (6)	100.0 (5)	100.0 (6)	- -	Poor (1)	Good (3)	- -
Beaver Creek	2.6	- -	- -	- -	- -	- -	- -	- -	Aquatic toxicity
Southbranch Creek above W. Bradley Road	0.1	100.0 (30)	100.0 (30)	100.0 (32)	3.3 (30)	38.7 (31)	- -	- -	- -
Southbranch Creek between W. Bradley Road and N. 55th Street	0.2	100.0 (39)	100.0 (34)	100.0 (32)	12.1 (33)	32.4 (34)	- -	- -	- -
Southbranch Creek between N. 55th Street and N. 47th Street	0.5	100.0 (36)	100.0 (36)	100.0 (30)	11.4 (35)	22.2 (36)	- -	- -	- -

Table 43 (continued)

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a]					Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
		Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria			
Lower Milwaukee River Subwatershed (continued)									
Southbranch Creek between N. 47th Street and Teutonia Avenue	0.5	91.4 (35)	100.0 (35)	100.0 (28)	29.4 (34)	8.6 (35)	- -	- -	- -
Indian Creek	1.9	100.0 (32)	100.0 (32)	100.0 (28)	75.0 (28)	71.9 (32)	Very poor (1)	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature[o]
Lincoln Creek Subwatershed									
Lincoln Creek above N. 60th Street	0.9	100.0 (81)	100.0 (81)	100.0 (74)	57.5 (80)	76.3 (80)	- -	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature
Lincoln Creek between N. 60th Street and N. 51st Street	1.5	100.0 (79)	100.0 (80)	100.0 (65)	77.2 (79)	47.5 (80)	- -	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature
Lincoln Creek between N. 51st Street and N. 55th Street	1.1	100.0 (61)	100.0 (61)	100.0 (56)	81.7 (60)	73.3 (60)	- -	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature
Lincoln Creek between N. 55th Street and N. 47th Street	2.5	100.0 (100)	100.0 (100)	100.0 (83)	37.6 (93)	34.5 (84)	Very poor (1)	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature
Lincoln Creek between N. 47th Street and Green Bay Avenue	2.9	97.6 (83)	100.0 (422)	100.0 (78)	14.6 (82)	37.3 (83)	Very poor (2)	- -	Aquatic toxicity, degraded habitat, dissolved oxygen, temperature
Oak Creek Mainstem									
Oak Creek above W. Ryan Road	3.7	56.9 (51)	100.0 (52)	100.0 (52)	75.0 (52)	15.7 (51)	- -	- -	Aquatic toxicity
Oak Creek between STH 38 and Ryan Road	0.8	98.1 (53)	100.0 (54)	100.0 (48)	79.2 (53)	15.1 (53)	- -	- -	Aquatic toxicity
Oak Creek between Forest Hill Road and STH 38	3.0	75.0 (52)	100.0 (53)	100.0 (46)	58.5 (53)	25.0 (52)	- -	- -	Aquatic toxicity
Oak Creek between Pennsylvania Avenue and Forest Hill Road	1.5	84.6 (53)	100.0 (53)	100.0 (46)	69.2 (52)	18.9 (53)	- -	- -	Aquatic toxicity
Oak Creek between 15th Avenue and Pennsylvania Avenue	1.9	100.0 (54)	100.0 (55)	100.0 (52)	63.6 (55)	14.5 (55)	- -	- -	Aquatic toxicity
Oak Creek between Oak Creek Parkway East of STH 32 and 15th Avenue	1.8	100.0 (45)	100.0 (46)	100.0 (37)	72.3 (47)	17.0 (47)	- -	- -	Aquatic toxicity
Oak Creek between Oak Creek Parkway East of S. Lake Drive and Oak Creek Parkway East of STH 32	0.8	100.0 (52)	100.0 (53)	100.0 (48)	75.9 (54)	13.0 (54)	- -	- -	Aquatic toxicity

Table 43 (continued)

Stream Reach	Stream Length (miles)	Percent of Samples Meeting Water Quality Standards and Criteria[a] Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria	Fish Biotic Index Rating[a,d]	Macroinvertebrate Biotic Index Rating (HBI)[a,d]	303(d) Impairments[e]
Oak Creek Tributaries									
Mitchell Field Drainage Ditch	5.8	- -	100.0 (1)	100.0 (10)	45.5 (11)	- -	- -	- -	Aquatic toxicity
Root River Mainstem									
Root River above W. Cleveland Avenue	1.1	46.4 (28)	100.0 (28)	100.0 (27)	64.3 (28)	21.4 (28)	- -	- -	Dissolved oxygen
Root River between the intersection of W. National Avenue and W. Oklahoma Avenue and W. Cleveland Avenue	0.5	44.4 (27)	100.0 (27)	100.0 (23)	42.3 (26)	7.4 (27)	- -	- -	Dissolved oxygen
Root River between W. Cold Spring Road and the intersection of W. National Avenue and W. Oklahoma Avenue	0.8	53.6 (28)	100.0 (28)	100.0 (26)	67.9 (28)	25.0 (28)	Fair (1)	- -	Dissolved oxygen
Root River between W. Grange Avenue and W. Cold Spring Road	2.5	79.5 (39)	100.0 (39)	100.0 (33)	78.9 (38)	16.1 (31)	Very poor (1)	- -	Dissolved oxygen
Root River between W. Ryan Road and W. Grange Avenue	8.7	90.6 (32)	100.0 (32)	100.0 (26)	75.8 (33)	36.7 (30)	Very poor (1)	- -	Dissolved oxygen
Root River between W. County Line Road and W. Ryan Road	4.2	100.0 (25)	100.0 (26)	100.0 (24)	26.9 (26)	34.6 (26)	Very poor(1)	- -	Dissolved oxygen
Root River between Johnson Park and W. County Line Road[p]	12.3	97.6 (42)	100.0 (62)	100.0 (31)	47.4 (38)	79.5 (39)	Very poor to fair (4)	Fair to very good (6)	Dissolved oxygen[f]
Root River between below the Horlick Dam and Johnson Park	5.6	94.3 (106)	100.0 (171)	100.0 (2)	10.7 (56)	53.6 (9)	Fair (1)	Fair to very good (3)	- -
Root River between near the mouth of the River and below the Horlick Dam	5.5	32.5 (120)	100.0 (181)	- -	8.3 (48)	20.0 (5)	Fair to excellent (2)	Fair to very good (2)	Fish consumption advisory
West Branch of the Root River Canal	10.7	- -	- -	- -	- -	- -	- -	- -	Dissolved oxygen
Root River Canal	5.5	77.6 (98)	100.0 (104)	- -	3.9 (51)	60.0 (10)	Very poor (1)	- -	Dissolved oxygen
Husher Creek	5.2	100.0 (4)	100.0 (6)	100.0 (4)	33.3 (6)	- -	Very poor (1)	Poor to fair (2)	- -
Lake Michigan Direct Drainage Area									
Fish Creek above W. Port Washington Road	2.3	88.2 (34)	100.0 (34)	100.0 (33)	60.6 (33)	28.1 (32)	- -	- -	- -
Fish Creek between W. Port Washington Road and Broadmoor Drive	0.6	97.1 (34)	100.0 (34)	100.0 (33)	51.5 (33)	33.3 (33)	- -	- -	- -

[a]*Number in parentheses shows number of samples.*

[b]*Based upon the acute toxicity criterion for ammonia.*

[c]*Total phosphorus is compared to the concentration recommended in the original regional water quality management plan as documented in SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979.*

[d]*The State of Wisconsin has not promulgated water quality standards or criteria for biotic indices.*

Table 43 Footnotes (continued)

[e] *As listed in the Approved Wisconsin 303(d) Impaired Waters List.*

[f] *Except as noted, evaluations of dissolved oxygen, temperature, ammonia, total phosphorus, and fecal coliform bacteria are based on data from 1998-2001.*

[g] *A special variance dissolved oxygen standard of 2.0 milligrams per liter applies to the Kinnickinnic River and the Menomonee River downstream of the confluence with Honey Creek, Honey Creek and Underwood Creek from the confluence with the Menomonee River upstream to Juneau Boulevard.*

[h] *A special variance standard for fecal coliform bacteria concentration applies to the Kinnickinnic River. Membrane filter fecal coliform counts shall not exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 2,000 per 100 ml in more than 10 percent of all samples in any month.*

[i] *The lower Menomonee River upstream from the estuary was evaluated for biotic indices as a single reach.*

[j] *A special variance standard for fecal coliform bacteria concentration applies to the Menomonee River downstream from the confluence with Honey Creek, Honey Creek and Underwood Creek from the confluence with the Menomonee River upstream to Juneau Boulevard. Membrane filter fecal coliform counts shall not exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 2,000 per 100 ml in more than 10 percent of all samples in any month.*

[k] *The downstream 1.2 miles of this reach are listed as impaired due to aquatic toxicity, bacteria, low dissolved oxygen concentration, and fish consumption advisories. The upstream portion of this reach is not listed as impaired.*

[l] *The estuary was evaluated for biotic indices as a single reach.*

[m] *Based upon data collected in 2003.*

[n] *Based upon data collected from 2001-2004.*

[o] *The natural channel downstream of IH 43 is considered impaired. Reaches upstream from IH 43 are not considered impaired.*

[p] *The upstream 1.9 miles of this reach are listed as impaired due to low dissolved oxygen concentrations. The downstream portion of this reach is not listed as impaired.*

Source: SEWRPC.

Root Rivers, Oak Creek, and those tributaries for which data exist to assess achievement of water use objectives. Review of data since 1998 shows the following:

- Ammonia concentrations in almost all samples collected from the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers, Oak Creek, and 23 tributary streams to these Rivers were below the acute toxicity criterion for fish and aquatic life for ammonia, indicating compliance with the standard.
- Dissolved oxygen concentrations from the vast majority of samples collected from stations along the mainstem of the Kinnickinnic, Menomonee, and Milwaukee Rivers were at or above the relevant standard in the vast majority of samples, indicating substantial compliance with the standard. Dissolved oxygen concentrations at most stations along the mainstem of Oak Creek were at or above the relevant standard for fish and aquatic life waters in the vast majority of samples, indicating substantial compliance with the standard. The major exception to this generalization occurred in the portion of the mainstem upstream from the confluence with the North Branch of Oak Creek (above W. Ryan Road). In this reach, dissolved oxygen concentrations were below the standard in a substantial portion of the samples, indicating substantial noncompliance with the standard. Dissolved oxygen concentrations from stations along the mainstem of the Root River upstream of W. Grange Avenue and from the station near the mouth of the River were commonly below the relevant standard, indicating frequent violation of the standard. Dissolved oxygen concentrations were at or above the relevant standards in the vast majority of samples in 15 tributary streams, indicating compliance. In four streams, Fish Creek, Lincoln Creek, Quaas Creek, and Southbranch Creek, dissolved oxygen concentrations were occasionally below the relevant standard. Dissolved oxygen concentrations in six other streams, the North Branch of the Milwaukee River, the North Branch of Oak Creek, the Root River Canal, the South Branch of Underwood Creek, Underwood Creek, and the West Branch of the Milwaukee River, were commonly to frequently below the relevant standard, indicating more frequent violation of the standard.
- Water temperatures in all samples taken from the mainstems of the Milwaukee and Root Rivers and Oak Creek were at or below the relevant standard, indicating substantial compliance with the standard. Water temperatures at two sampling stations along the mainstem of the Kinnickinnic River and one sampling station along the mainstem of the Menomonee River occasionally exceeded the relevant standard during the summer, indicating occasional violation of the standard. Water temperatures in 24 tributary streams were always at or below the relevant standard, indicating compliance with the standard. The water temperature in one of 127 samples taken from Cedar Creek was above the relevant standard, indicating an isolated incidence of violation of the standard.
- Fecal coliform bacteria standards were commonly exceeded at stations along the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers, indicating frequent violation of the standard. Fecal coliform bacteria standards were generally exceeded along the mainstem of Oak Creek, indicating a general violation of the standard. Fecal coliform bacteria concentrations were below the standard in one tributary stream and exceeded the standard in one sample out of 14 for a second tributary stream, indicating substantial compliance with the standard in these streams. Concentrations of fecal coliform bacteria in nine tributary streams, Fish Creek, Honey Creek, Indian Creek, Lincoln Creek, the North Branch of the Milwaukee River, the Root River Canal, Southbranch Creek, the South Branch of Underwood Creek, and Underwood Creek, commonly exceeded the relevant standard, indicating frequent violation of the standard.
- Concentrations of total phosphorus in the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek commonly exceeded the recommended levels in the original regional water quality management plan.[89] Total phosphorus concentrations in 20 tributary streams commonly

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[89]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume One, Inventory Findings, September 1978; Volume Two, Alternative Plans, February 1979; and Volume Three, Recommended Plan, June 1979.*

exceeded the recommended concentration. Total phosphorus concentrations in four tributary streams occasionally exceeded the recommended concentration. Total phosphorus concentrations in four tributary streams were at or below the recommended levels.

Thus, during the baseline period the stream reaches for which data are available only partially achieved the designated water use objectives.

Lake Michigan Beaches
During the 1998-2005 extended baseline period for which beach data were analyzed, the designated water use objectives were only being partially achieved at public beaches in the Lake Michigan direct drainage area. Table 44 shows the results of comparisons of water quality data from the baseline period to supporting water quality standards. Review of data from 1998 to 2005 shows that concentrations of *E. coli* occasionally exceeded 235 cells per ml at some beaches and frequently exceeded this standard at others.

Milwaukee Outer Harbor
During the 1998-2004 extended baseline period for which outer Harbor data were analyzed, the water quality criteria for fish and aquatic life were, for the most part, being achieved in the outer harbor. Table 45 shows the results of comparisons of water quality data from the baseline period to supporting water quality standards. Review of data from 1998 to 2004 shows the following:

- Ammonia concentrations in all samples taken in the outer harbor were below the acute toxicity criterion for fish and aquatic life for ammonia, indicating compliance with the standard.

- Dissolved oxygen concentrations in the vast majority of samples taken in the outer harbor were above the standard of 5.0 mg/l, indicating compliance with the standard.

- Water temperatures in all samples taken from the outer harbor were at or below the relevant standard, indicating compliance with the standard.

- Concentrations of fecal coliform bacteria at most sampling stations in the outer harbor occasionally exceeded 200 cells per 100 ml. At station OH-01 at the confluence with the Milwaukee River, concentrations of fecal coliform bacteria commonly exceeded 200 cells per 100 ml.

- Concentrations of total phosphorus occasionally exceeded the planning levels recommended in the original regional water quality management plan (SEWRPC PR No. 30). This was especially the case at stations located at the mouth of the Milwaukee River and the outfall from the Jones Island WWTP.

- It is important to note that about 88 percent of samples of *E. coli* collected in the outer harbor had cell counts below 235 cells per 100 ml, the recreational use criterion promulgated for designated bathing beaches by the USEPA.

Toxicity
An additional issue to consider when examining whether stream reaches are achieving water use objectives is whether toxic substances are present in water, sediment, or tissue of aquatic organisms in concentrations sufficient to impair beneficial uses. Table 46 summarizes the data from 1998 to 2004 regarding toxic substances in water, sediment, and tissue from aquatic organisms for the greater Milwaukee watersheds. For toxicants, the baseline period was extended to 2004 in order to take advantage of results from sampling conducted by the USGS for both Phase III of the MMSD Corridor Study Project and the regional water quality management plan update.

Pesticides were detected in water samples collected from the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek. In addition, pesticides were detected in water samples from six tributary streams. The concentrations detected did not exceed water quality standards. Pesticides were detected in two sediment samples collected from the mainstem of the Milwaukee River during the baseline period. Pesticides

Table 44

CHARACTERISTICS OF PUBLIC BEACHES IN THE LAKE MICHIGAN DIRECT DRAINAGE AREA: 1998-2005

Beach	Monitoring Priority in 2005[a]	Percent of Samples Meeting *E. coli* Standard	303(d) Impairments[b]
Lion's Den Nature Preserve	Not monitored	- -	- -
Virmond Park Beach	Not monitored	- -	- -
Doctors Park Beach	Medium	67.1 (108)	Bacteria
Klode Park Beach	Medium	76.4 (104)	- -
Big Bay Park Beach	Not monitored	- -	- -
Atwater Beach	Medium	82.1 (112)	- -
Bradford Beach	High	64.2 (1,130)	Bacteria
Watercraft Beach	High	81.7 (229)	- -
McKinley Beach	High	78.1 (777)	Bacteria
South Shore Beach	High	53.6 (786)	Bacteria
South Shore Beach Rocky Area	High	84.5 (232)	- -
Bay View Park Beach	Medium	81.1 (37)	- -
Sheridan Park Beach	Not monitored	- -	- -
Grant Park Beach	Medium	79.3 (115)	- -
Bender Park Beach	Medium	81.5 (92)	- -
Wind Point Lighthouse Beach	Not monitored	- -	- -
Shoop Park Beach	Not monitored	- -	- -
Parkway Beach	Not monitored	- -	- -
Michigan Boulevard Beach	Not monitored	- -	- -
Zoo Beach	High	87.1 (2,119)	- -
North Beach	High	85.4 (2,461)	- -

[a]*Number in parentheses show number of samples.*

[b]*As listed in the Approved Wisconsin 303(d) Impaired Waters List.*

Source: SEWRPC.

were detected in tissue from aquatic organisms collected from the Menomonee, Milwaukee, and Root Rivers during the baseline period.

PCBs were detected in water samples collected from the mainstems of the Kinnickinnic, Menomonee, and Milwaukee Rivers and from Cedar and Lincoln Creeks. When PCBs were detected, the concentrations exceeded Wisconsin's wildlife criterion for water quality. PCBs were also detected in sediment samples collected from sites in the Kinnickinnic and Milwaukee Rivers during the baseline period. In addition, PCBs were detected in sediment samples collected from Cedar and Lincoln Creeks and the North Branch Milwaukee River during the baseline period, and in tissue of fish collected from the mainstem of the Milwaukee River, Cedar Creek, and the Root River below Horlick Dam, often at concentrations necessitating the issuing of fish consumption advisories.

Water samples collected from the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek showed detectable concentrations of PAHs. Detectable concentrations of PAHs were also found in water samples collected from eight tributary streams. PAHs were detected in sediment samples from the Kinnickinnic and Root Rivers and four tributary streams including the Little Menomonee River. It is important to note that remediation activities are currently ongoing to address the presence of PAHs in sediment in this tributary.

Limited sampling for other organic compounds showed detectable concentrations of several compounds in water from the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek and from a few tributary streams such as Lincoln Creek. Compounds detected included pharmaceutical and personal care products such as the stimulant caffeine, industrial solvents such as isophorone, dye components such as carbazole,

Table 45

CHARACTERISTICS OF SAMPLING STATIONS IN THE MILWAUKEE OUTER HARBOR: 1998-2004

Harbor Station	Percent of Samples Meeting Water Quality Standards and Criteria[a]						Fish Biotic Index Rating[d]	Macroinvertebrate Biotic Index Rating (HBI)[d]	303(d) Impairments[e]
	Dissolved Oxygen	Temperature	NH_3[b]	Total Phosphorus[c]	Fecal Coliform Bacteria	*E. Coli*			
OH-01	95.5 (381)	100.0 (381)	100.0 (366)	84.9 (358)	69.9 (123)	100.0 (29)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-02	97.2 (249)	100.0 (249)	100.0 (249)	74.0 (246)	86.3 (80)	88.0 (25)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-03	100.0 (441)	100.0 (441)	100.0 (441)	90.7 (421)	75.0 (136)	100.0 (10)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-04	100.0 (288)	100.0 (288)	100.0 (279)	96.7 (275)	88.0 (83)	80.0 (10)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-05	100.0 (249)	100.0 (249)	100.0 (251)	98.0 (249)	93.9 (66)	- -	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-07	99.7 (363)	100.0 (363)	100.0 (263)	95.9 (362)	86.7 (113)	100.0 (25)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-09	100.0 (246)	100.0 (246)	100.0 (246)	97.5 (244)	88.4 (69)	92.0 (25)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-10	99.6 (246)	100.0 (246)	100.0 (246)	98.8 (245)	81.7 (71)	93.0 (25)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-11	99.4 (330)	100.0 (330)	100.0 (315)	94.9 (312)	83.2 (95)	90.0 (25)	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory
OH-15	100.0 (132)	100.0 (132)	100.0 (132)	95.3 (129)	93.3 (60)	- -	- -	- -	Aquatic toxicity, bacteria, fish consumption advisory

[a]*Number in parentheses shows number of samples.*

[b]*Based upon the acute toxicity criterion for ammonia.*

[c]*Total phosphorus is compared to the concentration recommended in the regional water quality management plan, as documented in SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume One,* Inventory Findings*, September 1978; Volume Two,* Alternative Plans*, February 1979; and Volume Three,* Recommended Plan*, June 1979.*

[d]*The State of Wisconsin has not promulgated water quality standards or criteria for biotic indices.*

[e]*As listed in the Approved Wisconsin 303(d) Impaired Waters List.*

Source: SEWRPC.

Table 46

TOXICITY CHARACTERISTICS OF STREAMS IN THE GREATER MILWAUKEE WATERSHEDS: 1998-2004[a]

Stream Reach	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Kinnickinnic River Mainstem															
Kinnickinnic River between Jones Island Ferry and Greenfield Avenue (extended)	- -	- -	- -	E-38 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-5 (43)	- -	- -
Kinnickinnic River between Greenfield Avenue (extended) and S. 1st Street	- -	- -	- -	E-31 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-4 (45)	- -	- -
Kinnickinnic River between S. 1st Street and S. 7th Street	- -	N (9)	- -	E-31 (13)	D (18)	- -	D (13)	D (18)	- -	- -	N (18)	- -	E-37 (43)	N (18)	- -
Kinnickinnic River between S. 7th Street and S. 27th Street	D (3)[c]	- -	- -	N (13)	- -	- -	D (13)	- -	- -	D (3)[c]	- -	- -	E-9 (43)	- -	- -
Kinnickinnic River above S. 27th Street	- -	- -	- -	N (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-16 (44)	- -	- -
Kinnickinnic River Tributaries															
Wilson Park Creek Tributary Upstream of Conduit	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (19)	- -	- -	E-8 (15)	- -	- -
Wilson Park Creek Tributary Downstream of Conduit	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (20)	- -	- -	E-18 (17)	- -	- -
Wilson Park Creek	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (21)	- -	- -	E-19 (16)	- -	- -
Menomonee River Mainstem															
Menomonee River above County Line Road	- -	- -	- -	E-8 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-57 (45)	- -	- -
Menomonee River between N. 124th Street and County Line Road	D (3)[d]	- -	- -	N (13)	- -	- -	D (13)	- -	- -	D (3)[d]	- -	- -	E-66 (67)	- -	- -
Menomonee River between W. Hampton Avenue and N. 124th Street	- -	- -	- -	E-8 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-48 (60)	- -	- -
Menomonee River between N. 70th Street and W. Hampton Avenue	D (3)	- -	- -	N (13)	- -	- -	D (16)	- -	- -	D (3)	- -	- -	E-58 (77)	- -	- -
Menomonee River between N. 25th Street and N. 70th Street	- -	- -	D (1)[e]	E-8 (13)	- -	D (1)[e]	D (13)	- -	- -	- -	- -	- -	E-48 (48)	- -	- -

Table 46 (continued)

Stream Reach	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Menomonee River Mainstem (continued)															
Menomonee River between Muskego Avenue and N. 25th Street	- -	- -	- -	E-8 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-13 (48)	- -	- -
Menomonee River between Burnham Canal and Muskego Avenue	- -	- -	- -	E-23 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-40 (47)	- -	- -
Menomonee River between S. 2nd Street and Burnham Canal	- -	- -	- -	E-38 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-13 (80)	- -	- -
Menomonee River Tributaries															
Willow Creek	D (3)	- -	- -	- -	- -	- -	D (3)	- -	- -	N (3)	- -	- -	- -	- -	- -
Little Menomonee River	D (3)	- -	- -	- -	- -	- -	D (3)	D	- -	D (3)	- -	- -	- -	- -	- -
South Branch of Underwood Creek	- -	- -	- -	- -	- -	- -	D (8)	- -	- -	- -	- -	- -	E-25 (8)	- -	- -
Underwood Creek	D (3)	- -	- -	- -	- -	- -	D (23)	- -	- -	D (3)	- -	- -	E-35 (20)	- -	- -
Honey Creek	D (3)	- -	- -	- -	- -	- -	D (23)	- -	- -	D (3)	- -	- -	E-35 (20)	- -	- -
Milwaukee River Mainstem															
Milwaukee River above Dam at Kewaskum	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-50 (2)	- -	- -
Milwaukee River between above Dam at Kewaskum and CTH M near Newburg	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (1)	- -	- -
Milwaukee River between CTH M near Newburg and Waubeka	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (1)	- -	- -
Milwaukee River between Waubeka and Pioneer Road near Cedarburg	D (3)	- -	- -	E-15 (13)	- -	E-22 (9)	D (13)	- -	- -	D (3)	- -	- -	E-77 (53)	- -	- -
Milwaukee River between Pioneer Road near Cedarburg and W. Brown Deer Road	- -	- -	- -	E-8 (13)	- -	E-100 (33)	D (13)	- -	- -	- -	- -	- -	E-70 (53)	- -	E-100 (9)
Milwaukee River between W. Brown Deer Road and E. Silver Spring Drive	- -	- -	- -	E-8 (12)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-72 (53)	- -	- -

Table 46 (continued)

Stream Reach	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Milwaukee River Mainstem (continued)															
Milwaukee River between E. Silver Spring Drive and N. Port Washington Road	- -	- -	- -	E-25 (12)	- -	- -	D (13)	- -	- -	D (6)	- -	- -	E-77 (53)	- -	- -
Milwaukee River between N. Port Washington Road and Estabrook Park	D (49)	D (2)	- -	- -	D (91)	- -	D (3)	- -	- -	- -	- -	- -	D (2)	D (4)	- -
Milwaukee River between Estabrook Park and former North Avenue Dam	- -	- -	- -	E-42 (12)	- -	- -	D (12)	- -	- -	- -	- -	- -	E-2 (46)	- -	- -
Milwaukee River between former North Avenue Dam and Walnut Street	- -	- -	D (3)	E-31 (13)	- -	E-100 (24)	D (12)	- -	- -	- -	- -	- -	E-23 (52)	- -	E-100 (9)
Milwaukee River between Walnut Street and Wells Street	- -	- -	- -	E-31 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-24 (49)	- -	- -
Milwaukee River between Wells Street and Water Street	- -	- -	- -	E-31 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-9 (53)	- -	- -
Milwaukee River between Water Street and Union Pacific Railroad	- -	- -	- -	E-23 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-3 (63)	- -	- -
Milwaukee River between Union Pacific Railroad and Confluence with Lake Michigan	D (3)	- -	- -	- -	- -	- -	D (3)	- -	- -	D (3)	- -	- -	- -	- -	- -
East Branch Milwaukee River Subwatershed															
East Branch Milwaukee River from Long Lake to STH 28	- -	N (4)	- -	- -	N (4)	- -	- -	D (4)	- -	- -	- -	- -	- -	D (4)	- -
Unnamed Creek (T14N R19E SE NW 36) Parnell Creek	N (3)	- -	- -	- -	- -	- -	N (3)	- -	- -	- -	- -	- -	- -	- -	- -
North Branch Milwaukee River Subwatershed															
North Branch Milwaukee River	D (6)	N (4)	- -	- -	D (4)	- -	- -	D (4)	- -	- -	- -	- -	- -	D (4)	- -
Cedar Creek Subwatershed															
Cedar Creek	- -	- -	- -	E-91 (22)	D (50)	E-80 (66)	- -	D (22)	- -	- -	- -	- -	N (1)	D (10)	D (4)

Table 46 (continued)

	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
Stream Reach	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Lower Milwaukee River Subwatershed															
Southbranch Creek above W. Bradley Road	- -	- -	- -	N (3)	- -	- -	D (3)	- -	- -	- -	- -	- -	E-7 (28)	- -	- -
Southbranch Creek between W. Bradley Road and N. 55th Street	- -	- -	- -	N (5)	- -	- -	D (5)	- -	- -	- -	- -	- -	E-25 (28)	- -	- -
Southbranch Creek between N. 55th Street and N. 47th Street	- -	- -	- -	N (5)	- -	- -	D (5)	- -	- -	- -	- -	- -	E-7 (29)	- -	- -
Southbranch Creek between N. 47th Street and Teutonia Avenue	- -	- -	- -	N (5)	- -	- -	D (5)	- -	- -	- -	- -	- -	E-40 (30)	- -	- -
Indian Creek	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-13 (8)	- -	- -
Lincoln Creek Subwatershed															
Lincoln Creek above N. 60th Street	- -	- -	- -	E-8 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-12 (66)	- -	- -
Lincoln Creek between N. 60th Street and N. 51st Street	- -	- -	- -	N (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-8 (49)	- -	- -
Lincoln Creek between N. 51st Street and N. 55th Street	- -	- -	- -	E-11 (9)	- -	- -	D (9)	- -	- -	- -	- -	- -	D (54)	- -	- -
Lincoln Creek between N. 55th Street and N. 47th Street	D (13)	N (1)	- -	N (12)	- -	- -	D (14)	- -	- -	D (11)	- -	- -	E-9 (67)	- -	- -
Lincoln Creek between N. 47th Street and Green Bay Avenue	- -	- -	- -	E-31 (13)	- -	- -	D (13)	- -	- -	- -	- -	- -	E-57 (54)	- -	- -
Lincoln Creek between Green Bay Avenue and the Confluence with the Milwaukee River	- -	- -	- -	- -	D (17)	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Oak Creek Mainstem															
Oak Creek above W. Ryan Road	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-24 (38)	- -	- -
Oak Creek between STH 38 and W. Ryan Road	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-15 (38)	- -	- -
Oak Creek between Forest Hill Road and STH 38	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-29 (39)	- -	- -
Oak Creek between Pennsylvania Avenue and Forest Hill Road	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-22 (37)	- -	- -

Table 46 (continued)

Stream Reach	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Oak Creek Mainstem (continued)															
Oak Creek between 15th Avenue and Pennsylvania Avenue	D (3)	- -	- -	- -	- -	- -	D (3)	- -	- -	D (3)	- -	- -	E-26 (39)	- -	- -
Oak Creek between Oak Creek Parkway East of STH 32 and 15th Avenue	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-35 (34)	- -	- -
Oak Creek between Oak Creek Parkway East of S. Lake Drive and Oak Creek Parkway East of STH 32	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	E-25 (40)	- -	- -
Oak Creek Tributaries															
Mitchell Field Drainage Ditch	- -	- -		- -	- -	- -	- -	- -	- -	- -	- -	- -	D (5)	- -	- -
Root River Mainstem															
Root River above W. Cleveland Avenue	- -	- -	- -	N (6)	- -	- -	D (6)	- -	- -	- -	- -	- -	E-44 (25)	- -	- -
Root River between the Intersection of W. National Avenue and W. Oklahoma Avenue and W. Cleveland Avenue	- -	- -	- -	N (6)	- -	- -	D (6)	- -	- -	- -	- -	- -	E-46 (24)	- -	- -
Root River between W. Cold Spring Road and the Intersection of W. National Avenue and W. Oklahoma Avenue	- -	- -	- -	N (6)	- -	- -	D (6)	- -	- -	- -	- -	- -	E-44 (25)	- -	- -
Root River between W. Grange Avenue and W. Cold Spring Road	D (5)	- -	- -	N (6)	- -	- -	D (9)	- -	- -	D (3)	- -	- -	E-45 (24)	- -	- -
Root River between W. Ryan Road and W. Grange Avenue	D (3)	- -	- -	N (6)	- -	- -	D (6)	- -	- -	D (3)	- -	- -	E-41 (25)	- -	- -
Root River between W. County Line Road and W. Ryan Road	- -	- -	- -	N (6)	- -	- -	D (6)	- -	- -	- -	- -	- -	E-50 (20)	- -	- -
Root River between Johnson Park and W. County Line Road	- -	- -	- -	N (6)	- -	- -	- -	- -	- -	- -	- -	- -	E-100 (10)	- -	- -

Table 46 (continued)

Stream Reach	Pesticides			Polychlorinated Biphenyls (PCBs)			Polycyclic Aromatic Hydrocarbons (PAHs)			Other Organic Compounds			Metals[b]		
	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue	Water	Sediment	Tissue
Root River Mainstem (continued)															
Root River between below the Horlick Dam and Johnson Park	D (5)	- -	- -	- -	- -	- -	- -	D (3)	- -	- -	- -	- -	D (6)	D (3)	- -
Root River between near the Mouth of the River and below the Horlick Dam	- -	- -	D (7)	- -	- -	E-100 (31)[f]	- -	- -	- -	- -	- -	- -	D (6)	- -	E-100 (13)[f]
Root River Tributaries															
Root River Canal	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (10)	- -	- -
Crayfish Creek	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	D (1)	- -
Lake Michigan Direct Drainage Area															
Fish Creek above N. Port Washington Road	- -	- -	- -	- -	- -	- -	D (26)[g]	- -	- -	- -	- -	- -	E-75 (8)	- -	- -
Fish Creek between N. Port Washington Road and Broadmoor Drive	- -	- -	- -	- -	- -	- -	D (26)[g]	- -	- -	- -	- -	- -	E-75 (8)	- -	- -

NOTE: E-X denotes exceedence of a water quality standard in X percent of the samples, D denotes detection of a substance in this class in at least one sample, N denotes that no substances in this class were detected in any sample.

[a] *Number in parentheses indicates sample size.*

[b] *Metals sampled were arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Sample sizes are shown for most metals. Mercury was sampled less frequently.*

[c] *These samples were taken at S. 11th Street.*

[d] *These samples were taken at Pilgrim Road.*

[e] *These samples were taken upstream of N. 35th Street.*

[f] *Tissue concentration exceeds threshold used by WDNR for issuing fish consumption advisories.*

[g] *This included samples for PAHs in water collected in 2005.*

Source: SEWRPC.

aroma and flavoring agents such as acetophenone and camphor, flame retardants, insect repellants such as DEET, and metabolites of nonionic detergents. In addition, the aircraft deicing compounds ethylene glycol and propylene glycol were detected in water samples from Wilson Park Creek. Where water quality criteria have been promulgated, the concentrations of these substances were below the relevant criteria.

Finally, water samples from stations along the mainstems of the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek and from a small number of tributary streams were examined for concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. While the sample sizes given in Table 46 are representative of sampling for most of these metals, it is important to note that mercury was sampled less intensively. The number of samples analyzed for mercury was about two-thirds the number analyzed for other metals. Detectable concentrations of each of these metals were present in samples from each of the major rivers and streams tested and from nine tributary streams. Concentrations of mercury in water commonly exceeded both the human threshold concentration for public health and welfare and the wildlife criterion for surface water quality. The percentage of samples exceeding the lower of these two concentrations is given in Table 46. Concentrations of copper in water samples occasionally exceeded the EPA's criterion maximum concentration (CMC) for copper. At some stations, concentrations of cadmium, chromium, lead, nickel, and zinc occasionally exceeded the chronic toxicity criteria for aquatic life, or more rarely, the acute toxicity criteria for aquatic life. Detectable concentrations of toxic metals were also found in sediment samples collected during the baseline period from sites along the mainstems of the Milwaukee and Root Rivers and from four tributary streams.

The summary above suggests that some beneficial uses are being impaired by the presence of contaminants, especially PCBs and mercury. The fish consumption advisories in effect shown in Tables 38 and 39 reflect this.

Impaired Waters

Section 303(d) of the Clean Water Act requires that the states periodically submit a list of impaired waters to the USEPA for approval. While Wisconsin most recently submitted this list in 2006, the most recent list approved by the USEPA as of April 2007 was submitted in 2004.[90] Maps 29 through 34 graphically depict and Table 43 lists stream reaches in the greater Milwaukee watersheds that are classified as being impaired waters in the most recently approved list.

One section of the mainstem of the Kinnickinnic River is listed as impaired, the 2.5-mile reach of variance water between the confluence with the Milwaukee River and S. Chase Avenue is considered impaired due to aquatic toxicity, bacterial contamination, fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach, and lack of compliance with standards for dissolved oxygen concentration. Bacteria, metals, phosphorus, and PCBs from contaminated sediment and a combination of point and nonpoint sources are cited as factors contributing to the impairment of this section of the River. One pond in the Kinnickinnic River watershed, Jackson Park Pond in the City of Milwaukee, is considered impaired due to fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this pond. Contaminated sediment is cited as a factor contributing to the impairment of this pond.

One section of the mainstem of the Menomonee River is listed as impaired, the 3.0-mile-reach of variance water between the confluence with the Milwaukee River and the site of the former Falk dam is considered impaired due to aquatic toxicity, bacterial contamination, fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach, and lack of compliance with standards for dissolved oxygen concentration. Bacteria, metals, phosphorus, and PCBs from contaminated sediment and a combination of point and nonpoint sources are cited as factors contributing to the impairment of this section of the River. One tributary in the Menomonee River watershed, the Little Menomonee River, is also considered impaired, due to aquatic toxicity related to the presence of PAHs in contaminated sediment.

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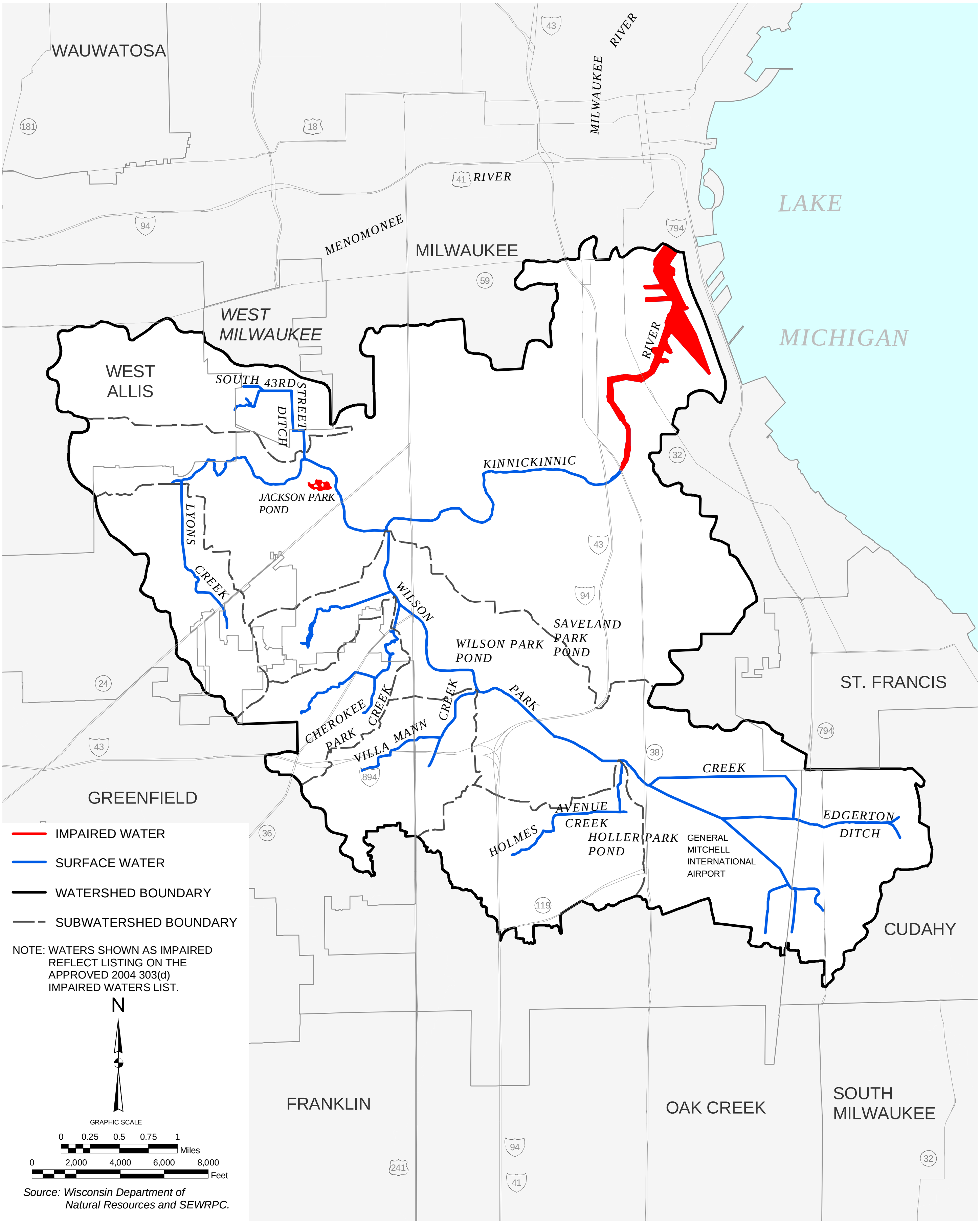
[90]*Wisconsin Department of Natural Resources*, Approved Wisconsin 303(d) Impaired Waters List, *August 2004.*

Map 29

IMPAIRED WATERS WITHIN THE KINNICKINNIC RIVER WATERSHED: 2004



IMPAIRED WATER

SURFACE WATER

WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

NOTE: WATERS SHOWN AS IMPAIRED REFLECT LISTING ON THE APPROVED 2004 303(d) IMPAIRED WATERS LIST.

N

GRAPHIC SCALE

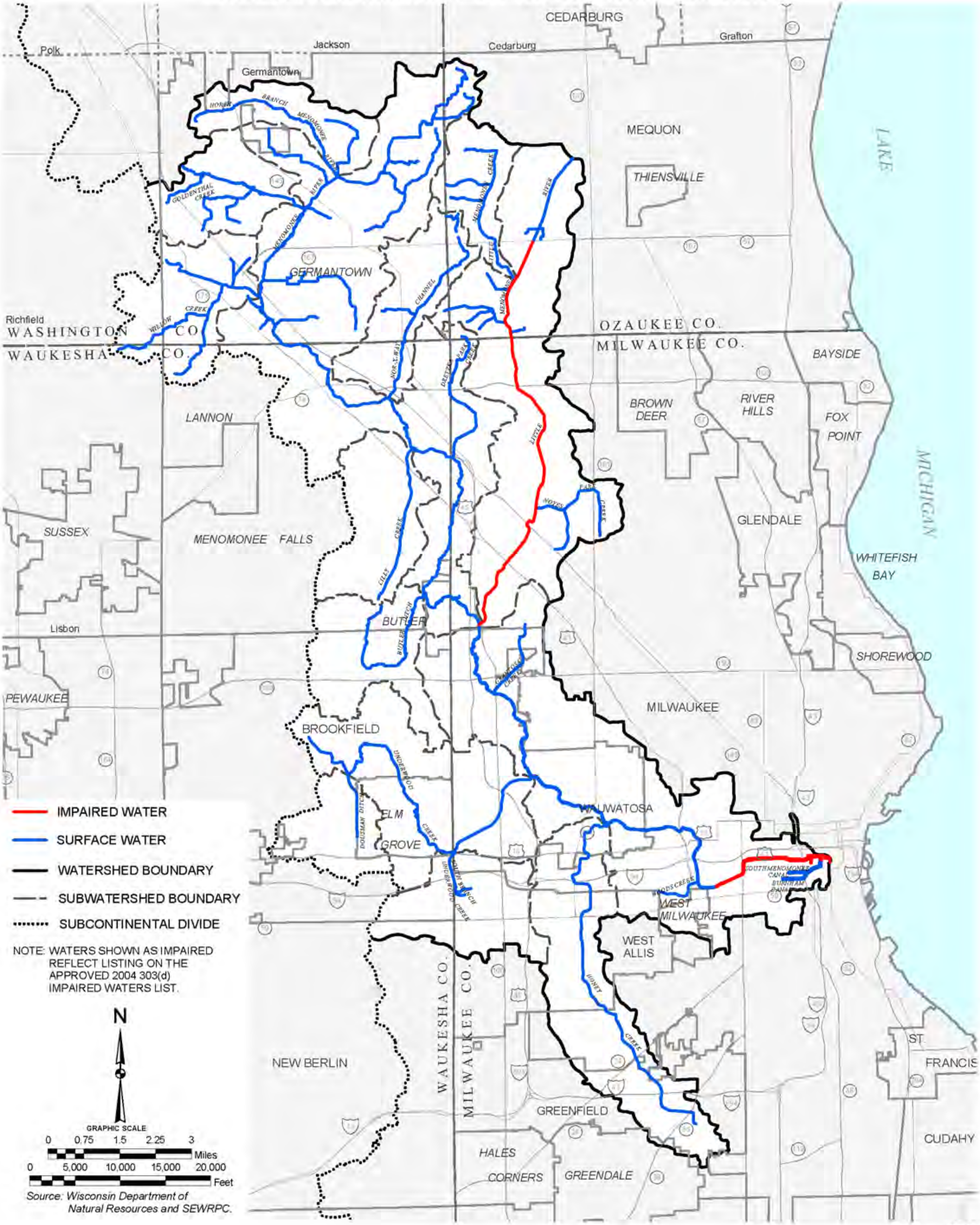
0 0.25 0.5 0.75 1 Miles

0 2,000 4,000 6,000 8,000 Feet

Source: Wisconsin Department of Natural Resources and SEWRPC.

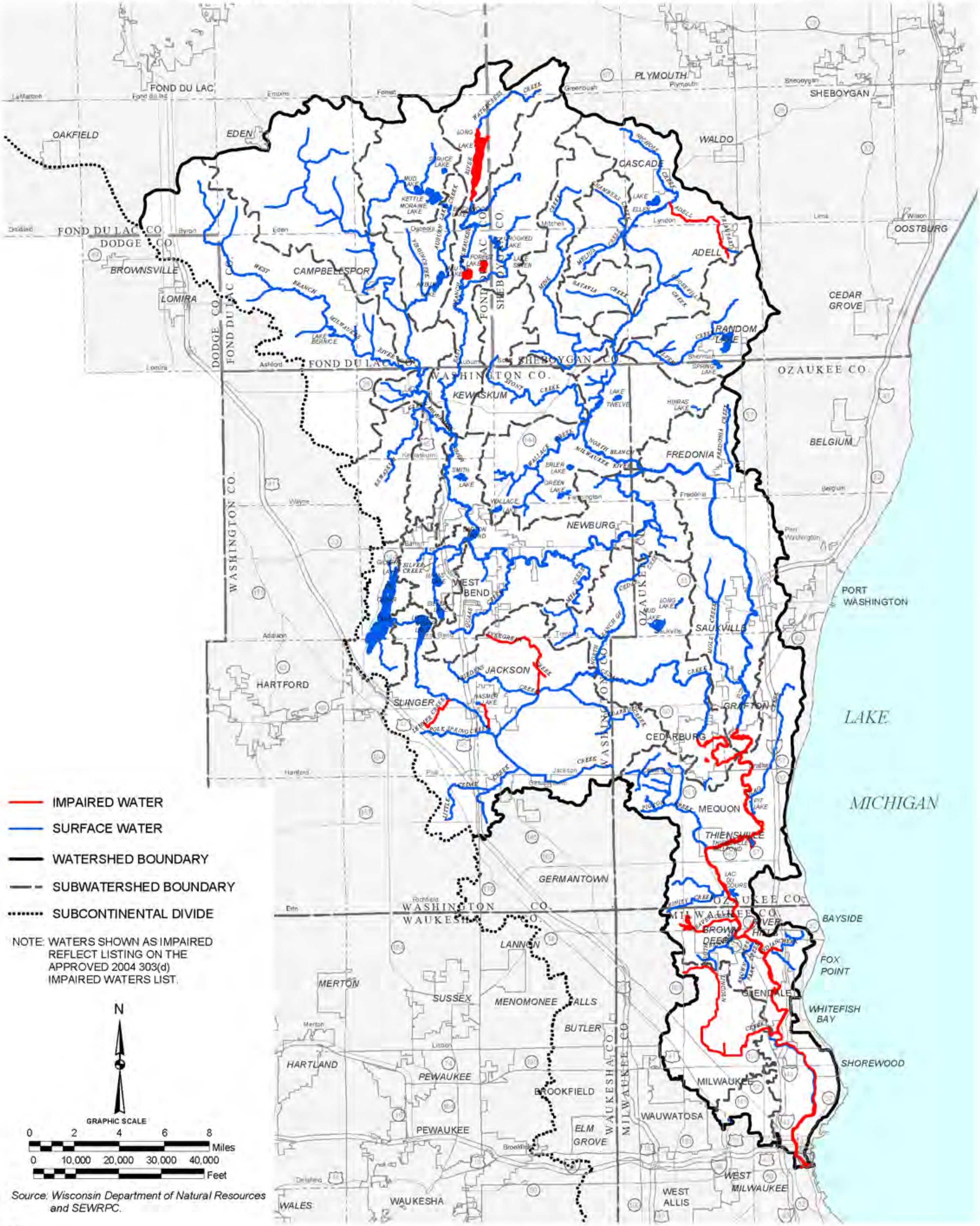
Map 30

IMPAIRED WATERS WITHIN THE MENOMONEE RIVER WATERSHED: 2004



Map 31

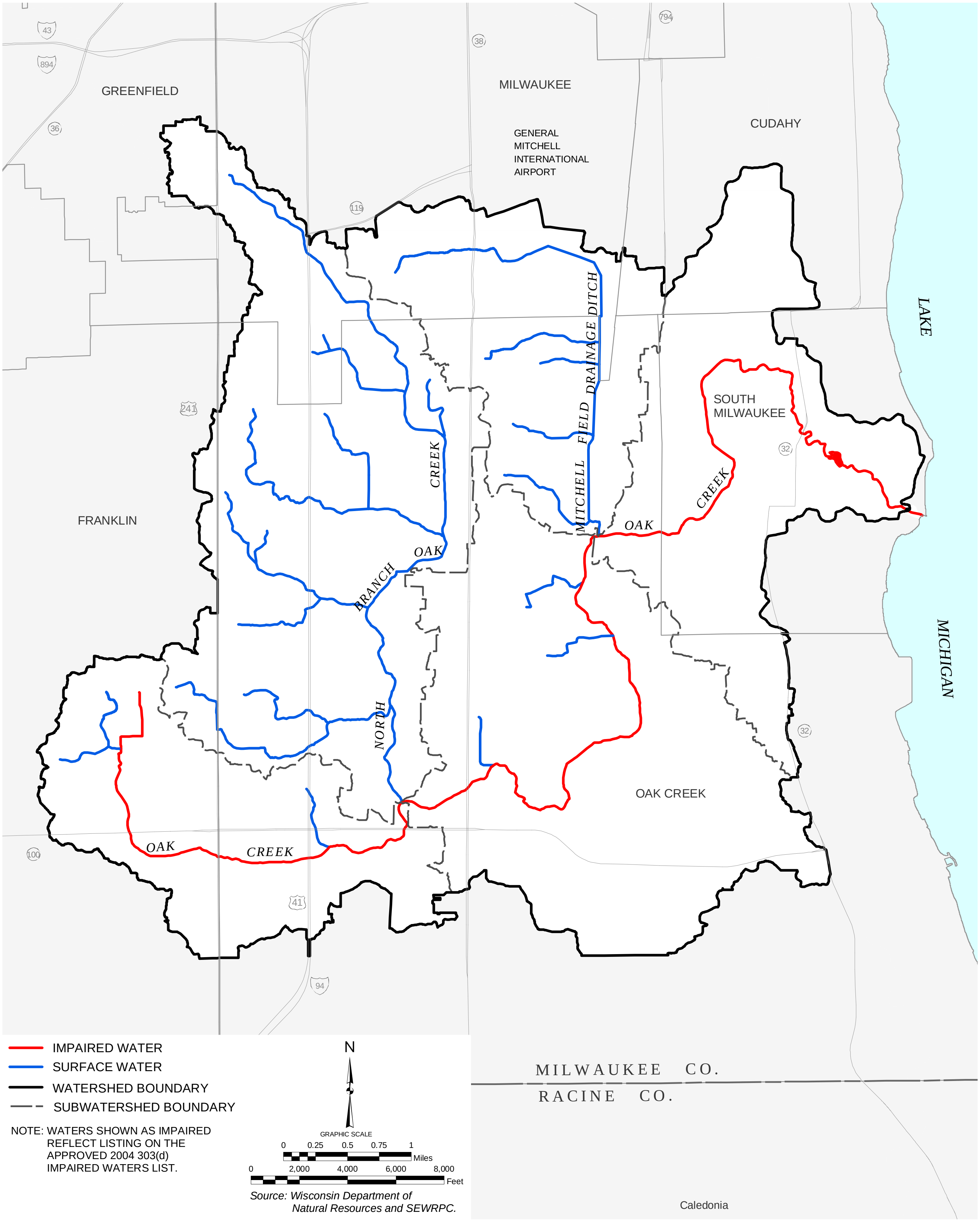
IMPAIRED WATERS WITHIN THE MILWAUKEE RIVER WATERSHED: 2004



Source: Wisconsin Department of Natural Resources and SEWRPC.

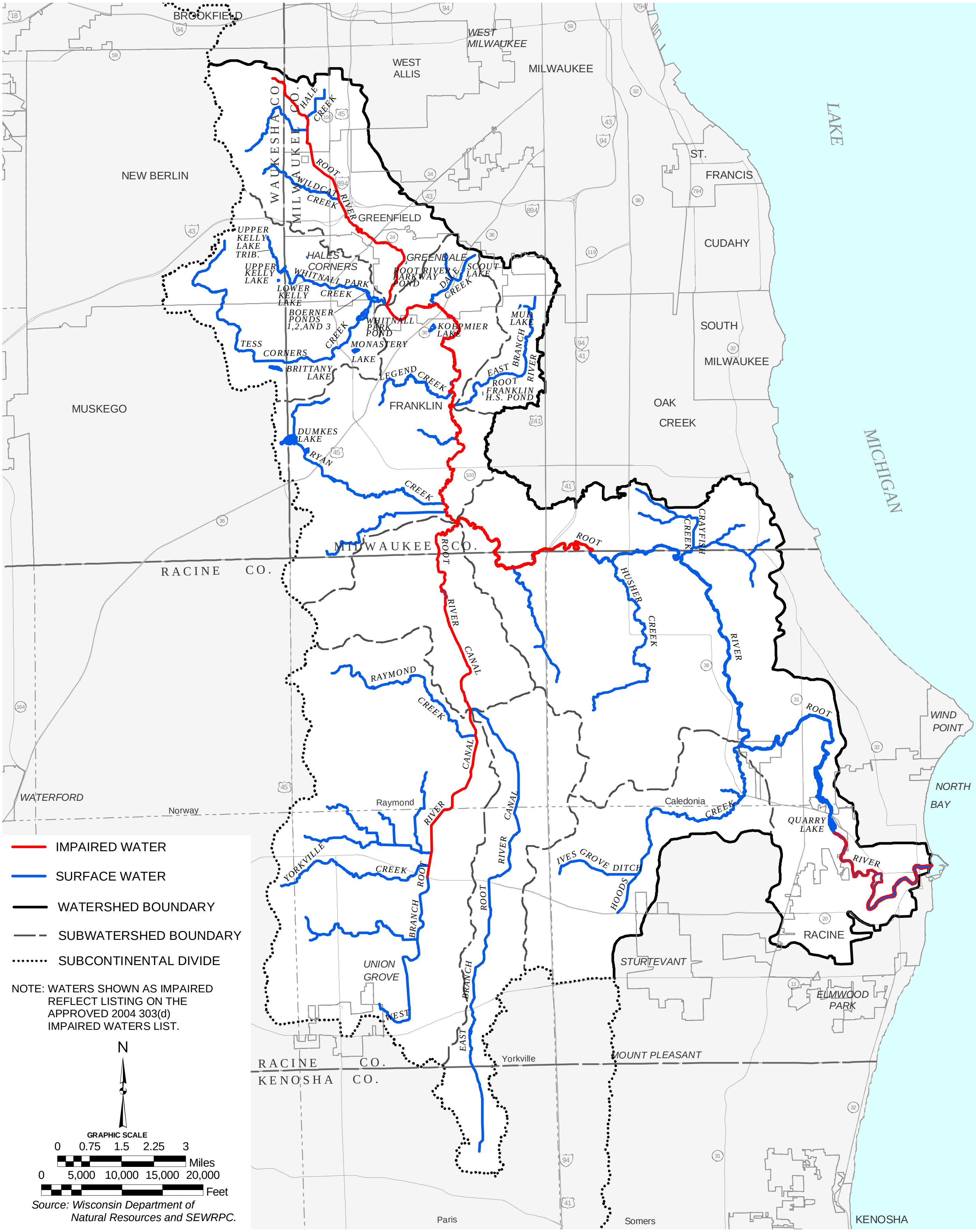
Map 32

IMPAIRED WATERS WITHIN THE OAK CREEK WATERSHED: 2004



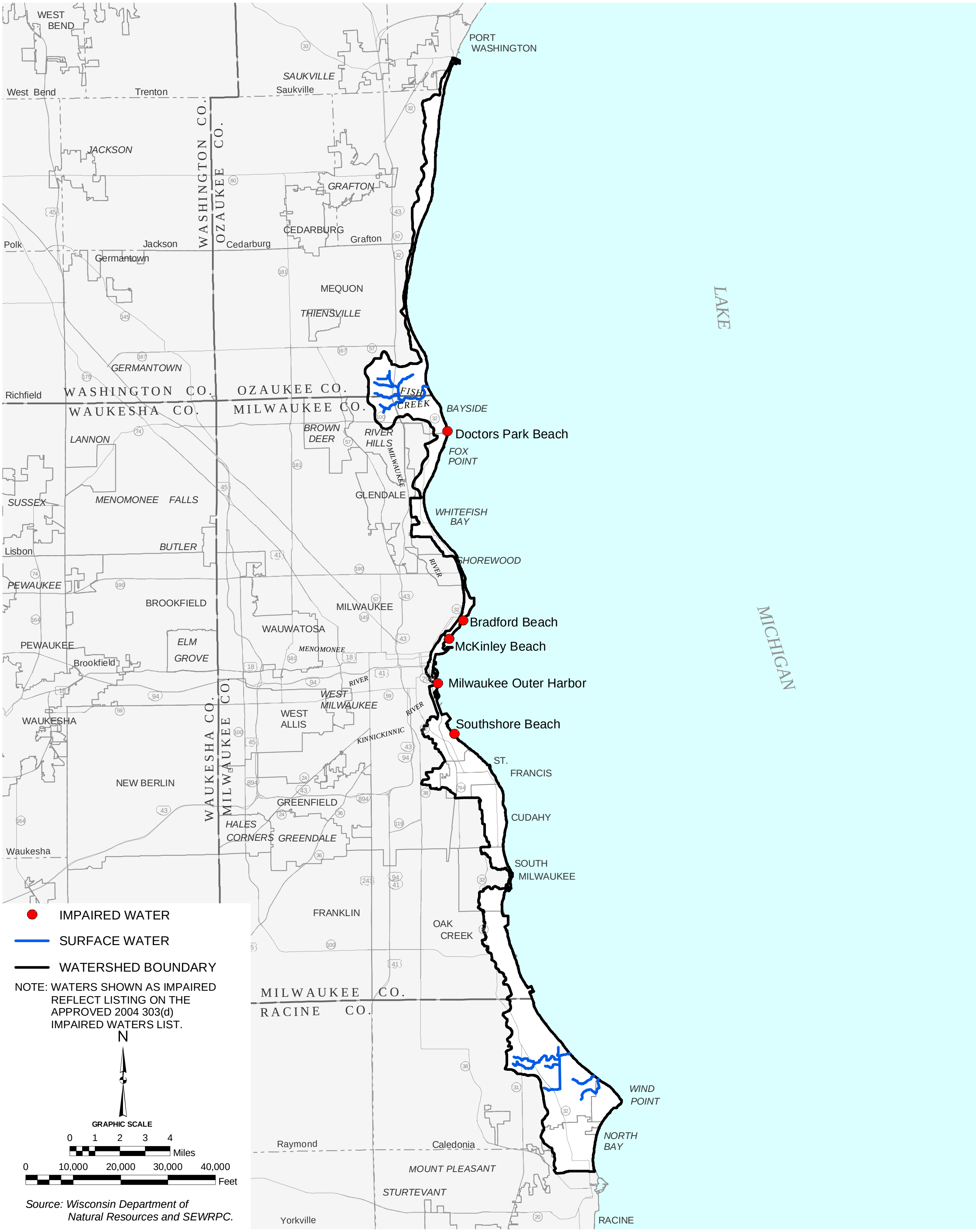
Map 33

IMPAIRED WATERS WITHIN THE ROOT RIVER WATERSHED: 2004



Map 34

IMPAIRED WATERS WITHIN THE AREA TRIBUTARY TO LAKE MICHIGAN: 2004



Three sections of the mainstem of the Milwaukee River are listed as impaired. The section of the River upstream of the Lime Kiln dam in the Village of Grafton is considered impaired due to fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach. A 25-mile section of the Milwaukee River between the City of Grafton and site of the former North Avenue dam is considered impaired due to bacterial contamination and fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach. The 3.1-mile reach of variance water between the confluence with Lake Michigan and the site of the former North Avenue dam is considered impaired due to aquatic toxicity, bacterial contamination, fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach, and lack of compliance with standards for dissolved oxygen concentration. Bacteria, metals, phosphorus, and PCBs from contaminated sediment and a combination of point and nonpoint sources are cited as factors contributing to the impairment of this section of the River. Several tributary streams are also listed as impaired. Adell Tributary, Evergreen Creek, Jackson Creek, and Lehner Creek are considered impaired due to habitat degradation from sedimentation related to nonpoint source pollution. Lehner Creek is also considered impaired due to high water temperatures. Beaver Creek is considered impaired due to aquatic toxicity related to nonpoint source pollution. A five-mile section of Cedar Creek between Bridge Road in the City of Cedarburg and the confluence with the Milwaukee River is considered impaired due to fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach. PCBs from contaminated sediments are cited as factors contributing to the impairment of this section of Cedar Creek. Indian Creek downstream from IH 43, which is classified as a variance water, is considered impaired due to aquatic toxicity, degraded habitat, lack of compliance with standards for dissolved oxygen concentration, and high temperatures. Metals, phosphorus, and sedimentation related to nonpoint source pollution are cited as contributing to the impairment of this section of stream. Lincoln Creek, which is classified as a variance water, is considered impaired due to aquatic toxicity, degraded habitat, lack of compliance with standards for dissolved oxygen concentration, and high temperatures. Metals, PAHs, phosphorus, and sedimentation from undetermined sources are cited as factors contributing to the impairment of this stream.

Two lakes and one pond in the Milwaukee River watershed are also listed as being impaired. Forest Lake and Mauthe Lake are considered impaired due to fish consumption advisories necessitated by high concentrations of mercury in the tissue of fish collected from these lakes. Atmospheric deposition of mercury is cited as contributing to these impairments. Zeunert Pond in the City of Cedarburg is also considered impaired due to fish consumption advisories necessitated by high concentrations of mercury in the tissue of fish collected from this pond. Mercury in contaminated sediment is cited as contributing to this impairment.

The entire 13.0-mile length of the mainstem of Oak Creek is listed as being impaired due to aquatic toxicity related to undetermined pollutants. A combination of point and nonpoint sources is cited as factors contributing to the impairment of the Creek.

Two sections of the mainstem of the Root River are listed as impaired. Approximately 12 stream-miles in the reach of the River between 21 and 43 miles upstream from the confluence with Lake Michigan is considered impaired due to lack of compliance with standards for dissolved oxygen concentration. Phosphorus and sedimentation from a combination of point and nonpoint sources are cited as factors contributing to the impairment of this section of the River. Samples collected during the extended baseline period suggest that low dissolved oxygen concentrations may no longer be impairing the downstream portion of this reach (see Chapter IX in SEWRPC Technical Report No. 39). A six-mile section of the Root River between the Horlick dam and the confluence with Lake Michigan is considered impaired due to fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this reach. Two tributary streams are also listed as impaired. The Root River Canal is considered impaired due to lack of compliance with standards for dissolved oxygen concentration. Phosphorus and sedimentation mostly from nonpoint sources are cited as factors contributing to the impairment of this stream. The West Branch of the Root River Canal is considered impaired due to lack of compliance with standards for dissolved oxygen concentration. Phosphorus and sedimentation mostly from nonpoint sources are cited as factors contributing to the impairment of this stream.

The Milwaukee Harbor estuary and outer harbor are classified as being impaired waters. As described above, the portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers in the estuary are listed as impaired due to aquatic toxicity, high bacteria concentrations, low concentrations of dissolved oxygen, and fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this area. Bacteria, metals, phosphorus, and PCBs from contaminated sediment and a combination of point and nonpoint sources are cited as factors contributing to the impairment of the estuary. The outer harbor is listed as impaired due to aquatic toxicity, high bacteria concentrations, and fish consumption advisories necessitated by high concentrations of PCBs in the tissue of fish collected from this area. Bacteria, metals, and PCBs from contaminated sediment and a combination of point and nonpoint sources are cited as factors contributing to the impairment of the outer harbor.

Four public beaches along the Lake Michigan shore in the Lake Michigan direct drainage area are also listed as being impaired. Bradford Beach, Doctors Park Beach, McKinley Beach, and South Shore Beach are considered impaired due to bacteria counts exceeding standards from the Beach Act of 2000.

GROUNDWATER CONDITIONS

SEWRPC, working with the USGS, Wisconsin Geological and Natural History Survey (WGNHS), the University of Wisconsin-Milwaukee (UWM), and the WDNR, has completed two major groundwater studies for the Southeastern Wisconsin Region that will be important resources for regional and local planning. These studies include a regional groundwater inventory and analysis and the development of a regional aquifer simulation model. The groundwater inventory and analysis findings are presented in SEWRPC Technical Report No. 37, *Groundwater Resources of Southeastern Wisconsin,* June 2002. The aquifer simulation model is documented in SEWRPC Technical Report No. 41, *A Regional Aquifer Simulation Model for Southeastern Wisconsin*, June 2005. In addition, the third, and final, component of the SEWRPC regional groundwater planning program is underway and is documented in SEWRPC Planning Report No. 52, *A Regional Water Supply Plan for Southeastern Wisconsin,* in progress. Groundwater quality data available for the Region are provided in SEWRPC Technical Report No. 37 and the data summarized here are largely drawn from that report. These data have been supplemented with data obtained from the WDNR Groundwater Retrieval Network (GRN) databases.

Geology and Groundwater Resources

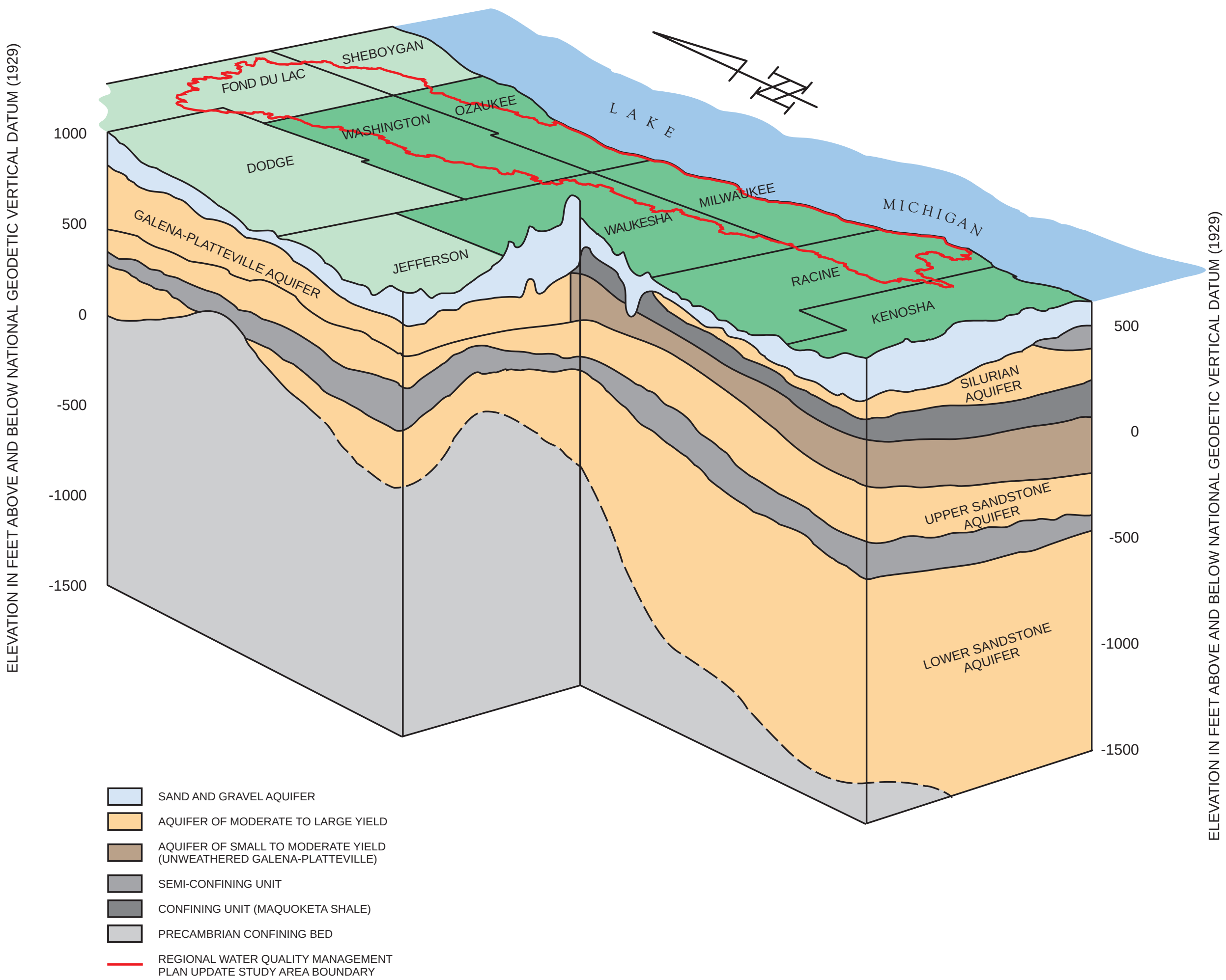
From the standpoint of groundwater occurrence, all rock formations that underlie the Region can be classified as either aquifers or as confining beds. An aquifer is a rock formation or sand and gravel unit that will yield water in a useable quantity to a well or spring. A confining bed, such as shale or siltstone, is a rock formation unit having relatively low permeability that restricts the movement of groundwater either into or out of adjacent aquifers and does not yield water in useable amounts to wells and springs.

In general, groundwater occurs within three major aquifers that underlie the study area. From the land’s surface downward, they are: 1) the sand and gravel deposits in the glacial drift; 2) the shallow dolomite strata in the underlying bedrock; and 3) the deeper sandstone, dolomite, siltstone and shale strata. Because of their proximity to the land’s surface and hydraulic interconnection, the first two aquifers are commonly referred to collectively as the “shallow aquifer,” while the latter is referred to as the deep aquifer. Within the study area, the shallow and deep aquifers are separated by the Maquoketa shale, which forms a relatively impermeable barrier between the two aquifers (See Figure 46).

The aquifers of southeastern Wisconsin extend to depths, reaching in excess of 1,500 feet in the eastern parts of the Region, including the regional water quality management plan update study area. The general characteristics of three major aquifers set forth above can be refined to group rock formations within the study area into five aquifers, two confining beds, and two semi-confining beds (See Figure 46 and Table 47). The aquifers are, in descending order, the Quaternary sand and gravel; Silurian dolomite; Galena-Platteville; upper sandstone; and lower sandstone. The confining beds are the Maquoketa Formation and the Precambrian crystalline rock. The shaly Antrim formation and siltstone and shaly dolomite of the Milwaukee Formation constitute the uppermost

Figure 46

AQUIFER SYSTEMS IN SOUTHEASTERN WISCONSIN



Source: Eaton, 1997; Mai and Dott, 1985; Peters, 1997; and Young, 1992.

semi-confining bed; the silty dolomite and fine-grained sandstone of the St. Lawrence Formation-Tunnel City Group constitute the lower semi-confining bed in parts of the Region.[91]

Like surface water, groundwater is susceptible to depletion in quantity and to deterioration in quality as a result of urban and rural development. Consequently, water quality management planning must appropriately consider the potential impacts of urban and rural development on this important resource. Water quality management and land use planning must also take into account, as appropriate, natural conditions which may limit the use of groundwater as a source of water supply, including relatively high levels of naturally occurring radium in groundwater in the deep sandstone aquifer, found in certain parts of the study area. Other considerations that may limit the uses of groundwater include decreasing aquifer levels and increasing concentrations of dissolved solids and other constituents.

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[91]*A more-detailed description of the areal extent and lithography of aquifers and confining units, including water table depths and elevation mapping can be found in SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002.*

Table 47

HYDROGEOLOGIC UNITS OF SOUTHEASTERN WISCONSIN

Geologic Age	Rock Unit		Hydrogeologic Unit	Water Yield
Quaternary	Undifferentiated		Sand and gravel aquifer	Small to large yields; thick sections yield several hundred gallons per minute
Devonian	Antrim Fm.[1]		Semi-confining unit	Yields little water
	Milwaukee Fm.[1]			
	Thiensville Fm.[1]		Silurian dolomite aquifer	Small to large yields (10s – 100s gpm) depending upon lithology and number and size of solution channels and fractures. Main water-producing units: Thiensville, basal member of Racine, and Mayville (Rovey and Cherkauer, 1994a)
Silurian	Waubekee Fm.[1]			
	Racine Fm.[2]			
	Waukesha Fm.[2]			
	Brandon Bridge beds[2]			
	Byron Fm.[2]			
	Mayville Fm.[2]			
Ordovician	Maquoketa Fm.[2]		Confining unit	Yields little or no water
	Sinnipee Group	Galena Fm.	Galena-Platteville aquifer	Yields little water where overlain by Maquoketa Formation. Commonly yields a few tens of gpm west of Maquoketa
		(Decorah Fm.)[3]		
		Platteville Fm.		
	Ancell Group	(Glenwood Fm.)[3]	Upper sandstone aquifer	Moderate to large yields (100-500 gpm)
		St. Peter Fm.		
	Prairie du Chien Group	Shakopee Fm.[2]		Small yields (10s of gpm)
		Oneota Fm.[2]		
Cambrian	Trempealeau Group	Jordan Fm.[2]		Moderate yields (100s gpm)
		St. Lawrence Fm.[2]	Semi-confining unit	Yields little water
	Tunnel City Group			Yields little water
	Elk Mound Group	Wonewoc Fm.[2]	Lower sandstone aquifer	Moderate to large yields (100s – 1,000s of gpm)
		Eau Claire Fm.		
		Mt. Simon Fm.		
Precambrian	Undifferentiated		Confining bed	Yields little or no water

NOTE: Fm. = Formation; gpm = gallons per minute; for description, see Chapter V; [1] only in eastern Milwaukee and Ozaukee Counties; [2] not always present in the entire Region; [3] thin or locally absent.

Source: A. Zaporozec, 1997.

Groundwater Quality

The chemical composition of groundwater largely depends on the composition and physical properties of the soil and rock formations it has been in contact with, the residence time of the water, and the antecedent water quality. The chemical composition of groundwater in the Region and the study area is primarily a result of its movement through, and interaction with, Pleistocene unconsolidated materials and Paleozoic rock formations. The latter contain large amounts of dolomite—$CaMg(CO_3)_2$—that is dissolved by water passing through the rock formations. In general, groundwater quality tends to be relatively uniform within a given aquifer, both spatially and temporally, but major differences in groundwater quality exist within the Region. The current quality of groundwater in both the shallow and deep aquifers underlying the Region is generally good and suitable for most uses, although localized water quality problems occur in some areas. The exception to this is the concentration of radium exceeding drinking water standards which occurs in some portions of the deep sandstone aquifer underlying the Region, but which is not prevalent in wells in the study area.

Groundwater in the Region contains all the major ions that commonly dominate the composition of natural waters: calcium (Ca^{2+}), magnesium (Mg^{2+}), and sodium (Na^{+}) cations and bicarbonate (HCO_3^-), sulfate (SO_4^{2-}), and chloride (Cl^-) anions. The areal distribution and predominance of these major ions can be used to classify the groundwater into hydrochemical facies, i.e., the chemical type of water. Groundwater may be classified as a calcium-magnesium-bicarbonate (Ca-Mg-HCO_3) type in most of the Region. The water chemistry of the shallow and deep aquifers systems underlying the Region are very similar. The most pronounced geochemical changes occur in the confined parts of the deep aquifer system. From the western edge of the Maquoketa shale east toward Lake Michigan, water chemistry changes sequentially from Ca-Mg-HCO_3 to Ca-Na-SO_4-Cl to Na-SO_4-Cl type.[92]

Dissolved Solids

Dissolved solids concentration and hardness are good initial indicators of water quality. Concentrations of dissolved solids are primarily in the 300 to 400 mg/l range within the Region. The recommended maximum concentration for drinking water of 500 mg/l is exceeded only locally in isolated areas, primarily in the east-central part of the Region, which includes part of the regional water quality management plan update study area. The dissolved-solids concentration generally increases from west to east, generally in the direction of groundwater movement, and with depth and increased thickness of the aquifer. Available data show negligible differences between individual aquifers on a Regional basis. Dissolved solids concentrations in the sand and gravel aquifer are generally between about 300 mg/l to 400 mg/l, though locally they may exceed 400 mg/l. Dissolved solids concentrations in the Silurian dolomite aquifer are between about 300 mg/l to 400 mg/l, though they are generally lower along the Lake Michigan shore and higher in Ozaukee and Milwaukee Counties and eastern Waukesha County. Dissolved solids concentrations in the sandstone aquifer are generally between about 300 mg/l to 400 mg/l in the west, increasing toward the east to more than 600 mg/l.

Map 35 shows the distribution of dissolved-solids concentration in the Silurian dolomite aquifer, the prevalent shallow aquifer in the Region and the study area. The map also shows those wells for which available data indicate concentrations above 1,000 mg/l. Water containing high dissolved solids is occasionally reported by drillers of new wells in the aquifer. Water containing more than 1,000 mg/l dissolved solids is considered saline water. The highest concentration of dissolved solids documented within the Region was 6,690 mg/l for a composite sample from a well tapping the Silurian dolomite, Galena-Platteville dolomite, and St. Peter sandstone aquifers in northeastern Milwaukee County.

Hardness

Hardness in groundwater underlying the Region and the study area is generally high due to the dominance of calcium-magnesium cations in the groundwater (Map 36). Hardness is reported in terms of equivalent concentration of calcium carbonate in milligrams per liter (mg/l as $CaCO_3$). No Federal or State standards for hardness have been promulgated, but water with a hardness of less than 100 mg/l as $CaCO_3$ is generally considered as suitable for domestic uses. Water having more than 180 mg/l as $CaCO_3$ is considered very hard, and softening is required for most purposes. Hardness does vary somewhat between the aquifers underlying the study area.[93] Hardness levels in the sand and gravel aquifer vary in the Region, ranging from 164 mg/l as $CaCO_3$ in Racine County to 353 mg/l as $CaCO_3$ in Waukesha County. Mean hardness levels in the Silurian dolomite aquifer range from 241 mg/l as $CaCO_3$ in Kenosha County to 722 mg/l as $CaCO_3$ in Ozaukee County. Mean hardness levels in the sandstone aquifer range from 154 mg/l as $CaCO_3$ in Kenosha County to between 350 mg/l as $CaCO_3$ and 390 mg/l as $CaCO_3$ in Milwaukee, Ozaukee, Washington, and Waukesha Counties.

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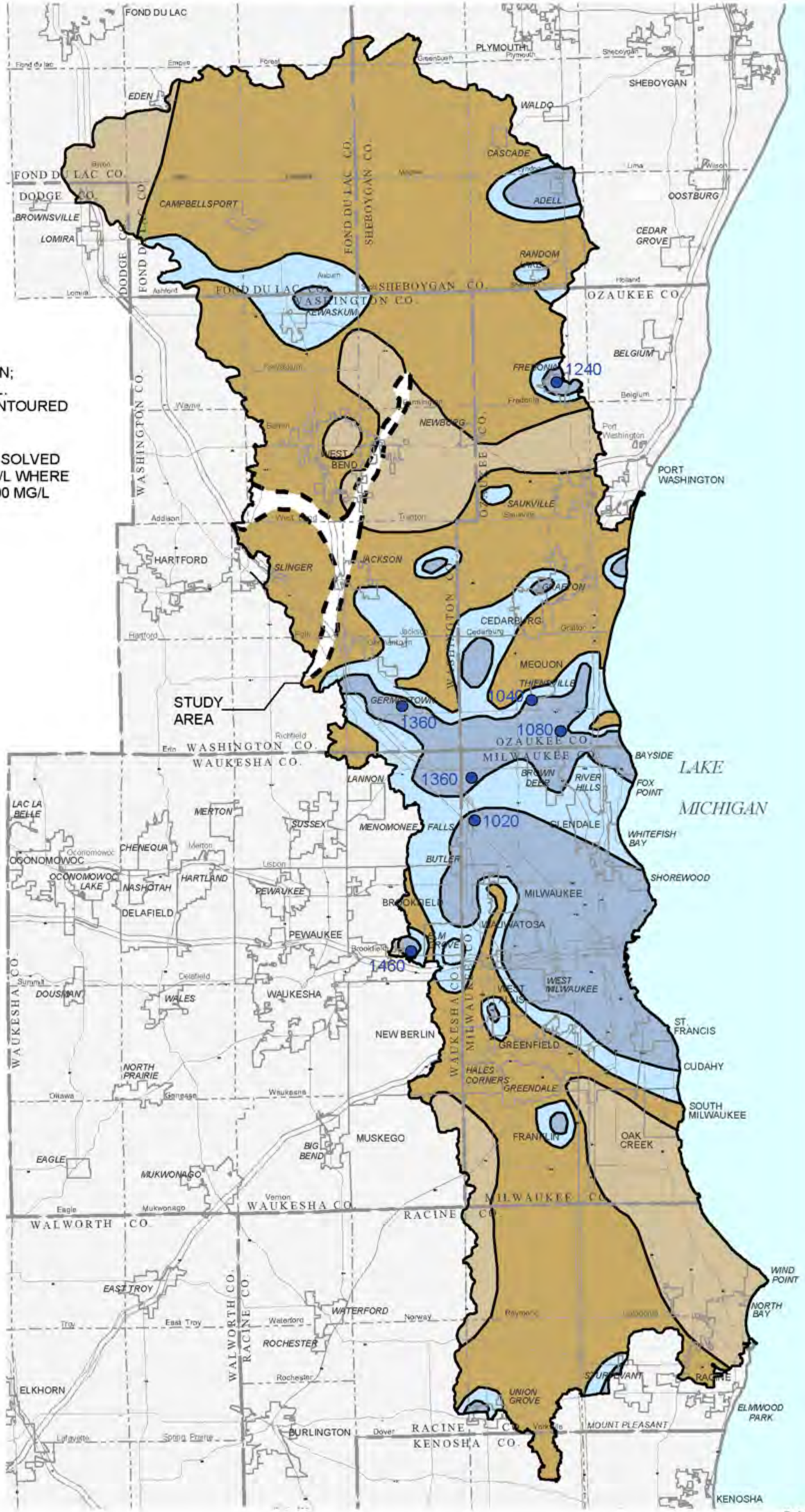
[92]*D.I. Siegel,* Geochemistry of the Cambrian-Ordovician Aquifer System in the Northern Midwest, United States, *(Regional Aquifer-System Analysis report), U.S. Geological Survey Professional Paper 1405-D, 1989.*

[93]*P.A. Kammerer, Jr.,* Groundwater Quality Atlas of Wisconsin, *U.S. Geological Survey and University of Wisconsin-Extension, Wisconsin Geological and Natural History Survey, Information Circular 39-1981.*

Map 35

GENERALIZED MAP OF TOTAL DISSOLVED SOLIDS CONCENTRATION IN THE SILURIAN DOLOMITE AQUIFER WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



LINE OF EQUAL CONCENTRATION; CONTOUR INTERVAL IS 100 MG/L. MAXIMUM CONCENTRATION CONTOURED IS 500 MG/L.

1460 WELL LOCATION AND TOTAL DISSOLVED SOLIDS CONCENTRATION IN MG/L WHERE CONCENTRATIONS EXCEED 1,000 MG/L

BOUNDARY OF SILURIAN DOLOMITE AQUIFER

200 - 300 MG/L

300 - 400 MG/L

400 - 500 MG/L

500 MG/L AND MORE

NOTE:
IN GENERAL, THE DATA WITHIN THE SOUTHEASTERN WISCONSIN REGION WERE DEVELOPED BY THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY AND THE U.S. GEOLOGICAL SURVEY. THE DATA IN DODGE, FOND DU LAC, AND SHEBOYGAN COUNTIES AND IN THE VICINITY OF THE NORTHERN BOUNDARIES OF WASHINGTON AND OZAUKEE COUNTIES WERE TAKEN FROM THE U.S. GEOLOGICAL SURVEY HYDROLOGIC INVESTIGATIONS ATLAS 432, "WATER RESOURCES OF WISCONSIN - LAKE MICHIGAN BASIN, 1973".

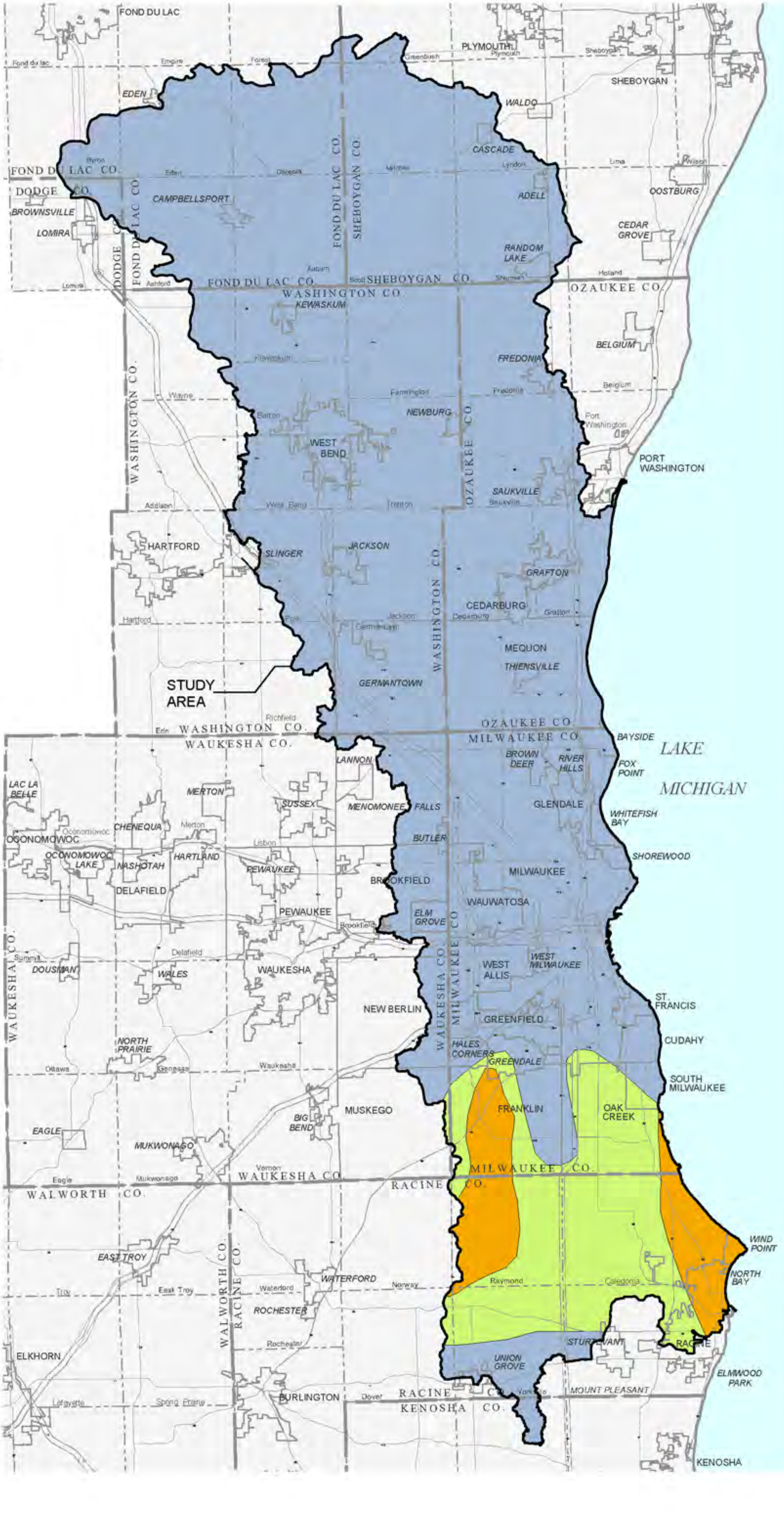
Source: Wisconsin Geological and Natural History Survey and U.S. Geological Survey, and SEWRPC

Map 36

AREAL DISTRIBUTION OF HARDNESS OF GROUNDWATER IN THE SHALLOW AQUIFERS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

HARDNESS IN MG/L $CaCO_3$

- 61 - 120 MODERATELY HARD
- 121 - 180 HARD
- GREATER THAN 180 VERY HARD



Source: Wisconsin Geological and Natural History Survey.

The hardest water in the Region is found in the regional water quality management plan update study area in northern Milwaukee County and northeastern Waukesha County with values exceeding 360 mg/l as $CaCO_3$. Hardness in excess of 360 mg/l as $CaCO_3$, or even 500 mg/l as $CaCO_3$ is common in wells in the Villages of Brown Deer and Menomonee Falls, and the Cities of Brookfield, Glendale, and Milwaukee. Two wells in the Village of River Hills have measured hardness exceeding 1,500 mg/l as $CaCO_3$.

Trace Elements

Concentrations of some constituents, normally found in trace amounts, exceeded limits in some areas of the Region and may limit the usefulness of groundwater for certain purposes. Barium concentrations may exceed the limit of one mg/l in a 30-mile broad band running through the western part of Washington County, most of Waukesha County, eastern Walworth County, and western Racine and Kenosha Counties. The band includes significant portions of the study area. The higher barium concentrations may be attributed to a zone of reducing conditions in the confined aquifer system, extending from northeastern Illinois to Wisconsin. Radium concentrations (radium-226 and radium-228 combined) in some parts of the confined deep aquifer system exceed the current drinking water standard. The sources of the high radium concentrations in the groundwater may be attributed to the occurrence of uranium and thorium in the matrix of sandstones.

Water Quality Concerns

Some water quality problems are caused by natural factors, which cannot be controlled. For example, the abundant dolomite material in the Region releases calcium and magnesium, which form about one-half of all ions in groundwater and are the principal components of hardness. Therefore, hardness is objectionably high in the groundwater underlying most of the study area (see Map 36), and softening is required for almost all water uses.

The deep aquifer water in some parts of the Region contains saline water, that is, water with dissolved solids concentrations greater than 1,000 mg/l. But saline water can also occur in the shallow aquifer system through hydraulic connection between the deep and shallow aquifer systems. Dissolved solids concentrations in excess of 1,000 mg/l have been documented in the study area in southeastern Ozaukee County and northeastern Milwaukee County.[94] Several areas in southwestern Ozaukee, northeastern Waukesha, and northern Milwaukee Counties have been reported where saline water is suspected or has been found to be beneath the shallow aquifer system.[95] Some locations of wells in the shallow aquifer system containing more than 1,000 mg/l of dissolved solids are shown on Map 35.

Naturally occurring radioactivity in groundwater, including radium and radon, has become a concern in Wisconsin in recent years. The State initiated several studies to examine the occurrence and extent of these naturally occurring contaminants. Radon does not appear to be a problem in the shallow aquifer of Southeastern Wisconsin. The source of radium in groundwater is the naturally occurring radium content of certain types of rock formations in the deep sandstone aquifer. Based on the consumer confidence reports for 2005 issued by the WDNR, only one of the 18 water supply systems in the study area reported an exceedence of the current five picocuries per liter EPA and State maximum contaminant level (MCL) standard for radium (combined radium-226 and radium-228). The 2005 consumer confidence reports also reported an exceedence of the current MCL standard for radionucleides.

Another naturally occurring element, arsenic, is also a concern. The new Federal and State MCL standard is 10 μg/l. The primary zone of arsenic mineralization is considered to be below the bottom of the Galena-Platteville dolomite formation (see Table 47). In 2005, none of the water supply systems in the study area reported exceedences of arsenic.

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[94]*R.W. Ryling,* A Preliminary Study of the Distribution of Saline Water in Bedrock Aquifers of Eastern Wisconsin, *Wisconsin Geological and Natural History Survey, Information Circular 5, 1961.*

[95]*P.A. Kammerer, Jr.,* Ground-Water Flow and Quality in Wisconsin's Shallow Aquifer System, *U.S. Geological Survey Water-Resources Report 90-4171, 1995.*

Contaminants resulting from human activities, causing groundwater problems in the Region, included bacteria, nitrate, pesticides, and volatile organic compounds (VOCs). The first three can affect water quality of private wells, but generally do not cause major problems in the Region.

The coliform bacteria test has traditionally been used to measure the sanitary condition of well water. Although coliform bacteria are not known to usually cause disease, their presence in well-water samples may be an indication that more harmful bacteria also exist in a well. Bacteria can be introduced into wells from septic tanks, leaking sanitary sewer lines, feed lots, and manure pits and piles. Their presence usually indicates an improperly constructed well or a well too shallow for local conditions, such as thin soil or fractured bedrock. Coliform bacteria have been detected in, on average, 15 percent of the private wells in the Region, although there is wide geographic and seasonal variability. In shallow, fractured bedrock aquifers, up to 73 percent of wells have been tested "unsafe." Protected aquifer wells average less than 6 percent unsafe.[96] Overall, coliform detection rates are three times higher in late summer months than midwinter.[97] *E. coli*, the coliform most strongly associated with fecal contamination, is found in fewer than 2.6 percent of private wells.[98] Well bacterial contamination may not always be caused by poor aquifer conditions or substandard well construction. Incidental sources, such as insects under well caps, careless pump work, and iron biofilms are believed responsible for many coliform detects.

In Wisconsin, nitrate-nitrogen is the most commonly found groundwater contaminant that exceeds State drinking water standards. Nitrate can enter groundwater from many sources, including nitrogen-based fertilizers, animal waste storage facilities, feedlots, septic tanks, and municipal and industrial wastewater and sludge disposal sites. Data from the WDNR GRN databases suggest that nitrate contamination is a relatively minor problem in the study area. In samples collected from 841 wells in the study area during the period 1998-2006, nitrate-nitrogen was found to exceed the enforcement standard of 10 mg/l in 1.3 percent of wells and the preventive action limit of 2 mg/l in 9.4 percent of wells. It is important to note that because the GRN databases do not include data from monitoring wells associated with some actions such as USEPA Superfund sites and some contaminated groundwater remediation actions, these percentages may underestimate the extent of nitrate-nitrogen contamination in groundwater in the study area.

Pesticide contamination of groundwater results primarily from agricultural field applications, spills, misuse, or improper storage and disposal of pesticides. In 1992 the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) initiated a rural well sampling program for testing of atrazine, the most widely used triazine herbicide in Wisconsin for weed control, primarily in corn. Triazine was detected in 63 of the 263 samples collected by DATCP in all of the counties within southeastern Wisconsin, except Milwaukee.[99] However, none of the samples were found to exceed the State drinking water standard. Data from the WDNR GNR databases indicate that during the period 1998-2006, wells in the study area were sampled for 24 different pesticides. The number of wells sampled varied by compound, ranging between 43 and 395 with a mean number of 193. Most compounds were detected in fewer than 15 percent of the wells sampled. Ten of these compounds were compared to preventive action limits and enforcement standards. Only one pesticide was found to exceed either standard. Pentachlorophenol exceeded its preventive action limit in slightly over 2 percent of the wells sampled. It did not exceed its enforcement standard in any well sampled. As previously noted, the GRN databases

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[96]*Sharon Shaver,* Investigation of Bacteriological Water Quality in Private Water Supply Wells in Waukesha County*, WDNR Report 1996. Data from WDNR Groundwater Retrieval Network (GRN) and Waukesha County Environmental Health Department.*

[97]*Jon Standridge, Wisconsin State Laboratory of Hygiene data; Sharon Shaver, Ozaukee County GRN Data, 1990-1995.*

[98]*Centers for Disease Control,* A Survey of the Quality of Water Drawn for Domestic Wells in Nine Midwestern States*, 1994.*

[99]*Charles A. Czarkowski, WDNR Drinking Water and Groundwater Expert, Public Water System database.*

do not include data from monitoring wells associated with some actions such as USEPA Superfund sites and some contaminated groundwater remediation actions. Thus, these percentages may underestimate the extent of pesticide contamination in groundwater in the study area.

The presence in certain locations of VOCs is also a cause of concern. Sources of VOCs include landfills, leaking underground storage tanks, and spills of hazardous substances. Data from the WDNR GRN databases indicate that during the period 1998-2006, wells in the study area were sampled for 101 different VOCs. The number of wells sampled varied by compound, ranging between five and 1,089 with a mean number of 529. Most compounds were detected in fewer than 10 percent of the wells sampled. For most compounds, preventive action limits and enforcement standards were exceeded in less than 1 percent of the wells sampled. As previously noted, the GRN databases do not include data from monitoring wells associated with some actions such as USEPA Superfund sites and some contaminated groundwater remediation actions. Thus, these percentages may underestimate the extent of VOC contamination in groundwater in the study area.

Natural sources of chloride in potable water, other than weathering of minerals, include atmospheric deposition and connate water. Human and animal wastes, salt used for snow and ice removal, and water softening contributions to wastewater are important sources of chloride in some areas. Because chloride is, itself, a possible contaminant, and is also found in contaminants, such as wastewater and animal wastes, it is potentially useful as a general indicator of groundwater contamination when it is present in greater-than-ambient concentrations.

Chloride concentrations in water from the aquifer systems in southeastern Wisconsin are commonly low. Wisconsin's secondary drinking water standards specify a maximum concentration of 250 mg/l for chloride in drinking water. The standard is based on aesthetic (taste) considerations.

Concentrations of chloride in water from the shallow aquifer are generally from 10 to 30 mg/l in the Region;[100] however, limited areas of the Silurian dolomite aquifer have naturally occurring chloride concentrations which exceed 100 mg/l. In addition, isolated areas of the sand and gravel aquifer have been found to have levels exceeding the 250 mg/l standard due to contamination sources. As documented in previous sections of this chapter, chloride concentrations in surface waters in the study area have been found to be increasing; however, no specific data on trends in the concentration of chloride in groundwater are available.

Groundwater in the study area has also been examined for concentrations of inorganic compounds of public health and welfare concern and for values of groundwater quality indicator parameters. Data from the WDNR GRN databases indicate that during the period 1998-2006, wells in the study area were sampled for 47 different inorganic compounds and indicator parameters. The number of wells sampled varied by compound, ranging between one and 932 with a mean number of 277. On average, each compound or indicator parameter was detected in about 67 percent of wells sampled. Of these compounds and indicator parameters, 25 were compared to preventive action limits and enforcement standards. Methodologies for establishing preventive action limits have been issued for an additional 11 of these compounds and indicator parameters; however, these standards were not computed in the GRN databases. Preventive action limits were exceeded in at least some wells in the study area for 20 inorganic compounds. The fraction of wells sampled that exceeded the preventive action limits varied among the compounds, ranging from less than 1 percent to 69 percent of wells. Enforcement standards were exceeded for at least some wells in the study area for 18 inorganic compounds. The fraction of wells sampled that exceeded the enforcement standards also varied among the compounds, ranging from less than 1 percent to 56 percent of wells, with a mean value of about 4 percent. As previously noted, the GRN databases do not include data from monitoring wells associated with some actions such as USEPA Superfund sites and some contaminated groundwater remediation actions. Thus, these percentages may underestimate the extent of inorganic compound contamination in groundwater in the study area.

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[100]*P.A. Kammerer, Jr., Investigations Report 90-4171,* op. cit.

SUMMARY

The water quality inventory for the greater Milwaukee watersheds has been summarized by answering four basic questions. The chapter provided information needed to answer these questions. More detailed information is provided in SEWRPC Technical Report No. 39. The information is summarized below.

How Have Water Quality Conditions Changed Since 1975?
Water quality conditions in the greater Milwaukee watersheds have both improved in some respects and declined in other respects since 1975.

Improvements in Water Quality
Concentrations of several pollutants associated with combined sewer overflows, such as BOD, fecal coliform bacteria, and ammonia, have decreased in much of the Kinnickinnic, Menomonee, and Milwaukee Rivers and in much of the Milwaukee Harbor estuary. In addition, total phosphorus concentrations in much of the estuary have also decreased. These reductions in nutrients and oxygen-demanding wastes have produced some improvements in dissolved oxygen concentrations and in lower chlorophyll-*a* concentrations in the estuary. One important, though not the only, factor responsible for these decreases is the reduction in combined and separate sewer overflows resulting from construction and operation of MMSD's inline storage system. These improvements also likely reflect both changes in the types of industries present in the watershed, the connection of most process wastewaters to the MMSD sewerage system, and the implementation of treatment requirements for all industrial discharges. Concentrations of ammonia and BOD in Oak Creek and portions of the Root River have also decreased. Decreases in the concentrations of some pollutants have also been detected in the outer harbor and nearshore area. These include decreases in concentrations of ammonia, BOD, fecal coliform bacteria, total nitrogen, and total phosphorus in the outer harbor and decreases in concentrations of ammonia and total nitrogen in the nearshore area. These reductions in pollutant concentrations have resulted in some improvements in chlorophyll-*a* and Secchi depths at some stations in the outer harbor and nearshore area. Improvements have also occurred in the concentrations of several toxic metals. The improvements in concentrations of toxic metals likely reflect both changes in the types of industries present in the watersheds, the connection of most process wastewaters to the sanitary sewerage systems, the implementation of treatment requirements for all industrial discharges, and the phasing out of the use of lead as an additive to gasoline.

No Change or Reductions in Water Quality
Concentrations of suspended and dissolved pollutants typically associated with stormwater runoff and other nonpoint source pollution, such as chloride, copper, total suspended solids, and zinc have remained unchanged or increased at sampling stations along the major streams and rivers of the greater Milwaukee watersheds. In addition, specific conductance has increased in several stream reaches, suggesting that the total concentration of dissolved material in the water has increased. In other reaches, the concentration of dissolved material, as indicated by specific conductance, has remained unchanged. At some locations, concentrations of fecal coliform bacteria have increased. Water temperatures at most stations in the estuary and some stations in the outer harbor have increased, especially during the summer.

How Have Toxicity Conditions Changed Since 1975?
In some respects, toxicity conditions in the greater Milwaukee watersheds have improved since 1975; in other respects, they have declined or not changed.

Improvements in Toxicity Conditions
There have been several improvements in toxicity conditions in the greater Milwaukee watersheds since 1975. Concentrations of some toxic metals in water have decreased in many sampling locations. Concentrations of PAHs in water have decreased in the portions of the Kinnickinnic and Menomonee Rivers upstream from the estuary. Concentrations of PCBs in the tissue of fish appear to have decreased; however, fish consumption advisories remain in effect for PCB contamination in Lake Michigan and much of the greater Milwaukee watersheds. Concentrations of some pesticides in fish tissue have decreased. Remediation of sediment contaminated with PAHs in the Little Menomonee River and with PCBs in Ruck Pond and the former Hamilton Pond along

Cedar Creek should reduce toxic effects related to toxic sediment. Other remediation efforts for toxic sediment are ongoing or in planning stages. While this does not constitute a change, concentrations of mercury in the tissue of fish collected from the Kinnickinnic and Menomonee Rivers remains low.

Worsened Toxicity Conditions

Other toxicity conditions have worsened in the greater Milwaukee watersheds. Concentrations of copper and zinc in water are increasing. Concentrations of the pesticide atrazine and its metabolites have increased at several locations. Concentrations of PAHs in water have increased in the estuary portions of the Kinnickinnic and Menomonee Rivers.

Inconclusive Toxicity Data

In some cases data are not adequate to assess changes. Various pesticides have been detected in water in the greater Milwaukee watersheds, but different compounds were screened for in recent samplings than in historical samplings. Changes in methodology and the number of compounds screened for make it difficult to compare concentrations in some recent samplings of PCBs and PAHs to concentrations in earlier samplings. In some locations, no recent data exist on tissue concentrations of some bioaccumulative contaminants. At other locations, concentrations of mercury and PCBs in tissue of aquatic organisms appears to have decreased since 1975, but the fact that different species were assessed in different years makes it unclear whether these trends represent actual reductions or interspecies differences.

Sediment Conditions

Sediment quality, as measured by mean PEC-Q remains poor. At several locations, sediment contains concentrations of PCBs, PAHs, pesticides, or heavy metals high enough to pose substantial risks to benthic organisms. At other locations concentrations of contaminants are high enough to be likely to produce toxic effects in benthic organisms. As a result of recent remediation efforts, sediment contaminated with PCBs has been removed from Ruck Pond and the banks of the former Hamilton Pond along Cedar Creek and sediment contaminated with PAHs has been removed from the Little Menomonee River. This should reduce toxicity in these locations. Deposits of contaminated sediment are still present at a number of locations, including Cedar Creek below Ruck dam, Zeunert Pond in Cedarburg, Thiensville Millpond and Estabrook Impoundment along the mainstem of the Milwaukee River, Lincoln Creek, the Milwaukee Harbor estuary, and the Milwaukee outer harbor. Remediation efforts for some of these are ongoing or in planning stages.

What Is the Current Condition of the Fishery?

The Kinnickinnic River, Oak Creek, and Root River watersheds seem to have very poor fisheries and macroinvertebrate communities at present. The fish communities contain relatively few species of fishes, are trophically unbalanced, contain few or no top carnivores, and are dominated by tolerant fishes. The macroinvertebrate communities are equally depauperate and dominated by tolerant taxa. Since water quality has generally been improving in these watersheds for some constituents, habitat seems to potentially be the most important factor limiting both the fishery and macroinvertebrate communities.

The Menomonee River watershed seems to have a poor fishery community at present. The fish community contains relatively few species of fishes, is trophically unbalanced, contains few or no top carnivores, and is dominated by tolerant fishes. The quality of the macroinvertebrate community has improved substantially since 1993 and is generally indicative of fair to very good water quality. Since water quality has generally been improving in the watershed and habitat seems to be adequate, it is likely that some other factor, such as periodic stormwater loads, is limiting the fishery community.

Except for some areas within the Upper Milwaukee River, West Branch of the Milwaukee River, East Branch of the Milwaukee River, Middle Milwaukee River, Upper Lower Milwaukee River, and Lower Milwaukee River subwatersheds that contain good and in some cases excellent fishery quality, the Milwaukee River watershed in general contains a poor to fair fishery. The fish community contains a high abundance of both warmwater and coldwater species of fishes, seems trophically balanced in the highest quality areas, contains a good percentage of top carnivores (except for those species stocked), and is not dominated by tolerant fishes. Macroinvertebrate communities are classified as fair to good-very good at present. The macroinvertebrate community is also generally trophically balanced and not dominated by tolerant taxa. Overall, the fish and macroinvertebrate communities in the Milwaukee River watershed are of a better quality than those communities in the other watersheds in the study area.

To What Extent Are Water Use Objectives and Water Quality Standards Being Met?

Major Rivers and Streams

During the study baseline period, the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek only partially met the water quality criteria supporting their designated water use classifications. In almost all samples collected from the mainstems of these streams, concentrations of ammonia were in compliance with the relevant water quality standard. In almost all samples collected from the mainstems of these streams, temperatures were in compliance with the relevant water quality standard. Only in occasional samples in some reaches in the Kinnickinnic and Menomonee Rivers were temperatures above the standard of 31.7ºC.

While high levels of compliance with the applicable standards for dissolved oxygen were observed in many stream reaches, some sections of these streams showed lower compliance with dissolved oxygen standards. In the vast majority of the samples taken from the mainstem of the Kinnickinnic River, concentrations of dissolved oxygen were in compliance with the relevant water quality standards. Only in occasional samples in the reaches between S. 27th Street and S. 1st Street were dissolved oxygen concentrations below the special variance standard of 2.0 mg/l that applies to the Kinnickinnic River. In the vast majority of the samples taken from the mainstem of the Menomonee River, concentrations of dissolved oxygen were in compliance with the relevant water quality standards. In occasional samples collected in the reaches upstream from W. Hampton Avenue, dissolved oxygen concentrations were below the standard of 5.0 mg/l that applies to fish and aquatic life waters. At most stations along the mainstem of the Milwaukee River, concentrations of dissolved oxygen in all samples equaled or exceeded the applicable standard. There were three exceptions to this: concentrations of dissolved oxygen occasionally fell below 5.0 mg/l in the sections of the River above the dam at Kewaskum in Washington and Fond du Lac Counties, between E. Silver Spring Drive and N. Port Washington Road in Milwaukee County, and between Estabrook Park and the site of the North Avenue dam, also in Milwaukee County. At most stations along the mainstem of Oak Creek, dissolved oxygen concentrations were above the standard for fish and aquatic life in the majority of samples. In the upstream reaches above W. Ryan Road dissolved oxygen concentrations were below the standard of 5.0 mg/l in about 43 percent of the samples. The proportion of samples from the mainstem of the Root River in which dissolved oxygen concentrations equaled or exceeded the 5.0 mg/l standard for fish and aquatic life varied considerably among stations, with compliance being lowest at the upstream stations and at the station near the mouth of the River. For example, in the upstream reaches above W. Grange Avenue, dissolved oxygen concentrations were below the standard in about 21 to 56 percent of the samples, depending upon the station.

Lower levels of compliance were seen with the applicable standards for fecal coliform bacteria. Concentrations of fecal coliform bacteria in the Kinnickinnic River often exceeded the special variance standard of 1,000 cells per 100 ml which applies to the River. The rate of compliance with this standard increased from upstream to downstream from about 30 percent to about 77 percent of samples. Concentrations of fecal coliform bacteria in the estuary portion of the Menomonee River often exceeded the special variance standard of 1,000 cells per 100 ml which applies to the estuary. Similarly, in the vast majority of samples collected from the section of the River upstream of the estuary, the concentrations of fecal coliform bacteria exceed the standard of 200 cells per 100 ml. The rate of compliance with this standard varies among reaches from about 24 percent to 60 percent of samples. Concentrations of fecal coliform bacteria in the estuary sections of the Milwaukee River were usually less than or equal to the variance standard of 1,000 cells per 100 ml. While the rate of compliance varied among stations, it was generally between 65 percent and 77 percent. In the section of the Milwaukee River upstream from the estuary, concentrations of fecal coliform bacteria usually exceeded the recreational use standard of 200 cells per 100 ml. Between Pioneer Road in Cedarburg and the site of the former North Avenue dam, concentrations of fecal coliform bacteria exceeded 200 cells per ml in the majority of samples. Depending upon the station, the percentage of samples in this section of the River that complied with the standard ranged between about 20 and 55 percent. Upstream from Pioneer Road, fecal coliform bacteria concentrations met, or were below, the standard in the majority of samples at the stations at Waubeka, Newburg, and above the dam at Kewaskum, although, at Newburg and Kewaskum, concentrations occasionally exceeded the standard. Concentrations of fecal coliform bacteria in the mainstem of Oak Creek usually exceed the recreational use standard of 200 cells per 100 ml which applies to the Creek. Compliance varied among stations with concentrations of fecal coliform bacteria meeting or being below the standard in between 15 and 35 percent of the samples. Concentrations of fecal coliform bacteria in the mainstem of the Root River usually exceed the recreational use standard of 200 cells per 100 ml which applies to the River. While the rate of compliance varied among stations, it was generally low.

Lower levels of compliance were also seen with the standard for total phosphorus recommended in the original regional water quality management plan documented in SEWRPC PR No. 30. In the Kinnickinnic River, compliance with the recommended 0.1 mg/l standard increased from upstream to downstream from a low of about 30 percent to a high of about 74 percent. Compliance with the recommended total phosphorus standard also varied among reaches in the Menomonee River, with the number of samples showing total phosphorus below the 0.1 mg/l standard ranging between about 32 percent and about 66 percent. Compliance with the recommended standard for total phosphorus was also low in the Milwaukee River with the number of samples showing total phosphorus below the 0.1 mg/l planning standard ranging from 37 to 79 percent at stations along the mainstem. Low levels of compliance with the planning standard for total phosphorus were also observed in Oak Creek, with the number of samples showing total phosphorus below the 0.1 mg/l standard ranging from 58 and 79 percent at stations along the mainstem of the Creek. The levels of compliance with the recommended standard for total phosphorus in the Root River were also low with the number of samples showing total phosphorus below the 0.1 mg/l standard ranging from 8 to 79 percent at stations along the mainstem.

Tributary Streams

Relatively few data are available for assessing whether tributary streams in the greater Milwaukee watersheds are meeting water use objectives and water quality standards.

In the Kinnickinnic River watershed, data were available to assess this for only one stream: Wilson Park Creek. Based on available data, Wilson Park Creek is only partially meeting its water use objectives. While ammonia concentrations in this stream were below the acute toxicity standard for fish and aquatic life in almost all samples, total phosphorus concentrations exceeded the recommended concentration in about 30 percent of the samples.

In the Menomonee River watershed, data were available to assess this in four streams: Butler Ditch, Honey Creek, the Little Menomonee River, and Willow Creek. Based on available data, Honey Creek, the Little Menomonee River, and Willow Creek are only partially meeting their water use objectives. In all samples collected from each of these streams, ammonia concentrations were below the acute toxicity standard for fish and aquatic life, water temperatures are under the 31.7ºC standard, and dissolved oxygen concentrations were above the applicable standard. Concentrations of fecal coliform bacterial in Honey Creek generally exceeded the variance standard of 1,000 cells per 100 ml which applies to this stream. Total phosphorus concentrations in the Little Menomonee River and Willow Creek exceeded the recommended concentration in about 20 percent of the samples. Based on limited sampling, Butler Ditch appears to be meeting water use objectives and water quality standards. In all of the samples taken, dissolved oxygen concentrations and temperatures were in compliance with the applicable water quality standards.

In the Milwaukee River watershed, data were available to evaluate whether one or more standard was met for 19 of 76 tributary streams. In 16 tributary streams, temperatures in all samples were at or below the 31.7ºC fish and aquatic life standard. In one other tributary, Cedar Creek, temperatures were at or below the standard in the vast majority of samples. In the 15 tributary streams for which data were available, ammonia concentrations were at or below the applicable standard in all samples. Dissolved oxygen concentrations in 11 tributaries equaled or exceeded the applicable standard in all samples, indicating compliance with the standard. In four tributaries, Lincoln Creek, the North Branch Milwaukee River, Quaas Creek, and Southbranch Creek, dissolved oxygen concentrations occasionally dropped below the standard. In only one tributary, the West Branch Milwaukee River, were dissolved oxygen concentrations frequently below the standard. Fecal coliform concentrations frequently exceeded the applicable standard in four tributaries: Indian Creek, Lincoln Creek, the North Branch Milwaukee

River, and Southbranch Creek. In the North Branch Milwaukee River and Southbranch Creek, concentrations of fecal coliform bacteria were out of compliance with the standard in the majority of samples. By contrast, concentrations of fecal coliform bacteria only occasionally exceeded the applicable standard in Cedar Creek. Concentrations of fecal coliform bacteria in the East Branch Milwaukee River were at or below the applicable standard in all samples collected. Total phosphorus concentrations exceeded the 0.1 mg/l planning standard recommended in the original regional water quality management plan, documented in SEWRPC PR No. 30, in most tributaries for which data were available. In three tributaries, Polk Springs Creek, Southbranch Creek, and Wallace Creek, total phosphorus concentrations exceeded the recommended planning standard in the majority of samples. In eight more tributaries, Batavia Creek, Indian Creek, Kewaskum Creek, Lincoln Creek, the North Branch Milwaukee River, Parnell Creek, Quaas Creek, and the West Branch Milwaukee River, total phosphorus concentrations frequently exceeded the recommended standard. In three more tributaries, Cedar Creek, the East Branch Milwaukee River, and Friedens Creek, total phosphorus concentrations occasionally exceeded the recommended standard. In only four tributaries, Crooked Lake Creek, Mole Creek, Pigeon Creek, and Stony Creek, were total phosphorus concentrations at or below the recommended standard in all samples.

In the Oak Creek watershed, data were available to assess whether water use objectives and water quality standards are being met for only one tributary stream: the Mitchell Field Drainage Ditch. Based on available data, this tributary is only partially meeting its water use objectives. While ammonia concentrations in this stream were below the acute toxicity standard for fish and aquatic life for all samples, total phosphorus concentrations exceeded the recommended concentration in about 55 percent of the samples.

In the Root River watershed, data were available to assess whether water use objectives and water quality standards are being met for only two tributary streams: Husher Creek and the Root River Canal. Based on available data, these streams are only partially meeting their water use objectives. While ammonia concentrations in Husher Creek were below the acute toxicity standard for fish and aquatic life in all samples and dissolved oxygen concentrations and temperatures were in compliance with the applicable standards in all samples, total phosphorus concentrations exceeded the recommended concentration in about 67 percent of the samples. While temperatures in the Root River Canal were in compliance in all samples, dissolved oxygen concentrations were below the standard for fish and aquatic life in about 23 percent of the samples and concentrations of fecal coliform bacteria exceeded the recreational use standard of 200 cells per 100 ml in about 40 percent of samples. In the vast majority of samples collected from the Root River Canal, total phosphorus concentrations exceeded the standard recommended for total phosphorus in the original regional water quality management plan documented in SEWRPC PR No. 30.

Milwaukee Harbor Estuary, Outer Harbor, and Nearshore Lake Michigan Area

During the 1998 to 2004 extended study baseline period, the Milwaukee Harbor estuary partially met the water quality criteria supporting its designated water use classification. In all of the samples taken from the estuary, concentrations of ammonia were in compliance with the relevant water quality standards. In almost all of the samples from the estuary, temperatures were in compliance with the relevant water quality standards. In the majority of samples, dissolved oxygen concentrations equaled or exceeded the 2.0 mg/l special variance standard applying to the estuary. Concentrations of fecal coliform bacteria in the estuary were usually less than or equal to the variance standard of 1,000 cells per 100 ml. While the rate of compliance varied among stations, it was generally between 20 percent and 77 percent. Compliance with the planning standard for total phosphorus recommended in the original regional water quality management plan, documented in SEWRPC PR No. 30, was also low with the number of samples showing total phosphorus below the 0.1 mg/l planning standard ranging from 37 to 75 percent at stations in the estuary.

During the 1998 to 2004 extended study baseline period, the water quality criteria for fish and aquatic life were, for the most part, being achieved in the Milwaukee outer harbor. In all of the samples taken from the outer harbor, concentrations of ammonia and temperatures were in compliance with the fish and aquatic life standards. In almost all of the samples from the outer harbor, dissolved oxygen concentrations equaled or exceeded the 5.0 mg/l fish and aquatic life standard. Concentrations of fecal coliform bacteria in the outer harbor occasionally exceeded 200 cells per 100 ml. Concentrations of total phosphorus were usually less than or equal to the 0.1 mg/l planning standard. In the majority of samples from the outer harbor, concentrations of *E. coli* bacteria were below the standard of 235 cells per 100 ml promulgated by the USEPA for coastal and Great Lakes recreation waters.

Lake Michigan beaches partially met applicable water use objectives. The percentages of samples from public bathing beaches along Lake Michigan less than or equal to the standard of 235 cells per 100 ml promulgated by the USEPA for coastal and Great Lakes recreation waters, varied from about 54 percent to 87 percent.

Impaired Waters

A number of sections of streams and other waterbodies in the greater Milwaukee watersheds are listed as impaired pursuant to Section 303(d) of the Clean Water Act. The Milwaukee Harbor estuary and outer harbor are listed as impaired. Reaches of the mainstems of the Kinnickinnic, Menomonee, and Milwaukee Rivers upstream from the estuary are listed as impaired. Sections of the mainstem of the Root River and the entire mainstem of Oak Creek are listed as impaired. Eleven tributary streams, including one in the Menomonee River watershed, seven in the Milwaukee River watershed, one in the Oak Creek watershed, and two in the Root River watershed are listed as impaired. Two lakes and one pond in the Milwaukee River watershed, as well as one pond in the Kinnickinnic River watershed, are listed as impaired. Four Lake Michigan public beaches are listed as impaired. The causes of these impairments vary among the waterbodies. They include aquatic toxicity, high concentrations of bacteria, low concentrations of dissolved oxygen, degraded habitat, high temperatures, and fish consumption advisories necessitated by high concentrations of PCBs or mercury in the tissue of fish collected in the waterbodies.

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Chapter IV

SOURCES OF WATER POLLUTION

INTRODUCTION

An evaluation of water quality conditions in a watershed must include an identification, characterization, and where feasible, quantification of known pollution sources. This identification, characterization, and quantification is intended to aid in determining the probable causes of water pollution problems. This chapter presents a summary of the sources of pollution in the greater Milwaukee watersheds. More-detailed information is presented in SEWRPC Technical Report 39, *Water Quality and Sources of Pollution in the Greater Milwaukee Watersheds,* which is a companion report to this water quality plan.

POLLUTION SOURCE CATEGORIES

Pollutants can reach surface waters by several pathways. First, pollutants may be discharged from discrete outfall points into surface waters. Second, pollutants associated with the land may be transported to the stream system either in surface runoff associated with wet-weather events or through dry-weather pathways. Third, pollutants may be transported from their point of origin through the atmosphere to the watershed. These substances may then be carried into surface waters either through precipitation or dry deposition processes. Finally, pollutants sequestered in sediments within a waterbody may be released to the overlying surface waters. In general, sources of pollutants are divided into two categories: point sources and nonpoint sources.

Point source pollution is defined as pollutants that are discharged to surface waters at discrete locations. Examples of such discrete discharge points include sanitary sewerage flow relief devices, sewage treatment plant discharges, and industrial discharges.

Nonpoint source pollution, also referred to as diffuse source pollution, consists of various discharges of pollutants to the surface waters which cannot be readily identified as point sources. Nonpoint source pollution is transported from the rural and urban land areas of a watershed to the surface waters by means of direct runoff from the land via overland routes, via storm sewers and channels, and by interflow during and shortly after rainfall or rainfall-snowmelt events. Nonpoint source pollution also includes pollutants conveyed to the surface waters via groundwater discharge—base flows—which is a major source of stream flow between runoff events.

The distinction between point and nonpoint sources of pollution is somewhat arbitrary since a nonpoint source pollutant, such as sediment being transported in overland rainfall runoff, can be collected in open channels or in storm sewers and conveyed to points of discharge, such as a storm sewer outfall. Thus, for purposes of this report, nonpoint source pollution includes substances washed from the land surface or subsurface by rainfall and snowmelt runoff and then conveyed to the surface waters by that runoff, even though the entry into the surface waters may be through a discrete location, such as a storm sewer outfall.

Nonpoint source pollution is similar in composition to point source pollution in that it can cause toxic, organic, nutrient, pathogenic, sediment, radiological, and aesthetic pollution problems. Nonpoint source pollution is becoming of increasing concern in water resources planning and engineering as efforts to abate point source pollution become increasingly successful. The control of nonpoint source pollution is a necessary step in the process of improving surface waters to render such waters suitable for full recreational use and a healthy fishery.

Nonpoint source pollution generally differs from point source pollution in one important respect: nonpoint source pollution is transported to the surface water at a highly irregular rate because large portions of the overall transport occur during rainfall or snowmelt events. In the dry period after washoff events, potential nonpoint source pollutants gradually accumulate on the land surface as a result of human activities, becoming available for transport to the surface waters during the next runoff event. The following activities, or effects of human activities, result in nonpoint source pollution: 1) dry fallout and washout of atmospheric pollution; 2) vehicle exhaust and lubricating oil and fuel leakage; 3) the gradual wear and disintegration of tires, pavements, structures, and facilities; 4) improper disposal of grass clippings and leaves; 5) improperly located and maintained onsite wastewater disposal systems; 6) poor soil and water conservation practices; 7) improper management of livestock wastes; 8) excessive use of fertilizers and pesticides; 9) debris, careless material storage and handling, and poor property maintenance; 10) construction and demolition activity; 11) application of deicing salts and sand; 12) streambank erosion; and 13) domestic and wild animal litter.

DATA SOURCES AND ANALYSIS PROCEDURES

Commission staff obtained lists of discharge permits issued under the Wisconsin Pollution Discharge Elimination System (WPDES) that were effective in February 2003 for the study area. These lists included permits for discharges from public and private wastewater treatment plants, permits issued under the general permit program for discharges from industrial and related facilities, individual permits for discharges from industrial and related facilities, and permits for the discharge of stormwater. Map locations of the permitted facilities were determined based upon the address of the facility. The facilities were then assigned to the appropriate watershed based on the location. In some instances, facilities were located on aerial photographs and confirmed by site visits.

Locations of sewage bypasses and overflows and data on bypass dates and volumes were obtained from two sources. Information on those sites within the Milwaukee Metropolitan Sewerage District (MMSD) 2020 Facilities Plan study area was provided by the MMSD. Information on sites outside of the MMSD 2020 Facilities Plan study area was provided by the Wisconsin Department of Natural Resources (WDNR). In some instances, bypass site locations were located on aerial photographs and confirmed by site visits.

Pollution loadings were developed through watercourse modeling. The modeling procedures are described in Chapter V of this report. Data from three types of point sources were included in the model: public and private wastewater treatment facilities, facilities permitted to discharge noncontact cooling water under the WDNR’s WPDES general permit program, and facilities with individual permits under the WDNR’s WPDES individual permit program. Monitoring data for public and private wastewater treatment facilities were taken from compliance maintenance annual reports (CMARs) submitted to the WDNR. Monitoring data for facilities discharging under individual or noncontact cooling water permits were taken from discharge monitoring reports (DMRs) submitted to the WDNR. Nonpoint source pollutant loads were estimated through application of the water quality model. For the purposes of comparing wet-weather and dry weather instream pollutant loads, daily average instream pollutant loads were estimated by appropriately combining daily average flow and pollutant ambient concentration.

POINT SOURCE POLLUTION

Sewage Treatment Plants

In 2004, there were 17 public sewage treatment plants in the greater Milwaukee watersheds, as shown in Table 48. Map 37 shows that 12 of these were located in the Milwaukee River watershed, two were located in the

Table 48

WASTEWATER TREATMENT FACILITIES IN THE GREATER MILWAUKEE WATERSHEDS: 2004

Number on Map 37	Facility Name	Address	Municipality	Ownership
1	Campbellsport Wastewater Treatment Facility	110 Columbus Park Court	Campbellsport	Public
2	Cascade Wastewater Treatment Facility	N3191 Bates Road	Cascade	Public
3	Cedarburg Wastewater Treatment Facility	W54 N370 Park Lane	Cedarburg	Public
4	Fonk's Mobile Home Park No. 1	5035 Schoen Road	Union Grove	Private
5	Fredonia Municipal Sewer and Water Utility	210 Park Avenue	Fredonia	Public
6	Grafton Water and Wastewater Utility	1900 9th Avenue	Grafton	Public
7	Jackson Wastewater Treatment Plant	W194 N16658 Eagle Drive	Jackson	Public
8	Kettle Moraine Correctional Institution	W9071 Forest Road	Plymouth	Private
9	Kewaskum	204 First Street	Kewaskum	Public
10	Long Lake Recreational Area	N1765 Highway G	Campbellsport	Private
11	Milwaukee Metropolitan Sewerage District-Jones Island Plant	700 E. Jones Street	Milwaukee	Public
12	Milwaukee Metropolitan Sewerage District-South Shore Plant	8500 S. Fifth Avenue	Oak Creek	Public
13	Newburg	P.O. Box 50	Newburg	Public
14	Random Lake Sewage Treatment Plant	96 Russell Drive	Random Lake	Public
15	Saukville Village Sewer Utility	1600 Cottontail Lane	Saukville	Public
16	South Milwaukee	3033 Fifth Avenue	South Milwaukee	Public
17	Town of Scott Sanitary District No. 1	N1614 Highway 28	Adell	Public
18	Union Grove	3710 67th Drive	Union Grove	Public
19	West Bend	512 Municipal Drive	West Bend	Public
20	Yorkville Sewer Utility District No. 1	720 Main Street	Union Grove	Public

Source: SEWRPC.

Root River watershed, and three were located in the Lake Michigan direct drainage area. In 2004, there were no public sewage treatment plants located in the Kinnickinnic River, Menomonee River, and Oak Creek watersheds.

In the Milwaukee River watershed, the plants for the Cities of Campbellsport and Cedarburg and the Village of Jackson discharge effluent to Cedar Creek. The plants for the City of West Bend and the Villages of Fredonia, Grafton, Kewaskum, Newburg, and Saukville discharge effluent to the mainstem of the Milwaukee River. The Village of Cascade plant discharges effluent to a tributary of the North Branch of the Milwaukee River. The Village of Random Lake plant discharges effluent to Silver Creek (Sheboygan County). The Town of Scott Sanitary District No. 1 plant discharges effluent to a soil absorption system.

In the Root River watershed, the Village of Union Grove plant discharges effluent to the West Branch of the Root River Canal. The Town of Yorkville Sewer Utility District plant discharges effluent to Hoods Creek.

In the Lake Michigan direct drainage area, the MMSD South Shore plant and the City of South Milwaukee plant discharge effluent to Lake Michigan. The MMSD Jones Island plant discharges effluent to Lake Michigan via the Milwaukee Outer Harbor.

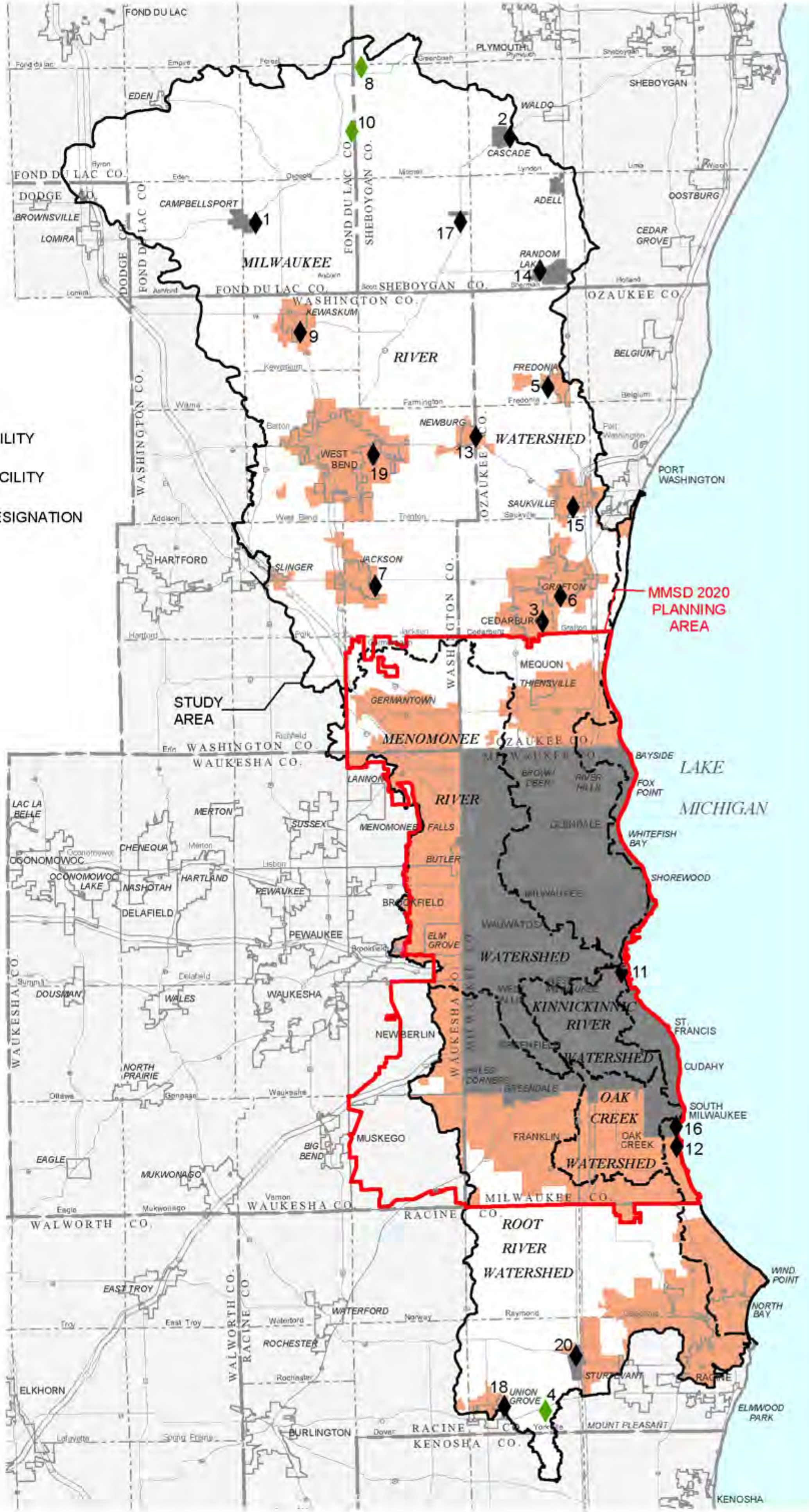
In 2004, there were also three private sewage treatment facilities in the greater Milwaukee watersheds (Table 48). Two of these were located in the Milwaukee River watershed and one was located in the Root River watershed (Map 37). In 2004, there were no private sewage treatment plants located in the Kinnickinnic and Menomonee River watersheds, the Oak Creek watershed, or the Lake Michigan direct drainage area.

In the Milwaukee River watershed, the sewage treatment plants serving the Kettle Moraine Correctional Institution and the Long Lake Recreational area discharge effluent to the soil for absorption.

Map 37

PLANNED SEWER SERVICE AREAS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- UNREFINED SANITARY SEWER SERVICE AREA: DECEMBER 31, 2006
- REFINED SANITARY SEWER SERVICE AREA: DECEMBER 31, 2006
- ◆ PUBLIC SEWAGE TREATMENT FACILITY
- ◆ PRIVATE SEWAGE TREATMENT FACILITY
- 9 SEWAGE TREATMENT FACILITY DESIGNATION (See Table 48)
- — — WATERSHED BOUNDARY



N

GRAPHIC SCALE

0 2 4 6 8 Miles

0 10,000 20,000 30,000 40,000 50,000 Feet

Source: SEWRPC.

In the Root River watershed, the sewage treatment plant serving Fonk's Mobile Home Park No. 1 discharges effluent to the East Branch of the Root River Canal.

The initial regional water quality management plan recommended that all of the sanitary sewer areas identified in the plan be refined and detailed in cooperation with the local units of government concerned.[1] Within the Southeastern Wisconsin Region, there are 29 sanitary sewer service areas identified within, or partially within, the greater Milwaukee watersheds. As of 2005, all of these areas with the exception of the MMSD and South Milwaukee service areas and a portion of the Yorkville service area had undergone refinements as recommended. In addition the Franklin and Oak Creek sewer service areas, which were initially included as part of the MMSD service area, were identified and refined since the initial plan. In the portions of the Milwaukee River watershed that are outside of the Region, there are six sanitary sewer service areas. Responsibility for refining these service areas rests with relevant state and local authorities. The planned sanitary sewer service areas in the portions of the greater Milwaukee watersheds in the Region, as refined through June 2005, total about 249 square miles. In addition, about 181 square miles of the greater Milwaukee watersheds are contained in unrefined sanitary sewer service areas in the Southeastern Wisconsin Region and about 5 square miles are contained in planned sanitary sewer service areas in portions of the greater Milwaukee watersheds outside of the Region. Planned sanitary sewer service areas in the greater Milwaukee watersheds are shown on Map 37 and are inventoried in SEWRPC Technical Report No. 39.

Sanitary Sewer Overflow Sites

During the period from August 1995 to August 2002, separate sanitary sewer overflows (SSOs) were reported at 133 locations. Table 49 summarizes the number of locations at which SSOs were reported in each of the watersheds. It is important to note that the number of overflows varied considerably among locations. The SSO sites which were incorporated into the water quality model are indicated on Map 38. More-detailed information on SSOs is given in SEWRPC Technical Report 39.

Combined Sewer Overflows

Combined sewer overflows (CSOs) are potential sources of pollution in the greater Milwaukee watersheds. MMSD has 121 CSO outfalls that discharge into the Kinnickinnic River, Menomonee River, Milwaukee River, and Lake Michigan. These outfalls can convey diluted sewage from the combined sewer system to the surface water systems as a result of high water volume from stormwater, snow meltwater, and infiltration and inflow of clear water during wet weather conditions. This conveyance to surface waters occurs to prevent damage to buildings or the mechanical elements of the conveyance system. Table 49 summarizes the numbers of CSO sites in each of the watersheds. It is important to note that the number of overflows varied considerably among locations. The locations of the CSO outfalls in the greater Milwaukee watersheds are indicated on Map 38. More-detailed information on CSOs is given in SEWRPC Technical Report 39.

Other Known Point Sources

Industrial Discharges

Table 50 summarizes the numbers of industrial discharge permits in effect through the Wisconsin Pollution Discharge Elimination System (WPDES) during February 2003 in the greater Milwaukee watersheds. At that time, 398 permits were in effect in the study area. Individual permits represented 41 of these permits, the rest were spread among 14 categories of general permits. The most common category of permit issued in the greater Milwaukee watersheds was for noncontact cooling water which regulates the discharge of noncontact cooling water, boiler blowdown, and air conditioner condensate. There were 154 facilities in the study area covered by permits in this category. Other common categories of permits were for the discharge of hydrostatic test water, the discharge from contaminated groundwater remedial actions, and the discharge from swimming pool facilities. These types of facilities represented 43, 40, and 34 permits, respectively. The other general permit categories were

[1]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000*, Volume Three,* Recommended Plan*, February 1979.*

Table 49

SEPARATE SANITARY SEWER OVERFLOW SITES (SSO) AND COMBINED SEWER OVERFLOW SITES (CSO) IN THE GREATER MILWAUKEE WATERSHEDS: 1995-2002

Permit Type	Watershed						
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Total
Separate Sanitary Sewer Overflow Sites	8	36	54	7	15	22	133
Combined Sewer Overflow Sites	26	28	65	- -	- -	2	121

Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 50

PERMITTED WASTEWATER DISCHARGERS UNDER THE WPDES GENERAL PERMIT AND INDIVIDUAL PERMIT PROGRAMS IN THE GREATER MILWAUKEE WATERSHEDS: FEBRUARY 2003

Permit Type	Watershed						
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Total
Carriage/Interstitial Water from Dredging	- -	- -	1	- -	- -	1	2
Concrete Products Operations	1	6	6	- -	5	- -	18
Contaminated Groundwater Remediation Actions	3	17	16	1	3	- -	40
Discharge to Subsurface Absorption System	- -	- -	- -	- -	1	- -	1
Hydrostatic Test Water and Water Supply System	1	12	15	1	8	6	43
Land Applying Food Process Byproduct Solids	- -	- -	- -	- -	1	- -	1
Land Applying Liquid Industrial Wastes	- -	1	1	- -	1	- -	3
Land Applying Sludge	- -	- -	1	- -	1	- -	2
Noncontact Cooling Water	16	67	46	3	6	16	154
Nonmetallic Mining Operations	- -	4	13	- -	2	1	20
Petroleum Contaminated Water	1	10	- -	3	1	1	16
Pit/Trench Dredging	- -	1	2	- -	- -	- -	3
Potable Water Treatment and Conditioning	1	9	3	1	4	2	20
Swimming Pool Facilities	5	11	10	2	3	3	34
Individual Permits	5	10	14	1	5	6	41
Total	33	148	128	12	41	36	398

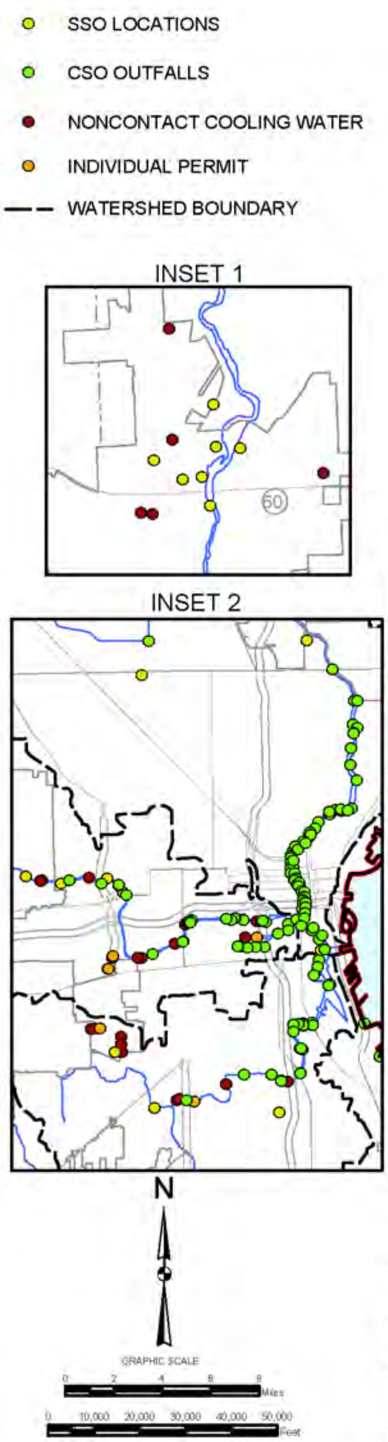
Source: Wisconsin Department of Natural Resources and SEWRPC.

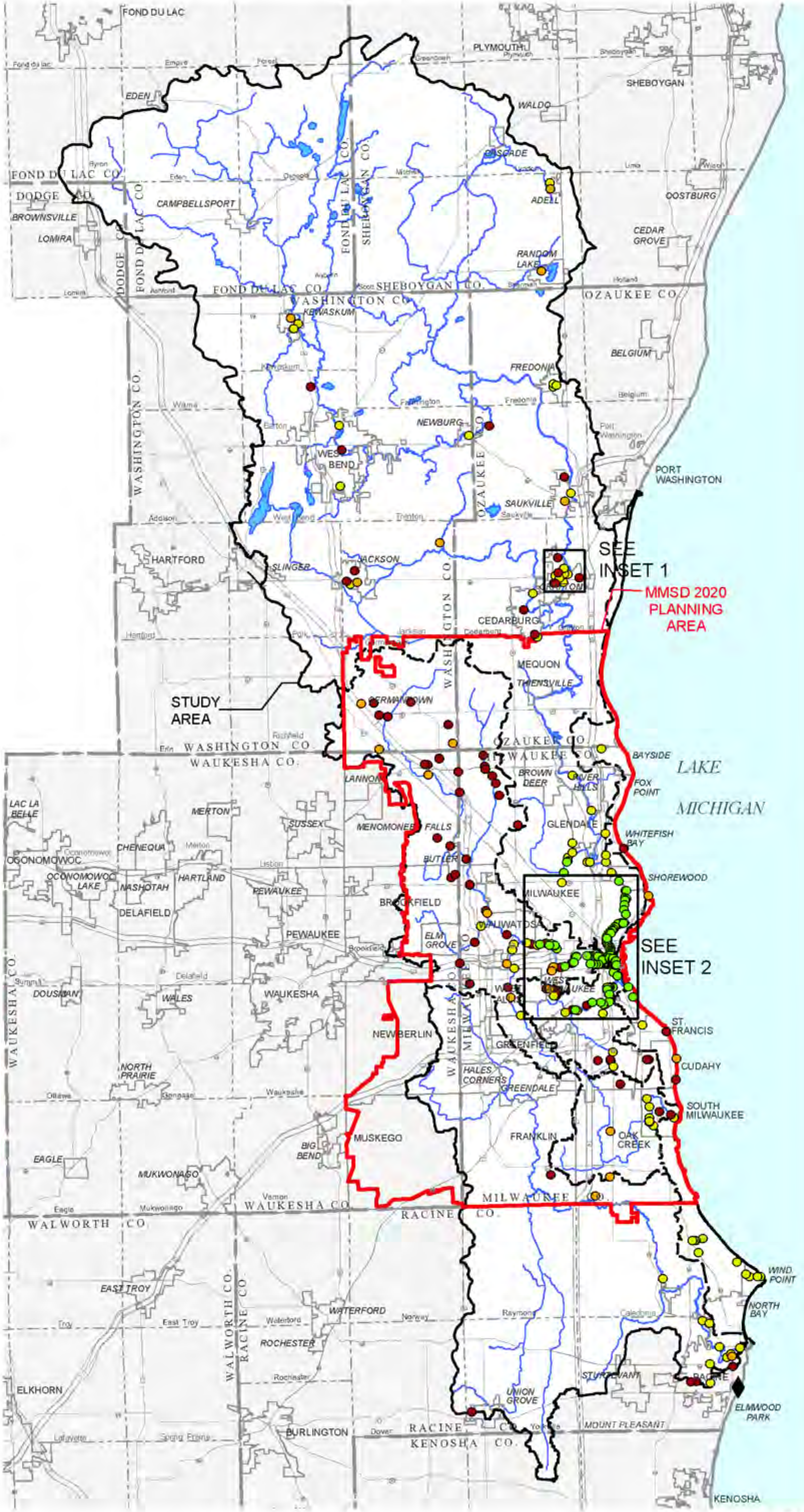
each represented by 20 or fewer facilities. Data from discharge monitoring reports for several facilities covered by individual permits or general permits for noncontact cooling water were included in the water quality model described in Chapter V of this report. These sites are shown on Map 38.

The Menomonee River watershed had the highest number of industrial discharge permits. In February 2003, 148 of these permits were in effect (Table 50). The Milwaukee River and Root River watersheds had the next highest numbers of permits with 128 and 41, respectively in effect in February 2003. The Kinnickinnic River and Oak Creek watersheds and the Lake Michigan direct drainage area had 33, 12, and 36 industrial discharge permits, respectively in effect at that time. In most of the watersheds, the most common category of permit issued was for the discharge of noncontact cooling water. The Oak Creek watershed was the exception to this generalization. In this watershed, the most common categories of permits issued were for the discharge of noncontact cooling water and for the discharge of petroleum contaminated water.

Map 38

MODELED POINT SOURCES OF POLLUTION WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2003





Source: SEWRPC.

More-detailed information on the numbers and types of industrial discharge permits in effect in the greater Milwaukee watersheds in February 2003 is given in SEWRPC Technical Report No. 39.

Due to the dynamic nature of permitted point sources, it is recognized that the number of wastewater sources in the greater Milwaukee watersheds will change as industries and other facilities change locations or processes and as decisions are made with regard to connection of such sources to public sanitary sewer systems.

NONPOINT SOURCE POLLUTION

Urban Stormwater Runoff

Regulation of Urban Nonpoint Source Pollution through the Wisconsin Pollutant Discharge Elimination System Permit Program

Facilities engaged in industrial activities listed in Section NR 216.21(2)(b) of the *Wisconsin Administrative Code* must apply for and obtain a stormwater discharge permit. The WDNR originally developed a three tier system of industrial stormwater permits. Tier 1 permits apply to facilities involved in heavy industry and manufacturing, including facilities involved in lumber and wood product manufacturing, leather tanning, and primary metal industries. Tier 2 permits apply to facilities involved in light industry and manufacturing and transportation facilities, including facilities involved in printing, warehousing, and food processing. Tier 3 permits used to be issued to facilities which have certified, with WDNR concurrence, that they have no discharges of contaminated stormwater. WDNR authority for Tier 3 permits no longer exists and the Tier 3 permits have been terminated. Facilities now submit a certificate of no exposure. In addition, the WDNR also issues separate permits for automobile parts recycling facilities and scrap recycling facilities. Associated with each category of permit are specific requirements for monitoring and inspection. For all categories of permits except Tier 3 industrial permits, the permit requires the facility to develop and follow a stormwater pollution prevention plan (SWPPP). Specific requirements for the SWPPP are listed in Chapter NR 216.27 of the *Wisconsin Administrative Code*. They include provisions related to site mapping, implementation scheduling, conducting annual plan assessments, and monitoring of discharge.

As shown in Table 51, 677 industrial stormwater permits were in effect in the greater Milwaukee watersheds in February 2003. A total of 414 of these were Tier 2 permits, representing slightly over 61 percent of the permitted facilities in the study area. Tier 3 permits were the next most common in the study area. In February 2003, 137 of these were in effect. This was followed by Construction Site permits and Tier 1 Permits. In February 2003, 107 and 59 of these, respectively, were in effect. The number of Automobile Parts Recycling permits and Scrap Recycling permits in effect in the greater Milwaukee watersheds in February 2003 were 36 and 21, respectively.

The Menomonee River watershed had the highest number of industrial stormwater permits. In February 2003, 300 were in effect (Table 51). The Milwaukee River and Root River watersheds had the next highest numbers of permits with 124 and 105, respectively in effect in February 2003. The Kinnickinnic River and Oak Creek watersheds and the Lake Michigan direct drainage area had 84, 27, and 64 industrial stormwater permits, respectively in effect at that time.

More-detailed information on the industrial stormwater permits in effect in the greater Milwaukee watersheds in February 2003 is given in SEWRPC Technical Report No. 39.

The WDNR also issues and administers construction site stormwater permits through the WPDES General Permit program. All construction sites that disturb one acre of land or more are required to obtain coverage under the General Permit. Permitted construction sites are required to implement a construction site erosion control plan, and a post-construction stormwater management plan as required in Chapter NR 216.46 and Chapter NR 216.47 of the *Wisconsin Administrative Code*. Owners of permitted construction sites are also required to conduct inspections of their construction erosion control measures on a weekly basis and within 24 hours of a precipitation event of 0.5 inches or more. Due to the dynamic nature of construction activities, it is recognized that the number of sites requiring Construction Site Storm Water permits in the greater Milwaukee watersheds will change as construction projects are completed and new projects are initiated.

Table 51

WPDES PERMITTED STORMWATER FACILITIES IN THE GREATER MILWAUKEE WATERSHEDS: FEBRUARY 2003

Permit Type	Watershed						
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Total
Industrial Permits							
Storm Water Auto Parts Recycling	5	11	13	2	3	2	36
Storm Water Construction Site	6	34	17	3	44	3	107
Storm Water Industrial Tier 1	10	12	20	2	7	8	59
Storm Water Industrial Tier 2	45	179	14	12	39	28	414
Storm Water Industrial Tier 3	11	56	54	2	11	3	137
Storm Water Scrap Recycling	3	8	6	1	1	2	21
Subtotal	80	300	124	22	105	46	677
Municipal Stormwater Permits	4	7	13	5	9	18	29[a]
Total	84	307	137	27	114	64	706[a]

[a]*The total number of municipal stormwater permits is less than the sum of the permits in the watersheds because several municipalities extend into two or more watersheds.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The WPDES stormwater permits for municipalities within the greater Milwaukee watershed are described below and summarized in Table 52.

Chapter NR 151 of the Wisconsin Administrative Code

Chapter NR 151, “Runoff Management,” of the *Wisconsin Administrative Code* establishes performance standards for the control of nonpoint source pollution from agricultural lands, nonagricultural (urban) lands, and transportation facilities. The standards for urban lands apply to areas of existing development, redevelopment, infill, and construction sites. In general, the construction erosion control, post-construction nonpoint source pollution control, and stormwater infiltration requirements of NR 151 apply to projects with construction activities that disturb at least one acre of land.

The urban standards are applied to activities covered under the WPDES program for stormwater discharges. As noted below, communities with WPDES discharge permits must adopt stormwater management ordinances that have requirements at least as stringent as the standards of Chapter NR 151. Those communities must also achieve levels of control of nonpoint source pollution from areas of existing development (as of October 1, 2004), that are specified under Chapter NR 151.

Stormwater Management Systems

Stormwater management facilities are defined, for the purposes of this report, as conveyance, infiltration, or storage facilities, including, but not limited to, subsurface pipes and appurtenant inlets and outlets, ditches, streams and engineered open channels, detention and retention basins, pumping facilities, infiltration facilities, constructed wetlands for treatment of runoff, and proprietary treatment devices based on settlement processes and control for oil and grease. Such facilities are generally located in urban areas and constructed or improved and operated for purposes of collecting stormwater runoff from tributary drainage areas and conveying, storing, and treating such runoff prior to discharge to natural watercourses. In the larger and more intensively developed urban communities, these facilities consist either of complete, largely piped, stormwater drainage systems which have been planned, designed, and constructed as systems in a manner similar to sanitary sewer and water utility systems, or of fragmented or partially piped systems incorporating open surface channels to as great a degree as possible. In the greater Milwaukee watersheds, the stormwater drainage systems provide the means by which a significant portion of the nonpoint sources pollutants reach the surface water system.

Table 52

STORMWATER MANAGEMENT INFORMATION FOR CITIES, VILLAGES, AND TOWNS WITHIN THE LAKE MICHIGAN DIRECT DRAINAGE AREA

Civil Division	Stormwater Management Ordinance and/or Plan	Construction Erosion Control Ordinance	Stormwater Utility, General Fund, and/or Established Stormwater Fee Program	Obtained WPDES Stormwater Discharge Permit
Dodge County[a]	- -	X	- -	- -
Village of Lomira	- -	- -	- -	- -
Town of Lomira	- -	X[a]	- -	- -
Fond du Lac County[b]	X	X	- -	- -
Village of Campbellsport	- -	X	- -	- -
Village of Eden	- -	- -	- -	- -
Town of Ashford	X[b]	X[b]	- -	- -
Town of Auburn	X[b]	X[b]	- -	- -
Town of Byron	X[b]	X[b]	- -	- -
Town of Eden	X[b]	X[b]	- -	- -
Town of Empire	X[b]	X[b]	- -	- -
Town of Forest	X[b]	X[b]	- -	- -
Town of Osceola	X[b]	X[b]	- -	- -
Kenosha County				
Town of Paris	- -	- -	- -	- -
Milwaukee County				
City of Cudahy	X	X	X	X
City of Franklin	X	X	- -	X
City of Glendale	X	X	X	X
City of Greenfield	X	X	X	X
City of Milwaukee	X	X	X	X
City of Oak Creek	X	X	X	X
City of St. Francis	X	X	X	X
City of South Milwaukee	X	X	- -	X
City of St. Francis	X	X	X	X
City of Wauwatosa	X	X	X	X
City of West Allis	X	X	X	X
Village of Bayside	X	X	- -	X
Village of Brown Deer	X	X	- -	X
Village of Fox Point	X	X	- -	X
Village of Greendale	X	X	X	X
Village of Hales Corners	X	X	- -	X
Village of River Hills	X	X	- -	X
Village of Shorewood	X	X	- -	X
Village of West Milwaukee	- -	X	- -	X
Village of Whitefish Bay	X	X	- -	X
Ozaukee County				
City of Cedarburg	X	X	- -	X
City of Mequon	X	X	- -	X
City of Port Washington	X	X	X	- -
Village of Fredonia	X	X	- -	- -
Village of Grafton	X	X	- -	X
Village of Newburg	- -	X	- -	- -
Village of Saukville	X	X	- -	- -
Village of Thiensville	X	X	- -	X
Town of Cedarburg	- -	- -	- -	- -
Town of Fredonia	- -	- -	- -	- -
Town of Grafton	X	X	- -	X
Town of Port Washington	- -	- -	- -	- -
Town of Saukville	- -	- -	- -	- -

Table 52 (continued)

Civil Division	Stormwater Management Ordinance and/or Plan	Construction Erosion Control Ordinance	Stormwater Utility, General Fund, and/or Established Stormwater Fee Program	Obtained WPDES Stormwater Discharge Permit
Racine County				
City of Racine	X	X	X	X
Village of Caledonia	X	X	X	X
Village of Mt. Pleasant	X	X	- -	X
Village of North Bay	- -	- -	- -	- -
Village of Sturtevant	- -	X	X	- -
Village of Union Grove	X	X	- -	- -
Village of Wind Point	- -	- -	- -	- -
Town of Dover	- -	X	- -	- -
Town of Norway	X	X	- -	- -
Town of Raymond	- -	- -	- -	- -
Town of Yorkville	- -	- -	- -	- -
Sheboygan County				
Village of Adell	- -	- -	- -	- -
Village of Cascade	- -	- -	- -	- -
Village of Random Lake	- -	X	- -	- -
Town of Greenbush	X[c]	X[c]	- -	- -
Town of Holland	X[c]	X[c]	- -	- -
Town of Lyndon	X[c]	X[c]	- -	- -
Town of Mitchell	X[c]	X[c]	- -	- -
Town of Scott	X[c]	X[c]	- -	- -
Town of Sherman	X[c]	X[c]	- -	- -
Washington County				
City of West Bend	X	X	- -	- -
Village of Germantown	X	X	- -	X
Village of Jackson	X	X	- -	- -
Village of Kewaskum	X	X	- -	- -
Village of Newburg	- -	X	- -	- -
Village of Slinger	- -	- -	- -	- -
Town of Addison	X[d]	X[d]	- -	- -
Town of Barton	X[d]	X[d]	- -	- -
Town of Farmington	X[d]	X[d]	- -	- -
Town of Germantown	X[d]	X[d]	- -	- -
Town of Jackson	X[d]	X[d]	- -	- -
Town of Kewaskum	X	X	- -	- -
Town of Polk	X[d]	X[d]	- -	- -
Town of Richfield	X[d]	X[d]	- -	- -
Town of Trenton	X[d]	X[d]	- -	- -
Town of Wayne	X	X	- -	- -
Town of West Bend	X	X	- -	- -
Waukesha County				
City of Brookfield	X	X	- -	X
City of Muskego	X	X	- -	- -
City of New Berlin	X	X	X	X
Village of Butler	X	X	X	X
Village of Elm Grove	X	X	X	X
Village of Menomonee Falls	X	X	- -	- -
Town of Brookfield	X	X	X	- -
Town of Lisbon	X	X	- -	X

[a] *The Town of Lomira is covered under the Dodge County construction erosion control ordinance.*

[b] *All towns are covered under Fond du Lac County's stormwater management and construction erosion control ordinance.*

[c] *All towns are covered under Sheboygan County's stormwater management and construction erosion control ordinance.*

[d] *In the indicated towns, Washington County administers either 1) the county stormwater management and construction erosion control (SWM & CEC) ordinance, or 2) a SWM & CEC ordinance adopted by the town.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

With the relatively recent application of the WPDES permitting program to stormwater discharges and the adoption of local stormwater management ordinances, controls on the quality of stormwater runoff prior to discharge to receiving streams have become more common. Table 52 indicates the status of stormwater management activities in each of the communities in the greater Milwaukee watersheds.

In the Kinnickinnic River watershed, all of the communities have been issued WPDES stormwater discharge permits, including the Cities of Cudahy, Greenfield, Milwaukee, St. Francis, and West Allis and the Village of West Milwaukee.

In the Menomonee River watershed, the Cities of Brookfield, Greenfield, Mequon, Milwaukee, New Berlin, Wauwatosa, and West Allis; the Villages of Butler, Elm Grove, Germantown, Greendale; Menomonee Falls, and West Milwaukee; and the Towns of Brookfield and Lisbon have WPDES stormwater discharge permits Thus, all of the incorporated communities in the watershed and two Towns comprising 98 percent of the watershed area have been issued WPDES stormwater discharge permits.

In the Milwaukee River watershed, the Cities of Cedarburg, Glendale, Mequon, and Milwaukee; the Villages of Bayside, Brown Deer, Fox Point, Grafton, River Hills, Shorewood, Thiensville, and Whitefish Bay; and the Town of Grafton have received WPDES stormwater discharge permits. The remaining communities in the watershed do not currently have stormwater discharge permits. Thus, communities comprising 16 percent of the watershed area have been issued WPDES stormwater discharge permits.

All of the communities in the Oak Creek watershed, including the Cities of Cudahy, Franklin, Greenfield, Milwaukee, Oak Creek, and South Milwaukee have WPDES stormwater discharge permits.

In the Root River watershed, the Cities of Franklin, Greenfield, Milwaukee, New Berlin, Oak Creek, Racine, and West Allis; the Villages of Caledonia, Greendale, Hales Corners, and Mt. Pleasant have WPDES stormwater discharge permits. The City of Muskego; the Villages of Sturtevant and Union Grove; and the Towns of Dover, Norway, Paris, Raymond, and Yorkville do not currently have stormwater discharge permits. Thus, communities comprising 62 percent of the watershed area have been issued WPDES stormwater discharge permits.

In the Lake Michigan direct drainage area, the Cities of Cudahy, Glendale, Mequon, Milwaukee, Oak Creek, Racine, St. Francis, and South Milwaukee; the Villages of Bayside, Caledonia, Fox Point, Mt. Pleasant, River Hills, Shorewood, and Whitefish Bay; and the Town of Grafton have received WPDES stormwater discharge permits. The City of Port Washington submitted an application for coverage under the WPDES stormwater municipal separate storm sewer system general permit in June 2006 and the Village of Wind Point is required to submit an application for coverage under the general permit. The Village of North Bay and the Town of Port Washington do not currently have stormwater discharge permits. Thus, communities comprising 99 percent of the direct drainage area have been issued, or will be issued, WPDES stormwater discharge permits.

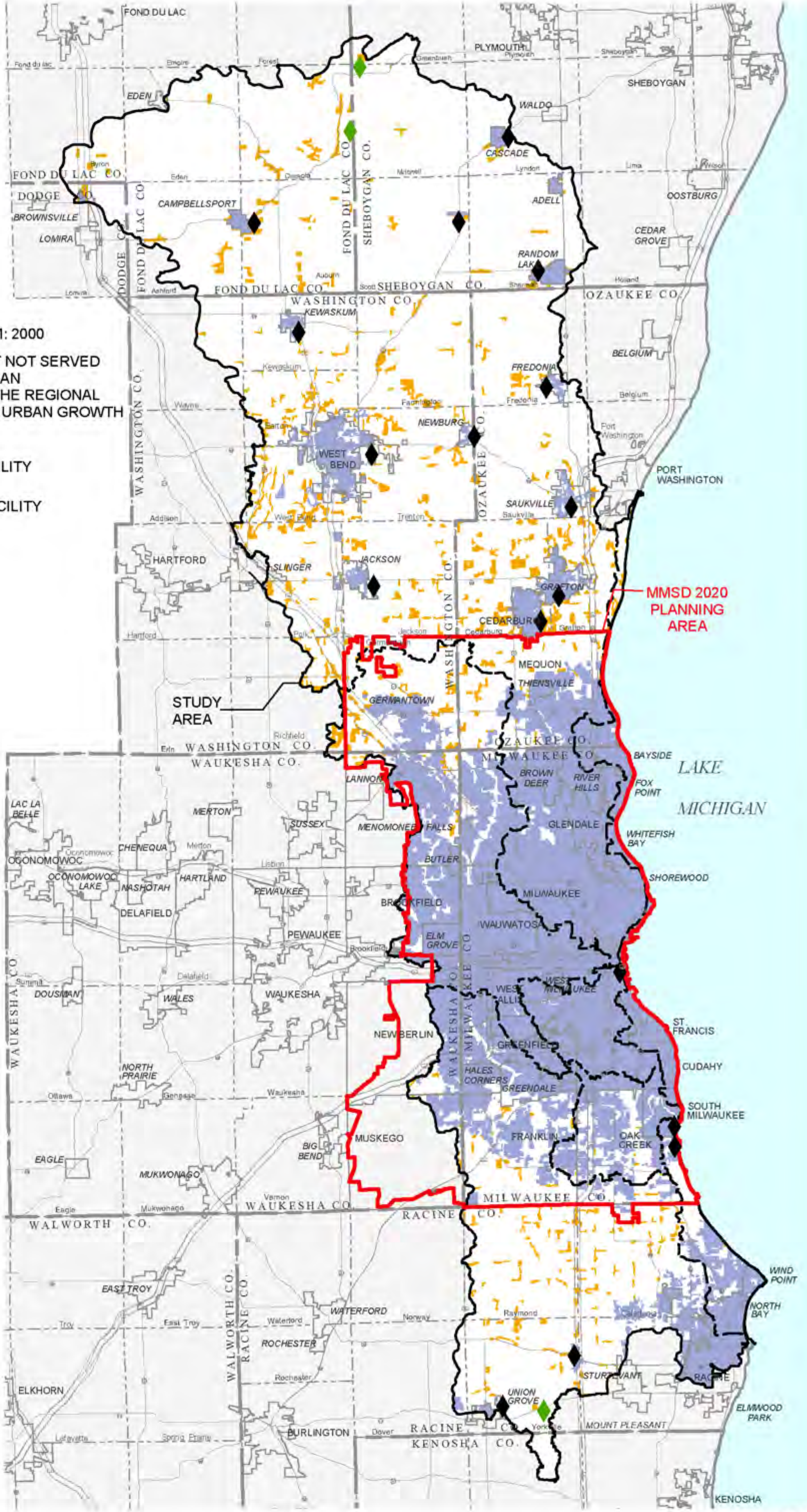
Overall, communities comprising about 42 percent of the area of the greater Milwaukee watersheds have been issued, or will be issued, WPDES stormwater discharge permits. In addition to specific nonpoint source pollution control activities recommended under their WPDES permits, these communities will all be required to develop new, or update existing, stormwater management ordinances to be consistent with the standards of Chapter NR 151 of the *Wisconsin Administrative Code*. As part of their permit application, each community prepared maps of the stormwater outfalls that are part of the municipal separate stormwater system.

Urban Enclaves Outside Planned Sewer Service Areas

Map 39 shows areas served by centralized sanitary sewer service areas in the greater Milwaukee watersheds in 2000. In that year, 190,664 acres of the watersheds were served by sanitary sewer systems. In addition, there were about 25,242 acres of urban-density enclaves that were not served by public sanitary sewer systems. As shown on Map 40, about 17,354 acres of these enclaves are in areas served by onsite sewage disposal systems that were developed prior to 1980. These older systems may be at particular risk for malfunctioning. As described in

Map 39

AREAS SERVED BY CENTRALIZED SANITARY SEWERAGE SYSTEMS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000



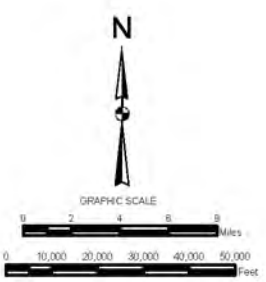
AREA SERVED BY CENTRALIZED SEWERAGE SYSTEM: 2000

EXTENT OF URBAN DEVELOPMENT NOT SERVED BY PUBLIC SEWER: INCLUDES URBAN DEVELOPMENT AS IDENTIFIED IN THE REGIONAL PLANNING COMMISSION HISTORIC URBAN GROWTH RING ANALYSIS

PUBLIC SEWAGE TREATMENT FACILITY

PRIVATE SEWAGE TREATMENT FACILITY

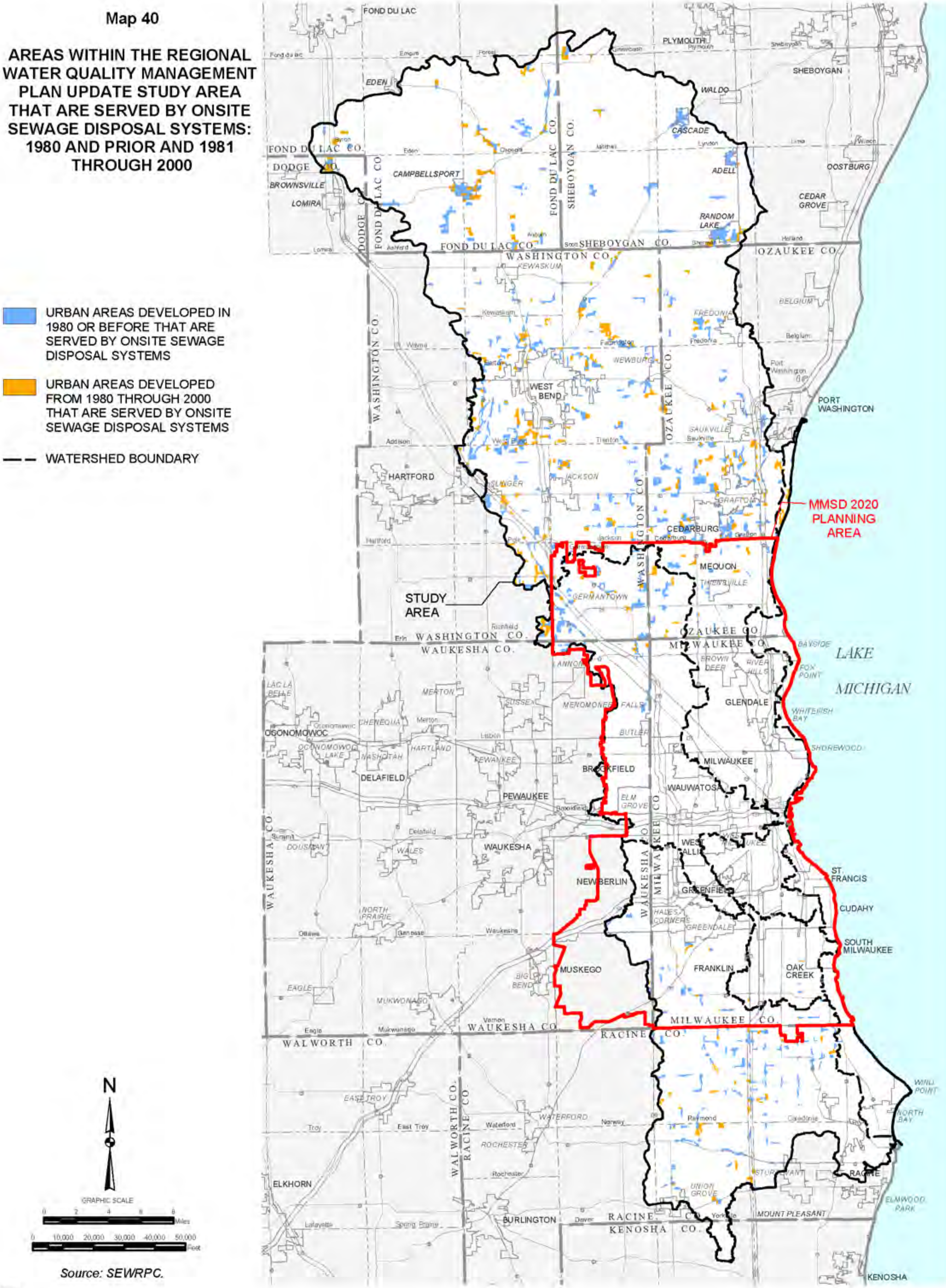
WATERSHED BOUNDARY



Source: SEWRPC.

Map 40

AREAS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA THAT ARE SERVED BY ONSITE SEWAGE DISPOSAL SYSTEMS: 1980 AND PRIOR AND 1981 THROUGH 2000



Source: SEWRPC.

Chapter II of SEWRPC Technical Report No. 39, failure of onsite sewage disposal systems can contribute nonpoint source pollutants to streams and groundwater.

Solid Waste Disposal Sites

Solid waste disposal sites are a potential source of surface water, as well as groundwater, pollution. It is important to recognize, however, the distinction between a properly designed and constructed sanitary landfill and the variety of operations that are referred to as refuse dumps, especially with respect to potential effects on water quality. A solid waste disposal site may be defined as any land area used for the deposit of solid wastes regardless of the method of operation, or whether a subsurface excavation is involved. A sanitary landfill may be defined as a solid waste disposal site which is carefully located, designed, and operated to avoid hazards to public health or safety, or contamination of ground water or surface waters. The proper design of sanitary landfills requires careful engineering to confine the refuse to the smallest practicable area, to reduce the refuse mass to the smallest practicable volume, to avoid surface water runoff, to minimize leachate production and percolation into the groundwater and surface waters, and to seal the surface with a layer of earth at the conclusion of each day's activities or at more frequent intervals as necessary.

In order for a landfill to produce leachate, there must be some source of water moving through the fill material. Possible sources of water include precipitation, the moisture content of the refuse itself, surface water infiltration, groundwater migrating into the fill from adjacent land areas, or groundwater rising from below to come in contact with the fill. In any event, leachate is not released from a landfill until a significant portion of the fill material exceeds its saturation capacity. If external sources of water are excluded from the sanitary landfill, the production of leachates in a well-designed and -managed landfill can be effectively minimized, if not entirely avoided. The quantity of leachate produced will depend upon the quantity of water that enters the solid waste fill site minus the quantity that is removed by evapotranspiration. Studies have estimated that for a typical landfill, from 20 to 50 percent of the rainfall infiltrated into the solid waste may be expected to become leachate. Accordingly, a total annual rainfall of about 32 inches, which is about the average rainfall reported for the period 1950 to 2003 for five meteorological stations located in or near the greater Milwaukee watersheds, could produce from 170,000 to 440,000 gallons of leachates per year per acre of landfill if the facility is not properly located, designed, and operated.

Table 53 shows that as of 2005, there were six active solid waste disposal sites in the greater Milwaukee watersheds. Two of these were located in the Milwaukee River watershed and one each in the Menomonee River, Oak Creek, and Root River watersheds and the Lake Michigan direct drainage area. In addition, there are 78 known inactive solid waste disposal sites. The locations of active and inactive solid waste disposal sites are shown on Map 41. Additional information on solid waste disposal sites in the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

Rural Stormwater Runoff

Rural land uses in the greater Milwaukee watersheds include agricultural—both livestock operations and crop production—and woodlands, wetlands, water, and other open lands as set forth in Chapter II of this report. As noted above, Chapter NR 151 of the *Wisconsin Administrative Code* establishes performance standards for the control of nonpoint source pollution from agricultural lands, nonagricultural (urban) lands, and transportation facilities. Agricultural performance standards are established for soil erosion, manure storage facilities, clean water diversions, nutrient management, and manure management. Those standards must only be met to the degree that grant funds are available to implement projects designed to meet the standards.

Most of the watersheds comprising the greater Milwaukee watersheds contain rural land uses. The Kinnickinnic River watershed is an exception to this. There are no significant rural lands within the Kinnickinnic River watershed.

Livestock Operations

The presence of livestock and poultry manure in the environment is an inevitable result of animal husbandry and is a major potential source of water pollutants. Animal manure composed of feces, urine, and sometimes bedding

Table 53

NUMBER OF ACTIVE AND INACTIVE SOLID WASTE DISPOSAL SITES IN THE GREATER MILWAUKEE WATERSHEDS: 2005

Type	Watershed						
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan Direct Drainage Area	Total
Active	0	1	2	1	1	1	6
Inactive	1	7	47	7	13	3	78
Total	1	8	49	8	14	4	84

Source: Wisconsin Department of Natural Resources and SEWRPC.

material, contributes suspended solids, nutrients, oxygen-demanding substances, bacteria, and viruses to surface waters. Animal waste constituents of pastureland and barnyard runoff, and animal wastes deposited on pastureland and cropland and in barnyards, feedlots, and manure piles, can potentially contaminate water by surface runoff, infiltration to groundwater, and volatilization to the atmosphere. During the warmer seasons of the year the manure is often scattered on cropland and pastureland where the waste material is likely to be taken up by vegetative growth composing the land cover. However, when the animal manure is applied to the land surface during the winter, the animal wastes are subject to excessive runoff and transport, especially during the spring snowmelt period.

Major livestock operations are not common in the greater Milwaukee watersheds. Within this study area, there are six farm operations with more than 1,000 animal units. Five of these are in the Milwaukee River watershed and one is in the Root River watershed. Numerous smaller operations raise a number of different animals including dairy and beef cattle, pigs, sheep, and poultry. The largest numbers of these operations are in the portions of the Milwaukee River watershed in Fond du Lac and Sheboygan Counties.

More-detailed information on livestock operations in the greater Milwaukee watersheds in is given in SEWRPC Technical Report No. 39.

Crop Production

Runoff from cropland can have an adverse effect upon water quality in waterbodies of the greater Milwaukee watersheds by contributing excessive sediments, nutrients and organic matter, including pesticides to streams. Negative effects associated with soil erosion and transport to waterbodies includes reduced water clarity, sedimentation on streambeds, and contamination of the water from various agricultural chemicals and nutrients that are attached to the individual soil particles. Some of these nutrients, in particular phosphorus, and to some extent nitrogen, are directly associated with eutrophication of water resources. The extent of the water pollution from cropping practices varies considerably as a result of the soils, slopes, and crops, as well as in the numerous methods of tillage, planting, fertilization, chemical treatment, and conservation practices. Conventional tillage practices, or moldboard plowing, involve turning over the soil completely, leaving the soil surface bare of most cover or residue from the previous year's crop, and making it highly susceptible to erosion due to wind and rain. The use of conservation tillage practices has become common in the greater Milwaukee watersheds in recent years within the areas most susceptible to erosion and surface water impacts.

Crops grown in the greater Milwaukee watersheds include row crops, such as corn and soybeans; small grains, such as winter wheat and oats; hay, such as alfalfa and clover; and vegetables, such as cabbages, snap peas, and sweet corn. Row and vegetable crops, which have a relatively higher level of exposed soil surface, tend to contribute higher pollutant loads than do hay and pastureland, which support greater levels of vegetative cover. Crop rotations typically follow a two- or three-year sequence of corn and soybeans and occasionally winter wheat in the third year; however, hay is periodically included as part of a long-term rotation of corn, oats, and alfalfa.

Map 41

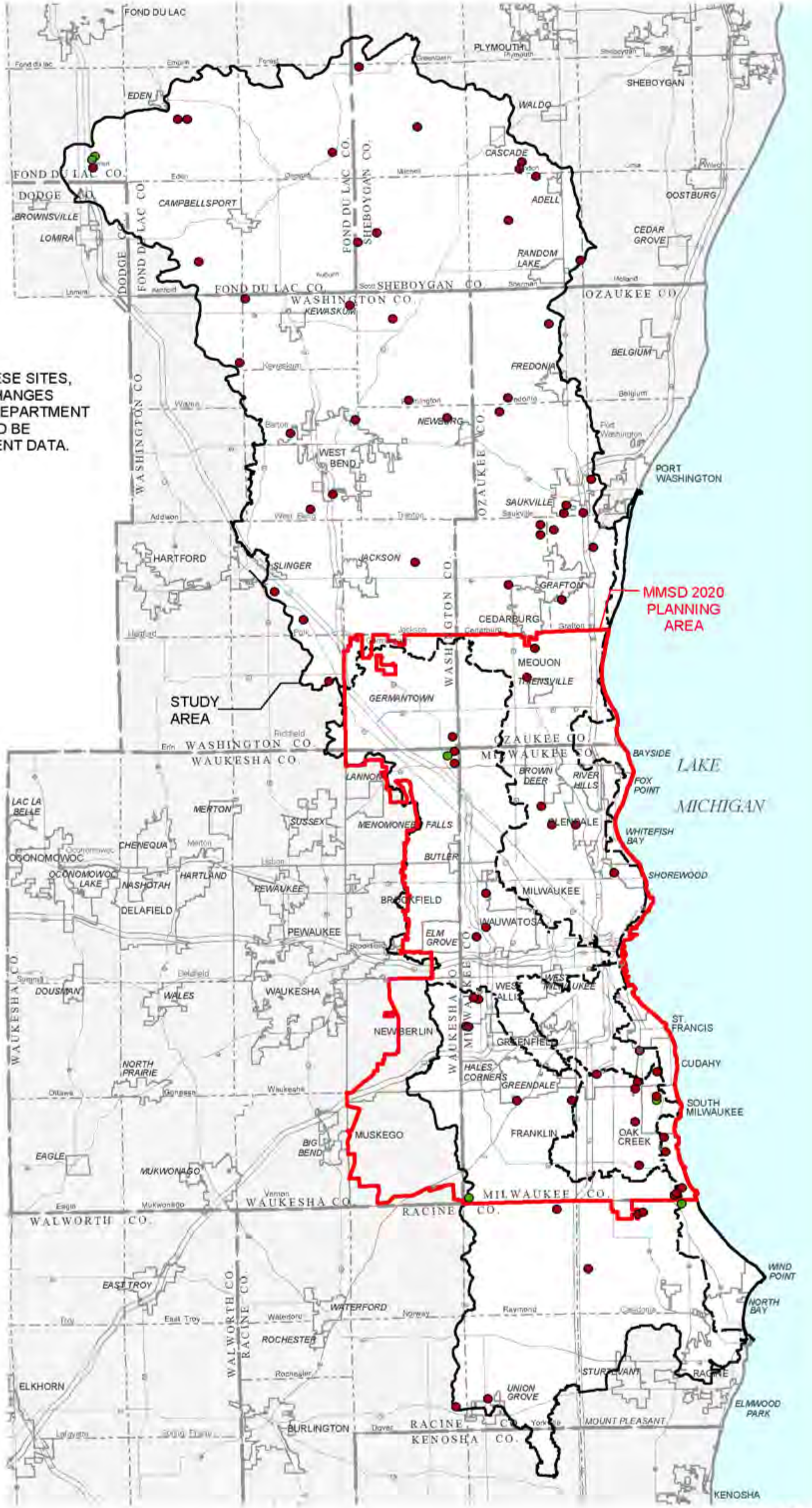
ACTIVE AND INACTIVE SOLID WASTE DISPOSAL SITES WITHIN AND ADJACENT TO THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2005

ACTIVE SITE

INACTIVE SITE

WATERSHED BOUNDARY

NOTE: BECAUSE OF THE NATURE OF THESE SITES, THE INVENTORY INFORMATION CHANGES PERIODICALLY. THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES SHOULD BE CONTACTED FOR THE MOST RECENT DATA.



N

GRAPHIC SCALE

Source: Wisconsin Department of Natural Resources and SEWRPC.

Since the early 1930s, it has been a national objective to preserve and protect agricultural soil from wind and water erosion. Federal programs have been developed to achieve this objective, with the primary emphasis being on sound land management and cropping practices for soil conservation. An incidental benefit of these programs has been a reduction in the amount of eroded organic and inorganic materials entering surface waters as sediment or attached to sediment. Some practices are effective in both regards, while others may enhance the soil conditions with little benefit to surface water quality. Despite the implementation of certain practices aimed at controlling soil erosion from agricultural land, and development of soil erosion plans and/or land water resource management plans for Kenosha,[2] Milwaukee,[3] Ozaukee,[4] Racine,[5] Washington,[6] and Waukesha[7] Counties, such erosion and the resultant deposition of sediment in streams of the greater Milwaukee watersheds remains a problem.

Nutrients such as phosphorus and agri-chemicals, including herbicides and pesticides, are electrostatically attracted to silt sized particles and are transported to surface waters through soil erosion. As previously mentioned, phosphorus is one of the primary nutrients associated with eutrophication of water resources, and agri-chemicals can negatively impact the life cycles of aquatic organisms. In the eutrophication process, phosphorus enhances growth of aquatic vegetation and algae, which has the effect of accelerating the aging process of a water resource. Phosphorus is not usually susceptible to downward movement through the soil profile; instead, the majority of phosphorus reaches water resources by overland flow, or erosion. Nitrogen also is a nutrient that contributes to eutrophication; however, it is most often associated with subsurface water quality contamination. Nitrogen in the form of nitrate can be associated with respiration problems in newborn infants. Nitrogen is susceptible to downward movement through the soil profile; however, due to the nature of soils in the watershed, nitrogen is not a significant threat due to various chemical reactions that occur in the soil.[8]

Woodlands

A well-managed woodland contributes few pollutants to surface waters. Under poor management, however, woodlands may have detrimental water quality effects through release of sediments, nutrients, organic matter, and pesticides into nearby surface waters. If trees along streams are cut, thermal pollution may occur as the direct rays of the sun strike the water. Disturbances caused by tree harvesting, livestock grazing, tree growth promotion, tree disease prevention, fire prevention, and road and trail construction are a major source of pollution from silvicultural activities. Most of these activities are seldom practiced in the greater Milwaukee watersheds.

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[2]*SEWRPC Community Assistance Planning Report No. 164,* Kenosha County Agricultural Soil Erosion Control Plan, *April 1989.*

[3]*Milwaukee County Land Conservation Committee,* Milwaukee County Land and Water Resource Management Plan, *April 2001.*

[4]*SEWRPC Community Assistance Planning Report No. 171,* Ozaukee County Agricultural Soil Erosion Control Plan, *February 1989.*

[5]*SEWRPC Community Assistance Planning Report No. 160,* Racine County Agricultural Soil Erosion Control Plan, *July 1988.*

[6]*SEWRPC Community Assistance Planning Report No. 170,* Washington County Agricultural Soil Erosion Control Plan, *March 1989.*

[7]*SEWRPC Community Assistance Planning Report No. 159,* Waukesha County Agricultural Soil Erosion Control Plan, *June 1988.*

[8]*Soils that have a high clay content and stay wet for long periods of time, or even well-drained soils after a rainfall event, are susceptible to nitrogen losses to the atmosphere through a chemical reaction known as denitrification. This reaction converts nitrate, NO_3^-, to gaseous nitrogen, N_2, which is lost to the atmosphere.*

Annual Pollutant Loadings

Annual average pollutant loadings to the greater Milwaukee watersheds are summarized in Tables 54 through 59. These estimates represent point and nonpoint source loads delivered to the modeled stream reaches, after accounting for any trapping factors that would retain pollutants on the surface of the land. They include loads from groundwater. It is important to note that the stream channel pollutant loads may be expected to be different from the actual transport from the watersheds, because physical, chemical, and biological processes may retain or remove pollutants or change their form during transport over the land surface or within the stream system. These processes include particle deposition or entrapment on the land surface or in floodplains, stream channel deposition or aggradation, biological uptake, and chemical transformation and precipitation. The total pollutant loads summarized in Tables 54 through 59 are representative of potential pollutants moved from the greater Milwaukee watersheds into stream channels, but are not intended to reflect the total amounts of pollutants moving from those sources through the entire hydrologic-hydraulic system.

It is important to note that when average annual pollutant loadings are examined at the scale of the study area, the largest single source of contributions of total phosphorus, total nitrogen, BOD, and copper are the sewage treatment plants located in the Lake Michigan direct drainage area which discharge directly to Lake Michigan, or indirectly to the Lake through the Milwaukee outer harbor. Depending on the pollutant, these account for about 42 to 68 percent of estimated average annual contributions of these four pollutants to the greater Milwaukee watersheds. In addition, while the contribution of total suspended solids (TSS) from these sewage treatment plants represents a small fraction of the total average annual loading of TSS to the greater Milwaukee watersheds, it represents about 88 percent of the loadings from point sources. Because the high proportion of contributions represented by this source and the lower proportions represented by other pollutions sources in the Lake Michigan direct drainage area are not representative of the mix of contributions from pollution sources in the other watersheds. Tables 54 through 59 also present subtotals of pollutant loadings to both the entire riverine system of the greater Milwaukee watersheds and to those three Rivers—the Kinnickinnic River, the Menomonee River, and the Milwaukee River—that discharge into the Milwaukee outer harbor. In general the fraction of the average annual loadings represented by each category of point source to the total loadings to the three Rivers discharging to the harbor do not differ greatly from the fractions of average annual loadings represented by each category of point source to the total loadings to the entire riverine system.

More-detailed information on estimated annual pollutant loadings in the greater Milwaukee watersheds is set forth in SEWRPC Technical Report No. 39.

Point Source Loadings

Average annual total point source loads for six pollutants in the greater Milwaukee watersheds are summarized in Tables 54 through 59. In most of the watersheds, contributions of most of these pollutants by point sources represent a minor portion of the combined total average loads from point and nonpoint sources, generally about 25 percent or less, except for total phosphorus loads in the Menomonee River and Milwaukee River watersheds, in which point sources account for 38 and 54 percent, respectively, of the total loads and fecal coliform bacteria loads in the Kinnickinnic River watershed, in which point sources account for about 31 percent of the total load. In the Lake Michigan direct drainage area, point sources account for much higher fractions of the combined total average loads from point and nonpoint sources, generally about 94 percent or more, except for the TSS load, which is split evenly between point and nonpoint sources and the fecal coliform bacteria load, of which point sources represent about one third. The higher point source loads in the Lake Michigan direct drainage area reflect the presence of three public sewage treatment plants in the area which discharge effluent to Lake Michigan, either directly or indirectly via the Milwaukee outer harbor.

Average annual total point source loads of total phosphorus in the greater Milwaukee watersheds are summarized in Table 54. The total average annual point source load of total phosphorus is about 491,040 pounds. Sewage treatment plants and industrial dischargers account for about three-fourths and one-fourth, respectively, of the contributions of total phosphorus from point sources with much smaller contributions from combined sewer overflows and separate sanitary sewer overflows. The total average annual point source load of total phosphorus to the riverine system of the greater Milwaukee watersheds only is about 174,290 pounds. Industrial dischargers

Table 54

AVERAGE ANNUAL LOADS OF TOTAL PHOSPHORUS IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources: Industrial Point Sources (pounds)	Point Sources: SSOs (pounds)	Point Sources: CSOs (pounds)	Point Sources: Sewage Treatment Plants (pounds)	Point Sources: Subtotal (pounds)	Nonpoint Sources: Urban (pounds)	Nonpoint Sources: Rural (pounds)	Nonpoint Sources: Subtotal (pounds)	Total (pounds)
Kinnickinnic River	1,440	890	490	- -	2,820	9,860	70	9,930	12,750
Menomonee River	17,550	580	1,880	- -	20,010	29,040	4,070	33,110	53,120
Milwaukee River	93,840	780	1,790	51,740	148,150	45,290	81,060	126,350	274,500
Subtotal from Rivers to Harbor	112,830	2,250	4,160	51,740	170,980	84,190	85,200	169,390	340,370
Percent of Load from Rivers to Harbor	33.1	0.7	1.2	15.2	50.2	24.8	25.0	49.8	100.0
Oak Creek	10	10	- -	- -	20	8,500	2,110	10,610	10,630
Root River	130	10	- -	3,150	3,290	26,510	54,260	80,770	84,060
Riverine Subtotal	112,970	2,270	4,160	54,890	174,290	119,200	141,570	260,770	435,060
Percent of Riverine Load	26.0	0.5	1.0	12.6	40.1	27.4	32.5	59.9	100.0
Lake Michigan Direct Drainage Area	- -	40	160	316,550	316,750	13,180	2,240	15,420	332,170
Total	112,970	2,310	4,320	371,440	491,040	132,380	143,810	276,190	767,230
Percent of Total Load	14.7	0.3	0.6	48.4	64.0	17.3	18.7	36.0	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Table 55

AVERAGE ANNUAL LOADS OF TOTAL SUSPENDED SOLIDS IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources: Industrial Point Sources (pounds)	Point Sources: SSOs (pounds)	Point Sources: CSOs (pounds)	Point Sources: Sewage Treatment Plants (pounds)	Point Sources: Subtotal (pounds)	Nonpoint Sources: Urban (pounds)	Nonpoint Sources: Rural (pounds)	Nonpoint Sources: Subtotal (pounds)	Total (pounds)
Kinnickinnic River	12,410	51,270	42,810	- -	106,490	5,162,520	29,760	5,192,280	5,298,770
Menomonee River	58,740	33,590	182,960	- -	275,290	15,738,270	1,950,230	17,688,500	17,963,790
Milwaukee River	454,000	24,000	143,650	294,000	915,650	17,708,000	39,760,000	57,468,000	58,383,650
Subtotal from Rivers to Harbor	525,150	108,860	369,420	294,000	1,297,430	38,608,790	41,739,990	80,348,780	81,646,210
Percent of Load from Rivers to Harbor	0.6	0.1	0.5	0.4	1.6	47.3	51.1	98.4	100.0
Oak Creek	1,930	500	- -	- -	2,430	4,414,270	888,310	5,302,580	5,305,010
Root River	480	1,030	- -	10,400	11,910	8,987,470	74,772,050	83,759,520	83,771,430
Riverine Subtotal	527,560	110,390	369,420	304,400	1,311,770	52,010,530	117,400,350	169,410,880	170,722,650
Percent of Riverine Load	0.3	0.1	0.2	0.2	0.8	30.4	68.8	99.2	100.0
Lake Michigan Direct Drainage Area	- -	1,600	16,040	6,926,460	6,944,100	5,541,730	1,227,220	6,768,950	13,713,050
Total	527,560	111,990	385,460	7,230,860	8,255,870	57,552,260	118,627,570	176,179,830	184,435,700
Percent of Total Load	0.3	<0.1	0.2	3.9	4.5	31.2	64.3	95.5	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Table 56

AVERAGE ANNUAL LOADS OF FECAL COLIFORM BACTERIA IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources					Nonpoint Sources			Total (trillions of cells)
	Industrial Point Sources (trillions of cells)	SSOs (trillions of cells)	CSOs (trillions of cells)	Sewage Treatment Plants (trillions of cells)	Subtotal (trillions of cells)	Urban (trillions of cells)	Rural (trillions of cells)	Subtotal (trillions of cells)	
Kinnickinnic River	0.00	978.06	554.79	- -	1,532.85	3,358.20	0.31	3,358.51	4,891.36
Menomonee River	0.00	640.82	1,727.39	- -	2,368.21	14,111.84	393.11	14,504.95	16,873.16
Milwaukee River	12.11	429.04	1,878.91	41.54	2,361.60	24,098.90	14,366.16	38,465.06	40,826.66
Subtotal from Rivers to Harbor	12.11	2,047.92	4,161.09	41.54	6,262.66	41,568.94	14,759.58	56,328.52	62,591.18
Percent of Load from Rivers to Harbor	<0.1	3.3	6.6	<0.1	10.0	66.4	23.6	90.0	100.0
Oak Creek	0.00	9.55	- -	- -	9.55	2,602.87	179.69	2,782.56	2,792.11
Root River	0.00	19.65	- -	3.29	22.94	9,213.70	2,543.51	11,757.21	11,780.15
Riverine Subtotal	12.11	2,077.12	4,161.09	44.83	6,295.15	53,385.51	17,482.78	70,868.29	77,163.44
Percent of Riverine Load	<0.1	2.7	5.4	<0.1	8.2	69.2	22.6	91.8	100.0
Lake Michigan Direct Drainage Area................	- -	33.82	132.23	2,043.01	2,209.06	3,907.44	155.13	4,062.57	6,272
Total	12.11	2,110.94	4,293.32	2,087.84	8,504.21	57,292.95	17,637.91	74,930.86	83,435.07
Percent of Total Load	<0.1	2.5	5.1	2.5	10.2	68.7	21.1	89.8	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Table 57

AVERAGE ANNUAL LOADS OF TOTAL NITROGEN IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources					Nonpoint Sources			Total (pounds)
	Industrial Point Sources (pounds)	SSOs (pounds)	CSOs (pounds)	Sewage Treatment Plants (pounds)	Subtotal (pounds)	Urban (pounds)	Rural (pounds)	Subtotal (pounds)	
Kinnickinnic River	6,730	1,870	2,290	- -	10,890	61,870	1,370	63,240	74,130
Menomonee River	55,650	1,230	11,610	- -	68,490	209,340	118,410	327,750	396,240
Milwaukee River	75,530	3,280	17,910	123,210	219,930	227,480	1,733,700	1,961,180	2,181,110
Subtotal from Rivers to Harbor	137,910	6,380	31,810	123,210	299,310	498,690	1,853,480	2,352,170	2,651,480
Percent of Load from Rivers to Harbor	5.2	0.2	1.2	4.6	11.3	18.8	69.9	88.7	100.0
Oak Creek	340	20	- -	- -	360	60,650	36,100	96,750	97,110
Root River	540	40	- -	26,520	27,100	162,160	953,910	1,116,070	1,143,170
Riverine Subtotal	138,790	6,440	31,810	149,730	326,770	721,500	2,843,490	3,564,990	3,891,760
Percent of Riverine Load	3.6	0.2	0.8	3.8	8.4	18.5	73.1	91.6	100.0
Lake Michigan Direct Drainage Area................	- -	80	1,120	8,261,880	8,263,080	87,380	38,010	125,390	8,388,470
Total	138,790	6,520	32,930	8,411,610	8,589,850	808,880	2,881,500	3,690,380	12,280,230
Percent of Total Load	1.1	<0.1	0.3	68.5	69.9	6.6	23.5	30.1	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Table 58

AVERAGE ANNUAL LOADS OF BIOCHEMICAL OXYGEN DEMAND IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources: Industrial Point Sources (pounds)	Point Sources: SSOs (pounds)	Point Sources: CSOs (pounds)	Point Sources: Sewage Treatment Plants (pounds)	Point Sources: Subtotal (pounds)	Nonpoint Sources: Urban (pounds)	Nonpoint Sources: Rural (pounds)	Nonpoint Sources: Subtotal (pounds)	Total (pounds)
Kinnickinnic River	15,850	12,620	6,880	- -	35,350	369,940	3,210	373,150	408,500
Menomonee River	116,510	8,270	58,680	- -	183,460	993,390	175,850	1,169,240	1,352,700
Milwaukee River	290,450	5,540	23,270	399,810	719,070	1,303,560	3,210,530	4,514,090	5,233,160
Subtotal from Rivers to Harbor	422,810	26,430	88,830	399,810	937,880	2,666,890	3,389,590	6,056,480	6,994,360
Percent of Load from Rivers to Harbor	6.0	0.4	1.3	5.7	13.4	38.1	48.5	86.6	100.0
Oak Creek	3,440	120	- -	- -	3,560	237,740	61,160	298,900	302,460
Root River	830	260	- -	13,020	14,110	734,810	2,509,700	3,244,510	3,258,620
Riverine Subtotal	427,080	26,810	88,830	412,830	955,550	3,639,440	5,960,450	9,599,890	10,555,440
Percent of Riverine Load	4.0	0.3	0.8	3.9	9.1	34.5	56.5	90.9	100.0
Lake Michigan Direct Drainage Area................	- -	440	2,980	7,380,790	7,384,210	333,860	63,900	397,760	7,781,970
Total	427,080	27,250	91,810	7,793,620	8,339,760	3,973,300	6,024,350	9,997,650	18,337,410
Percent of Total Load	2.3	0.1	0.5	42.5	45.5	21.7	32.9	54.5	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Table 59

AVERAGE ANNUAL LOADS OF COPPER IN THE GREATER MILWAUKEE WATERSHEDS[a]

Watershed	Point Sources: Industrial Point Sources (pounds)	Point Sources: SSOs (pounds)	Point Sources: CSOs (pounds)	Point Sources: Sewage Treatment Plants (pounds)	Point Sources: Subtotal (pounds)	Nonpoint Sources: Urban (pounds)	Nonpoint Sources: Rural (pounds)	Nonpoint Sources: Subtotal (pounds)	Total (pounds)
Kinnickinnic River	7	8	15	- -	30	525	1	526	556
Menomonee River	4	5	48	- -	57	1,768	106	1,874	1,931
Milwaukee River	0	3	52	634	689	2,305	1,352	3,657	4,346
Subtotal from Rivers to Harbor	11	16	115	634	776	4,598	1,459	6,057	6,833
Percent of Load from Rivers to Harbor	0.2	0.2	1.7	9.3	11.4	67.3	21.3	88.6	100.0
Oak Creek	0	<1	- -	- -	0	445	52	497	497
Root River	3	<1	- -	40	43	1,348	548	1,896	1,939
Riverine Subtotal	14	16	115	674	819	6,391	2,059	8,450	9,269
Percent of Riverine Load	0.1	0.2	1.2	7.3	8.8	69.0	22.2	91.2	100.0
Lake Michigan Direct Drainage Area................	- -	<1	4	10,445	10,449	622	48	670	11,119
Total	14	16	119	11,119	11,268	7,013	2,107	9,120	20,388
Percent of Total Load	0.1	0.1	0.6	54.5	55.3	34.4	10.3	44.7	100.0

[a]Loads from groundwater are included. The results are annual averages based on simulation of year 2000 land use conditions and approximated current point source loads and wastewater conveyance, storage, and treatment system operating conditions. The simulations were made using meteorological data from 1988 through 1997, which is a representative rainfall period for the study area.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

and sewage treatment plants account for about 65 percent and 31 percent, respectively, of the contributions of total phosphorus from point sources to the riverine system with much smaller contributions from combined sewer overflows and separate sanitary sewer overflows.

Average annual total point source loads of total suspended solids in the greater Milwaukee watersheds are summarized in Table 55. The total average annual point source load of TSS is about 8,255,870 pounds. Sewage treatment plants account for most of the contributions of TSS from point sources with smaller contributions from combined sewer overflows, industrial dischargers, and separate sanitary sewer overflows. The total average annual point source load of TSS to the riverine system of the greater Milwaukee watersheds only is about 1,311,770 pounds. Industrial dischargers, combined sewer overflows, and sewage treatment plants account for about 40 percent, 28 percent and 23 percent, respectively, of the contributions of TSS from point sources to the riverine system with separate sanitary sewer overflows making up the remaining 9 percent.

Average annual total point source loads of fecal coliform bacteria in the greater Milwaukee watersheds are summarized in Table 56. The total average annual point source load of fecal coliform bacteria is about 8,504 trillion cells. Combined sewer overflows account for about half of the contributions of fecal coliform bacteria from point sources with substantial contributions from sewage treatment plants and separate sanitary sewer overflows. Industrial dischargers account for a small portion of contributions. The total average annual point source load of fecal coliform bacteria to the riverine system of the greater Milwaukee watersheds only is about 6,295 trillion cells. Combined sewer overflows and separate sanitary sewer overflow account for about 66 percent and 33 percent, respectively, of the contributions of fecal coliform bacteria from point sources to the riverine system with much smaller contributions from sewage treatment plants and industrial dischargers.

Average annual total point source loads of total nitrogen in the greater Milwaukee watersheds are summarized in Table 57. The total average annual point source load of total nitrogen is about 8,590,000 pounds. Sewage treatment plants account for 98 percent of the contributions of total nitrogen from point sources with much smaller contributions from industrial dischargers, combined sewer overflows, and separate sanitary sewer overflows. The total average annual point source load of total nitrogen to the riverine system of the greater Milwaukee watersheds only is about 326,800 pounds. Sewage treatment plants and industrial dischargers account for about 46 percent and 42 percent, respectively, of the contributions of total nitrogen from point sources to the riverine system with much smaller contributions from combined sewer overflows and separate sanitary sewer overflows.

Average annual total point source loads of biochemical oxygen demand (BOD) in the greater Milwaukee watersheds are summarized in Table 58. The total average annual point source load of BOD is about 8,339,800 pounds. Sewage treatment plants account for about 93 percent of the contributions of BOD from point sources with much smaller contributions from combined sewer overflows, industrial dischargers, and separate sanitary sewer overflows. The total average annual point source load of BOD to the riverine system of the greater Milwaukee watersheds only is about 955,600 pounds. Industrial dischargers and sewage treatment plants account for about 45 percent and 43 percent, respectively, of the contributions of BOD from point sources to the riverine system with much smaller contributions from combined sewer overflows and separate sanitary sewer overflows.

Average annual total point source loads of copper in the greater Milwaukee watersheds are summarized in Table 59. The total average annual point source load of copper is about 11,270 pounds. Sewage treatment plants account for over 99 percent of the contributions of copper from point sources with much smaller contributions from combined sewer overflows, industrial dischargers, and separate sanitary sewer overflows. The total average annual point source load of copper to the riverine system of the greater Milwaukee watersheds only is about 819 pounds. Sewage treatment plants account for 82 percent of the contributions of copper from point sources to the riverine system with much smaller contributions from combined sewer overflows, separate sanitary sewer overflows, and industrial dischargers.

Nonpoint Source Loads

Because nonpoint source pollution is delivered to streams in the greater Milwaukee watersheds through many diffuse sources, including direct overland flow, numerous storm sewer and culvert outfalls, and swales and engineered channels, it would be prohibitively expensive and time-consuming to directly measure nonpoint source pollution loads to streams. Thus, the calibrated water quality model was applied to estimate average annual nonpoint source pollutant loads delivered to streams in the greater Milwaukee watersheds. The results of that analysis are summarized in Tables 54 through 59. General water quality modeling procedures are described in Chapter V of this report. Estimates of average annual nonpoint source pollution loads for individual sub-watersheds are given as existing loads in Appendix B of this report and in Chapters V through X of SEWRPC Technical Report No. 39.

The average annual nonpoint load of total phosphorus is estimated to be 276,190 pounds per year. About 17 percent of the total point and nonpoint source load is from urban nonpoint sources and 19 percent is from rural nonpoint sources (Table 54). Contributions of total phosphorus vary among the watersheds from about 9,930 pounds per year from the Kinnickinnic River watershed to about 126,350 pounds per year from the Milwaukee River watershed.

The average annual nonpoint load of total suspended solids is estimated to be 176,179,830 pounds per year. About 31 percent of the total point and nonpoint source load is from urban nonpoint sources and 64 percent is from rural nonpoint sources (Table 55). Contributions of total suspended solids vary among the watersheds from about 5,192,280 pounds per year from the Kinnickinnic River watershed to about 83,759,520 pounds per year from the Root River watershed.

The average annual nonpoint load of fecal coliform bacteria is estimated to be 74,930.86 trillion cells per year. About 69 percent of the total point and nonpoint source load is from urban nonpoint sources and 21 percent is from rural nonpoint sources (Table 56). Contributions of fecal coliform bacteria vary among the watersheds from about 2,782.56 trillion cells per year from the Oak Creek watershed to about 38,465.06 trillion cells per year from the Milwaukee River watershed.

The average annual nonpoint load of total nitrogen is estimated to be 3,690,380 pounds per year. About 7 percent of the total point and nonpoint source load is from urban nonpoint sources and 24 percent is from rural nonpoint sources (Table 57). Contributions of total nitrogen vary among the watersheds from about 63,240 pounds per year from the Kinnickinnic River watershed to about 1,961,180 pounds per year from the Milwaukee River watershed.

The average annual nonpoint load of BOD is estimated to be 9,997,650 pounds per year. About 22 percent of the total point and nonpoint source load is from urban nonpoint sources and 33 percent is from rural nonpoint sources (Table 58). Contributions of BOD vary among the watersheds from about 298,900 pounds per year from the Oak Creek watershed to about 4,514,090 pounds per year from the Milwaukee River watershed.

The average annual nonpoint load of copper is estimated to be 9,120 pounds per year. About 34 percent of the total point and nonpoint source load is from urban nonpoint sources and 10 percent is from rural nonpoint sources (Table 59). Contributions of copper vary among the watersheds from about 497 pounds per year from the Oak Creek watershed to about 3,657 pounds per year from the Milwaukee River watershed.

Wet-Weather and Dry-Weather Loads

It is important to distinguish between instream water quality during dry weather conditions and during wet weather conditions. Differences between wet-weather and dry-weather instream water quality reflect differences between the dominant sources and loadings of pollutants associated with each condition. Dry-weather water quality reflects the quality of groundwater discharge to the stream plus the continuous or intermittent discharge of various point sources, for example industrial cooling or process waters, and leakage or other unplanned dry-weather discharges from sanitary sewers or private process water systems. While instream water quality during wet weather conditions includes the above discharges, and in extreme instances discharges from separate and/or combined sanitary sewer overflows, the dominant influence, particularly during major rainfall or snowmelt runoff events, is likely to be the soluble or insoluble substances carried into streams by direct land surface runoff. That direct runoff moves from the land surface to the surface waters by overland routes, such as drainage swales, street and highway ditches, and gutters, or by underground storm sewer systems.

Daily average loads of six pollutants—biochemical oxygen demand, copper, fecal coliform bacteria, total nitrogen, total phosphorus, and total suspended solids—were estimated for both wet-weather and dry-weather conditions for seven sites in the greater Milwaukee watersheds based upon flow and water quality data. A water quality sample was assumed to represent wet-weather conditions when the daily mean flow was in the upper 20th percentile of the flow duration curve for the relevant flow gage. This includes flows that are high due to rainfall events, runoff from snowmelt, or a combination of rainfall and snowmelt. Daily average pollutant loads were estimated by appropriately combining daily average flow and pollutant ambient concentration. The flow duration curves for the sampling stations and more-detailed information on the methods are given in SEWRPC Technical Report No. 39.

Table 60 summarizes dry-weather and wet-weather pollutant loads for six pollutants from the Kinnickinnic River at S. 7th Street, the Menomonee River at N. 70th Street, the Milwaukee River at Pioneer Road, the Milwaukee River at N. Port Washington Road, Oak Creek at S. 15th Avenue, the Root River at W. Ryan Road, and the Root River at Johnson Park for the baseline period used to characterize water quality in the greater Milwaukee watersheds.[9] In all cases, the estimated pollutant loads occurring during wet-weather periods were considerably higher than the estimated loads occurring during dry-weather periods. Comparison of maximum estimated daily wet-weather loads to mean estimated daily wet-weather loads in Table 60 indicates that individual wet-weather events can sometimes contribute a substantial fraction of the annual pollutant load to a stream or river. For example, the maximum daily estimated wet-weather load of TSS at the N. 70th Street station along the Menomonee River for the baseline period was about 3.6 million pounds. Comparing this to the modeled data set forth in Table 55 shows that this single day's load represents about 20 percent of the estimated average annual load of TSS for the entire watershed.

More-detailed information on wet-weather and dry-weather pollutant loads for the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

SOURCES OF GROUNDWATER CONTAMINATION

Potential sources of groundwater contamination are many and varied because, in addition to some natural processes, such as dissolved and particulate matter in precipitation, decay of organic matter, natural radioactivity and dissolution of arsenic-containing minerals, many types of facilities or structures and many human activities may eventually contribute to groundwater quality problems. This section summarizes the activities and practices that may affect groundwater quality in the Southeastern Wisconsin Region and greater Milwaukee watersheds and outlines the nature of contamination that may result from such activities. It also describes the nature and extent of potential groundwater contamination sources in the study area. No attempt has been made, however, to rank quantitatively the various potential contamination sources. For the purposes of this study, the sources that were considered to have potential to create contamination problems in the greater Milwaukee watersheds are summarized according to their location in Table 61. More-detailed information on sources of groundwater contamination in the greater Milwaukee watersheds and the Southeastern Wisconsin Region are given in SEWRPC Technical Report No. 39 and SEWRPC Technical Report No. 37, *Groundwater Resources of Southeastern Wisconsin,* June 2002, respectively.

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[9]*The baseline period was originally set as 1998-2001. During the course of the study, more recent data were incorporated into analyses as they became available. Thus, the baseline period used for these assessments in the Menomonee River, Kinnickinnic River, and Oak Creek watersheds was 1998-2001. Because more recent data were available when the analyses were conducted, the baseline period used for the Milwaukee River and Root River watersheds and the Lake Michigan direct drainage area was 1998-2004.*

Table 60

DAILY AVERAGE POLLUTANT LOADS AT WATER QUALITY SAMPLING STATIONS IN THE GREATER MILWAUKEE WATERSHEDS: 1998-2004[a]

Sampling Station	Water Quality Parameter	Dry Weather			Wet Weather		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean
Kinnickinnic River at S. 7th Street	Biochemical Oxygen Demand (pounds)	4.1	655.5	167.5	187.3	31,096.6	4,281.2
	Copper (pounds)	0.2	1.0	0.4	1.3	102.0	12.0
	Fecal coliform bacteria (trillions of cells)	<0.1	11.4	1.1	0.3	434.5	60.4
	Total nitrogen (pounds)	18.6	168.9	69.2	148.4	15,548.3	1,525.5
	Total phosphorus (pounds)	1.4	13.1	5.4	7.0	1,172.5	159.1
	Total suspended solids (pounds)	28.6	1,884.5	397.9	730.4	764,643.0	85,060.1
Menomonee River at N. 70th Street	Biochemical Oxygen Demand (pounds)	16.7	2,589.0	408.4	97.6	85,680.2	15,825.9
	Copper (pounds)	0.3	6.0	2.4	4.9	538.5	66.6
	Fecal coliform bacteria (trillions of cells)	<0.1	405.2	18.8	2.1	3,972.8	303.8
	Total nitrogen (pounds)	41.5	975.1	341.8	1,140.8	51,598.5	9,002.6
	Total phosphorus (pounds)	1.2	85.8	22.0	56.0	5,712.0	963.7
	Total suspended solids (pounds)	129.4	17,723.3	3,024.4	7,371.9	3,617,470.0	400,346.0
Milwaukee River at Pioneer Road	Biochemical Oxygen Demand (pounds)	79.0	12,492.6	2,420.4	611.6	45,103.2	19,972.7
	Copper (pounds)	2.3	27.8	11.1	19.3	472.7	74.5
	Fecal coliform bacteria (trillions of cells)	<0.1	356.4	9.1	1.6	675.8	128.0
	Total nitrogen (pounds)	717.6	10,547.0	4,091.9	6,390.0	49,025.7	22,339.8
	Total phosphorus (pounds)	9.4	874.5	207.6	126.1	5,819.6	1,644.1
	Total suspended solids (pounds)	927.7	148,118.0	20,240.7	10,692.2	2,174,690.0	415,419.0
Milwaukee River at N. Port Washington Road	Biochemical Oxygen Demand (pounds)	96.5	20,660.1	4,169.2	663.4	82,249.7	23,574.9
	Copper (pounds)	1.8	38.8	13.2	21.0	149.9	64.2
	Fecal coliform bacteria (trillions of cells)	<0.1	3,467.3	82.6	1.4	680.3	134.9
	Total nitrogen (pounds)	706.0	9,279.8	3,983.2	9,295.6	68,330.5	23,367.6
	Total phosphorus (pounds)	21.4	957.9	230.4	276.6	6,116.0	1,862.5
	Total suspended solids (pounds)	1,889.9	225,236.0	35,126.0	71,243.8	3,828,360.0	761,321.0

Table 60 (continued)

Sampling Station	Water Quality Parameter	Dry Weather			Wet Weather		
		Minimum	Maximum	Mean	Minimum	Maximum	Mean
Oak Creek at 15th Avenue	Biochemical Oxygen Demand (pounds)	2.3	385.1	60.0	14.0	15,147.9	3,079.4
	Copper (pounds)	0.2	9.5	2.4	1.8	151.5	46.7
	Fecal coliform bacteria (trillions of cells)	<0.1	4.6	0.3	<0.1	82.9	9.8
	Total nitrogen (pounds)	3.4	150.6	57.0	176.8	5,856.4	1,555.6
	Total phosphorus (pounds)	<0.1	8.6	2.9	7.0	1,013.4	164.5
	Total suspended solids (pounds)	19.9	3,117.5	552.1	1,823.0	824,193.0	17,205.5
Root River at W. Ryan Road	Biochemical Oxygen Demand (pounds)	3.8	830.6	83.4	442.3	16,638.7	4,417.3
	Copper (pounds)	0.1	1.3	0.5	1.7	41.6	13.3
	Fecal coliform bacteria (trillions of cells)	<0.1	25.8	1.2	0.3	176.9	35.8
	Total nitrogen (pounds)	7.2	574.8	113.8	521.8	8,371.3	2,809.7
	Total phosphorus (pounds)	0.5	35.6	5.9	36.8	494.0	155.8
	Total suspended solids (pounds)	58.9	10,204.7	1,418.2	11,499.1	727,918.0	122,046.0
Root River at Johnson Park	Biochemical Oxygen Demand (pounds)	- -[b]	- -[b]	- -[b]	- -[b]	- -[b]	- -[b]
	Copper (pounds)	<0.1	1.33	0.3	- -[b]	- -[b]	- -[b]
	Fecal coliform bacteria (trillions of cells)	<0.1	0.3	0.1	0.3	8.0	2.6
	Total nitrogen (pounds)	23.7	3,971.5	1,045.2	2,657.5	20,955.0	8,366.6
	Total phosphorus (pounds)	0.5	118.5	22.8	80.3	512.9	257.5
	Total suspended solids (pounds)	125.5	31,506.3	3,728.7	12,673.6	99,052.1	53,059.1

[a]*The baseline period for the study was originally set as 1998-2001. During the course of the study, more recent data were incorporated into analyses as they became available. Thus, the period used for these assessments for the Menomonee River, Kinnickinnic River, and Oak Creek watersheds was 1998-2001. Because more recent data were available when the analyses were conducted, the period used for the Milwaukee River and Root River watersheds and the Lake Michigan direct drainage area was 1998-2004.*

[b]*Insufficient data were available for calculating daily average pollutant load for this pollutant.*

Source: U.S. Environmental Protection Agency, Wisconsin Department of Natural Resources, Milwaukee Metropolitan Sewerage District, City of Racine Health Department, and SEWRPC.

Table 61

HUMAN ACTIVITIES THAT MAY CREATE GROUNDWATER QUALITY PROBLEMS IN THE GREATER MILWAUKEE WATERSHEDS

Originating on the Land	Originating Below Land Surface
Above-ground storage tanks (bulk fuel storage)	Above Water Table
Accidental spills	Animal waste storage facilities
Agricultural activities:	Landfills
Animal feedlots	Leakage:
Fertilizer and pesticide storage, mixing, and loading	Underground storage tanks
Fertilizer and pesticide application	Underground pipelines
Irrigation return flow	Sewers
Silage and crop residue piles	Onsite sewage disposal systems
Dumps	Surface wastewater impoundments
Highway de-icing, including material storage sites	Sumps, dry wells
Waste spreading or spraying (sewage, sludge, septage, whey)	Waste disposal in dry excavations
Stockpiles (chemicals and waste)	Below Water Table
Infiltration of contaminated surface water or precipitation	Ground water development:
Salvage yards	Improperly abandoned wells and holes
Application of fertilizers and pesticides to urban lawns and gardens	Improper well construction
Urban runoff	Overpumping
	Drainage or disposal wells
	Waste disposal in wet excavations

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

Onsite Sewage Disposal Systems

Private wastewater systems are used to dispose of sanitary wastes in unsewered areas. A conventional onsite system consists of a septic tank and a soil absorption field. Most solids settle at the bottom of the tank where they are partially digested by bacteria. The liquid waste flows from the tank to the soil absorption field where it is purified as it moves through the soil. If these systems are properly installed in suitable soils and located a sufficient distance from a water supply source, most contaminants are removed or attenuated before they can reach the water supply. However, local groundwater contamination may occur in areas of concentrated suburban or rural residential development where individual onsite systems are densely spaced. This may be of most concern where older systems are in place, which may not meet current design criteria. Specifically, the amount of nitrate and chloride may not be significantly reduced.

In addition to conventional onsite systems, newer alternative onsite sewage disposal systems designed to overcome certain types of soil limitations are in use in the greater Milwaukee watersheds. Such systems include "mound-type systems," in-ground pressure distribution systems, and at-grade systems. Holding tanks that temporarily store wastewater prior to pumping out to a tank truck and transport to a sewage treatment plant are also used.

During 2000, the Wisconsin Legislature amended Chapter Comm 83 of the *Wisconsin Administrative Code*, which regulates private sewage systems, and adopted new rules governing onsite sewage disposal systems. These rules, which had an effective date of July 1, 2000, increased the number of types of onsite sewage disposal systems that legally could be used from four to nine, significantly altered the previous regulatory framework, and increased the area in which onsite sewage disposal systems may be utilized.

It is estimated that less than 5 percent of the study area population was served by individual onsite systems as of 2000. Map 40 shows areas of urban density that are served by onsite sewage disposal systems. More-detailed maps are included in SEWRPC Technical Report No. 39. The potential contamination sources inventory conducted for the SEWRPC regional groundwater study[10] focused on areas of clustered onsite sewage disposal

[10]*SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin*, June 2002.*

systems, defined as areas with more than 32 housing units per U.S. Public Land Survey section. In the study area, onsite systems tend to be concentrated in Fond du Lac, Ozaukee, Racine, and Washington Counties. Significant portions of Fond du Lac, Ozaukee, and Washington Counties within the study area tend to have relatively permeable soils, especially in the major river valleys. Therefore, clustered onsite systems in these areas are a potential source of contamination to the groundwater. However, sites located in southern and eastern Ozaukee County and in much of Racine County have less permeable soils, thus groundwater contamination is not as great a concern in those locations.

Land Disposal of Solid Waste

Solid waste disposal is an important potential groundwater contamination source. Continuous or intermittent contact between deposited waste and water produces a liquid called leachate, which contains high concentrations of potential contaminants. Landfill leachate is defined as a contaminated liquid characterized by high concentrations of dissolved chemicals, high chemical and biological oxygen demand, and high hardness. Its composition in extremely variable, and is a function of the composition of waste and the volume of water. The threat to groundwater from solid waste disposal sites depends on the nature of leachate, the availability of moisture, the type of soil through which the leachate passes, and the hydrogeology of the site. Because the greater Milwaukee watersheds lie in a humid climatic zone, most waste disposal sites will eventually produce leachate. Disposal site success depends on how leachate production and movement is managed either by engineering design or by locating the site in a more protective environment. Locations of active and inactive solid waste disposal sites in the greater Milwaukee watersheds are shown on Map 41. More-detailed information on active and inactive solid waste disposal sites is set forth in SEWRPC Technical Report No. 39.

Underground Storage Tanks

Storage and transmission of a wide variety of fuels and chemicals are inherent in many industrial, commercial, agricultural, and individual activities. Petroleum and petroleum products are the most common potential contaminants. Throughout the study area and the Region, underground storage tanks for gasoline, oil, and other liquids were installed during the 1950s and 1960s and have now reached or exceeded their expected 20- to 30-year life. The large volume and high concentration of hazardous materials that can leak or can be released from a storage tank or associated piping in a small area creates an onsite, and sometimes offsite, contamination risk. The majority of existing tanks are in urban areas and, as a result, are relatively close to municipal water supply wells. Leaks in petroleum-product conveyance and transmission lines also are a potential source of groundwater contamination.

SEWRPC Technical Report No. 37 used WDNR file data to develop an inventory of underground storage tank sites within the Region, where there has been a release of contaminants. The number of sites per county was tabulated and the site density in sites per square mile was mapped.

The majority of the sites was located in the regional water quality management plan update study area with the highest concentration in Milwaukee County. The WDNR’s classification system considers a leaking underground storage tank to be a high-priority when it is known that the site is causing contamination to the groundwater, or where there is a high potential for such contamination. Additionally, those sites that are assigned a medium priority have known soil contamination or a potential for groundwater contamination. Where high- and medium-priority leaking underground storage tanks occur within the study area, their density generally ranges from one to 10 sites per square mile. In Milwaukee County, the site density ranges from one to 10 sites per square mile up to 41 to 50 sites per square mile. Because of the nature of these potential contamination sites, the number and location are subject to frequent change. The WDNR should be contacted for the most recent inventory data.

Land Application of Liquid Waste and Sewage Sludge

Sludge and biosolids are organic by-products of treated wastewater. Most of the land application of such materials in southeastern Wisconsin involves biosolids which are treated residuals from sewage treatment plants that can be used beneficially. They are composed mostly of water and organic matter. Both industrial sludges or residual solids and municipal biosolids may contain hazardous chemicals and metals removed by the wastewater treatment process. Metals often found in biosolids at variable concentrations include arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. The types and concentrations of the metals found in sludge depend upon the source of the wastewater. Other constituents of sludge that may have an impact on the groundwater are nitrate, chloride, and pathogenic bacteria and viruses.

The land application of municipal sludge is regulated under Chapter NR 104 of the *Wisconsin Administrative Code* and 40 CFR Part 503. Industrial sludges are also applied in the Region although the majority of the wastewater biosolids is domestic sewage sludge. Industrial sludge is regulated under Chapter NR 214. Wastewater biosolids must meet the requirements of the above regulations before being land applied. The requirements include ceiling concentrations for contaminants, pathogen reduction requirements, and vector reduction options.

Sites for storage and land application of wastewater and sludge in the Region were inventoried under SEWRPC Technical Report No. 37. As of 1999, for counties within both the study area and the Region, WDNR-approved sites were located in Washington (1,065 sites), Ozaukee (408 sites), Waukesha (400 sites), Racine (275 sites), and Kenosha (127 sites) Counties. The number and location of these sites is constantly changing and the WDNR should be contacted for the latest information on the approved sites.

Some land application of wastewater from other sources such as vegetable processing and dairy operation byproducts (whey), septage, and, in some cases, holding tank wastes are also practiced. Sludge and wastewater are only applied to agricultural land in the study area. Biosolids are land-applied to improve the structure of the soil, or as a fertilizer to supply nutrients to crops and other vegetation in the soil. Land application in the study area is done by spreading, spraying, injection, or incorporation of sewerage sludge onto or below the surface of the land to take advantage of the soil enhancing qualities of the biosolids. Almost all of the sludge and wastewater is injected or incorporated into the soil, although there are some spray irrigation systems.

Contamination of groundwater from land application of sludge and wastewater depends upon the concentration of contaminants, application rate, physical and chemical soil properties, amount of precipitation, and distance to the water table. Coarse-textured soils, a shallow water table, and high rates of precipitation favor groundwater contamination. Currently, the wastewater biosolids are applied in such a manner that there should be no impact on the groundwater. All of the municipal residuals that are land-applied in the study area and in southeastern Wisconsin have been treated to meet the appropriate quality parameters. The type of soil, application rate, distance to bedrock and groundwater, slopes, porosity of the soils, percolation rates, solum depth, and distance to lakes, streams, ponds, and other water sources are evaluated for every site approved for land application prior to application.

Major Livestock Operations

Major livestock operations are not common in the greater Milwaukee watersheds. As noted previously, the Milwaukee and Root River watersheds have six farm operations with more than 1,000 animal units. The principal contaminants associated with animal farm operations and feedlots are nitrogen, phosphorus, chloride, oxygen-demanding material, and microorganisms. Feedlots may also cause objectionable odor. The potential for groundwater contamination will depend on the volume of waste produced at a given site, waste handling practices, and general farm operations. Typically, animal waste is stored in a storage facility such as a manure pile, lagoon, or holding tank, and then periodically applied to the land as a source of plant nutrients. Unless livestock manure is applied to sandy soils that are prone to rapid internal drainage, most nutrient loss, especially of phosphorus, occurs by erosion from overland runoff, and presents the greatest potential environmental threat to surface waters.

The WDNR regulates livestock operations with greater than 1,000 animal units through the WPDES permit program. One animal unit is equivalent to a single mature beef unit weighing 1,000 pounds, for example 200,000 chickens (broilers) equal 1,000 animal units. Proper plant nutrient management plays a critical role in assuring that large livestock operations manage the large volumes of animal waste they generate and minimizes detrimental effects on the environment. Because of the nature of these facilities, the number and location changes periodically.

More-detailed information on livestock operations in the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

Agricultural Chemical Facilities
Table 62 summarizes the number of bulk agricultural chemical (fertilizers and pesticides) storage and loading facilities in the greater Milwaukee watersheds. Commercial fertilizers include a variety of types and concentrations of nitrogen, phosphorus, potassium, and trace elements, most of which are intended to improve plant growth and market value. While both nitrogen and phosphorus may contribute to eutrophication of surface waters, the nitrogen component of fertilizer has generated the most concern regarding groundwater quality. More-detailed information on bulk agricultural chemical storage facilities in the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

Salvage Yards
Salvage yards are a minor potential source of contamination. The danger of groundwater contamination increases if the sites handle hazardous materials from various automotive parts and accessories, such as grease, oil, solvents, and battery acids. Well-operated salvage yards present a minimal threat to groundwater. Salvage yards within the Region were inventoried for SEWRPC Technical Report No. 37. Within the study area, the majority of these sites are located in Milwaukee County and eastern Waukesha County.

Salt Storage Facilities
Salt storage, road salting, and snow dumping are all common practices used in the Region in relation to road deicing and improvement of winter driving conditions. These activities may contribute to high salt concentrations in both groundwater and surface water. Of these activities, salt storage in uncovered piles appears to be the most critical with respect to potential groundwater contamination. Rainfall can dissolve the salt, which may then seep into shallow aquifers.

Table 62 summarizes the number of salt storage facilities in the greater Milwaukee watersheds. Nearly all of these facilities are covered. Most of these sites are located in counties with a dense network of highways such as Milwaukee and Waukesha. The WDNR has reported documented cases of groundwater contamination due to past salt storage and handling practices; however, current design and maintenance of storage facilities minimizes the potential for infiltration of salt into groundwater.

More-detailed information on salt storage facilities in the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

Temporary Solid and Hazardous Waste Storage Sites
Temporary storage of solid and hazardous waste represents a minor threat to the groundwater. If the waste is handled correctly and regularly transferred to a long-term facility, contamination from these areas should not be significant. An inventory of these sites was made for SEWRPC Technical Report No. 37. Within the greater Milwaukee watersheds, these sites are generally located in urban areas, with the greatest concentration occurring in Milwaukee County. Due to the nature of these facilities, data on the facilities are subject to periodic change. The WDNR should be contacted for the most recent data.

Bulk Fuel Storage Facilities
Bulk fuel storage sites are a potential source of groundwater contamination in the event of a spill or leak at the storage facility. Table 62 summarizes the number of known bulk fuel storage sites in the greater Milwaukee watersheds. Should a spill or leak occur, sites overlying sand and gravel materials would cause the greatest threat to contamination of the groundwater. In other areas, such incidents could also be potential sources of contamination to both groundwater and surface water. Installation of containment structures under and around the storage tanks minimizes the risk of contamination due to ruptures and spills. More-detailed information on bulk fuel storage facilities in the greater Milwaukee watersheds is given in SEWRPC Technical Report No. 39.

Table 62

BULK AGRICULTURAL CHEMICAL STORAGE AND MIXING/LOADING FACILITIES, SALT STORAGE FACILITIES, AND BULK FUEL STORAGE FACILITIES IN THE GREATER MILWAUKEE WATERSHEDS

County	Facility		
	Bulk Agricultural Chemical Storage	Salt Storage	Bulk Fuel Storage
Dodge	- -	- -	- -
Fond du Lac	- -	6	- -
Kenosha	- -	- -	- -
Milwaukee	7	38	18
Ozaukee	3	9	1
Racine	- -	6	2
Sheboygan	2	4	2
Washington	2	14	4
Waukesha	4	4	- -
Total	18	81	27

NOTE: The inventory data summarized on this table is subject to periodic change due to the nature of the facilities. For the most recent data, the Wisconsin Department of Agriculture, Trade and Consumer Protection; the Wisconsin Department of Commerce; and the Wisconsin Department of Transportation should be contacted.

Source: Wisconsin Department of Agriculture, Trade, and Consumer Protection; Wisconsin Department of Commerce; Wisconsin Department of Transportation; and SEWRPC.

Spills of Hazardous Materials

Approximately 1,200 accidental or unintentional spills of hazardous materials are reported in Wisconsin every year, with nearly one-third of these spills occurring within the Southeastern Wisconsin Region. An undetermined number of additional spills and illegal dumping of hazardous materials go unreported. Fortunately, many spills are small and can be cleaned up quickly before much of the substance can reach the groundwater. The types of spills vary, and have included substances such as fuel, mineral spirits, mineral oil, heating oil, hydraulic fluid, transformer fluid, chlorinated solvents, lubricants, hydrocarbons, as well as other unknown substances. By far, petroleum products are the contaminants most commonly involved in spills. The sites are scattered throughout the Region, but most of them have occurred along highways and within urban areas near storage tanks. The spills that required a major cleanup effort have been primarily centered around urban areas, with most occurring in the eastern portion of the Region within the greater Milwaukee watersheds in areas underlain by clay tills with restricted permeability. Sites located on more permeable soils in the study area would be more susceptible to groundwater contamination. Spills of hazardous materials are also a potential hazard to surface waters, especially if the contaminant enters the storm sewer system.

Improperly Abandoned Wells

One of the most important, yet overlooked, sources of groundwater contamination are old wells that are no longer used, but have not been properly sealed when abandoned. Proper well abandonment means filling the well from the bottom up with cement grout or bentonite. The locations of old wells are often long-forgotten, and buildings or roads may have been built over the top of open boreholes. These wells can serve as a means for transmission of contaminants from the land surface to an aquifer and can permit contaminated water to migrate freely from one aquifer to another. This is particularly critical in Southeastern Wisconsin where the open intervals of most wells penetrate many different aquifer units. Even in areas where groundwater contamination potential is ordinarily considered low because of favorable soil and geological properties, such as Milwaukee and eastern Waukesha Counties, large numbers of improperly abandoned or unaccounted-for old wells create a significant threat to groundwater quality. In addition, an abandoned well can become a convenient receptacle for disposal of trash or a safety hazard.

More than 100,000 private domestic and other wells have been drilled in Southeastern Wisconsin since the turn of the 20th century, particularly before municipal water supply systems were established. Since 1936, well drillers have submitted Well Constructor's Reports (WCRs) for most of these wells to the WDNR, and these WCRs are subsequently filed and sorted by reported location at the Wisconsin Geological and Natural History Survey (WGNHS). Densities of wells drilled between 1936 and 1979 in Milwaukee County and the easternmost townships in Waukesha County were determined based on these records. Densities of wells for which records exist range from less than 10 per square mile in central and southern parts of Milwaukee County to more than 500 per square mile along the Milwaukee-Waukesha county line. Sections with at least 300 old well or boring records per square mile are located primarily in Brookfield, Wauwatosa, and Hales Corners.

Most of Milwaukee County was converted to municipal water supply by 1963. Thus, the 1936-1979 data represent a reasonable count of potentially improperly sealed wells with records. However, the areas in Milwaukee County with relatively low densities of well records undoubtedly contain many wells drilled prior to 1936, for which no records exist. In eastern Waukesha County, numerous wells have been drilled since 1979, thus the numbers of WCRs and boring records per section between 1936 and 1979 probably are a significant underestimate of the total number of wells actually drilled.

Recently, the WDNR has introduced well abandonment forms, which should be submitted when unused, abandoned wells are properly sealed. The WDNR maintains files of these forms. Unfortunately, it is not possible to match well abandonment records with the original WCRs. Areas with high likelihoods of improperly abandoned wells can be identified using the WCRs; however, for most areas estimates made this way represent an underestimate of the total number of wells drilled.[11]

It is difficult to accurately estimate the number of improperly abandoned wells in the greater Milwaukee watersheds. As municipal water supply service areas expanded, existing private domestic wells may have been sealed, or remain improperly abandoned, or are used for a secondary purpose, such as lawn watering, for which owners may or may not have been granted a permit. By comparing numbers from various sources, the WDNR has estimated that within the study area, three areas: Milwaukee County, eastern Waukesha County, and eastern Racine County, have the most abandoned wells. The WDNR estimated that Milwaukee County had up to 8,000 improperly abandoned wells, eastern Waukesha County within the study area had less than 3,000 improperly abandoned wells; and eastern Racine County within the study area had less than about 1,000 improperly abandoned wells.

The existence of unused, abandoned wells represents a significant contamination threat to both shallow and deep groundwater. It is not an intention of this report to show an accurate, absolute number of such wells, but rather to point out improperly abandoned wells as a serious problem in the greater Milwaukee watersheds.

Contamination Potential of Aquifers

The methodology for evaluating the vulnerability of groundwater to contamination in the study area and more-detailed information on the contamination potential of aquifers in the study area is presented in Chapter XI of SEWRPC Technical Report No. 39 and Chapter VII of SEWRPC Technical Report No. 37.

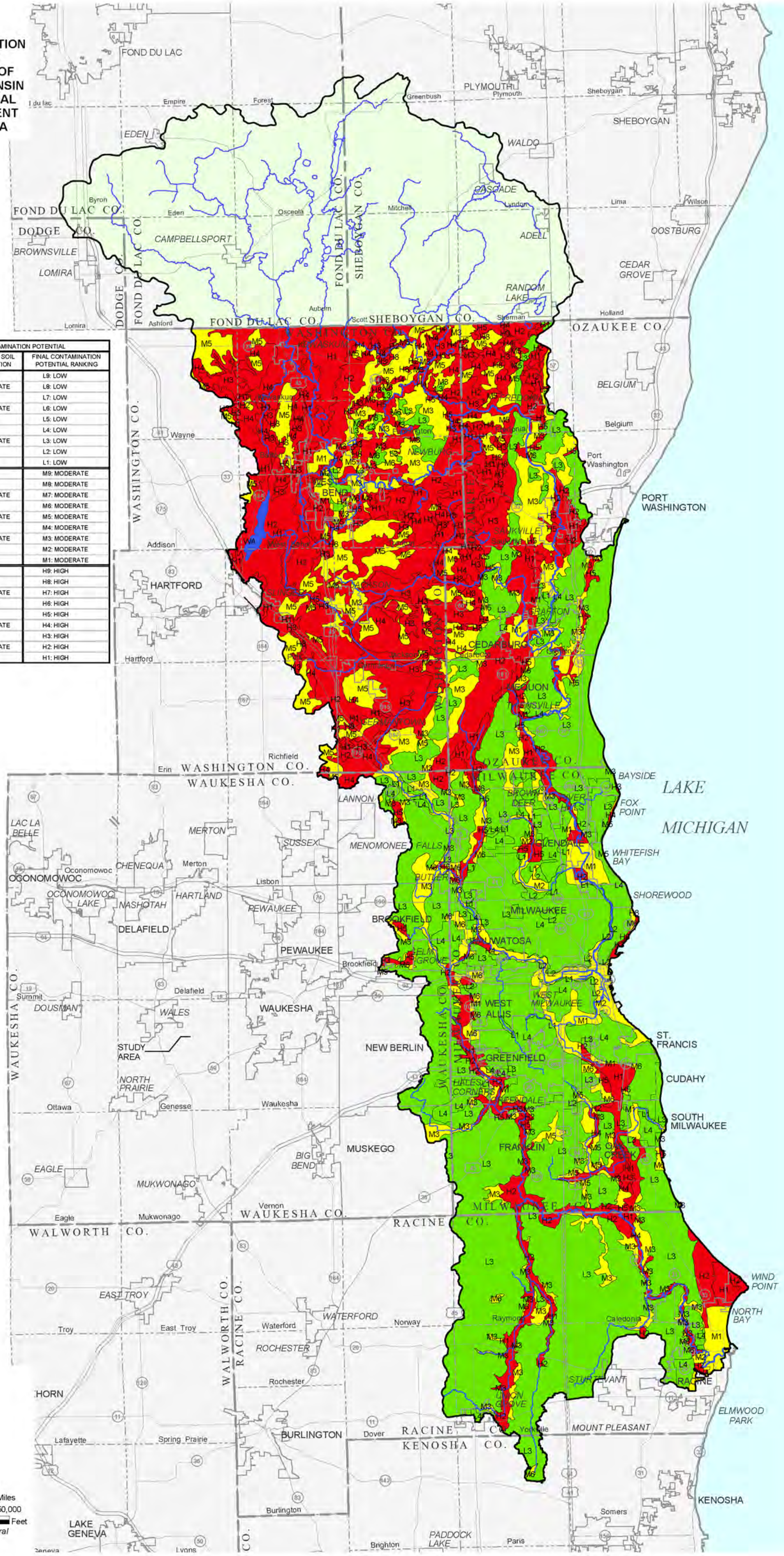
Contamination Potential of the Shallow Aquifer

Map 42 shows the groundwater contamination potential of shallow aquifers in the portions of the greater Milwaukee watersheds located in the Southeastern Wisconsin Region. Areas most vulnerable to contamination constitute approximately 36 percent of the study area within the Region (Table 63) and are located primarily in inland areas. Generally, the lakeshore areas contain more areas with low contamination potential, which are more suitable for the location of activities that may affect shallow groundwater. These areas cover about 45 percent of the study area within the Region. Within the study area in the Region, these areas can be found in the eastern

[11]*The WDNR has increased its surveillance of abandoned wells. The Department is currently in the process of developing a centralized database containing information on abandoned wells.*

Map 42

GROUNDWATER CONTAMINATION POTENTIAL OF SHALLOW AQUIFERS IN THE PORTION OF THE SOUTHEASTERN WISCONSIN REGION WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



COMBINATION OF PARAMETERS FOR CONTAMINATION POTENTIAL			
DEPTH TO AQUIFER IN FEET	ESTIMATED PERMEABILITY	ESTIMATED SOIL PERCOLATION	FINAL CONTAMINATION POTENTIAL RANKING
GREATER THAN 50	LOW	LOW	L9: LOW
GREATER THAN 50	LOW	MODERATE	L8: LOW
GREATER THAN 50	MODERATE	LOW	L7: LOW
GREATER THAN 50	MODERATE	MODERATE	L6: LOW
GREATER THAN 50	HIGH	LOW	L5: LOW
25 TO 50	LOW	LOW	L4: LOW
25 TO 50	LOW	MODERATE	L3: LOW
25 TO 50	MODERATE	LOW	L2: LOW
LESS THAN 25	LOW	LOW	L1: LOW
GREATER THAN 50	LOW	HIGH	M9: MODERATE
GREATER THAN 50	MODERATE	HIGH	M8: MODERATE
GREATER THAN 50	HIGH	MODERATE	M7: MODERATE
25 TO 50	LOW	HIGH	M6: MODERATE
25 TO 50	MODERATE	MODERATE	M5: MODERATE
25 TO 50	HIGH	LOW	M4: MODERATE
LESS THAN 25	LOW	MODERATE	M3: MODERATE
LESS THAN 25	MODERATE	LOW	M2: MODERATE
LESS THAN 25	HIGH	LOW	M1: MODERATE
GREATER THAN 50	HIGH	HIGH	H9: HIGH
25 TO 50	MODERATE	HIGH	H8: HIGH
25 TO 50	HIGH	MODERATE	H7: HIGH
25 TO 50	HIGH	HIGH	H6: HIGH
LESS THAN 25	LOW	HIGH	H5: HIGH
LESS THAN 25	MODERATE	MODERATE	H4: HIGH
LESS THAN 25	MODERATE	HIGH	H3: HIGH
LESS THAN 25	HIGH	MODERATE	H2: HIGH
LESS THAN 25	HIGH	HIGH	H1: HIGH

GROUNDWATER CONTAMINATION POTENTIAL

- HIGH
- MODERATE
- LOW
- SURFACE WATER
- AREA FOR WHICH GROUNDWATER CONTAMINATION POTENTIAL HAS NOT YET BEEN DETERMINED

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

Table 63

GROUNDWATER CONTAMINATION POTENTIAL AREAS BY COUNTY IN THE PORTION OF THE SOUTHEASTERN WISCONSIN REGION WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

County	High Potential		Moderate Potential		Low Potential		Total
	Area (acres)	Percent	Area (acres)	Percent	Area (acres)	Percent	
Kenosha	0	0	90	5	1,670	95	1,760
Milwaukee	18,370	12	24,710	16	111,800	72	154,880
Ozaukee	47,440	44	24,110	22	37,000	34	108,550
Racine	11,850	13	8,370	10	68,510	77	88,730
Washington	116,140	71	41,070	25	6,520	4	163,730
Waukesha	2,480	8	5,620	17	24,240	75	32,340
Total	196,280	36	103,970	19	249,740	45	549,990

Source: Wisconsin Geological and Natural History Survey and SEWRPC.

portion of Racine County, in the majority of Milwaukee County, and in eastern Ozaukee County. The remaining 19 percent of the study area within the Region has moderate contamination potential (Table 63).

Contamination Potential of Deeper Aquifers

The vulnerability of the deeper aquifers of southeastern Wisconsin and the study area to contamination is more difficult to assess; a complete evaluation of such vulnerability was beyond the scope of SEWRPC Technical Report No. 37, which is the source for much of the information on groundwater presented in this chapter and which is focused on the shallow groundwater system. In general, the greater thickness of overburden and the first two barriers to contamination—the soil layer and the underlying unlithified geologic conditions, provide an effective shield against contamination of the deeper aquifers. In addition, the deeper aquifers are protected by the ability of shallow aquifers to dilute contaminants. The possibility of contamination of deeper aquifers, however, is very real, although very difficult to detect, and may be impossible to reverse. In addition, the importance of the deeper aquifers as a source of municipal and industrial water supply within the study area cannot be understated. In some cases, these aquifers represent the only practical source of such supply.

A conceivable contamination scenario is the discharge of a large amount of liquid, such as petroleum, into an area where the shallow aquifer is relatively thin, unprotected, and directly connected with the deeper aquifers. A more insidious possibility is a smaller surface spill in the immediate vicinity of an old, forgotten deep well or open borehole that has not been properly abandoned. Another contamination scenario is the drilling of a deep borehole through a shallow contaminated aquifer into the deeper aquifers. Contaminated shallow groundwater can contaminate the deeper aquifers through the borehole before a casing is installed. Other than the possibility of deep open boreholes, if the shallow aquifer is indeed significantly contaminated in a given area, the potential that such contamination will eventually reach the deeper aquifers depends on the nature of the deep bedrock lithology and the direction of flow between aquifers. These factors can be considered to be the third and final barrier to deep groundwater contamination.

Unfortunately, the nature of the deep bedrock lithology of the Region and the study area is not well understood at present, particularly with regard to the distribution of different units and the importance of regional faulting. A major confining unit plays the most significant role in the protection of the deeper aquifers: the Maquoketa Formation, which is continuous over all of the study area. In general, in areas to the west of the edge of this formation and outside the study area, where the Maquoketa Formation is absent, the deeper aquifers are more vulnerable to contamination. However, the variability of lithology of the Maquoketa Formation is not known in detail. The dominant lithology is shale, which is relatively impermeable, but significant proportions of the thickness of this unit in some areas may be dolomite, which is much more permeable.

The other factor that determines the vulnerability of the deeper groundwater to contamination is the direction of flow in deep groundwater systems. In the very thick deep aquifers, groundwater flow is three-dimensional, depending on differences of pressure and gradient. Under steady state, nonpumping conditions gradients are downward in recharge areas and upward in discharge areas. If there is a source like a contaminated shallow aquifer in a regional recharge area, such as west of the Maquoketa confining unit, then deeper aquifers can be contaminated. However, downward gradients can also be caused by pumping from the deeper aquifers and can induce leakage from shallow to deep aquifers through the Maquoketa confining unit. If areas of downward gradients between aquifers near pumping centers coincide with locations of more permeable, dolomitic lithology in the Maquoketa shale, contaminants can penetrate into deeper aquifers over time. For this reason, protective measures for the deep aquifer recharge areas, as well as measures to avoid potential contamination routes through the confining unit, should be an important consideration in land use and water quality management planning.

SUMMARY

The pollution sources inventory for the greater Milwaukee watersheds has been summarized by answering three basic questions. This chapter summarized the information needed to answer the questions. The information is presented below.

What Are the Sources of Surface Water Pollution?

The greater Milwaukee watersheds contain several potential sources of surface water pollution. These sources fall into two broad categories: point sources and nonpoint sources.

Point Sources

Fourteen public and three private sewage treatment plants currently discharge into streams of the greater Milwaukee watershed. In addition, three public sewage treatment plants discharge into Lake Michigan, either directly or through the Milwaukee outer harbor. MMSD has 121 combined sewer overflow outfalls that discharge to the streams of the greater Milwaukee watersheds or to Lake Michigan. These outfalls convey a combination of stormwater runoff and sanitary sewage from the combined sewer system to the surface water system as a result of high water volume from stormwater, meltwater, and infiltration and inflow of clear water during wet weather conditions. Prior to 1994, overflows from these sites typically occurred around 50 times per year. Since MMSD’s inline storage system came online in 1994, the number of combined sewer overflows per year has declined to less than three. Since 1995, separate sanitary sewer overflows (SSOs) have been reported at 133 locations: 28 within MMSD’s SSO area and 105 in local communities. The number of SSO events occurring per year has also declined compared to the time prior to completion of the MMSD Water Pollution Abatement Program facilities in 1993. As of February 2003, 398 industrial dischargers and other point sources were permitted through the WPDES program to discharge wastewater to streams in the greater Milwaukee watersheds. About two fifths of the permitted facilities discharged noncontact cooling water. The remaining discharges are of a nature which typically meets or exceeds the Wisconsin Pollutant Discharge Elimination System permit levels which are designed to meet water quality standards.

Nonpoint Sources

The greater Milwaukee watersheds are comprised of combinations of urban land uses and rural land uses. As of 2000, about 67 percent of the area in the greater Milwaukee watersheds was in rural or other open land uses. About 39 percent of the study area is contained within planned sewer service areas: about 22 percent within planned sewer service areas in the Southeastern Wisconsin Region which have been refined, about 16 percent within planned sewer service areas in the Region which have not been refined, and about 1 percent in planned sewer service areas in counties outside the Region. The status of adoption of stormwater management ordinances and/or plans, of construction erosion control ordinances, of WPDES stormwater discharge permits in each community and county in the greater Milwaukee watersheds is summarized in Table 52. That table also indicates which communities have established stormwater utilities, general funds, or stormwater fee programs. As of 2005, there were six active sanitary landfills in the greater Milwaukee watersheds, two located in the Milwaukee River watershed, and one each located in the Kinnickinnic River, Menomonee River, and Oak Creek watersheds and the Lake Michigan direct drainage area. As summarized in Table 53 and shown on Map 41, there are 78 inactive solid waste disposal sites in the greater Milwaukee watersheds. While they are spread throughout the area, the majority are located in the Milwaukee River watershed.

Quantification of Pollutant Loads

The current annual average load of BOD to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 18,337,410 pounds per year. Nonpoint sources and sewage treatment plants contribute about 55 percent and 43 percent of this load, respectively. Industrial dischargers contribute about 2 percent of this load. The rest of the BOD load to the streams of the greater Milwaukee watersheds and Lake Michigan, less than 1 percent, is contributed by separate sanitary sewer overflows and combined sewer overflows. The current annual average load of BOD to streams of the greater Milwaukee watersheds only is estimated to be 10,555,440 pounds per year. Nonpoint sources contribute about 91 percent of this load. Industrial dischargers and sewage treatment plants each contribute about 4 percent of this load. The rest of the BOD load to the streams of the greater Milwaukee watersheds, about 1 percent, is contributed by combined sewer overflows and separate sanitary sewer overflows.

The current annual average load of TSS to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 184,435,700 pounds per year. Nonpoint sources and sewage treatment plants contribute about 95 percent and 4 percent of this load, respectively. The rest of the TSS load to the streams of the greater Milwaukee watersheds and Lake Michigan, less than 1 percent, is contributed by combined sewer overflows, industrial dischargers, and separate sanitary sewer overflows. The current annual average load of TSS to streams of the greater Milwaukee watersheds only is estimated to be 170,722,650 pounds per year. Nonpoint sources contribute 99 percent of this load. The rest of the TSS load to the streams of the greater Milwaukee watersheds, slightly over 1 percent, is contributed by industrial dischargers, combined sewer overflows, sewage treatment plants, and separate sanitary sewer overflows.

The current annual average load of total nitrogen to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 12,280,230 pounds per year. Sewage treatment plants and nonpoint sources contribute about 68 percent and 30 percent of this load, respectively. The rest of the total nitrogen load to the streams of the greater Milwaukee watersheds and Lake Michigan, less than 2 percent, is contributed by combined sewer overflows, industrial dischargers, and separate sanitary sewer overflows. The current annual average load of total nitrogen to streams of the greater Milwaukee watersheds only is estimated to be 3,891,760 pounds per year. Nonpoint sources contribute about 92 percent of this load. Sewage treatment plants and industrial dischargers each contribute 3.5 to 4 percent of this load. The rest of the total nitrogen load to the streams of the greater Milwaukee watersheds, about 1 percent, is contributed by combined sewer overflows and separate sanitary sewer overflows.

The current annual average load of fecal coliform bacteria to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 83,435.07 trillion cells per year. Nonpoint sources and combined sewer overflows contribute about 90 percent and 5 percent of this load, respectively. Sewage treatment plants and sanitary sewer overflows each contribute about 2.5 percent of this load. The rest of the fecal coliform bacteria load to the streams of the greater Milwaukee watersheds and Lake Michigan, less than 1 percent, is contributed by industrial dischargers. The current annual average load of fecal coliform bacteria to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 77,163.44 trillion cells per year. Nonpoint sources contribute about 92 percent of this load. Combined sewer overflows and separate sanitary sewer overflows contribute about 5 percent and 3 percent, respectively, of this load. The rest of the fecal coliform bacteria load to the streams of the greater Milwaukee watersheds, less than 1 percent, is contributed by sewage treatment plants and industrial dischargers.

The current annual average load of total phosphorus to streams of the greater Milwaukee watersheds and directly to Lake Michigan is estimated to be 767,230 pounds per year. Sewage treatment plants and nonpoint sources contribute about 48 percent and 36 percent of this load, respectively. Industrial dischargers contribute about 15 percent of this load. The rest of the total phosphorus load to the streams of the greater Milwaukee watersheds and Lake Michigan, less than 1 percent, is contributed by combined sewer overflows and separate sanitary sewer overflows. The current annual average load of total phosphorus to streams of the greater Milwaukee watersheds only is estimated to be 435,060 pounds per year. Nonpoint sources contribute about 60 percent of this load. Industrial dischargers and sewage treatment plants contribute about 26 percent and 13 percent, respectively, of this load. The rest of the total phosphorus load to the streams of the greater Milwaukee watersheds, slightly more than 1 percent, is contributed by combined sewer overflows and separate sanitary sewer overflows.

How Have the Sources of Surface Water Pollution Changed Since 1975?

Since 1975, the numbers and types of point sources present in the greater Milwaukee watersheds have changed. In 1975, there were 26 public sewage treatment facilities in the study area discharging treated wastewater to streams, groundwater, and Lake Michigan. By 2003, this number had decreased to 17. In 1975, 15 private sewage treatment plants discharged to streams, groundwater, and Lake Michigan in the study area. By 2003, this number had decreased to three. In 1975, there were 121 combined sewer outfalls and 352 known separate sewer overflow relief devices located in the greater Milwaukee watersheds. In 2003, there were 121 combined sewer outfalls. Between 1995 and 2002 separate sanitary sewer overflows were reported at 133 locations. In 1975, overflows typically occurred over 50 times per year. Currently combined sewer bypasses have been reduced to less than three per year. Likewise, the number of sanitary sewer overflows has been markedly reduced from the 1975 conditions. In 1975, there were 190 point sources of wastewater other than public and private sewage treatment plants that discharged industrial cooling, process, rinse, and wash waters directly, or indirectly, to the surface water system. In 2003, there were 400 of these point sources.

Figure 47 shows how the relative contributions of four pollutants by six pollution sources to the greater Milwaukee watersheds changed between 1975 and 2000. Two cautions must be kept in mind when interpreting these graphs. First, the breakdowns for 1975 and 2000 were estimated using different water quality models and modeling procedures. The assumptions underlying these models are somewhat different and categorization of nonpoint source loads as rural or urban may have been based on somewhat different criteria. Because of this, the estimates are not strictly comparable and comparisons based on them should be considered to be approximate. Second, between 1975 and 2000, pollutant loadings to streams in these watersheds decreased over time. Depending on the pollutant, total 1975 loads of these four pollutants, as estimated by the model developed for the 1979 regional water quality management plan, were 1.7 to 4.4 times the total 2000 loads, as estimated by the model. One consequence of this is that an increase in the relative contribution of a source to the total load does not necessarily represent an absolute increase in load from the source.

Keeping these caveats in mind, three differences are apparent between the relative contributions of these sources in 1975 and 2000.

First, the fraction of total pollutant contributions represented by combined sewer overflows has decreased dramatically. The most dramatic example of this change occurred for fecal coliform bacteria in the Kinnickinnic River watershed. Combined sewer overflows were estimated to account for 97 percent of contributions of fecal coliform bacteria to streams in this watershed in 1975. They were estimated to account for 11 percent of contributions of fecal coliform bacteria in 2000. While the magnitudes of the changes are generally not this large, the fraction of total pollutant contributions represented by combined sewer overflows decreased in all the watersheds in which combined sewer overflows were occurring in 1975. While several factors may account for this change, two deserve special mention. For the Kinnickinnic River, Menomonee River, and Milwaukee River watersheds, completion of MMSD's Water Pollution Abatement Program, including construction of the inline storage system, resulted in a reduction in the frequency of combined sewer overflows in the combined sewer area in the City of Milwaukee and the Village of Shorewood from over 50 per year before the inline storage system came online to less than three per year after the inline storage system came online. For the Root River watershed, separation of the remaining combined sewers in the City of Racine during the 1980s eliminated combined sewer overflows.

Second, for most pollutants in most watersheds the fraction of contributions accounted for by nonpoint sources has increased. For all four pollutants shown in Figure 47, in 2000 nonpoint pollution sources constituted the major sources of pollutant loads in these watersheds. In the Kinnickinnic River, Menomonee River, and Oak Creek

Figure 47

CHANGES IN POLLUTANT LOADINGS IN THE GREATER MILWAUKEE WATERSHEDS: 1975-2000

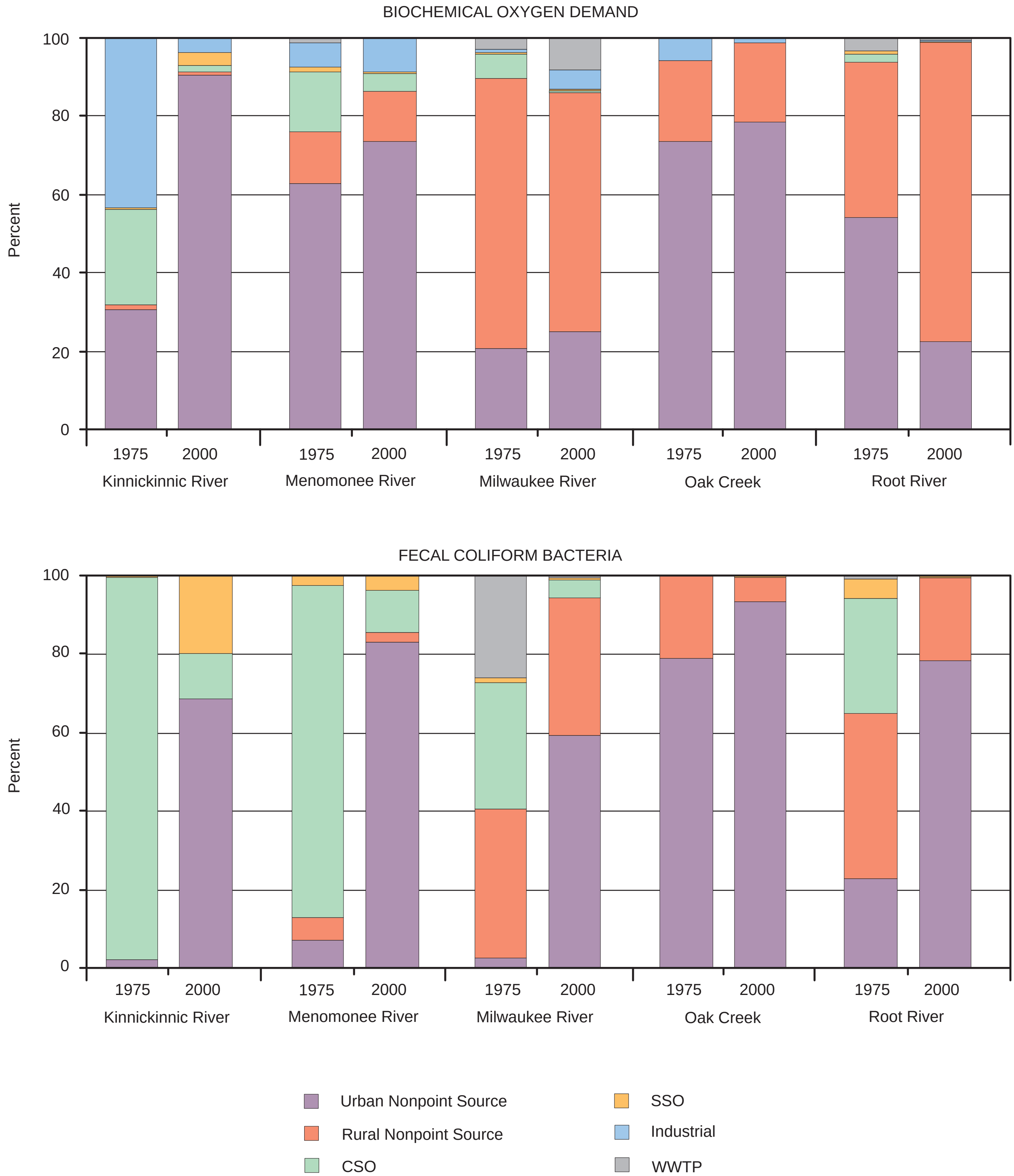
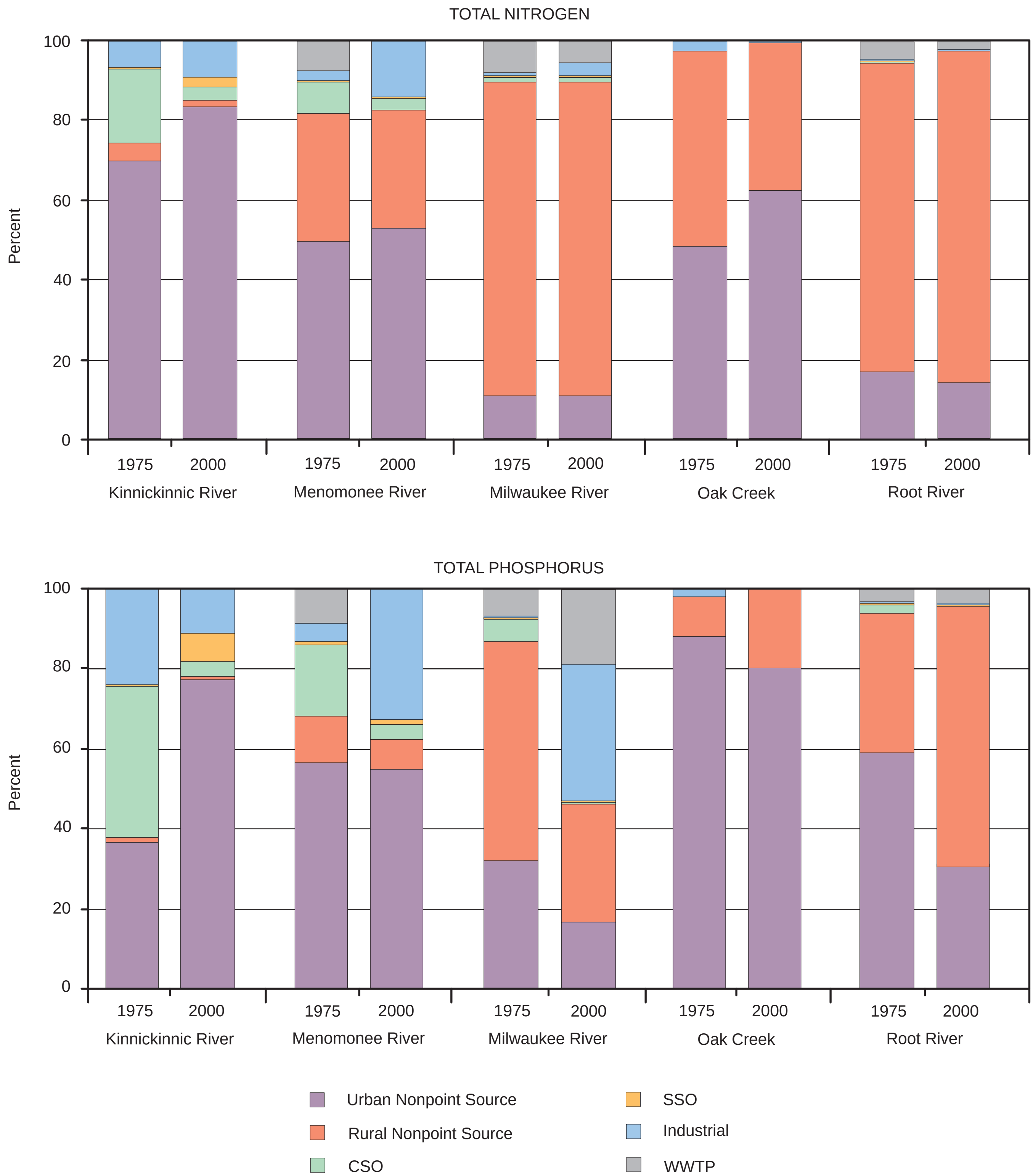


Figure 47 (continued)



Source: SEWRPC.

watersheds, the fractions of total contributions accounted for by urban nonpoint sources have generally increased and currently tend to predominate. Total phosphorus breakdowns in the Menomonee River and Oak Creek watersheds are exceptions to this generalization. While the fractions of total contributions accounted for by urban nonpoint sources decreased in these watersheds between 1975 and 2000, urban nonpoint sources still represent the dominant source of phosphorus. In the Root River watershed, for all the pollutants shown except fecal coliform bacteria, the fractions of total contributions accounted for by rural nonpoint sources have apparently increased and currently tend to predominate.

Third, for most watersheds, the fraction of contributions from industrial dischargers decreased or did not change much. In the Menomonee River watershed, the fractions of contributions of total nitrogen and total phosphorus increased. These increases are due to absolute increases in the loadings of these nutrients and may reflect the fact that between 1975 and 2003 the number of permitted industrial discharges in this watershed increased from 48 to 150. This increase represents about one half of the increase in the number of industrial dischargers in the greater Milwaukee watersheds since 1975.

What Are the Potential Sources of Groundwater Pollution?

Assessments of the groundwater contamination potential of shallow aquifers within the portions of the greater Milwaukee watersheds located in the Southeastern Wisconsin Region indicate that areas most vulnerable to contamination constitute about 36 percent of the study area within the region and are located primarily in inland areas and major river valleys (Map 42) Areas with low contamination potential cover about 45 percent of the study area within the region and can be found in eastern Ozaukee County, eastern Racine County, and the majority of Milwaukee County. The remaining 19 percent of the study area within the region has moderate contamination potential.

The vulnerability of deeper aquifers to contamination is more difficult to assess. Several barriers to contamination from the surface can serve to protect the integrity of deeper groundwater in portions of the study area. These include the soil layer, the unlithified geologic conditions, the presence of relatively impermeable geologic strata, and upward groundwater flow in groundwater discharge areas. The degree of protection that these factors provide may be compromised by both natural factors, such as faulting in the deep bedrock, and anthropogenic factors, such as the presence of improperly abandoned wells and downward gradients in groundwater movement induced by pumping from deeper aquifers.

Many types of facilities or structures and many human activities have the potential to contribute to groundwater quality problems. These include onsite sewage disposal systems, solid waste disposal sites, leaking underground storage tanks, land application of liquid wastes, major livestock operations, salvage yards, hazardous material spills, and bulk storage of agricultural chemicals, fuels, and salt. Proper design and operation can reduce the risks of groundwater contamination associated with some of these activities.

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Chapter V

WATER RESOURCE SIMULATION MODELS AND ANALYTIC METHODS

INTRODUCTION

Quantitative analyses of the hydrology, hydraulics, and water quality in the study area under existing and alternative future conditions are essential to this regional water quality management planning effort. These analyses were accomplished through the application of planning and engineering techniques that involve the formulation and application of mathematical models to simulate[1] the behavior of the surface and subsurface water system.

Mathematical simulation models were used extensively in plan design and evaluation for this study. This chapter explains the need for, and limitations of, simulation modeling, and describes the models used. That description includes input data requirements, data base development, and model calibration.

Due to the varying nature of the system being modeled, both man-made and naturally occurring, a series of simulation models were utilized. Those models were applied to simulate hydrologic, hydraulic, and water quality conditions, as appropriate in the following components of the Greater Milwaukee Watersheds:

- At the watershed/stream level,
- Within the Milwaukee Metropolitan Sewerage District (MMSD) conveyance and inline storage system, and
- Within the Milwaukee Harbor Estuary and nearshore Lake Michigan area.

Figure 48 presents an overview of the relationship of the simulation models. Output from 1) the watershed model for the Kinnickinnic, Menomonee, and Milwaukee River and Oak Creek watersheds and 2) the MMSD conveyance/storage model was input to the watercourse models for each watershed and that output was then input to the Harbor Estuary/Lake Michigan model, proceeding in a logical sequence from upstream to downstream. For some locations, output from the conveyance/storage model was also input to the Harbor Estuary/Lake Michigan model. Output from the watershed model for the Root River watershed was input to the watercourse model to

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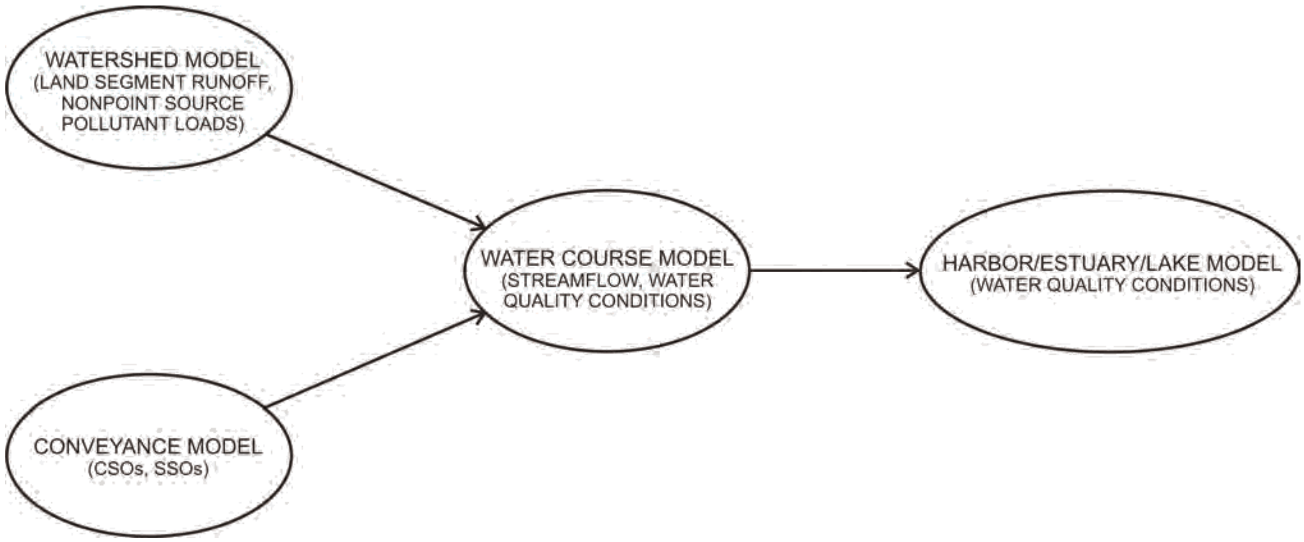
[1]*Simulation is defined as reproduction of the important behavioral aspects of a system. It should be emphasized that simulation, as used in system level planning such as this, does not normally achieve, or need to achieve, exact duplication of all aspects of system behavior.*

Figure 48

RELATIONSHIP OF SIMULATION MODELS USED FOR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE



Source: SEWRPC.

evaluate water quality conditions in the streams of that watershed. The study area does not include the nearshore Lake Michigan area in the vicinity of the Root River outlet to Lake Michigan, so the Lake model was not applied in that area.

Watershed/watercourse modeling of the riverine system was accomplished using the Load Simulation Program in C++ (LSPC) model. Simulation of the MMSD sewage conveyance and inline storage system was accomplished with a suite of models including the Flow Forecasting System (FFS) model for generation of flow, and MACRO and the Danish Hydraulic Institute Model of Urban Sewers (MOUSE) for evaluation of system hydraulics. The Milwaukee Harbor Estuary and nearshore Lake Michigan area were modeled using the Estuarine Coastal and Ocean Model-Sediment Transport (ECOMSED) and the Row-Column AESOP (RCA) model. For the Regional Water Quality Management Plan Update and the MMSD 2020 Facilities Plan, development and application of the simulation models was carried out by the following engineering consulting firms with direction, oversight, and review from SEWRPC and/or MMSD staff: Tetra Tech, Inc. (LSPC); Brown & Caldwell, Inc. (FFS/MACRO/MOUSE); and HydroQual, Inc. (ECOMSED/RCA).

NEED FOR AND LIMITATIONS OF SIMULATION MODELING

In this planning effort, simulation models were used both to describe existing and historical conditions and to predict probable future conditions. Existing conditions can be measured, monitored, or sampled but, as a practical matter, for only limited durations and areas. Budgetary limitations generally restrict the amount of data that can be collected. Moreover, critical historical conditions cannot be measured, monitored, or sampled after the fact. Such conditions can, however, be simulated if necessary model input data representing the period or conditions of interest are available.

Simulation modeling can also be used to provide information not only for sites where data have been collected, but for desired intermediate locations. This allows critical locations to be identified and characterized under historical, existing, and future conditions, and it assists in achieving both a more complete understanding of the system and of the probable future conditions in the system under alternative scenarios.

To ensure reliability and credibility, mathematical simulation models are calibrated by comparing observed data and simulated values and making appropriate changes in the model to improve the comparison until it is acceptable. Ideally simulation models should be validated by use of independent sets of data not used in the model calibration process. The utility of a simulation model is severely limited if insufficient data are available for model formation, calibration, and validation.

WATERSHED/WATERCOURSE MODEL

Simulation of pollutant loading and instream water quality conditions for the five watersheds included in the study area was conducted using the Loading Simulation Program in C++ (LSPC) which is derived from the Hydrological Simulation Program-Fortran (HSPF).[2,3] Both are public domain models developed for the U.S. Environmental Protection Agency (USEPA) and both have been used extensively across the country to develop water quality restoration plans through the Clean Water Act Total Maximum Daily Load (TMDL) Program. The HSPF model was originally chosen for use under this planning effort for a number of reasons, including:

- HSPF is a successor to the HYDROCOMP simulation programming package that was utilized for the initial Commission areawide water quality management plan.

- The HSPF model had been used for the MMSD watercourse system planning effort. Thus, existing model datasets were already available for the Oak Creek, Kinnickinnic River, Upper Root River, and Menomonee River watersheds.

- HSPF can be used on watersheds with both rural and urban land uses.

- HSPF can be used to simulate all of the constituents of interest for this project.

- HSPF allows long-term continuous simulations to predict hydrologic and water quality variability.

- HSPF provides adequate temporal resolution to facilitate a direct comparison to water quality standards.

- HSPF simulates surface runoff and subsurface flows.

- HSPF simulates receiving stream water quality processes in addition to land surface loads.

HSPF is a comprehensive watershed and receiving water quality model that was originally developed in the mid-1970s, with the hydrologic portion of the model being based on pioneering work in hydrologic-hydraulic modeling that was initiated in the early 1960s at Stanford University. The HSPF framework is developed in a modular fashion in which different components can be assembled in various ways depending on the objectives of the individual project. Three major modules are utilized: PERLND, IMPLND, and RCHRES. The PERLND and IMPLND modules simulate watershed processes on pervious and impervious land areas, respectively. The RCHRES module simulates processes in streams and vertically mixed lakes.

The LSPC modeling system includes HSPF algorithms for simulating hydrology, sediment, and general water quality on land as well as in the water column. One key advantage of using LSPC is that, unlike HSPF, it has no

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[2]*U.S. Environmental Protection Agency and Tetra Tech, Inc.,* The LSPC Watershed Modeling System, User's Manual, *November 2003.*

[3]*U.S. Environmental Protection Agency, Environmental Research Laboratory,* Hydrological Simulation Program-Fortran, User's Manual for Release 12, *Athens, Georgia, March 2001.*

inherent limitations in terms of modeling size or model operations. Thus, larger watersheds like the Milwaukee River watershed can be handled in one model setup, rather than being split into a number of smaller input datasets. In addition, the Microsoft Visual C++ programming architecture allows for seamless integration with widely available software, such as Microsoft Access and Excel, for post-processing of model output. Therefore, the modeling team decided to use the LSPC program since it incorporates the HSPF algorithms in a program with advantages for model execution and post-processing. Figure 49 graphically illustrates the overall structure of the watershed/watercourse model.

Hydrologic and Hydraulic Processes

The principal function of the hydrologic portion of LSPC is to determine the volume and temporal distribution of flow from the land surface to a given stream or lake. As used herein, the concept of runoff from the land surface is broadly interpreted to include surface runoff, interflow, and groundwater flow to the streams or lakes of the study area. The amount and rate of runoff from the land to the watershed stream system are largely a function of two factors. The first is the meteorological events that determine the quantity of water available on or beneath the land surface and the second is the nature and use of the land.

The basic conceptual hydrologic unit on which the model operates is called a land segment. A land segment is defined as a unique combination of meteorological characteristics, such as precipitation and temperature; land characteristics, such as pervious or impervious surfaces; soil type; and slope. A strict interpretation of this definition results in a virtually infinite number of unique hydrologic land segments within even a small watershed because of the large number of possible combinations of meteorological characteristics, land characteristics, and soils which exhibit a continuous, as opposed to discrete, spatial variation throughout the watershed. In practice, however, the number of land segments is kept to a more manageable size by keying in on the more predominant characteristics in the watershed. As described later in this chapter, a total of 17 basic land segments were identified for use in the study area.

The hydrologic processes explicitly simulated within LSPC are shown in Figure 50. The model continuously and sequentially maintains a water balance within and between various hydrologic processes. The water balance accounting procedure is based on the interdependence between the various hydrologic processes shown schematically in Figure 51. The model maintains a running account of the quantity of water that enters, leaves, and remains within each phase of the hydrologic cycle during each successive time interval.

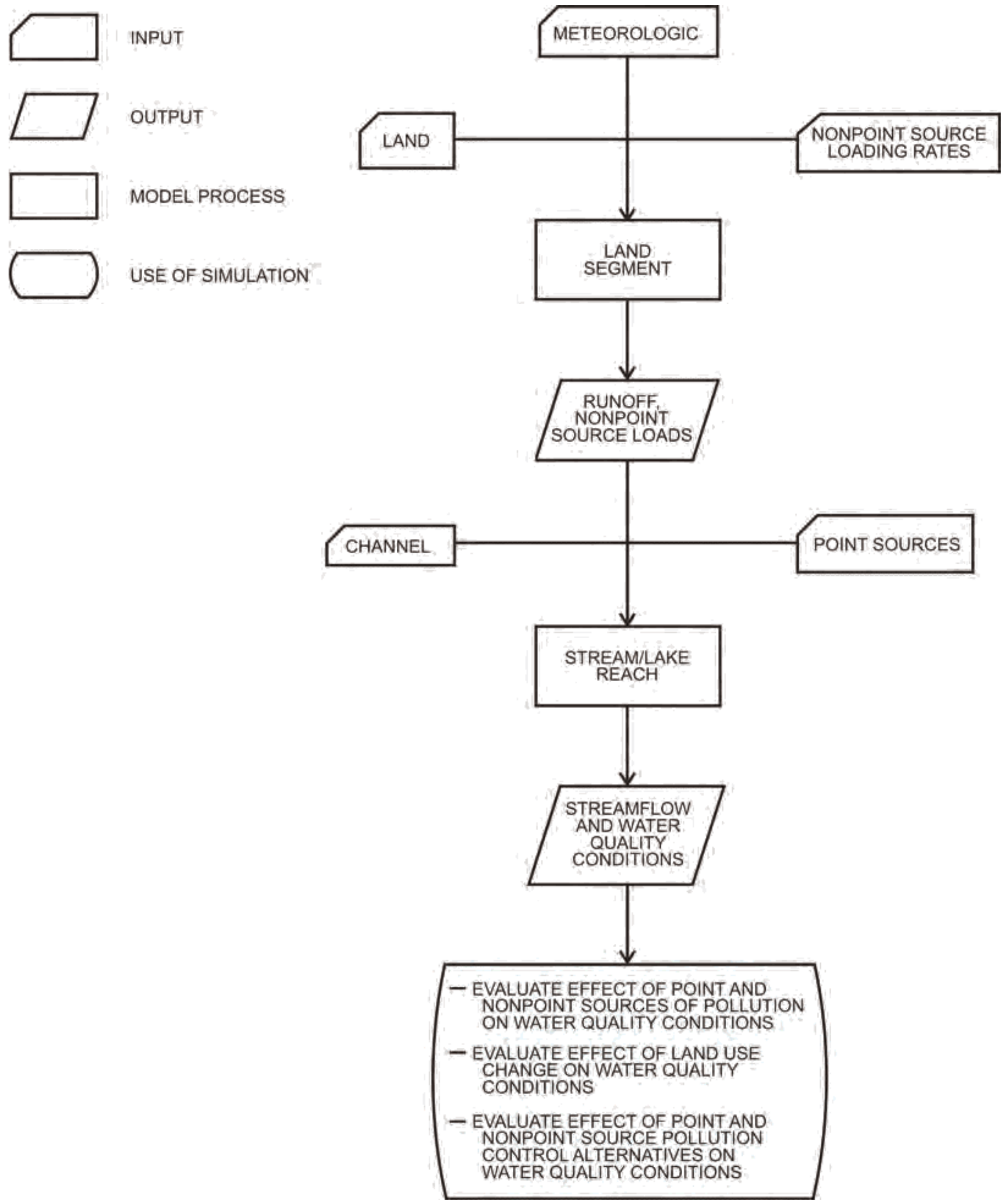
As already noted, the volume and rate of runoff from the land are determined by meteorological phenomena and the nature and use of the land. Therefore, meteorological data and land data constitute the two principal types of input data for each land segment in the model. Table 64 identifies eight categories of historic meteorological data sets, seven of which are input directly to the model for each land segment, and it indicates the use of each data set.[4] The procedures used to acquire or develop the meteorological data sets used in simulating the hydrologic response are described later in this chapter.

Table 65 identifies the hydrology-related parameters that are input to the model for each land segment and indicates the primary source of numerical values for each parameter. The numerical values assigned to each of these land parameters for a given land segment have the effect of adapting the model to the land segment. The procedures used to assign values to the land parameters for each land segment are described later in this chapter.

[4]*Six of the eight meteorological data sets are required as input for hydrologic simulation; the seventh, percent sunshine, is used to compute solar radiation, and the eighth, cloud cover, is required as input for simulation of some water quality processes.*

Figure 49

WATERSHED/WATERCOURSE MODEL USED FOR THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE



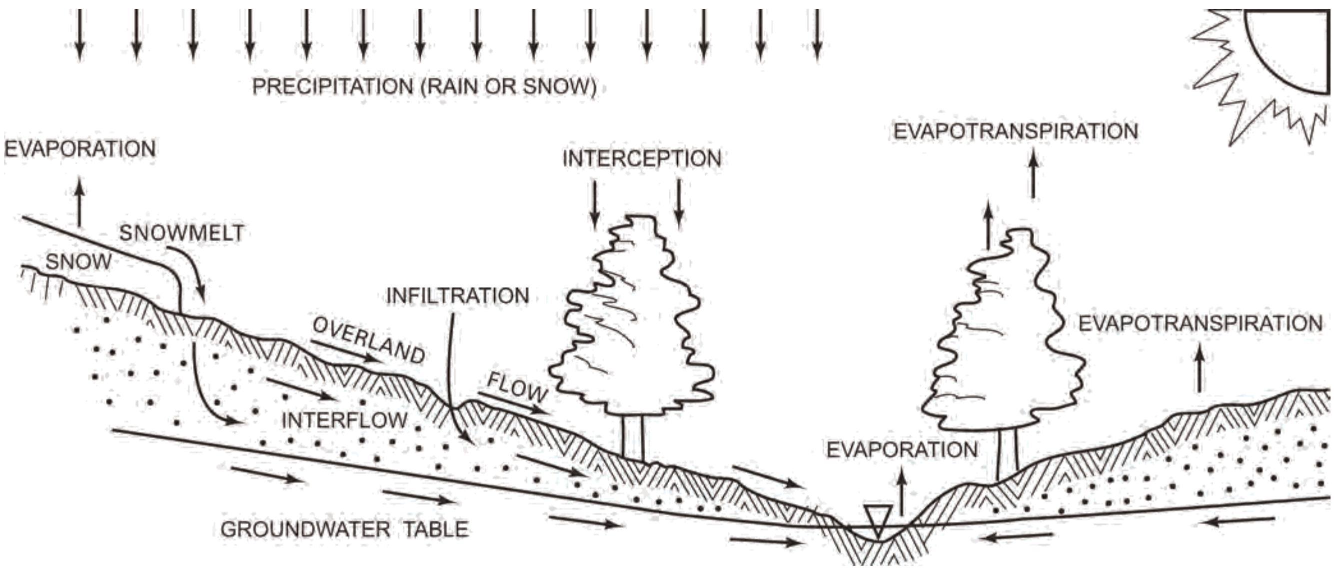
Source: SEWRPC.

The primary function of the hydraulic module of LSPC is to accept as input the runoff generated by the hydrologic processes, along with point source discharges, to combine the two, and to route[5] them through the

[5]*Routing refers to the mathematical technique used to represent the process in which a streamflow hydrograph for a point at the entrance to a river reach or an impoundment, such as a lake or reservoir, is translated and/or attenuated—that is, in the absence of additional inflowing runoff volume, the peak flow may be reduced and shifted in time and the time base is lengthened—through the reach or impoundment as a result of either temporary channel-floodplain storage or temporary impoundment storage.*

Figure 50

HYDROLOGIC PROCESSES SIMULATED BY LSPC



Source: Hydrocomp, Inc., SEWRPC.

stream system, thereby producing a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. The routing reaches are defined so that simulated output values can be obtained at sites where historic stream flow and water quality data are available, or at points located upstream or downstream of known sources of pollution. Contributing runoff comes from a combination of all hydrologic land segments contained within the land surface area tributary to the individual reach. The model performs routing calculations by employing the conservation of mass principle and basic hydraulic laws.

Reach routing is accomplished on a continuous basis using a storage, or reservoir, routing technique. Use of this analytic procedure requires that a stage-discharge-cumulative storage table be prepared for each reach with the values selected so as to encompass the entire range of physically possible water surface elevations encountered during the simulation period. As simulated by the routing algorithm, a volume of flow enters the reach during a particular time increment with the origin of the flow being discharge from a reach immediately upstream combined with both runoff from the additional tributary drainage area and any point source discharges within the reach. The incremental volume of flow is added to that already in the reach at the beginning of the time interval, and the stage-discharge-cumulative volume relationship is then used to estimate the rate of discharge from the reach during the time increment. The volume of water stored in the reach at the end of the time increment is calculated as the initial volume plus the inflow volume minus the outflow volume. This computational process is then repeated for subsequent time increments, with the result of each such computation being the discharge rate from the reach at the end of each time increment. Up to five stage-discharge relationships may be utilized for a given reach, facilitating the simulation of a variety of potential outlet works and operating procedures.

Water Quality Processes

The principal function of the water quality components of LSPC as used for this planning program is to simulate the time-varying unit loads and concentrations of the following 15 water quality indicators at selected points throughout the surface water system of the watershed:

- Total suspended solids (TSS)
- Total nitrogen
- Organic nitrogen

Figure 51

INTERDEPENDENCE BETWEEN HYDROLOGIC PROCESSES IN THE LSPC MODEL

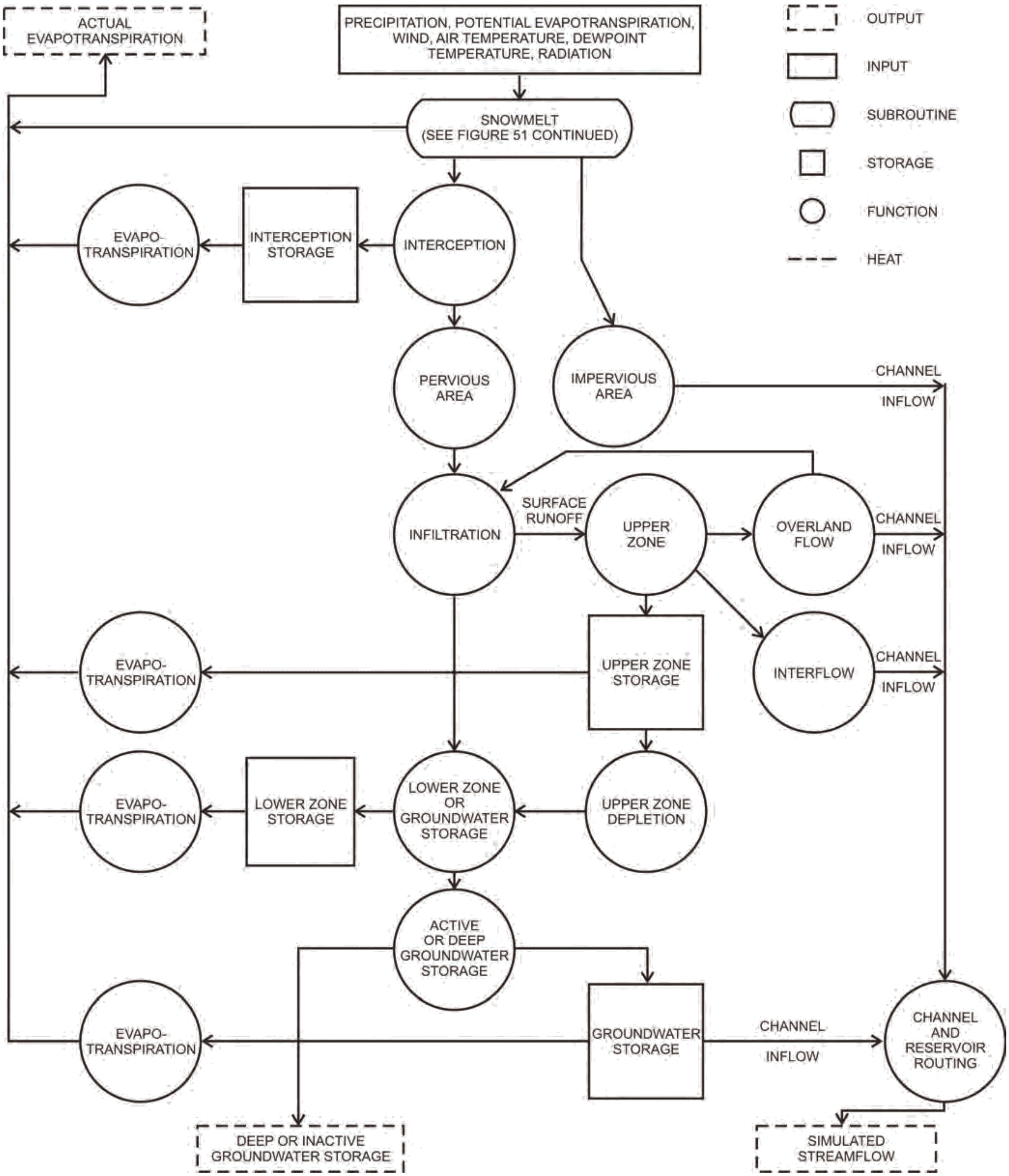
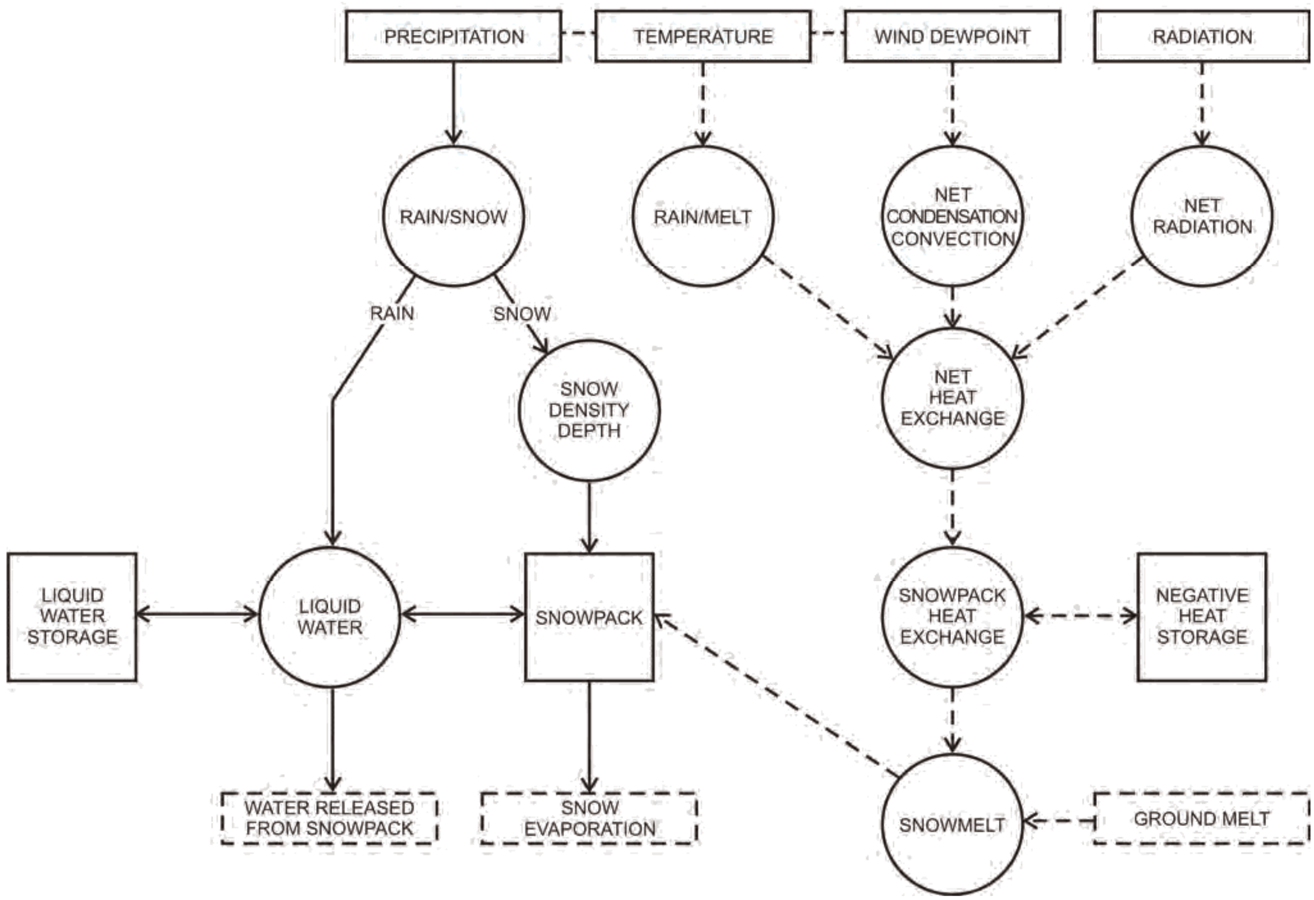


Figure 51 (continued)

FLOWCHART FOR SNOWMELT SUBROUTINE



Source: Hydrocomp, Inc., SEWRPC.

- Ammonia nitrogen
- Nitrate plus nitrite nitrogen
- Total phosphorus
- Orthophosphate
- Fecal coliform
- Dissolved oxygen
- Carbonaceous biochemical oxygen demand (CBOD)[6]
- Temperature
- Phytoplankton as represented by measured chlorophyll-*a* data
- Copper
- Zinc

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[6]*Biochemical oxygen demand data were available for the model calibration and validation, but the model actually simulated carbonaceous biochemical oxygen demand. Typically, carbonaceous biochemical oxygen demand may be assumed to approximate five-day biochemical oxygen demand values. Thus, the use of biochemical oxygen demand data for model calibration/validation is considered to be acceptable.*

Table 64

METEOROLOGICAL DATA SETS AND THEIR USE IN THE LSPC MODEL

Data Set	Units	Frequency		Origin of Data		Use in Hydrologic Processes	Use in Water Quality Processes	Use in Synthesizing Other Meteorological Input Data for the Model
		Desirable	Allowable	Historic	Computed			
Precipitation	10^{-2} inches	Hourly or more frequent	Daily	X	- -	Rain or snowfall applied to the land Data from hourly stations used to disaggregate data from daily stations	- -	- -
Radiation	Langleys/day[a]	Hourly	Daily	- -	X	Snowmelt	Water temperature-heat flux to water by short wave solar radiation	Compute potential evapotranspiration
Potential Evapo-transpiration	10^{-3} inches	Hourly	Daily	- -	X	Evaporation from lakes, reservoirs, wetlands, depres-sion storage, and interception storage Evapotranspiration from upper zone storage, lower zone storage, and groundwater storage Evaporation from snow	- -	- -
Temperature	°F	Hourly	- -	X	- -	Snowmelt Density of new snow Occurrence of precipitation as snow	Water temperature-heat flux to water surface by long wave solar radiation Water temperature-heat flux from water by conduction-convection	Average daily temperature used to compute potential evapotranspiration
Wind Movement	Miles/day	Hourly	Daily	X	- -	Snowmelt by conden-sation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation Lake reaeration	Compute potential evapotranspiration
Dewpoint Temperature[b]	°F	Daily	- -	X	- -	Snowmelt by conden-sation-convection Evaporation from snow	Water temperature-heat loss from water surface by evaporation	Compute potential evapotranspiration
Cloud Cover	Decimal fraction	Daily	- -	X	- -	Used indirectly	Water temperature-heat flux to water surface by long wave solar radiation	Compute solar radiation which was in turn used to compute potential evapotranspiration
Sunshine	Percent possible	Daily	- -	X	- -	Used indirectly	Used indirectly	Compute solar radiation which was in turn used to compute potential evapotranspiration

[a]*Solar energy flux, that is, the rate at which solar energy is delivered to a surface—such as the earth's surface—is expressed in terms of energy per unit area per unit time. The Langley expresses energy per unit area and is equivalent to 1.0 calories/cm^2 or 3.97 x 10^{-3} BTU/cm^2. Therefore, a Langley/day, which expresses solar energy flux in terms of energy per unit area per unit time, is equivalent to 1.0 calories/cm^2/day or 3.97 x 10^{-3} BTU/cm^2/day. The solar energy flux above the earth's atmosphere and normal to the radiation path is about 2,880 Langleys/day.*

[b]*Dewpoint temperature is the temperature at which air becomes saturated when cooled under conditions of constant pressure and constant water vapor content.*

Source: Hydrocomp, Inc. and SEWRPC.

These indicators were selected because they are either directly related to the water quality standards that support the adopted water use objectives set forth in Chapter VII of this report, or are required elements of those indicators (for instance, the individual nitrogen species that make up total nitrogen). The analysis of the simulated

Table 65

HYDROLOGIC PERFORMANCE PARAMETERS REQUIRED BY THE LSPC MODEL

Parameter		Definition or Meaning	Unit	Primary Source of Numerical Values[a]
Number	Symbol			
1	LAT	Latitude of segment	Degrees	U.S. Geological Survey quadrangle map
2	MELEV	Mean elevation of segment	Feet sea level datum	Topographic map
3	SHADE	Decimal fraction of segment shaded from solar radiation	None	Aerial photograph
4	SNOWCF	Adjust snowfall measurements to account for typical catch deficiency	None	- -[b]
5	COVIND	Water equivalent of snowpack when segment is completely covered by snow	Inches	- -[c]
6	RDCSN	Density of new snow at 0°F	None	- -[c]
7	TSNOW	Air temperature below which precipitation occurs as snow	°F	- -[c]
8	SNOEVP	Adjust theoretical snow evaporation equations to field conditions	None	- -[c]
9	CCFACT	Adjust theoretical snowmelt equations to field conditions	None	- -[c]
10	MWATER	Maximum water content of the snowpack expressed as a fraction of the water equivalent of the pack; that is, the maximum amount of liquid water that can be accumulated in the snowpack	None	- -[b]
11	MGMELT	Groundmelt rate attributable to conduction of heat from underlying soil to snow	Inches per day	- -[c]
12	FOREST[d]	Decimal fraction of segment covered by forest which will continue to transpire in winter	None	Aerial photographs
13	LZSN[d]	Nominal transient groundwater storage in the lower soil zones	Inches	Related to precipitation, but determined primarily by calibration
14	INFILT[d]	Nominal infiltration rate	Inches per hour	Calibration
15	LSUR	Average length of overland flow	Feet	Topographic maps
16	KVARY[d]	Allows groundwater recession flow to be nonexponential in its decay with time	1/inches	Hydrograph analysis and calibration
17	AGWRC[d]	Groundwater recession rate	None	Hydrograph analysis and calibration
18	PETMAX	Air temperature below which input evapotranspiration will be arbitrarily reduced	°F	- -[c]
19	PETMIN	Air temperature below which evapotranspiration will be set to zero	°F	- -[c]
20	DEEPFR[d]	Decimal fraction of the groundwater recharge that percolates to deep or inactive groundwater storage	None	- -[c]
21	BASETP[d]	Fraction of potential evapotranspiration which can be satisfied from groundwater outflow—relates to amount of riparian vegetation	None	Calibration
22	AGWETP[d]	Fraction of potential evapotranspiration which can be satisfied from active groundwater storage—relates to amount of deep-rooted vegetation	None	Calibration
23	CEPSC	Maximum interception storage (pervious areas) Surface retention storage capacity (impervious areas)	Inches	Extent and type of vegetation as determined from aerial photographs and field examination

Table 65 (continued)

Parameter				
Number	Symbol	Definition or Meaning	Unit	Primary Source of Numerical Values[a]
24	UZSN[d]	Nominal transient groundwater storage in the upper soils zones	Inches	Calibration
25	NSUR	Manning roughness coefficient for overland flow	None	Field reconnaissance
26	INTFW[d]	Index of interflow	None	Calibration
27	IRC[d]	Interflow recession rate	None	Hydrograph analysis and calibration
28	LZETP[d]	Decimal fraction of segment with shallow groundwater subject to direct evapotranspiration	None	Soils and topographic data
29	SLSUR	Average slope of overland flow	None	Topographic maps

[a]*Regardless of the primary source of parameter values, all land parameters were subject to adjustment during the calibration process.*

[b]*Initial values were assigned based on information and data reported in hydrology textbooks. See R.K. Linsley, M.A. Kohler, and J.L.H. Paulhus,* Hydrology for Engineers*, Second Edition, (New York: McGraw-Hill, 1975).*

[c]*Initial values were assigned based on experience with the model on watersheds having similar geographic or climatological characteristics.*

[d]*Required for pervious land segments only.*

Source: U.S. Environmental Protection Agency.

concentrations of the various water quality indicators provides an estimate of the effect on water quality of alternative measures to control both point and nonpoint sources of pollution.

The concentration of a particular water quality constituent in the surface waters of the watershed at a particular point and time is a function of three factors. The first is the temporal and spatial distribution of runoff—surface or overland runoff, interflow, and baseflow—which determines the amount of water available to transport a potential pollutant to and through the surface water system. The second factor is the nature and use of the land, with emphasis on those features that affect the quantity and quality of point and nonpoint sources of pollutants. For example, a portion of a watershed that supports agricultural activity may be a nutrient source for the surface waters and an urban portion may be a source of metals. The third factor is the characteristics of the stream system which determine the rate and manner in which a potential pollutant is either assimilated in, or transported from, the watershed.

Simulation of the above three factors that influence instream water quality requires a large and diverse data base, much of which is also required for the hydrologic and hydraulic elements of the model as described above. Simulation of water quality requires the input of six data sets—meteorological, land, channel, diffuse sources of pollution, point sources of pollution, and runoff generated by the hydrologic element of the model. The six categories of historic meteorological data sets that are utilized either directly or indirectly for water quality simulation are identified in Table 64.

The required land data is provided using the land segments previously described. In determining the various land segment categories to be applied in the model, additional consideration of land management practices needs to be given when using the model to simulate water quality as opposed to simulating only hydrology. For a given land segment, the different land management practices that affect pollutant runoff may produce different water quality responses but the same hydrologic response. For instance, it may be adequate to address the hydrologic response of paved surfaces with a single impervious land segment. However, proper accounting of the pollutant loads may require several impervious land segments, each representing a separate land management practice, such as roadways or industrial storage areas.

The channel data required for water quality simulation is the same as that described above for hydraulic routing. For water quality simulation, additional nonhydraulic channel data must also be provided, consisting primarily of water quality parameters and coefficients, such as the maximum phytoplankton growth rate and the temperature correction factor for benthic oxygen demand.

A set of nonpoint pollution source parameters is required for each constituent that is to be modeled on each land segment. Each set of parameters contains land surface buildup rates, expressed as a weight per unit area, and a loading limit, expressed in weight per unit area of land surface. The nonpoint source parameter set for each land segment also contains the concentration of the constituent in the interflow and groundwater flow from the segment to the stream system. Each point source of pollution similarly requires a data set consisting of identification of the river reach to which the source discharges, a series of volumetric flow rates, and a series of corresponding concentrations for each of the constituents to be simulated. The final category of input is the computed runoff volumes from the land segment as well as computed interflow and groundwater discharges to the stream system.

Similar to the hydrologic and hydraulic processes, the water quality simulation process may be viewed as being composed of a land phase and a channel phase, each of which is simulated continuously. In the land phase, the quantity of a given constituent that is available for washoff from the land at the beginning of a runoff event is equal to the amount of material remaining on the land surface after the last runoff event plus the net amount of material that has accumulated on the land surface since the last runoff event. The quantity of washoff from the land to the stream system during a runoff event is proportional to the amount of material on the land surface at the beginning of the computational time interval and it is also dependent on the runoff rate over the time interval. An exception to this rule is sediment, which the model assumes is unlimited in the amount available for washoff. The above process is not used to simulate the temperature and dissolved oxygen of land runoff. The model assumes that the temperature of the runoff is equal to surface temperature and that the runoff is fully saturated with dissolved oxygen. Pervious surface runoff and impervious surface runoff during and immediately after rainfall or rainfall-snowmelt events are the two mechanisms for transporting accumulated nonpoint source constituents from the land surface to the stream system. Interflow contributes additional subsurface pollutant loading during and after runoff events. Groundwater flow is the mechanism for continuously transporting potential pollutants to the stream system from the subsurface of the watershed.

As noted above, operating on a reach-by-reach basis, the channel phase of the model uses a storage, or reservoir, routing technique to determine the inflow to, outflow from, and net accumulation of flow within each reach during the simulation time step. This is followed by a summation over the time step of all mass inflows and outflows of each water quality constituent to determine an average concentration throughout the reach based on the assumption of complete, instantaneous mixing. The biochemical processes are then simulated so as to determine an average concentration at the end of the simulation time step. The channel phase computations are then repeated within the reach for subsequent time intervals and also are repeated for all other reaches. Water quality processes explicitly simulated within the model are indicated in Figure 52.

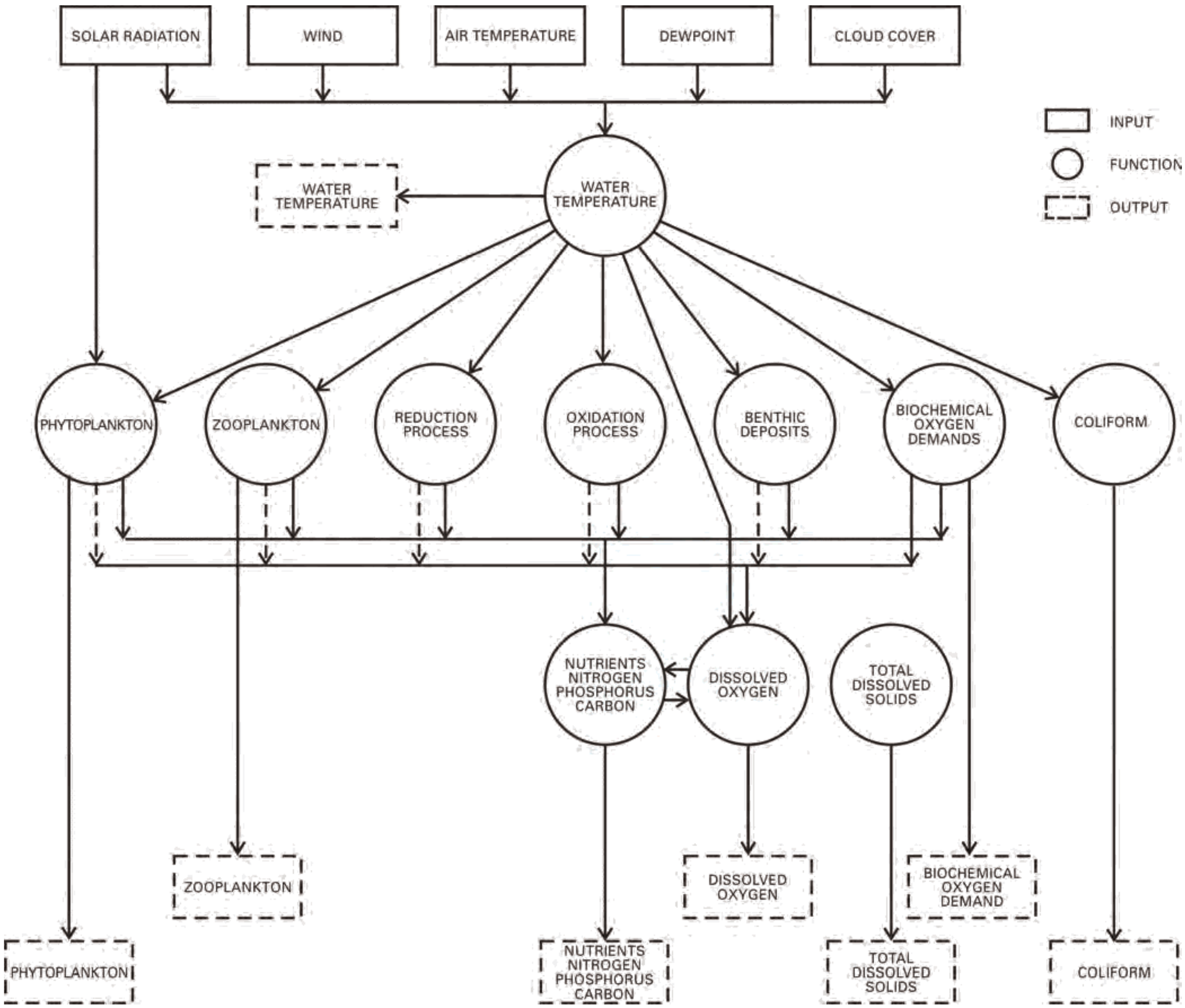
Data Base Development

The largest single work element in the preparation and application of the LSPC model is data base development. This consists of the acquisition, verification, and coding of data needed to develop, calibrate, validate, and apply the model. The data base consists of a file of information that quantitatively depicts the characteristics of the surface water system of the watershed.

As shown schematically in Figure 49, application of the model requires the development of a data base composed of the following five distinct categories of information: meteorologic conditions, land use and related conditions, channel conditions, diffuse sources of pollution, and point sources of pollution. Of the five input data sets, the meteorological data set is the largest, consisting of 17 years of daily, hourly, and subhourly information for each of the seven historic meteorological data types. The meteorological data set is also the most critical since experience with the model indicates that simulated stream discharges, stages, and water quality levels are very

Figure 52

INTERDEPENDENCE OF PROCESSES FOR WATER QUALITY SIMULATION



Source: Hydrocomp, Inc., SEWRPC.

sensitive to how well the meteorological data set—particularly precipitation—represents historical meteorological conditions.

With respect to origin, the data are largely historic, being based on existing records of past observations and measurements. For example, the bulk of the meteorological data in the data base are assembled from National Weather Service (NWS) and local rain gage records. Some of the data are original, having been obtained by field measurements made during the planning program. Some of the data are synthetic, having been calculated from other available historic data. Such calculated data sets were used when historic data were not available and it was impossible or impractical to obtain original data. The solar radiation data used, for example, are synthetic because of the absence of long-term historic radiation observations in or near the study area, and because of the impracticality of developing long-term original solar radiation data. Solar radiation data were computed from available historic daily percent sunshine or cloud cover index values.

A distinction should be drawn between model input data and model calibration data. The five categories of data previously identified constitute the input data needed to operate the model. Calibration and validation data, which are described in a subsequent section of this chapter, are not required to operate the model, but are important to the adjustment of the model parameters so that the model performance fits real world data. The principal types of calibration data used in this planning program are streamflow and water quality.

Each of the five types of input data, as well as the calibration and validation data, is described in the following sections.

Meteorological Data
As shown in Table 64, the following seven types of meteorological data are required as direct input to the watershed/watercourse model: precipitation, temperature, wind movement, solar radiation, dewpoint temperature, potential evapotranspiration, and cloud cover. Map 43 shows the location of the eight NWS meteorological observation stations and eight MMSD/City of Milwaukee rain gages used for operation of the model. Also depicted is the Thiessen polygon network that was constructed for the purpose of delineating the geographic area represented by each station.

Data collected at each of the recording stations used in the model varied by both type and recording interval. The eight stations operated by the MMSD or City of Milwaukee measure rainfall only at a 5-minute time interval. Data from these gages was accumulated into 15-minute intervals, corresponding to the shortest time step used in the model simulation. Temperature data applied to these stations was taken from nearby NWS station records. With the exception of General Mitchell International Airport (GMIA), only daily precipitation and daily maximum/minimum temperature was collected at the NWS stations. These daily precipitation records were distributed into hourly values using the data collected at GMIA, the NWS station at Hartford, and at a MMSD rainfall station located at Pioneer Road (CTH C) in the City of Mequon. For all of the stations utilized, the GMIA station was used as the source for dewpoint temperature, wind movement, solar radiation, potential evapotranspiration, and cloud cover. Hourly precipitation data, as well as daily maximum and minimum temperatures, wind movement, solar radiation, and potential evapotranspiration, were distributed into 15-minute or hourly values using a utility computer program (METCMP) developed by the U.S. Geological Survey (USGS). That program distributes weather–related time series data based on empirical relationships.

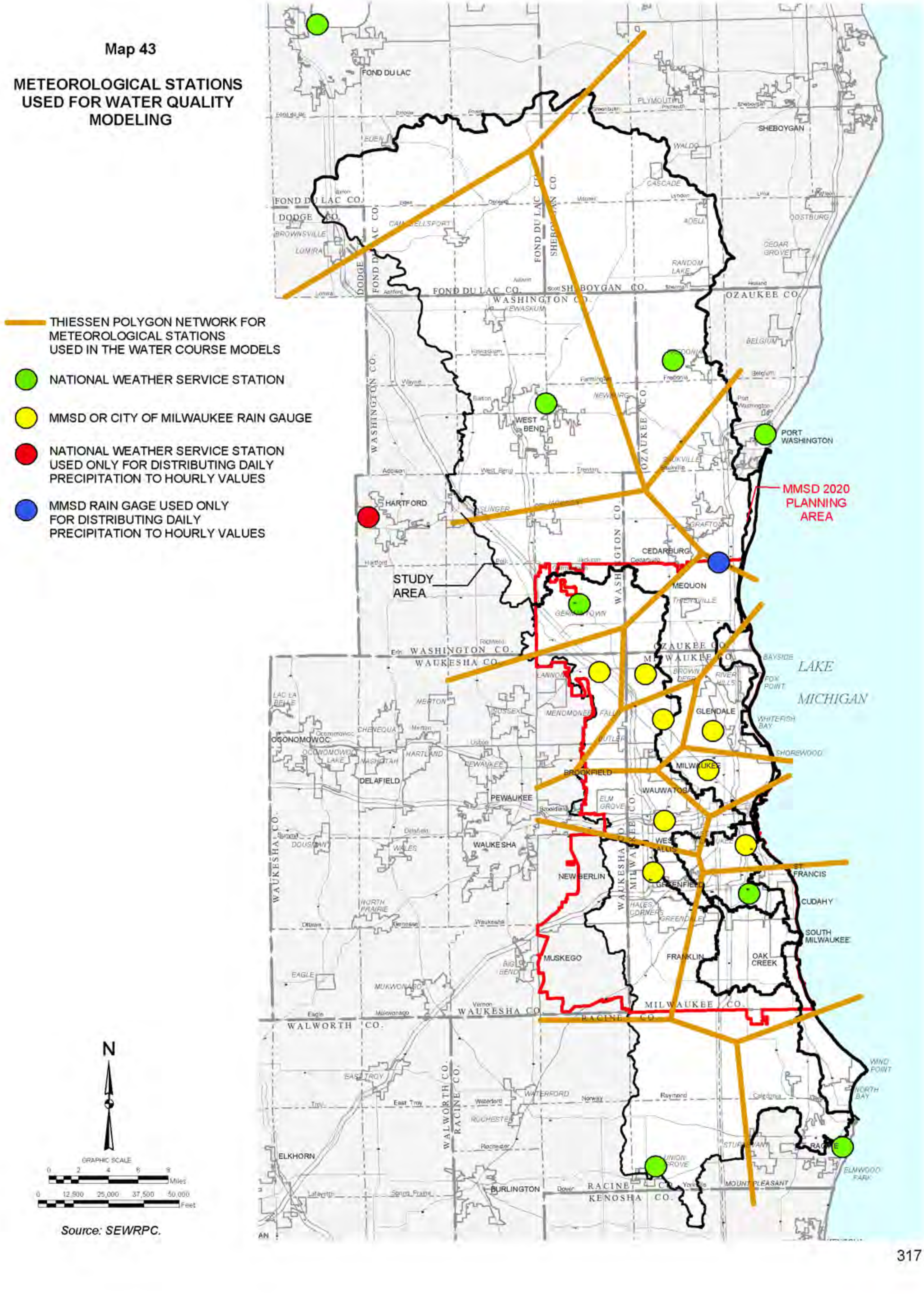
Much of the meteorological data base development was completed under other Regional Planning Commission work programs. The principal work element completed under this planning program was an extension of the time period represented by the meteorological data base, along with collection of precipitation data from the rain gages operated by the MMSD and City of Milwaukee. Meteorological data sets were developed for the 17-year period from 1988 through 2004. This period covers two different time frames utilized in the modeling process. For model calibration and validation purposes, the period from 1994 through 2002 was utilized. This period was selected since it coincided with the availability of water quality monitoring data and covered a period after the MMSD Inline Storage System began operation. Extension of the meteorological data through 2004 was required to incorporate additional validation data collected by the USGS for the upstream reaches of the Milwaukee River watershed and the downstream reaches of the Root River watershed, as discussed later in this chapter.

In addition to model calibration and validation, long-term simulation of the model was required in order to assess water quality conditions under the various land development and water quality control alternatives considered under this planning process. The 10-year period from 1988 through 1997 was selected for this purpose. This period was selected since it is representative of the long-term precipitation statistics as measured at the GMIA weather station for the 63-year period from 1940 through 2002. Utilization of a 10-year period allowed for shorter model run times and more manageable processing of model output, while still providing a sufficiently long simulation period to assess water quality conditions.

Land Data
As shown in Figure 49, land data are needed to simulate the hydrologic processes, the output of which influences streamflow and water quality. Table 65 identifies the land-related parameters that are required for each land

Map 43

METEOROLOGICAL STATIONS USED FOR WATER QUALITY MODELING



Source: SEWRPC.

segment that is to be simulated. The four land characteristics—meteorology, soil type, slope, and land use-cover—that are the major determinants of the magnitude and timing of surface runoff, interflow, and groundwater flow from the land to the watershed stream system form the basis for land segment identification. There are other land characteristics that may influence the hydrologic response of the land surface; for example, depth to bedrock and density of the stormwater drainage system. However, the four characteristics indicated were selected for use as both the most basic and the most representative.

Influence of Meteorological Stations
As already noted a Thiessen polygon network was constructed for the planning area in order to facilitate subdivision of the watersheds into areas lying closest to each of the 16 meteorological stations concerned.

Hydrologic Soil Group
The regional soil survey conducted by the U.S. Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, for the Regional Planning Commission, classified the soils of the Region into four hydrologic soil groups, designated A, B, C, and D, based upon those properties affecting runoff. In terms of runoff characteristics, these four soil groups range from Group A soils, which exhibit very little runoff because of high infiltration capacity, high permeability, and good drainage, to Group D soils, which generate large amounts of runoff because of low infiltration capacity, low permeability, and poor drainage. The planning area was determined to be covered primarily by Hydrologic Groups B and C soils.

Slope
Approximately 81 percent of the land in the project area was found to have slopes of 6 percent or less. Based on the analysis of slopes within the planning area and previous slope sensitivity studies, it was determined that the use of slope in the determination of required land segments was not warranted.

Land Use and Cover
The combination of land use and cover often reflects human influences on the hydrologic processes and water quality of a watershed. Land cover differs from land use in that land cover describes the types of surface—for example, paved, grassed, and wooded—whereas land use describes the purpose served by the land—for example, residential, commercial, and recreational. A total of five pervious and six impervious land use and cover types were identified for use in delineating land segments.

Resulting Land Segments
Application of the above process yielded a total of 17 different land segments for use in the planning area, not accounting for meteorological station. These basic land segments are identified in Table 66. Within the watershed models, these 17 land segments are further assigned by meteorological station, allowing for a total number of 272 possible land segments. Not all meteorological stations or land uses are represented in all of the watersheds in the project area. Thus, the actual number of land segments defined is smaller for each watershed model.

Channel Data
Channel conditions, including slope, channel roughness, and cross-section, are important determinants of the hydraulic behavior of a stream system. As indicated in Figure 49, channel data are needed to operate the hydraulic and instream water quality aspects of the model.

As noted earlier in this chapter, a stage-discharge-cumulative storage table must be provided along with the surface area for each stream routing reach. The process used to develop the stage-discharge-cumulative storage tables was initiated by subdividing the approximately 961 miles of stream system selected for water quality simulation into reaches and assigning tributary areas to those reaches. These drainage areas are shown on Maps 44 through 48. A total of 683 routing reaches were established in the study area. Reach lengths ranged from 0.08 to 5.97 miles, with an average length of about 1.4 miles. Drainage areas tributary to the individual reaches range from 0.01 to 13.1 square miles, with an average area of about 1.6 square miles.

Table 66

BASIC LAND SEGMENTS SELECTED FOR USE IN THE WATERSHED/WATERCOURSE MODEL

Identification Number	Land Segment Description
1	Commercial Impervious
2	Government/Institutional Impervious
3	Industrial Impervious
4	Residential Impervious
5	Freeway Impervious
6	Ultra-Low Use Impervious
7	Cropland, B-Soil
8	Cropland, C-Soil
9	Cropland, D-Soil
10	Forest
11	Grass, B-Soil
12	Grass, C-Soil
13	Grass, D-Soil
14	Pasture, B-Soil
15	Pasture, C-Soil
16	Pasture, D-Soil
17	Wetland

Source: SEWRPC.

After subdivision of the stream system into reaches, one of the following three procedures was applied to develop stage-discharge-cumulative storage data to be used for routing:

1. Detailed river hydraulic models developed under other planning programs were used to compute water surface profiles over a range of discharges. Model output included computed volume for each flow and corresponding water surface elevation. The hydraulic models used were developed mainly under the MMSD watercourse system planning for streams in the Kinnickinnic River, Menomonee River, and upper Root River watersheds. For the Milwaukee River, Oak Creek, and lower Root River watersheds, hydraulic models developed under the Federal flood insurance program and under other SEWRPC planning programs were used. The use of these detailed hydraulic models enabled consideration of such factors as the backwater effects of hydraulic structures.

2. A generalized cross section representative of the channel and adjacent floodplain was identified, along with the reach length, longitudinal slope, and coefficient of roughness. This information was used to compute the stage-discharge-cumulative storage table by applying Manning's formula for open channel flow.

3. For lakes and those impoundments for which a detailed hydraulic model was not available, stage-discharge relationships were developed based on the hydraulic characteristics of outlet control structures. Stage-cumulative storage relationships were derived from available hydrographic surveys, many of which were conducted by the Wisconsin Department of Natural Resources (WDNR).

In addition to the hydraulic data noted above, nonhydraulic data must also be provided for each channel or lake reach. These data consist of water quality parameters and coefficients, such as maximum algal growth rate, constituent decay rates, and the benthic release rates for nutrients. The principal sources of initial numerical values for these parameters and coefficients were state-of-the-art engineering practice and previous experiences with application of the water quality submodel. These values were later adjusted as part of the model calibration and validation process.

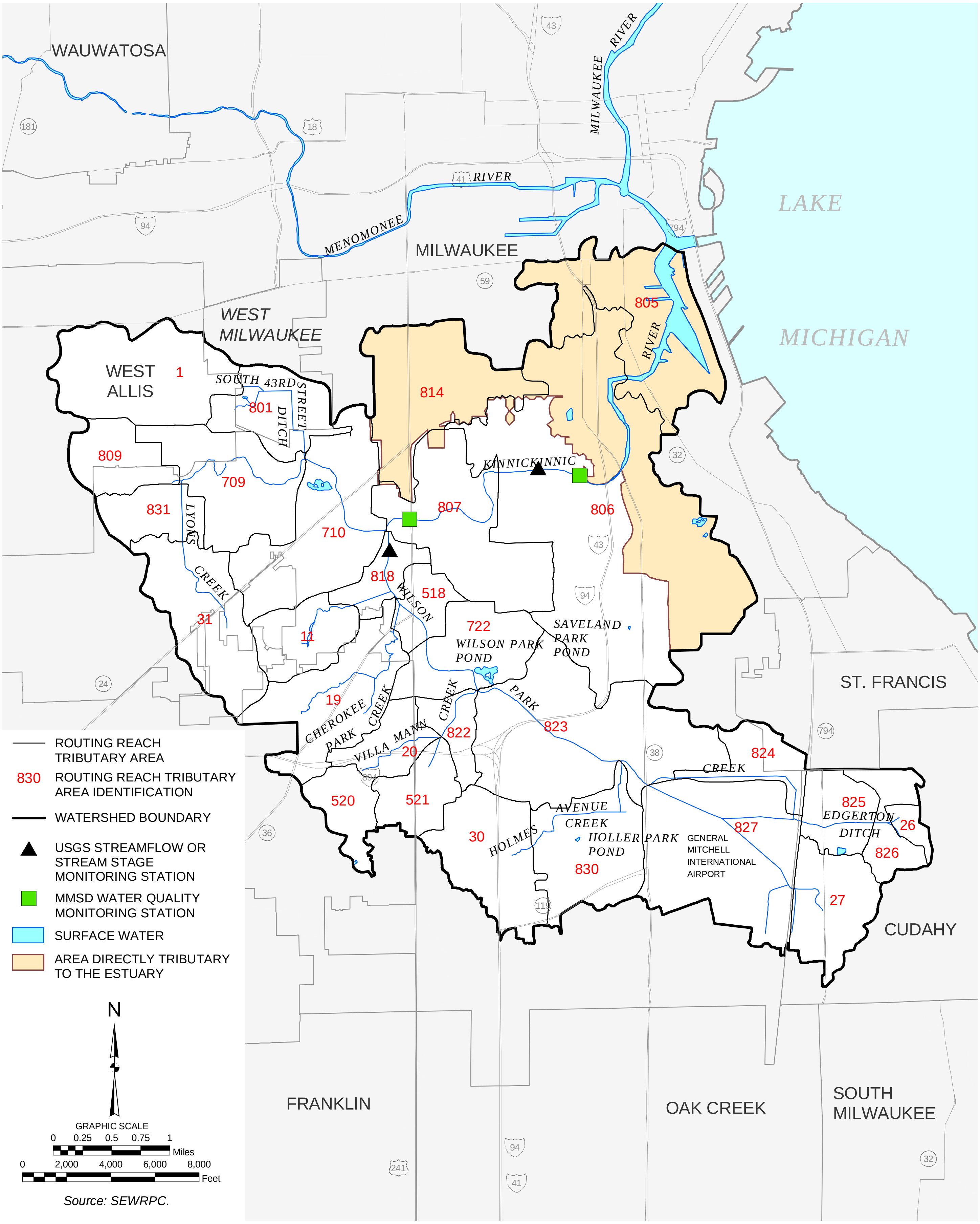
Nonpoint Source Data

Figure 49 illustrates how nonpoint source data were input to the watershed/watercourse model, along with meteorological, point source, channel data, and output from the hydrologic simulation. The choice of initial numerical values for some nonpoint source pollution parameters was based on values reported in the literature for urban and rural areas similar to the watersheds under study, on previous modeling experience, and in some instances derived to match loads from other water quality models.

As part of the regional water quality management plan update, a series of meetings to discuss modeling procedures was held between staff of the Regional Planning Commission, the MMSD, and the WDNR, as well as the modeling consultants. As a result of those meetings, it was decided that an effort would be made to adjust the

Map 44

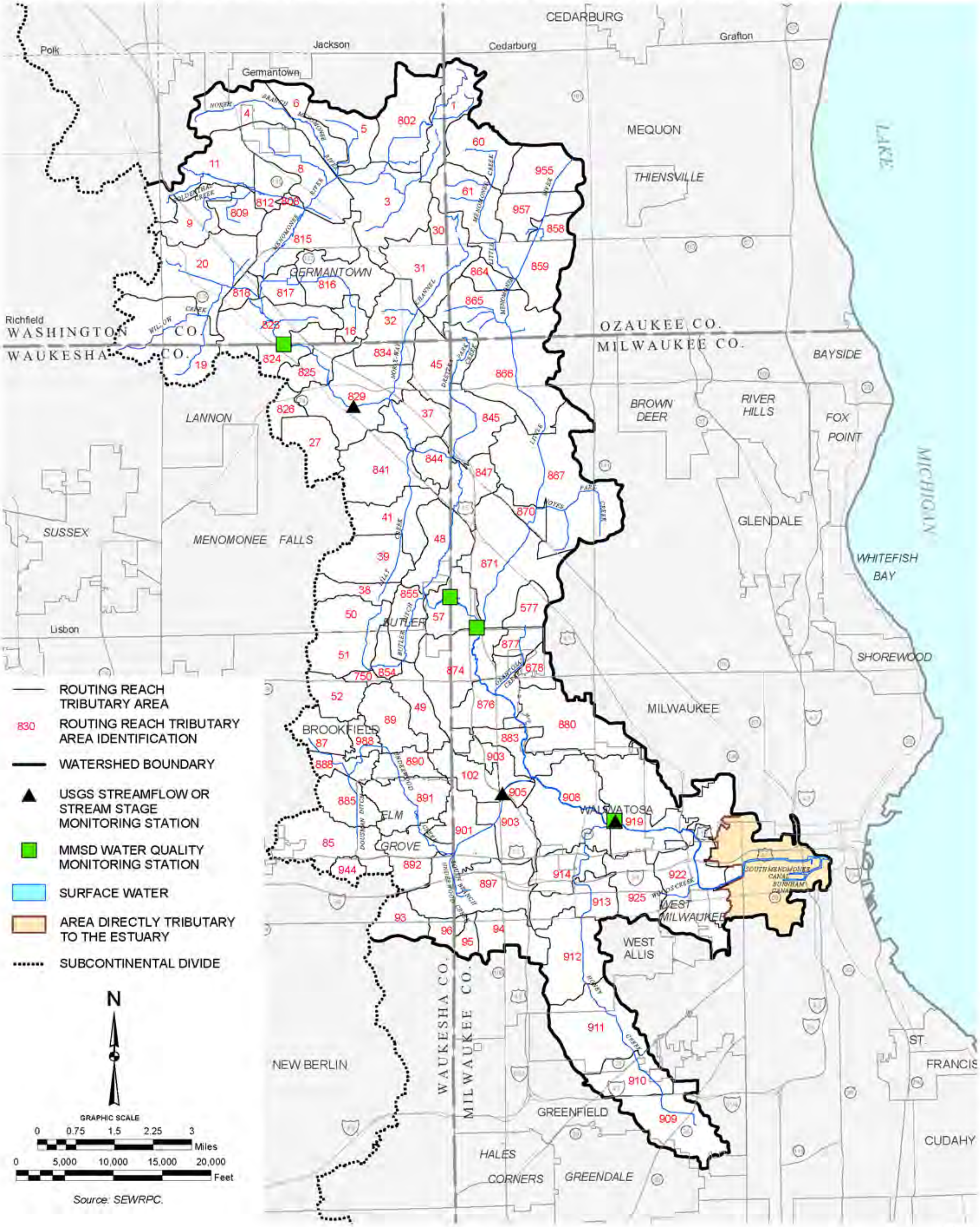
REPRESENTATION OF THE KINNICKINNIC RIVER WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

Map 45

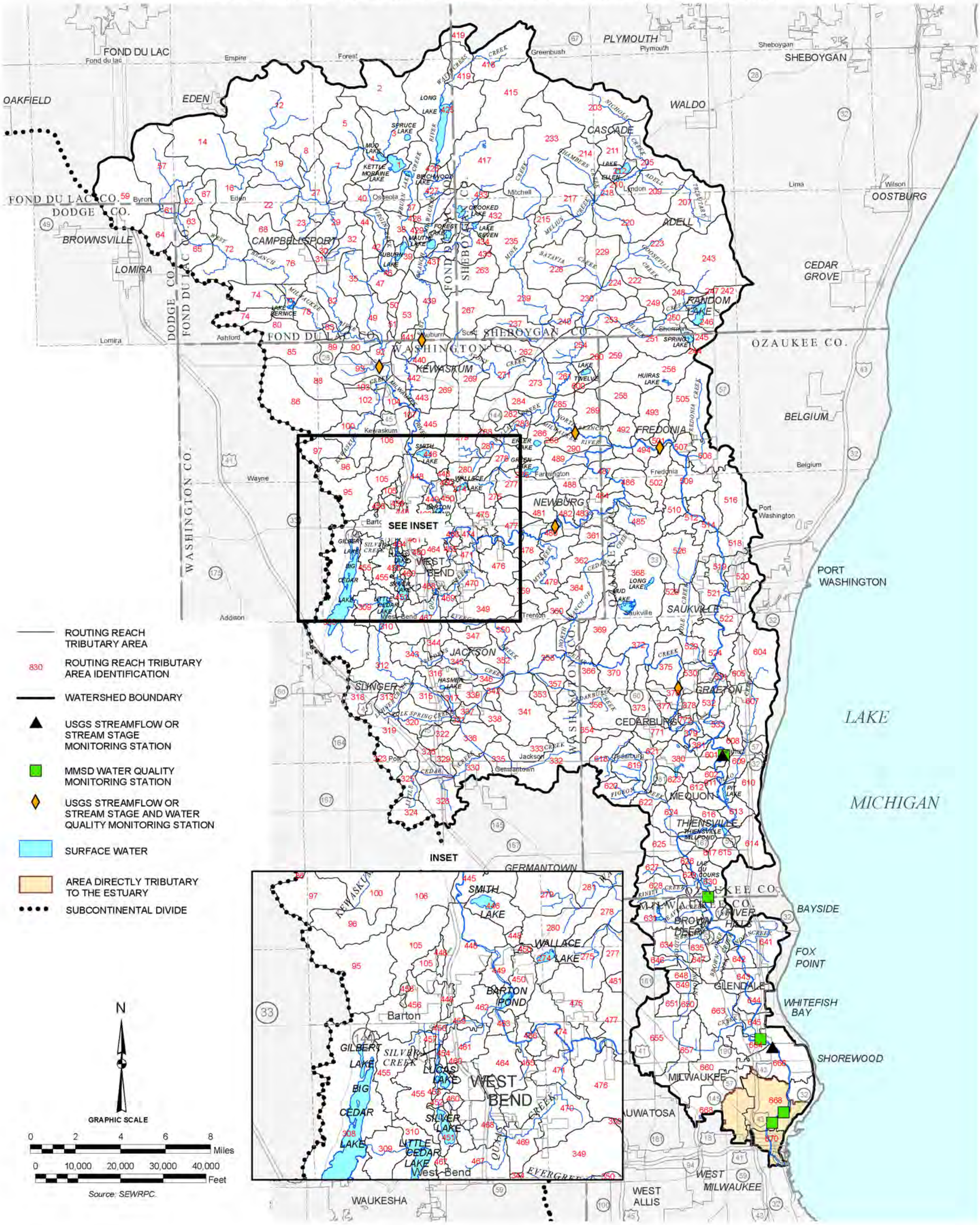
REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

Map 46

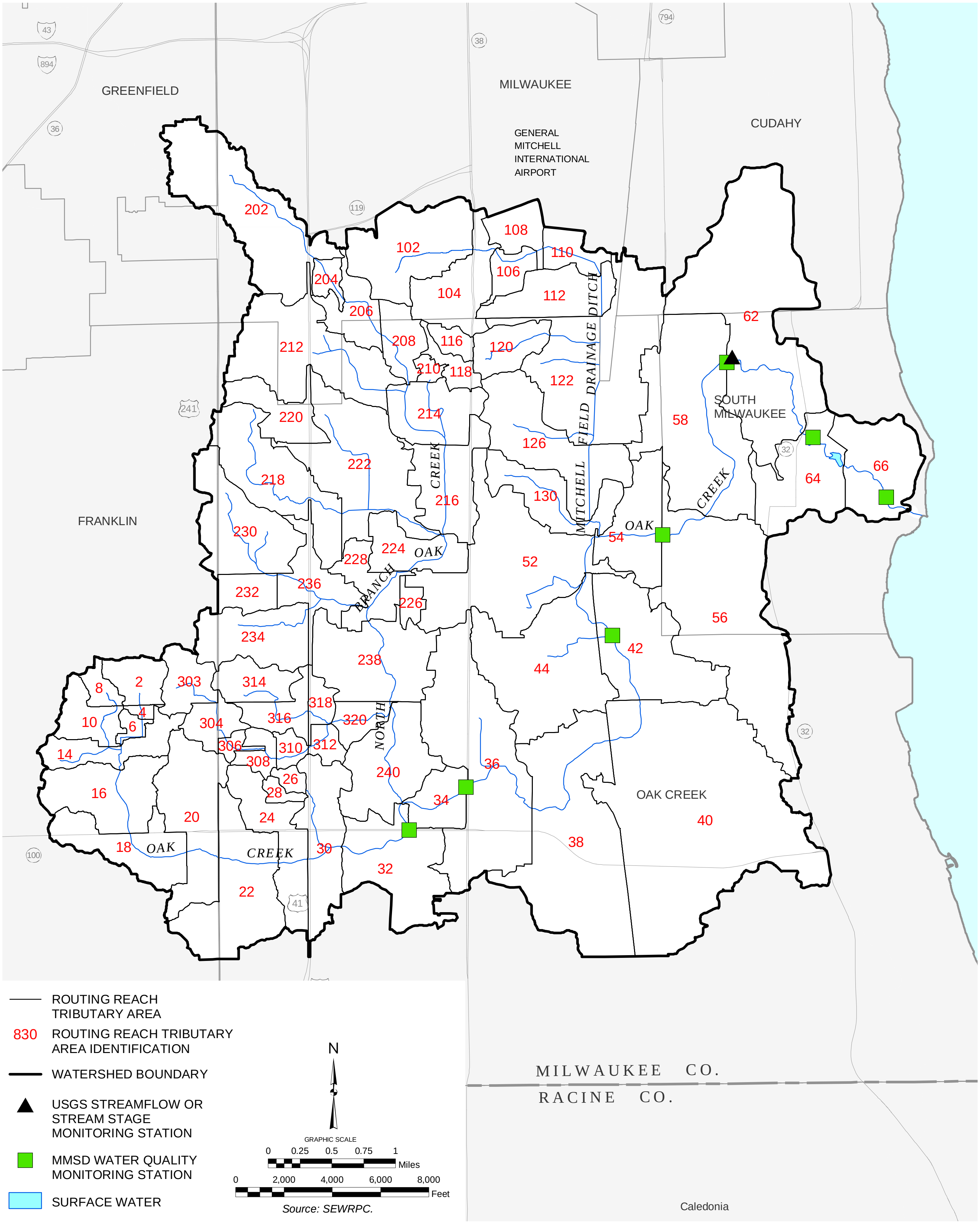
REPRESENTATION OF THE MILWAUKEE RIVER WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

Map 47

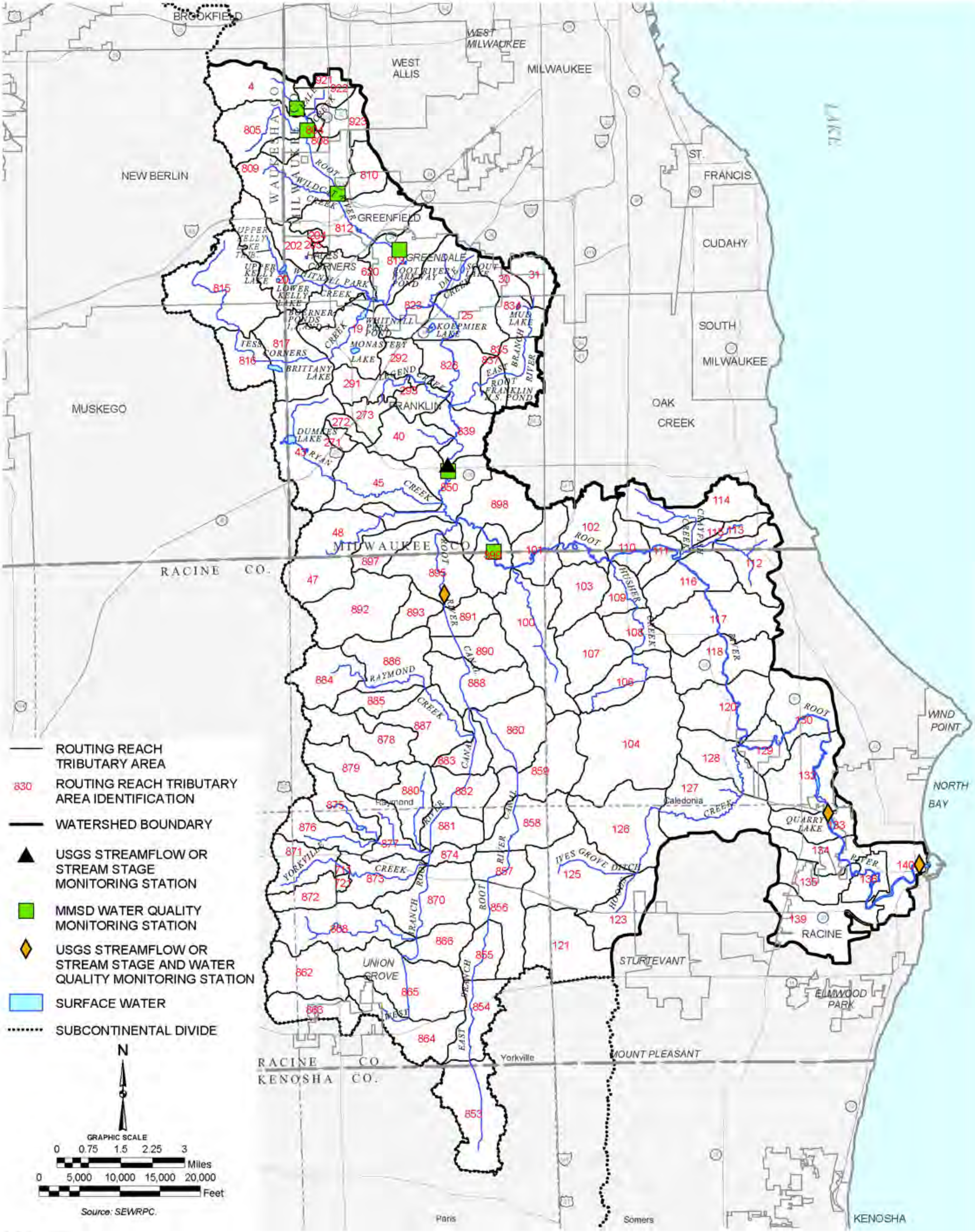
REPRESENTATION OF THE OAK CREEK WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

Map 48

REPRESENTATION OF THE ROOT RIVER WATERSHED FOR WATER QUALITY SIMULATION



Source: SEWRPC.

watershed/watercourse model loads so as to be consistent, to the extent practicable, with loads generated by the Source Loading and Management Model (SLAMM) and the Soil and Water Assessment Tool (SWAT). The SLAMM model, which is designed to compute urban pollutant loads, is preferred by the WDNR for use in assessing compliance with State urban nonpoint source pollutant regulations. The SWAT model is designed for rural watershed assessments, and is being used by the WDNR in Total Maximum Daily Load (TMDL) studies within Wisconsin. Values for two parameters used in the LSPC model—ACQOP which represents the daily pollutant buildup rate on the land surface, and SQOLIM which represents the maximum pollutant buildup—were derived so as to produce land segment loads consistent with the SLAMM and SWAT models. Some of these values were subsequently adjusted during the calibration process to improve the correlation between observed and simulated instream water quality conditions.

Point Source Data

Point source pollutants can significantly affect surface water quality, particularly during dry weather flow conditions. Under the water quality management plan update program, point sources were divided into three main categories: industrial discharges, combined sewer and separate sewer overflows (CSOs and SSOs), and public and private wastewater treatment plants (WWTPs). A detailed discussion of the development of point source data, including an inventory of such sources, is set forth in a draft MMSD Technical Memorandum[7] and a subsequent Regional Planning Commission staff memorandum.[8]

Industrial point source input data consisted of monthly effluent discharge and water quality values that were derived from Discharge Monitoring Reports (DMRs) that are required under the WDNR Wisconsin Pollutant Discharge Elimination System (WPDES) permitting program. Under that program, facilities are required to sample their discharges on a monthly, quarterly, or annual basis. The parameters monitored vary depending on the type of activity permitted. After review of the permits issued within the project area, it was determined that the two permit categories of particular interest were noncontact cooling water discharge and individual permits. Discharges that are covered under other permit categories were not included in the model for various reasons, including: they were representative of a limited time frame (construction activity); there was no monitoring of outflow required; or the parameters required to be monitored were not being evaluated under this study.

Point source information related to combined sewer overflows and sanitary sewer overflows was developed based on several sources. Volume of overflow from combined sewers and those separate sanitary sewers within the MMSD conveyance system were obtained from the MMSD conveyance system models that are described later in this chapter. Pollutant concentrations were assigned based on overflow sampling data collected by the MMSD, along with literature values and correlation estimates based on monitoring data from other areas of the country. The sanitary sewer overflow concentrations also took into account limited sampling data obtained by local municipalities.

Information related to historical sanitary sewer overflow from municipal systems was obtained from reports provided by the municipalities to the WDNR. Those reports typically provide information regarding the location of the overflow and an estimate of overflow volume. This information was used to develop overflow hydrographs for use in model calibration and validation. Pollutant concentrations assigned to the municipal overflows were the same as those assigned to the MMSD SSOs and reflect both MMSD and municipal overflow sampling data.

For production run purposes whereby the model is used to represent alternative plan conditions under existing or future operating conditions, the historic overflows could not be used since they reflect sewer system conditions that may no longer exist or were the result of mechanical failure rather than an inadequacy in the system.

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[7]*Triad Engineering and Tetra Tech MPS*, MMSD Draft Memorandum, Point Source Loadings Calculations for Purposes of Watercourse Modeling, *December 14, 2004*.

[8]*SEWRPC Technical Memorandum,* Point Source Loadings Calculations for Purposes of Watercourse Modeling—Addendum: Point Sources Located Outside of the MMSD Planning Area, *March 28, 2005*.

Therefore, in order to assign a contribution from sanitary sewer overflows, several methods were utilized. As noted previously, overflows from MMSD sewers were determined using the conveyance system model. For municipalities located within the MMSD planning area, regression relationships between the occurrence of historical MMSD system overflows and municipal system overflows were developed. Using these relationships and the output from the conveyance model, the timing of overflow events and their associated volumes were determined for the municipal systems. Due to the spatial distance of communities in the upper Milwaukee and lower Root River watersheds, a simpler approach was used in assigning SSOs. In those communities, the timing of overflow events was tied to a specified threshold rainfall amount, with the volume of overflow being set equal to the average of reported historical overflow volume. These average volumes were computed after first removing events that occurred due to mechanical failure and removing overflow locations where sewage conveyance and treatment system upgrades have since been undertaken by the community in question.

Similar to industrial point sources, wastewater treatment facility point source data consisted of monthly discharge and water quality values that were derived from Compliance Maintenance Annual Reports required by the WDNR as a condition of the plant operating permit. Copies of these reports were obtained from the WDNR.

Calibration/Validation Data

The five categories of data previously discussed—meteorological, land, channel, point pollution sources, and nonpoint pollution sources—constitute the total input data required to operate the watershed/watercourse simulation model. Of equal importance are calibration data. These data, which are derived entirely from actual field measurements, included recorded streamflow and water quality conditions. Since calibration data represent the actual historic response of the stream system of the watershed to a variety of hydro-meteorological events and conditions, such data may be compared to the simulated response of the watershed, and the model calibrated as necessary to provide an accurate simulation. The time period selected for model calibration and validation was from 1994 through 2002. This period was selected because the models were set up to reflect the condition since the MMSD Inline Storage System (ISS) was placed in operation in 1994.

Streamflow Data

The principal sources of historic streamflow information are the measurements made by the USGS at a series of continuous recording stations located throughout the planning area. These gages are maintained cooperatively by the USGS, local units of government, the MMSD, the Regional Planning Commission, and the WDNR. The locations of the gages used for model calibration and validation are shown on Maps 44 through 48. Average daily flow records covering the calibration/validation period of 1994 through 2002 were obtained from the USGS. These data were then used to calibrate and validate the hydrologic and hydraulic processes in the LSPC models for each of the five watersheds under consideration.

Water Quality Data

The principal source of stream water quality data used in the calibration of the watershed/watercourse models was the bi-weekly sampling program conducted by the MMSD. Under that program, samples are collected at selected points throughout the MMSD planning area at approximately two week intervals between March and November. The MMSD protocol calls for each monitoring location to have at least one survey per year meeting one of the following criteria: 1) after a wet weather event with a combined sewer overflow; 2) after a wet weather event without a combined sewer overflow; and 3) after a seven-day dry out period without a combined sewer overflow. Water quality parameters collected by the MMSD that were used in the watershed/watercourse models include total suspended solids, temperature, dissolved oxygen, total and dissolved phosphorus, biochemical oxygen demand (BOD), fecal coliform, chlorophyll *a*, ammonia nitrogen, nitrite plus nitrate nitrogen, total Kjeldahl nitrogen, and metals including copper and zinc.

The locations of the 24 sampling sites for which calibration data were obtained are shown on Maps 44 through 48. Data covering the period from 1994 through 2001 was obtained from the MMSD. Although the hydrologic calibration/validation period extended through 2002, the 2002 water quality sampling data were not available for model validation because final quality control procedures had not yet been completed at the time that model calibration was conducted.

Since the MMSD sampling program is confined to the District's planning area, there were gaps in the availability of recent monitoring data for the upper Milwaukee River and lower Root River watersheds. Therefore, as part of this regional water quality management plan update, the Regional Planning Commission contracted with the USGS to obtain data for sites in the outlying portions of those two watersheds. Under that sampling effort, data were collected at six sites within the upper Milwaukee River watershed—including Cedar Creek—and at three sites within the lower Root River watershed. The locations of these sites are shown on Maps 46 and 48. Data were collected from May through mid-November 2004 and consisted of continuous measurement of streamflow, temperature, dissolved oxygen, and specific conductance. In addition, sampling was conducted multiple times over the course of six runoff events at each site, along with two dry weather base line samples. Samples collected from two of the wet weather events and the two dry weather baseline samples were evaluated for 14 water quality parameters including; suspended solids, suspended sediment, chloride, chlorophyll-*a*, total zinc, total copper, total phosphorus, dissolved orthophosphate, Kjeldahl nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, E. coli, fecal coliform, and BOD. The remaining four wet weather event samples were evaluated only for suspended solids, chloride, and total phosphorus. For each site, one dry weather sample and one wet weather sample were also evaluated for mercury.

Model Calibration

Many of the algorithms comprising the watershed/watercourse model are mathematical approximations of complex natural phenomena. Therefore, before the model can be reliably used to simulate streamflow behavior and water quality under alternative plan conditions, it was necessary to calibrate the model—that is, to compare simulation model results with actual historical data—and, if significant differences were found, to make adjustments in the model parameters to enable the model to better represent the specific natural and man-made features of the watershed. Once the initial model calibration had been made, model validation was performed by simulating a monitoring period independent from the calibration data set. If the model did not properly simulate conditions for the independent data set, the calibration was deemed unacceptable and additional adjustments were made until adequate validation was achieved.

A schematic representation of the calibration process that was applied is shown in Figure 53. Since simulation of water quality is dependent on land segment runoff and instream flow rates, calibration and validation of the hydrologic and hydraulic functions of the model were carried out first. After those processes were adequately calibrated, calibration and validation of the water quality processes proceeded.

Once the simulation model is calibrated and validated over a wide range of conditions that have occurred in a particular watershed, the basic premise of subsequent simulation is that the model can adequately represent a wide range of hydrologic, hydraulic and water quality conditions and will respond accurately to a variety of model inputs representing hypothetical watershed conditions, such as land use changes and point source modifications, and thereby provide a powerful analytic tool in the watershed planning process.

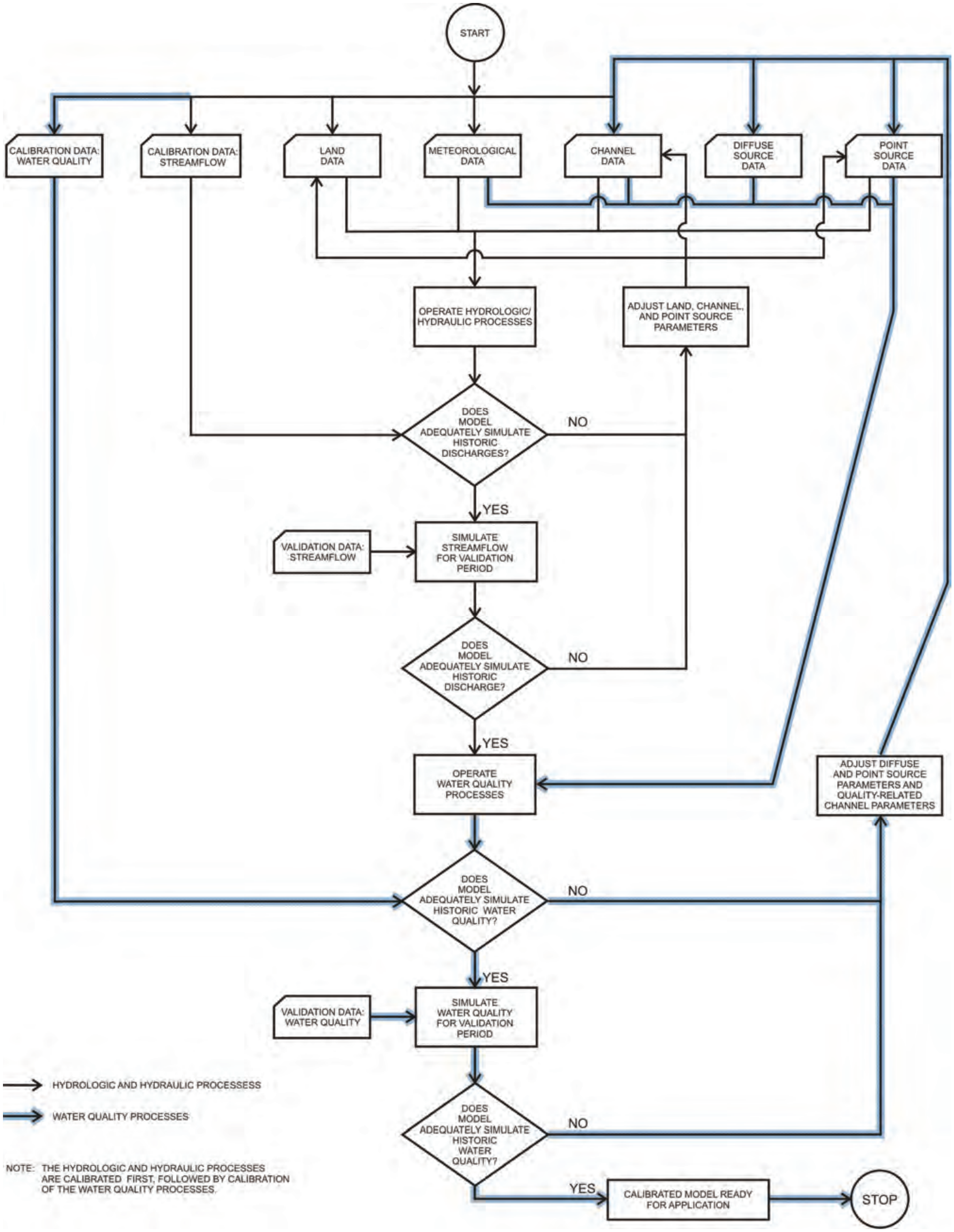
Hydrologic and Hydraulic Calibration and Validation

Meteorological, land segment, and channel data sets were prepared as described previously in this chapter. The choice of initial numerical values assigned to the parameters for each of the land segments was influenced by parameter values established for the models used in the MMSD watercourse system planning program, as well as experience gained from other modeling efforts.

For calibration purposes, the hydrologic and hydraulic elements of the model were operated for a four year period from January 1995 through December 1998. Adjustment was made to input parameters until the resulting simulated runoff volumes and flow rates adequately matched those from the USGS continuous recording stations selected for use in model calibration. In some instances it became necessary to make adjustments to the meteorological datasets, particularly precipitation, if it appeared that information from an assigned meteorological station was not representative of conditions over the basin being represented. Once the initial calibration was made, model validation was carried out by operating the model for a second four year period from January 1999 through December 2002. In the case of the Milwaukee and Root River watersheds, the validation period was

Figure 53

CALIBRATION/VALIDATION PROCESS USED FOR HYDROLOGIC-HYDRAULIC AND WATER QUALITY MODELING



Source: SEWRPC.

extended to 2004 in order to afford comparison to data collected in the outlying portions of those watersheds, as discussed previously.

As part of the calibration and validation process, model results were compared to observed conditions using both graphical and statistical procedures. Graphical comparisons are useful in judging the results because time-variable plots of observed versus modeled flow provide insight into the model's representation of storm hydrographs, baseflow recession, time distributions, and other pertinent factors often overlooked by statistical comparisons. Graphical comparisons that were used included time series plots of observed and simulated streamflow, scatter plots of observed versus simulated flow, and flow-duration plots. Statistical comparisons focused on the relative error method, with a small relative error indicating a better fit. The following model tolerance values were used in judging the adequacy of model fit to observed data:[9]

- Total runoff volume: ± 10 percent
- Seasonal runoff volume: ± 20 percent
- Highest 10 percent flow volume: ± 15 percent
- Lowest 50 percent flow volume: ± 10 percent
- Error in storm volumes: ± 20 percent

Details of the individual watershed hydrologic and hydraulic calibration and validation procedures, including a presentation of results, are set forth in a series of memorandum reports that were prepared by Tetra Tech, Inc. These memos are presented in Appendix C.

Water Quality Calibration and Validation

The water quality model calibration was initiated after calibration of the hydrologic and hydraulic processes. A sequential approach was used since successful water quality simulation is contingent on the hydrologic and hydraulic models effectively representing the transport mechanisms for water quality constituents. Those mechanisms are based on runoff from the land surface and flow in the stream. Similarly, model calibration is also sequential in terms of water quality indicators. For instance, sediment and dissolved pollutant transport depend directly on the representation of flow, while sorbed pollutant transport depends on the simulation of sediment. Although the model represents pollutant loading from the land surface by buildup-washoff formulations, sorption to sediment and settling is simulated in the stream reaches and has an important effect on the downstream transport of particle-reactive pollutants, including phosphorus, ammonium, and bacteria. Any inaccuracies in the flow and sediment simulations will propagate forward into the water quality simulation.

The instream water quality kinetics are also linked with one another. For example, most kinetic rates depend on temperature, while nutrient balances and dissolved oxygen are strongly linked to algal simulation. Therefore, the water quality calibration followed the following sequence:

1. Calibration of flow
2. Calibration of sediment
3. Calibration of water temperature
4. Initial calibration of gross nutrient transport
5. Initial calibration of carbonaceous biochemical oxygen demand and dissolved oxygen (DO)

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[9]*These tolerances are consistent with, and in some cases more stringent than, those recommended by the U.S. Geological Survey for calibration of the HSPF model. U.S. Geological Survey Water Resources Investigations Report 94-4168,* Users Manual for an Expert System (HSPEXP) for Calibration of the Hydrological Simulation Program-Fortran, *1994.*

6. Calibration of algae
7. Final calibration of nutrient species and DO
8. Calibration of fecal coliform
9. Calibration of metals

As noted earlier in this chapter, water quality data collected by the MMSD under its bi-weekly sampling program were only available through 2001 at the time of model calibration, thus allowing for one less year of validation data than was used for the hydrologic and hydraulic processes. In order to maintain a total calibration/validation period of eight years, the water quality calibration period was extended back by one year to include 1994 conditions. A comparison of simulated to observed streamflow for that year indicated an acceptable model fit and, therefore, the model was deemed adequate to apply to water quality calibration for 1994. Thus, for calibration purposes, the water quality processes of the model were operated for a five year period from January 1994 through December 1998. Adjustment was made to input parameters until the resulting simulated water quality indicators adequately matched the data collected by the MMSD. Once the initial calibration was made, model validation was carried out by operating the model for a three year period from January 1999 through December 2001. In the case of the Milwaukee and Root River watersheds, the validation period was extended to include 2004 in order to afford comparison to data collected in the outlying portions of those watersheds, as noted previously.

Evaluation of the model results utilized a weight of evidence approach.[10] That is, a variety of both graphical comparisons and statistical measures were applied, with no one absolute criterion being used to determine model acceptance or rejection. Comparisons made included time series plots of observed and simulated concentrations, concentration exceedance plots, plots of load versus flow and flow exceedance, the Student's *t*-test for equality of means, and a comparison of individual observed concentrations to simulated concentration and standard deviation.

Details of the individual watershed water quality calibration and validation procedure, including a presentation of results, are set forth in a series of memorandum reports that were prepared by Tetra Tech, Inc. These memos are presented in Appendix D.

MMSD CONVEYANCE SYSTEM MODELS

In order to simulate operation of the MMSD conveyance system a suite of models has been developed and maintained by the MMSD. Although these models do not actually compute water quality conditions in rivers and lakes, they simulate potential bypassing of flows from both the combined sewer and separate sanitary sewer systems operated by the MMSD, and, thus, provide essential input to the water quality simulation models. Therefore, a short description of these models is included herein. A more detailed description of the models, including their development and calibration, can be found in the conveyance report that was prepared under the MMSD 2020 facilities planning report on conveyance.[11]

The MMSD conveyance system transports wastewater from the municipal collector systems to the MMSD Jones Island and South Shore wastewater treatment plants (WWTPs). The system consists of the metropolitan interceptor system (MIS), the near surface collector system (NSCS) and the Inline Storage System (ISS) or deep tunnel. The purpose of the simulation models was to assist in: 1) determining peak wastewater flows; 2) identifying hydraulic restrictions; 3) estimating overflow frequencies and volumes for water quality assessment; and 4) identifying potential conveyance system improvements.

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[10]*A.S. Donigian, Jr.*, Watershed Model Calibration and Validation: The HSPF Experience, *Proceedings of the Water Environment Federation Conference on National TMDL Science and Policy 2002, November 2002.*

[11]*Milwaukee Metropolitan Sewerage District*, 2020 Facilities Plan Conveyance Report, Chapter 3, "Analytical Methods-Data Sources," *June 2007.*

The modeling system consists of two main components. The first generates wastewater hydrographs from individual tributary areas or sewersheds. The flow consists of the sum of the base sanitary flow and the infiltration/inflow (I/I) components. The Flow Forecasting System (FFS) model was used for this purpose. In addition, the Hydrological Simulation Program-Fortran (HSPF) that was described earlier in this chapter was also used to provide input to the FFS model. The second main modeling component consists of a dynamic hydraulic model of the conveyance system that routes the wastewater hydrographs generated by the first model through the conveyance system to the WWTPs. Simulation of the ISS operations as well as combined sewer and separate sewer system overflows is possible. System conveyance was modeled using the Model of Urban Sewers (MOUSE) software. An additional program called MACRO was developed to perform long-term volumetric evaluations of the conveyance system. Figure 54 shows the relationship between the models.

Flow Forecasting System (FFS) Model

As previously noted, the FFS program was used to compute wastewater flow hydrographs for sewersheds which in turn serve as input to the conveyance system hydraulic model. Wastewater discharge is computed on a continuous basis and represented by the sum of several components. For the separate sewer service area, those include the base sanitary flow and dry and wet weather infiltration/inflow. For the combined sewer area they include the base sanitary flow, both dry and wet weather infiltration/inflow, and wet weather surface runoff that enters the combined sewers.

Base sanitary flow from residential, commercial, and industrial lands is computed for each sewershed based on generation rates that were calibrated using monitored sewer flow data. In some cases, major commercial and industrial contributors were identified in the model as point sources, with their contributions being defined by an average flow rate. In both cases, weekly and diurnal patterns are applied to account for flow variability.

Sewer flow data for existing, planned year 2020, and buildout land use conditions, were developed using data on residential population and commercial and industrial land areas that were developed by SEWRPC. Existing condition data were based on the SEWRPC year 2000 digital land use inventory and U.S. Census Bureau year 2000 census block population and household data. Future condition data reflecting both the plan year 2020 and expected buildout conditions were developed by applying planned increments of development, including additional housing units and population estimates, to the year 2000 estimates. A series of meetings were held between the SEWRPC staff, plan consultants, and community staff representatives to review the data and allow the communities the opportunity to provide comments and request necessary changes. In the case of the City of Milwaukee, information regarding the incremental changes under future conditions was provided by the City. A more-detailed description of the development of population and land use data is set forth in Chapter VIII, “Future Situation: Anticipated Growth and Change,” of this report.

Infiltration and inflow depends on hydrologic conditions that change seasonally and in response to wet weather events. In order to account for this variability, the HSPF model was used to compute the surface flow, interflow, and active groundwater flow components of runoff. The hydrologic processes and input requirements of the HSPF model are the same as those described earlier in this chapter for the LSPC model used for watershed/watercourse simulation. Only the land segment hydrologic processes of HSPF were utilized for the conveyance system model. Actual I/I flow was computed within the FFS model by applying sewershed calibration factors to the three HSPF flow components. Surface runoff computed with the HSPF model was used to account for the combined sewer wet-weather flow component.

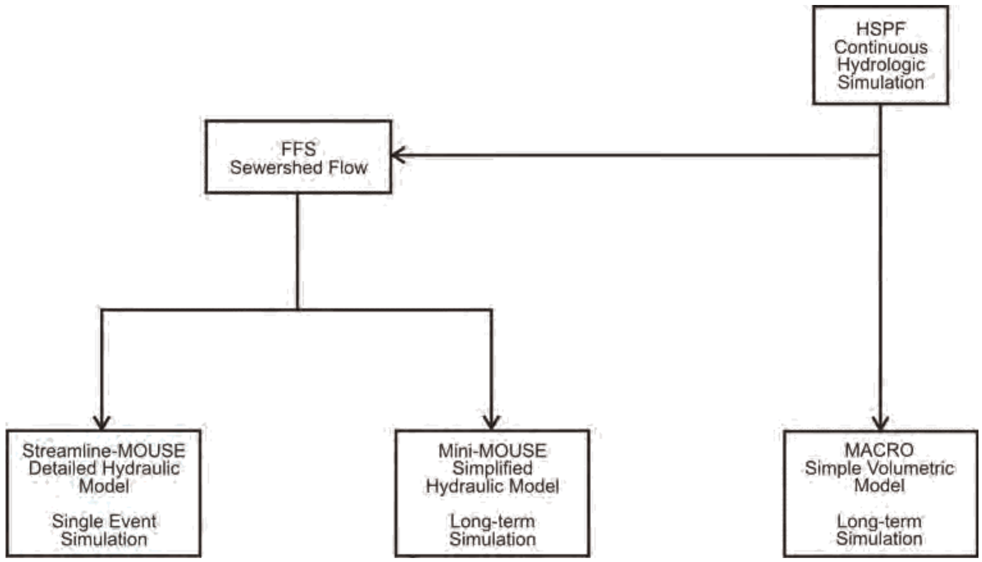
Model of Urban Sewers (MOUSE) Model

Characterization of the MMSD conveyance system hydraulics and operating procedures was accomplished through the use of the Model of Urban Sewers (MOUSE), proprietary software available from DHI Water & Environment (formerly the Danish Hydraulic Institute). Two versions of the model were used—Streamline-MOUSE and Mini-MOUSE—each representing a different level of system detail.

Streamline-MOUSE includes a full representation of the metropolitan interceptor system (MIS), the near surface collector system (NSCS), and the Inline Storage System (ISS). The system is represented in the model as a series

Figure 54

RELATIONSHIP BETWEEN MODELING TOOLS USED FOR SIMULATION OF THE MMSD CONVEYANCE SYSTEM



Source: Milwaukee Metropolitan Sewerage District.

of links, nodes, and storage elements. An algorithm based on the MMSD operating procedures controls the simulated operations of the ISS gates and pumps. Sewershed hydrographs developed with the FFS model are input as upstream boundary conditions, while the Jones Island and South Shore WWTPs represent downstream boundary conditions. The model computes both flows and water levels throughout the system in order to help identify hydraulic restrictions and locations where critical elevations are exceeded. The model was also used to simulate CSO and SSO discharges from specific overflow sites. Due to its complexity, this model version was used mainly to simulate individual wet weather events.

Mini-MOUSE is a simplified version of the Streamline-MOUSE model. By combining elements from the detailed model, the number of nodes and links was reduced from about 2,000 to about 200. These simplifications improved the computational efficiency of the model, allowing for simulation of long time periods in a single model run. The model was calibrated against the Streamline-MOUSE to ensure consistency between the two versions. The Mini-MOUSE model was used to evaluate long-term performance and flow-frequency characteristics of the system. In particular, it was used to generate long-term records of CSO and SSO discharge that serve as point source inputs to the riverine and Lake Michigan receiving water models. As described previously in the “Point Source Data” subsection of this chapter, pollutant concentrations were assigned based on overflow sampling data collected by the MMSD, along with literature values and correlation estimates based on monitoring data from other areas of the country. The sanitary sewer overflow concentrations also took into account limited sampling data obtained by local municipalities.

MACRO Model

Although the Mini-MOUSE version of the conveyance system model allowed for improved simulation run times over the more detailed Streamline-MOUSE model, it was still too computationally demanding to test the long-term impact of making systemwide changes or changes in operating procedures. For this reason, a third model was developed called MACRO. This is a simple volumetric/operational model that was used to quickly evaluate the overall response of the conveyance system to alternative system operations or new configurations.

Within MACRO, the MMSD conveyance system service area is represented by four subareas—two separate sewer areas and two combined sewer areas. Flows from the subareas are directed to the WWTPs or the ISS using a water balance approach, with excess flow becoming CSO and SSO discharges. As shown in Figure 54, the hydrologic driver for the model is the flow computed with the same HSPF model that also provides input to the FFS model.

The MACRO model is limited in that it represents the MIS simply as a volume through which flow is transferred, without accounting for hydraulic routing. Flow in the model is based on the treatment capacities of the WWTPs, the storage capacities of the MIS, NSCS, and ISS, and the pumping capacities. As a result, the MACRO model is limited to identifying SSO events that are related to tunnel closure and not to hydraulic capacity limitations. SSO events related to hydraulic capacity limitations, which tend to be smaller in terms of volume than the tunnel-related events, are evaluated with the MOUSE models.

MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN MODELS

The transport and mixing of pollutants introduced to the Milwaukee Harbor estuary and nearshore Lake Michigan area are controlled by the circulation characteristics of those waterbodies. These characteristics are influenced by both natural phenomena, such as surface wind stress, Lake Michigan-induced flows due to water level changes, and time-variable inflows from the tributary rivers, as well as man-made conditions, such as CSO and SSO events, the withdrawal and discharge of condenser cooling water by the We Energies Menomonee Valley and Oak Creek power plants, and large intermittent inflows from the Kinnickinnic River and Milwaukee River flushing tunnels.

In order to handle the complex physical processes of the Milwaukee Harbor estuary and nearshore Lake Michigan area, the ECOMSED/RCA computer modeling software package was used.[12] This nonproprietary software was developed by and is available from HydroQual, Inc. The Estuarine Coastal and Ocean Model-Sediment Transport (ECOMSED) model was used to simulate the hydrodynamic processes and water temperature. The Row-Column AESOP (Advanced Ecological Simulation Program), or RCA, was used to simulate water quality processes, including interaction with sediment. These models are derived in part from simulation programs developed by HydroQual, Inc. in the 1980s and used in the Regional Planning Commission’s study of the Milwaukee Harbor Estuary.[13] They were also used in the conduct of a bacteria source, transport, and fate study conducted for the Milwaukee Metropolitan Sewerage District.[14] The models as developed under that latter study served as the basis of the models used for the regional water quality management plan update.

The ECOMSED model has its origin in the mid 1980s with the creation of the Princeton Ocean Model and its version for shallow water environments named ECOM. In the mid 1990s, concepts for cohesive sediment resuspension, settling and consolidation were incorporated. Additional model enhancements have also been made that include generalized open boundary conditions, tracers, a submodel for bottom boundary layer physics, surface wave models, noncohesive sediment transport, and dissolved and sediment-bound tracer capabilities. The modeling framework for the ECOMSED model, including its linkage to the RCA model, is shown in Figure 55. It should be noted that only the hydrodynamic module (ECOM) and the water quality module (RCA) were utilized under this planning program.

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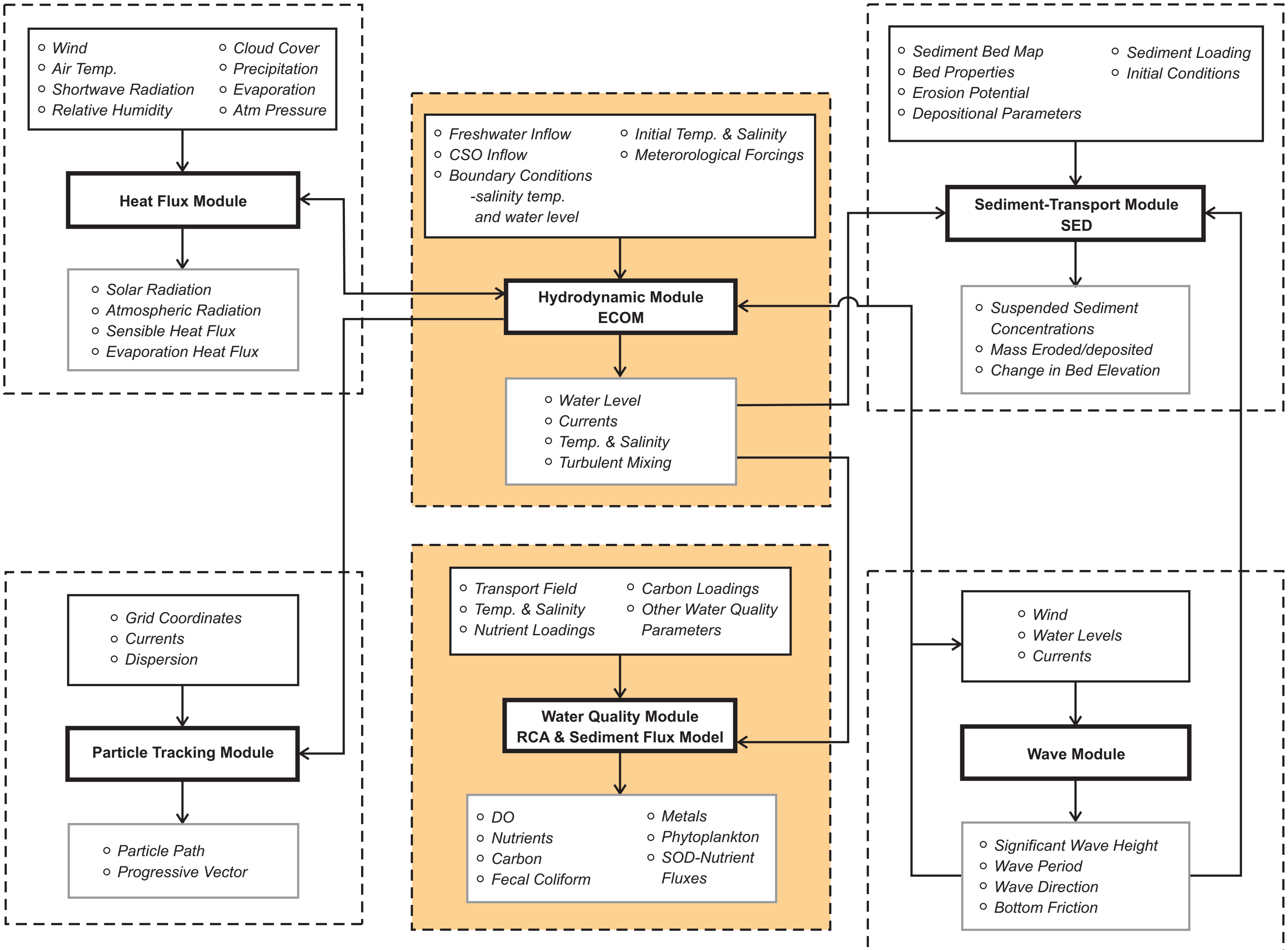
[12]*HydroQual, Inc.,* A Primer for ECOMSED Version 1.4, Users Manual, *December 2004* and *HydroQual, Inc.,* Users Guide for RCA (Release 3.0), *June 2004.*

[13]*SEWRPC Planning Report No. 37,* A Water Resources Management Plan for the Milwaukee Harbor Estuary, *Volume One,* Inventory Findings, *March 1987, and Volume Two,* Alternative and Recommended Plans, *December 1987.*

[14]*HydroQual, Inc., and Camp Dresser McKee,* Milwaukee Harbor Estuary Hydrodynamic & Bacteria Modeling Report, *Bacteria Source, Transport and Fate Study – Phase 1, August, 2005.*

Figure 55

ESTUARY/LAKE MICHIGAN MODELING FRAMEWORK



INPUT

MODULE

OUTPUT

NOTE: Only the shaded modules and corresponding inputs and outputs were applied for this modeling project.

Source: HydroQual, Inc. and SEWRPC.

The RCA model has its origin in the early 1970s with the Water Quality Analysis Simulation Program (WASP). That program is supported by the USEPA Center for Water Quality Modeling. A second generation program known as the Advanced Ecological Systems Modeling Program (AESOP) was developed in the late 1970s and contained several improvements over the original WASP code. The RCA model was developed to provide a WASP/AESOP-compatible computational framework for fine-mesh grids that can be used in conjunction with hydrodynamic applications for large lakes, rivers, and estuarine and coastal systems.

Hydrodynamic Processes

The purpose of the hydrodynamic model is to describe the movement and mixing of water within the Milwaukee Harbor estuary and nearshore Lake Michigan area due to input from tributary rivers, point source discharges, offshore lake effects, and meteorological conditions. The fate of water quality constituents is strongly influenced by the turbulent mixing created by surface wind stress, river flow, and large-scale dynamics occurring in Lake Michigan. This mixing leads to dispersion in the longitudinal and lateral directions, and to vertical dispersion throughout the water column. Coupled with the turbulent mixing are heat exchange processes between the water column and the atmosphere. All of these mechanisms are represented in the hydrodynamic model, which is then coupled to the water quality model to determine the distribution of constituents throughout the model domain.

The hydrodynamic model is a continuous simulation, three-dimensional coastal model that incorporates the Mellor and Yamada[15] level 2½ turbulent closure model to provide a realistic parameterization of the vertical mixing processes. A system of curvilinear coordinates is used to represent the study area in the horizontal direction, which allows for a smooth and accurate representation of variable shoreline geometry. In the vertical scale, the model uses a transformed coordinate system known as the σ-coordinate transformation to permit better representation of bottom topography. Water surface elevation, water velocity and temperature, and water turbulence are calculated in response to weather conditions, river inflow, and water elevation and temperature at open boundaries. The model solves a coupled system of differential, prognostic equations describing the conservation of mass, momentum, temperature, salinity (in ocean applications), turbulent kinetic energy, and turbulence macroscale. The momentum equations are nonlinear and incorporate a variable Coriolis parameter. Prognostic equations governing the thermodynamic quantities, temperature, and salinity account for water mass variations brought about by highly time-dependent coastal upwelling/downwelling processes, as well as horizontal advective processes. The prognostic equations are transformed into a terrain that follows the σ-coordinate and orthogonal curvilinear coordinate systems. The resulting equations are vertically integrated to extract barotropic variables, such as water elevation, that are only a function of the x-y directions and independent of the z-direction. The model also uses a mode-splitting technique so that fast-moving, external barotropic modes and significantly slower baroclinic modes are solved separately using different time steps.

Model representation of the Milwaukee Harbor estuary and nearshore Lake Michigan area is depicted on Map 49. The aerial extent of the model includes the Milwaukee River upstream to the former North Avenue dam location, the Menomonee River upstream to the former Falk Corporation dam, the Kinnickinnic River upstream to S. 11th Street, the Milwaukee Harbor and the nearshore Lake Michigan between Fox Point to the north and Wind Point to the south. Model coverage into the Lake extends easterly to about the 30-60 meter bathymetric contour, a distance that varies between four to six miles. The orthogonal, curvilinear grid system used to represent the area is shown on Map 49 and consists of a 96 x 42 segment grid in the horizontal plane with 11 equally spaced σ-levels in the vertical plane. The transformed σ-coordinate system allows the model to have an equal number of vertical segments in all of the computational grid boxes independent of water depth. In the horizontal plane, the curvilinear grid system allows for finer resolution near areas of interest, such as in the river/harbor areas, where a grid size as small as 90 x 50 meters was used. A courser grid system was adopted in the Lake Michigan areas, where the grid size used extends to as large as 1,500 x 1,000 meters.

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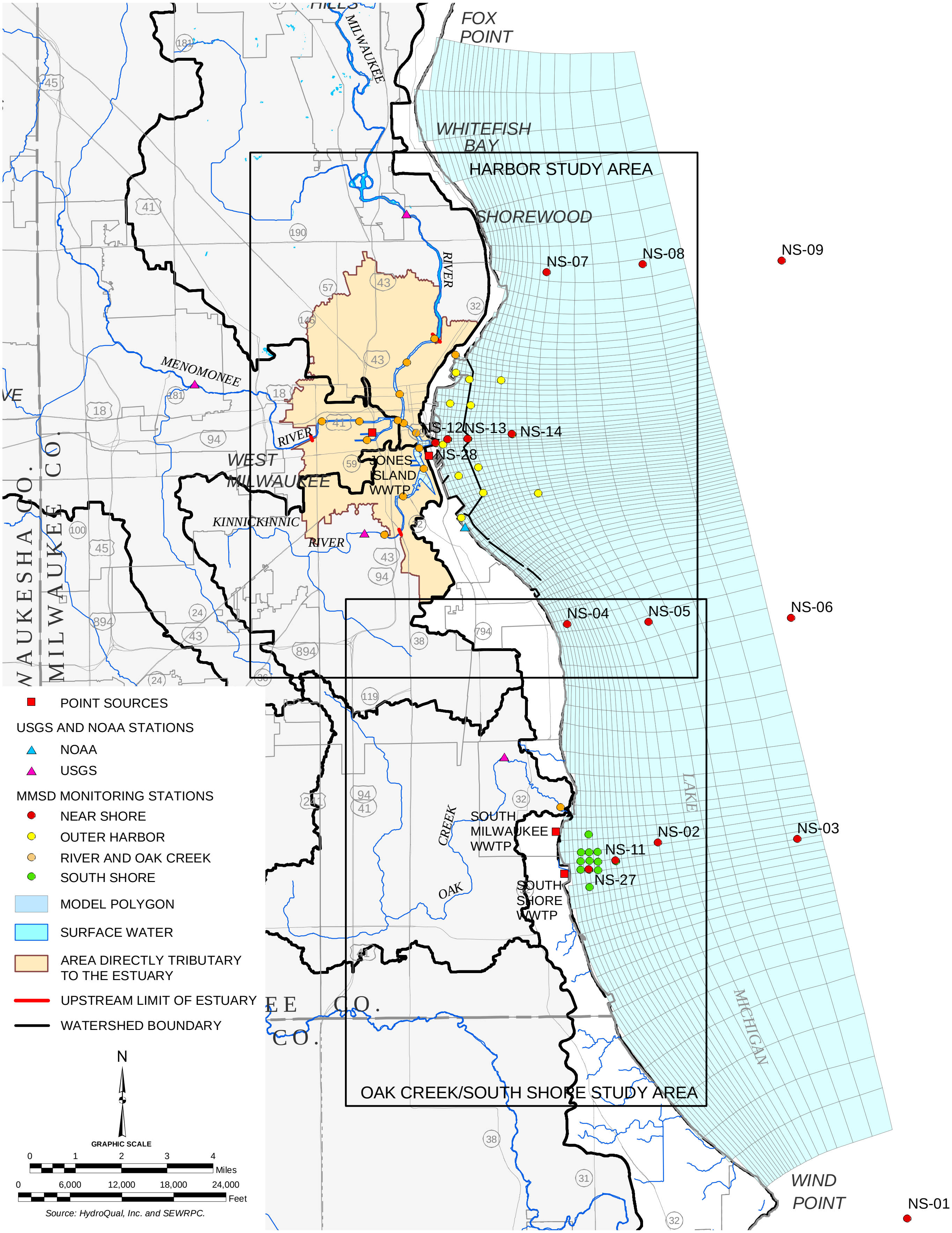
[15] *G.L. Mellor, and T. Yamada*, Development of a Turbulence Closure Model for Geophysical Fluid Problems, *Review of Geophysical Space Physics, 1982*.

Map 49

REPRESENTATION OF THE MILWAUKEE HARBOR ESTUARY AND LAKE MICHIGAN NEARSHORE AREA IN THE HYDRODYNAMIC/WATER QUALITY MODEL

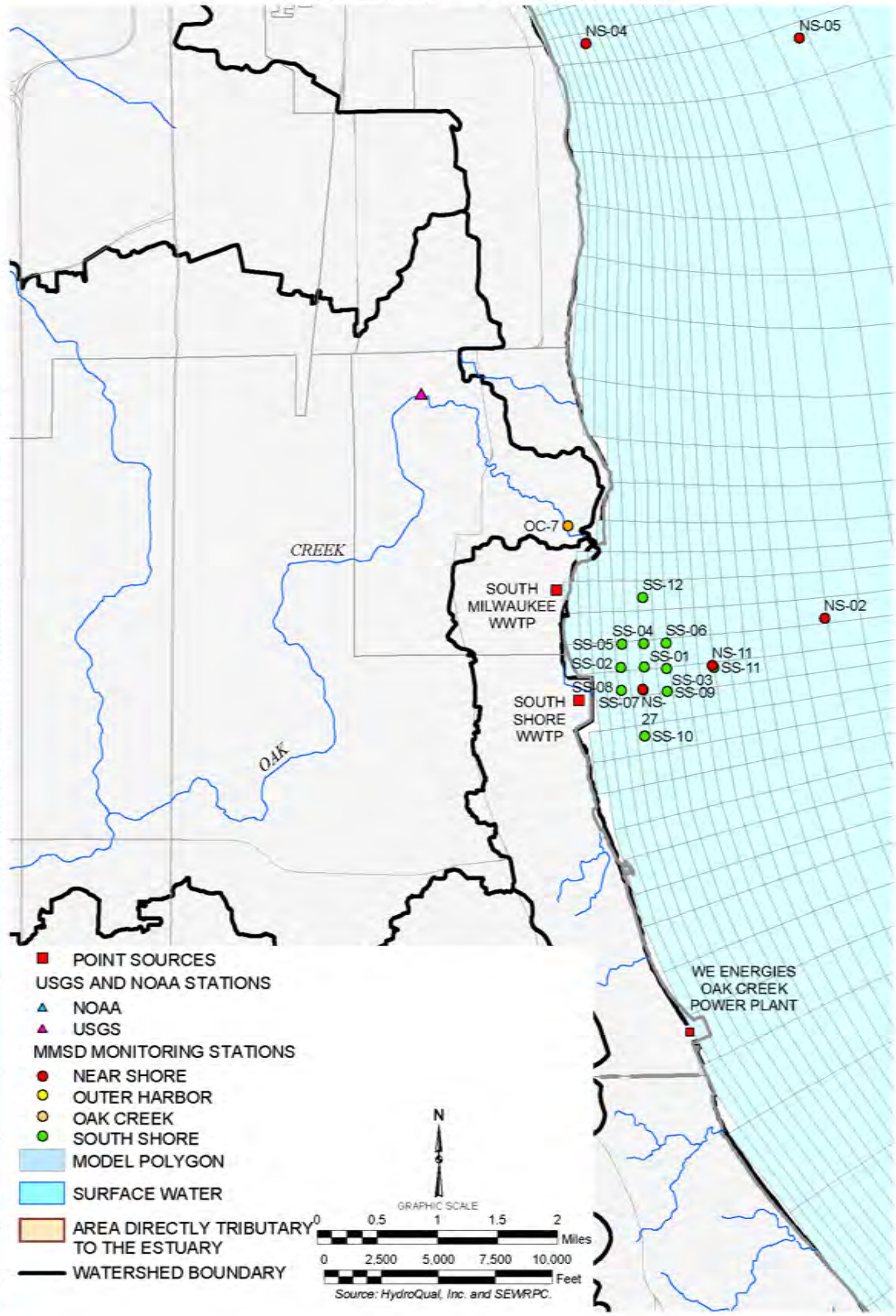


Source: HydroQual, Inc. and SEWRPC.

Map 49 (continued)

HARBOR STUDY AREA

OAK CREEK/SOUTH SHORE STUDY AREA



The breakwall that protects the outer harbor from rough water conditions on Lake Michigan extends from the Milwaukee Yacht Club to the north to just south of South Shore Beach. This breakwall tends to trap flow and pollutants within the harbor area and causes distinct plumes to emanate from several openings in the breakwall during high river flow events. The breakwall was represented in the hydrodynamic model as a series of thin wall dams in the model framework. This allowed for the effective and realistic calculation of water transport and circulation between the harbor and Lake Michigan.

Water Quality Processes

The principal function of the water quality model for the Milwaukee Harbor and nearshore Lake Michigan area as used for this planning program is to simulate the time-varying unit loads and concentrations of selected water quality indicators at various points of interest within those waterbodies. The water quality indicators evaluated are the same as those described for the watershed/watercourse models.

The water quality model contains both bacteria and eutrophication routines and is capable of evaluating fate and transport of conventional and toxic pollutants in surface waterbodies in one, two, or three dimensions. The model utilizes finite-difference techniques to simulate the time-varying processes of advection and dispersion, while considering point and nonpoint mass loading, boundary exchange, and linear and nonlinear losses and production. Information concerning the advective and dispersive transport fields is provided by the ECOMSED hydrodynamic model. The eutrophication model processes used for the regional water quality management plan update are shown graphically in Figure 56, and include simulation of one phytoplankton group, dissolved oxygen, and various organic and inorganic forms of nitrogen, phosphorus, and carbon or CBOD.

The mathematical framework for the bacteria model uses the same mass balance approach as the eutrophication model, with different state variables and reaction rates being used. The model was used to simulate fecal coliform as well as copper and zinc. It included five state variables: total copper, total zinc, and three fecal coliform systems. The three fecal coliform systems were used to track bacteria sources separately, those being CSOs and SSOs, river boundary conditions, and lake boundary conditions. For fecal coliform the model uses a first-order decay rate in addition to a die-off component due to light. As with the watershed/watercourse models, total copper and total zinc were modeled as conservative substances, with the first-order decay rates being set to zero.

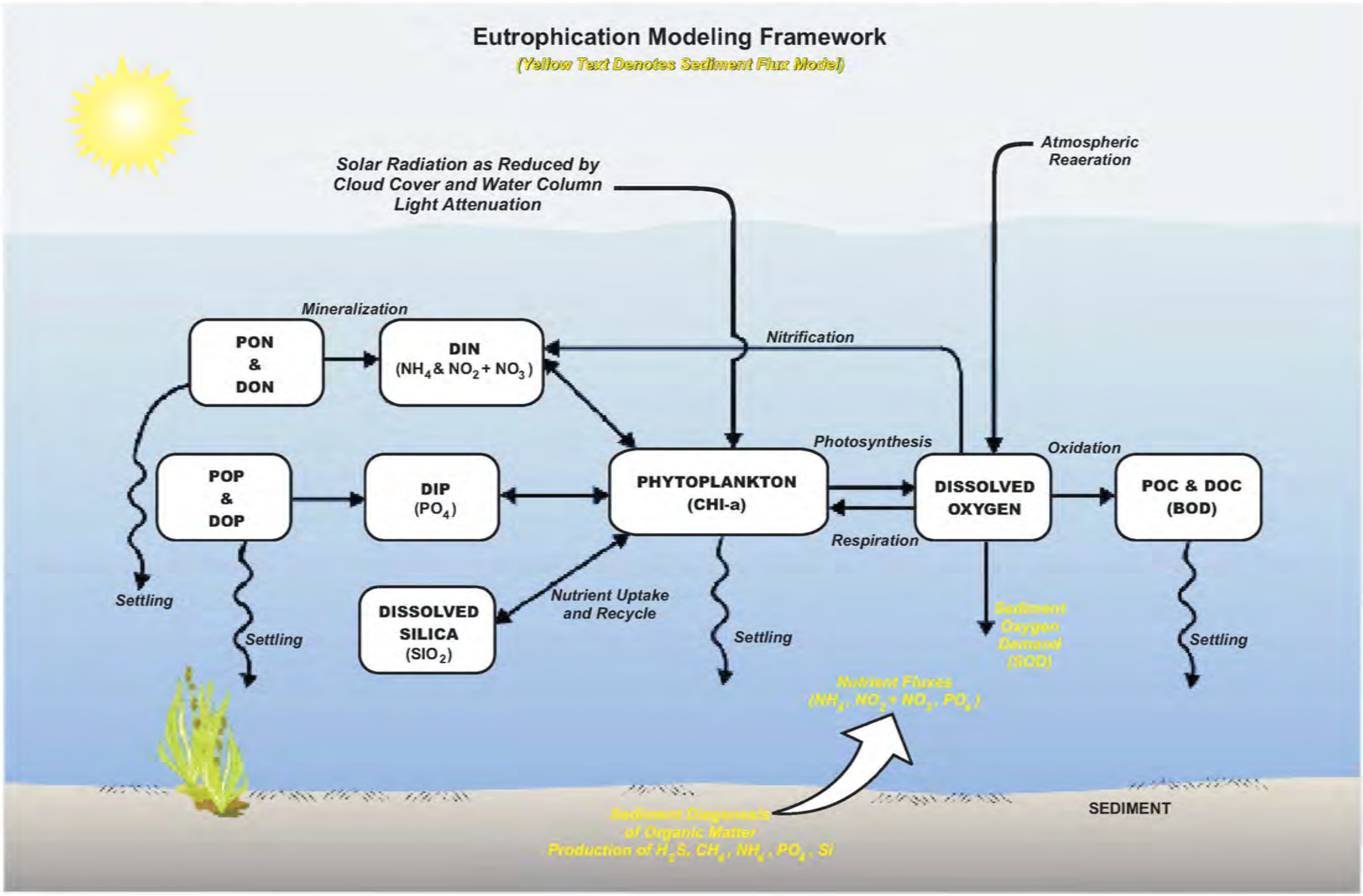
In addition to bacteria and eutrophication models, the water quality model includes a coupled sediment submodel that calculates the response of sediment fluxes (e.g., sediment oxygen demand) to settling organic matter. The sediment modeling framework describes the processes that affect sediment nutrient fluxes and sediment oxygen demand (SOD). The sediment submodel is formulated with two compartments, an aerobic sediment layer and an anaerobic sediment layer, using the settling fluxes from the eutrophication model as inputs. Particulate organic matter (POM) consisting of detrital or algal nitrogen, phosphorus, and carbon, settles through the water column and is deposited to the sediment. This settling of POM is the driving force behind various decay mechanisms occurring in the sediment. Once it settles it can either decompose through diagenesis, or mineralization, to the various end products of nitrogen, phosphorus, or carbon, or become buried in the sediment. The particulate organic nitrogen and phosphorus that settle to the sediment eventually decompose following various temperature dependent kinetic pathways into their associated inorganic forms of ammonia and orthophosphate. Depending upon overlying water dissolved oxygen concentrations and water column/sediment dissolved oxygen gradients, these inorganic forms can either flux out of or into the sediment. The temperature dependent decomposition of particulate organic carbon results in the formation of sulfide. Depending on the overlying water column dissolved oxygen concentration, the sulfide is either oxidized in the sediment or fluxed into the water column as oxygen demanding equivalents. In addition to the carbon component of the SOD, the nitrification of ammonia to nitrate consumes oxygen and, therefore, is also included in the calculation of total SOD.

Database Development

As with the watershed/watercourse models, the largest single work element in the preparation and application of the Milwaukee Harbor estuary and nearshore Lake Michigan area model is data base development. This consists of the acquisition, verification, and coding of data needed to develop, calibrate, validate, and apply the model. The

Figure 56

EUTROPHICATION PROCESSES IN THE MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN RCA MODEL



Source: HydroQual, Inc.

data base required for model development is composed of the following five distinct categories of information: meteorological data, bathymetric and channel data, model boundary conditions, diffuse sources of pollution, and point sources of pollution.

A distinction should be drawn between model input data and model calibration data. The five categories of data identified above constitute the input data needed to operate the model. Calibration and validation data are not required to operate the model, but are important to the adjustment of the model parameters so that the model performance fits real world data. The principal types of calibration data used are surface water levels, water temperature, and water quality.

Each of the five types of input data, as well as the calibration and validation data, is described in the following sections.

Meteorological Data

The following six types of meteorological data are required as direct input to the Milwaukee Harbor estuary and nearshore Lake Michigan area model: wind speed and direction, air temperature, relative humidity, atmospheric pressure, and solar radiation. These data were obtained for the NWS meteorological observation station at General Mitchell International Airport (GMIA), which is the only station for which these data are readily available within close proximity to the model domain.

The air temperature and solar radiation data are the same as that developed for use in the watercourse/watershed models previously described. As stated previously, solar radiation is not measured directly at GMIA, but was derived using cloud cover observations from that station. The four remaining data sets were obtained from the NWS specifically for use in the estuary/lake hydrodynamic and water quality models. The six required meteorological data sets are all based on an hourly time interval.

As for the watercourse/watershed models, meteorological data sets were developed for the 17-year period from 1988 through 2004. This period covers two different time frames utilized in the modeling process. For model calibration and validation purposes, the period from 1994 through 2002 was utilized. This period was selected since it coincided with the availability of water quality monitoring data and covered a period after the MMSD Inline Storage System began operation. In addition to model calibration and validation, long-term simulation of the model was required in order to assess water quality conditions under the various land development and water quality control alternatives considered under this planning process. The 10-year period from 1988 through 1997 was selected for this purpose. This period was selected since it is representative of the long-term precipitation statistics as measured at the GMIA weather station for the 63-year period from 1940 through 2002. Utilization of a 10-year period allowed for shorter model run times and more manageable processing of model output, while still providing a sufficiently long simulation period to assess water quality conditions.

Bathymetric and Channel Data

Factors affecting the hydraulic conditions within the estuary/lake model domain are important determinants of the circulation patterns within these waterbodies. These include the channel cross section in the river estuaries, bathymetry of the lakebed, and parameters defining the bed roughness. Depiction of the river cross section in the model is based on the assignment of a channel width and depth. Information on the channel geometry within the river estuaries was taken from U.S. Army Corps of Engineers dredging reports. Information regarding the outer harbor and Lake Michigan bathymetry was obtained from charts prepared by the National Oceanic and Atmospheric Administration (NOAA). Bed roughness factors were assigned based on previous modeling experience.

In addition to the factors that influence hydraulic behavior, nonhydraulic data must also be provided to the model. These data consist of water quality parameters and coefficients, such as oxygen transfer coefficients, light extinction coefficients, and BOD oxidation rates. The principal sources of initial numerical values for these parameters and coefficients were state-of-the-art engineering practice and previous experiences with application of the hydrodynamic and water quality models. In some instances, these values were based on evaluation of observed data. For instance, computation of phytoplankton is dependent on the surface light attenuation with depth, which is described in the model using a total light extinction coefficient. Initial values for this parameter were derived from Secchi disc measurements obtained by the MMSD, with a correction being made for algal concentrations in the water column.

Model Boundary Conditions

In order to operate the estuary/lake model, it is necessary to represent conditions at the upstream and downstream boundaries of the model. The upstream boundaries include the interface of the tributary rivers with the model domain and include the Kinnickinnic River at S. 11th Street,[16] the Menomonee River at the site of the former Falk Corporation dam, the Milwaukee River at the site of the former North Avenue dam, and Oak Creek at its mouth at Lake Michigan. The downstream boundary is the interface between Lake Michigan and the outer reaches of the modeled nearshore area.

Conditions at the upstream boundaries included time series of streamflow, water temperature, and water pollutant concentrations representative of both the model calibration/validation period and the production run period used for evaluation of alternative and recommended plan conditions. For the initial model calibration and validation, the required input time series were derived from observed data, including streamflow measurements from continuous recording gages operated by the USGS, and water quality measurements obtained by the MMSD as part of their bi-weekly sampling program. As indicated on Map 49, streamflow measurements were obtained from the USGS gages on the Kinnickinnic River at S. 11th Street, the Menomonee River at N. 70th Street, the Milwaukee River at Estabrook Park, and Oak Creek at 15th Avenue. Temperature and other water quality parameter data were obtained from the MMSD sampling stations for the Kinnickinnic River at S. 7th Street (MMSD site RI-13), the Menomonee River at N. 25th Street (MMSD site RI-11), the Milwaukee River at the former North Avenue dam (MMSD site RI-05), and Oak Creek near the mouth at Lake Michigan (MMSD site OC-07). The locations of these observation stations are also shown on Map 49. Both the observed streamflow and water quality datasets were later replaced with simulation output from the watershed/watercourse models once the development of those models, including calibration and validation, was completed.

Downstream boundary conditions required by the model included time series of water surface elevations, temperature, and pollutant concentrations for Lake Michigan at the interface with the modeled nearshore area. Water level measurements are available from the NOAA continuous recording station located within the outer harbor near the Milwaukee Coast Guard Station. This gage continually records water levels within the outer harbor at a six-minute time interval. The location of this gage is shown on Map 49. As was done with the initial upstream inputs, time series of water temperature and pollutant concentrations were developed for the downstream boundary using observed data obtained by the MMSD.

Nonpoint Source Data

Map 50 shows the aerial extent of land that is directly tributary to the nearshore Lake Michigan area that was included in the estuary/lake model. Runoff from this area enters the Lake via storm sewers, minor streams and drainageways, or as direct overland and subsurface flow. The estuary/lake model does not directly simulate runoff and pollutant loading processes on the land surface. Therefore, these were simulated using the land segment analysis component of the LSPC model that was previously described in the discussion of watershed/watercourse modeling.

Land segments categories used in the LSPC model were the same as those used in the watershed/watercourse models. Input parameter values used were the same as those derived through calibration of the adjacent watershed/watercourse models. Runoff volume and pollutant loading time series computed with the LSPC model were input directly to the estuary/lake model at various points along Lake Michigan. Map 50 illustrates the subbasin groupings for which nonpoint source loads were derived and input to the model.

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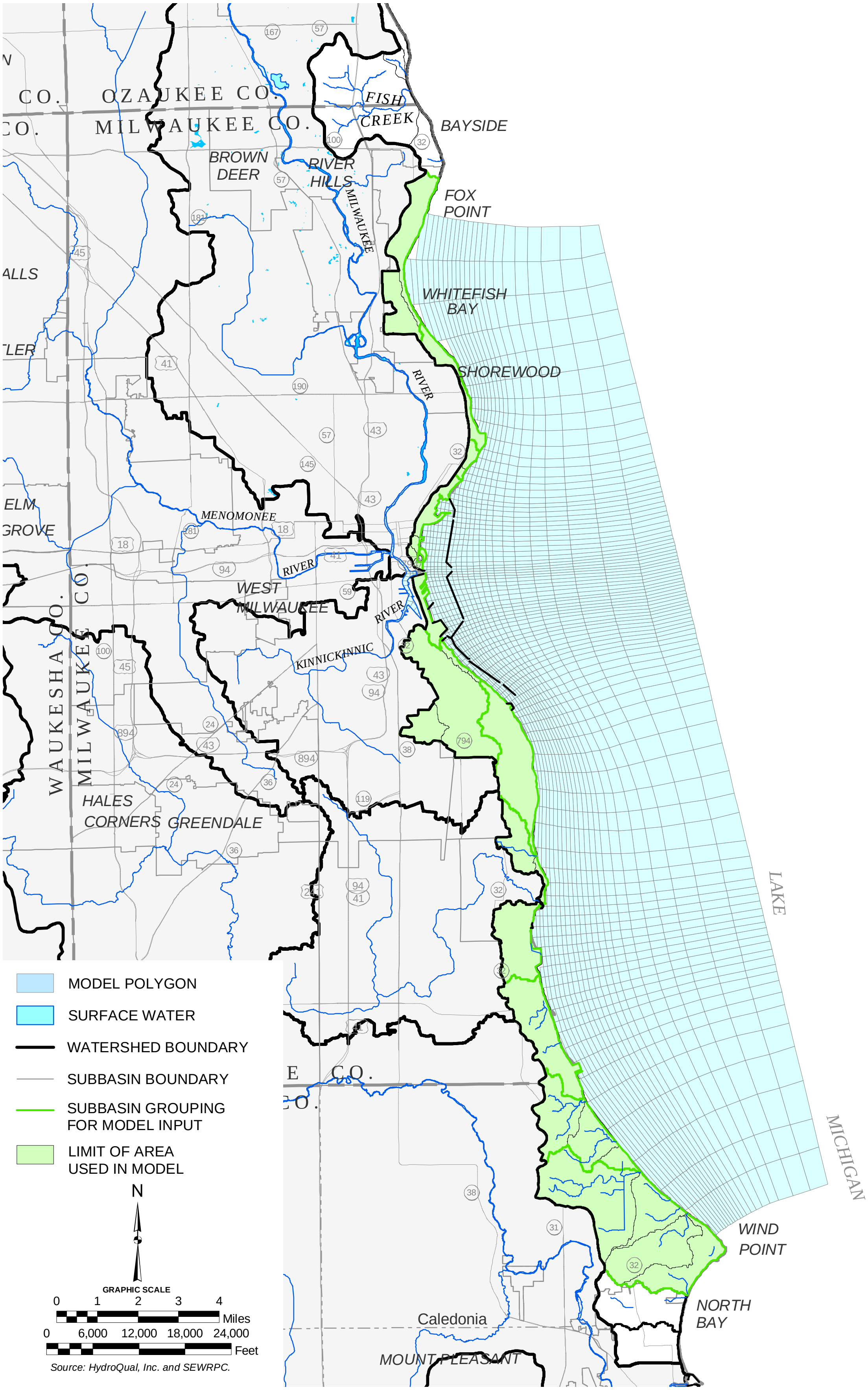
[16]*For the Kinnickinnic River, the model extends upstream of the upstream limit of the estuary, which is at S. Chase Avenue.*

Map 50

LAKE MICHIGAN DIRECT DRAINAGE AREA TRIBUTARY TO THE MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN MODELS



Source: HydroQual, Inc. and SEWRPC.

The remainder of the area tributary to the estuary/lake model domain is contained within the combined sewer service area. Runoff from this area enters the estuary and Lake Michigan via combined sewer bypass outfalls. These were treated as point sources within the model, as described below.

Point Source Data

Point sources of pollution that are located within the estuary/lake model domain consist of industrial cooling water discharges, combined sewer and separate sewer overflows (CSOs and SSOs), and public wastewater treatment plants (WWTPs). In addition, two flushing tunnels used by the MMSD to increase flow and associated dissolved oxygen levels in the lower reaches of the Kinnickinnic and Milwaukee Rivers were also accounted for as point sources in the model.

Industrial point sources within the model area include cooling water discharge from the We Energies Menomonee Valley and Oak Creek power plants, the locations of which are shown on Map 49. The Menomonee Valley plant draws cooling water from the Menomonee River and discharges it to the South Menomonee Canal. The Oak Creek plant draws cooling water from Lake Michigan and also discharges it back into the Lake. Plant discharge and temperature monitoring records were obtained from We Energies and used to determine the volume of water discharged and the temperature rise through the plant cooling systems. For other water quality parameters that were modeled, the quality of the discharge water was set equal to that simulated within the Menomonee River and Lake Michigan at the locations of the respective plant intakes.

The majority of the discharge points for combined sewer overflows are located within the area covered by the estuary/lake model. Two of these discharge directly to the outer harbor, while the remainder discharge to the river estuaries. In addition, there are several municipal sanitary sewer overflow points that are tributary to the nearshore Lake Michigan area. Information related to combined sewer overflows and sanitary sewer overflows was developed in the same manner as described previously in this chapter for the watershed/watercourse models. In addition to CSOs and SSOs, there are six small stormwater-only sewersheds located within the combined sewer service area and within the model domain. As with the CSOs, discharge time series from these areas were computed using the MMSD conveyance system models previously described in this chapter. Pollutant concentrations assigned to these flows were derived from stormwater sampling data obtained by the MMSD from 2000 through 2003.

The estuary/lake model also includes discharges from three public wastewater treatment plants. These include the MMSD Jones Island and South Shore plants and the City of South Milwaukee plant. The locations of these plants are shown on Map 49. Plant discharge and water quality parameter information was obtained from discharge monitoring report records and other plant data. In the case of effluent temperature, data was only available for the Jones Island plant. Temperatures based on information for that plant were also assigned to the South Shore and South Milwaukee WWTP effluent.

The two dilution water, or flushing, tunnels operated by the MMSD, one on the Kinnickinnic River and one on the Milwaukee River, are shown on Map 49. These tunnels are used to pull water from the outer harbor and discharge it to their respective rivers during periods of observed low dissolved oxygen levels in the rivers. The Milwaukee River tunnel intake is located near McKinley Marina, with a discharge point located just below the former North Avenue dam site. The Kinnickinnic River tunnel intake is located near South Shore Beach, with a discharge point located just downstream of Chase Avenue. Although these tunnels do not contribute to the pollutant loading in their receiving streams, they do affect discharge and circulation patterns, as well as constituent concentrations. Therefore, they were included as point sources in the estuary/lake model. Operation of the tunnels during the calibration/validation and production run periods was based on historic operating records obtained from the MMSD. As with the We Energies power plants cooling water discharges, water quality state variables computed at the outer harbor intake locations were assigned to the discharge concentrations from the tunnels. Unlike the power plants, no increased thermal load was assigned to the tunnel flows.

Calibration/Validation Data

The five categories of data discussed above—meteorological, bathymetric and channel, model boundary conditions, point pollution sources, and nonpoint pollution sources—constitute the total input data required to operate the estuary/lake model. Of equal importance are calibration data. These data, which are derived entirely from actual field measurements, included recorded water levels, streamflows and water quality conditions. Since calibration data represent the actual historic response of the estuary and nearshore lake system to a variety of hydro-meteorological events and conditions, such data may be compared to the simulated response of the system, and the model calibrated as necessary to provide an accurate simulation. The time period selected for model calibration and validation was from 1994 through 2002. This period was selected because the model was set up to reflect the condition since the MMSD Inline Storage System (ISS) was placed in operation in 1994.

Water Level Data

The principal source of water level data used in the estuary/lake model calibration is the NOAA continuous recording station previously described. Water surface elevation records covering the calibration/validation period of 1994 through 2002 were obtained from NOAA and used in the calibration and validation of the hydrodynamic model.

Streamflow Data

The principal source of historic streamflow information utilized in the calibration of the estuary/lake model is the measurements made by the USGS at a continuous recording station located on the Milwaukee River near the Jones Island WWTP. This gage was in operation between April 1994 and October 1995, between October 2001 and September 2003.[17] This gage is maintained cooperatively by the USGS and the MMSD. Available daily flow records contained within the calibration/validation time period of 1995 through 2002 were obtained from the USGS. These data were used to calibrate and validate the model flow characteristics.

Water Quality Data

The principal source of water quality data used in the calibration of the estuary/lake model was the bi-weekly sampling program carried out by the MMSD. That program was described earlier in this chapter in the discussion of calibration data for the watershed/watercourse models. In addition to riverine locations, water quality samples are also collected under that program at sites within the river estuaries, outer harbor, and the nearshore Lake Michigan area.

Water quality monitoring data covering the calibration/validation period of 1994 through 2002 were obtained from the MMSD. As noted previously in this chapter, quality control procedures for the 2002 monitoring data had not yet been completed when calibration of the watershed/watercourse models was conducted. However, since the calibration of estuary/lake model was initiated later than the watershed/watercourse models, the 2002 monitoring data were available for use. Thus, the time period applied for calibration and validation of the estuary/lake water quality model corresponds with the period used for the hydrodynamic model.

Model Calibration

Similar to the watershed/watercourse models many of the algorithms comprising the estuary/lake model are mathematical approximations of complex natural phenomena. Therefore, before the model can be reliably used to simulate water circulation behavior and water quality under alternative plan conditions, it was necessary to calibrate the model—that is, to compare simulation model results with actual historical data—and, if significant differences were found, to make adjustments in the model parameters to enable the model to better represent the specific natural and man-made features of the waterbodies involved. Once the initial model calibration had been made, model validation was performed by simulating a monitoring period independent from the calibration data set. If the model did not properly simulate conditions for the independent data set, the calibration was deemed unacceptable and additional adjustments were made until adequate validation was achieved.

[17]*The gage was reactivated in May 2006.*

The process used to calibrate the estuary/lake model was similar to that presented in Figure 53 for the watershed/ watercourse models, with the exception of the hydrodynamic model replacing the hydrologic and hydraulic processes. Since simulation of water quality is dependent on water movement, calibration and validation of the hydrodynamic model were carried out first. After that model was adequately calibrated, calibration and validation of the water quality model proceeded.

Once the simulation model is calibrated and validated over a wide range of conditions that have occurred in the river estuaries, outer harbor, and nearshore Lake Michigan area, the basic premise of subsequent simulation is that the model can adequately represent a wide range of hydraulic and water quality conditions and will respond accurately to a variety of model inputs representing hypothetical conditions, such as land use changes and point source modifications, and thereby provide a powerful analytic tool in the watershed planning process.

Hydrodynamic Model Calibration and Validation

Calibration and validation of the hydrodynamic model consisted of two parts. The first part was to demonstrate the model's capability to reproduce the time variable water elevations. Water level calibration is fundamentally important because it demonstrates that the model bathymetry, geometry and hydraulics are configured correctly. In order to achieve this, a comparison was made of simulated water elevations to the measurements obtained for the NOAA gage station located in the outer harbor near the Milwaukee Coast Guard station.

The second part of the hydrodynamic model calibration and validation was to demonstrate adequate reproduction of the transport characteristics of the rivers and harbor, which is important in determining the fate of water quality constituents. This includes the three-dimensional circulation dynamics as represented by the vertical temperature structure in the system. This was achieved by comparing the simulated vertical temperature profiles to the temperature measurements obtained by the MMSD as part of their bi-weekly monitoring program. Additional evaluation of the model's ability to reproduce transport characteristics of the system was accomplished through comparison of simulated flow to the available flow measurements obtained at the USGS continuous recording station located at the mouth of the Milwaukee River.

For calibration purposes, the hydrodynamic model was operated for a four year period from January 1995 through December 1998. Adjustments were made to input parameters until the resulting simulated water elevations, temperature profiles, and flow rates adequately matched the observed data. Once the initial calibration was made, model validation was carried out by operating the model for a second four year period from January 1999 through December 2002.

As part of the calibration and validation process, model results were compared to observed conditions using both graphical and statistical procedures. Graphical comparisons that were used included time series plots of observed and simulated water elevations and flow, and plots of the simulated and observed temperature profile at MMSD sampling locations throughout the model domain. Statistical comparisons included root mean square error and the relative root mean square error.

Details of the hydrodynamic model calibration and validation procedures, including a presentation of results, are set forth in a memorandum report prepared by HydroQual, Inc. This memo is presented in Appendix E.

Water Quality Model Calibration and Validation

Calibration of the estuary/lake water quality model was initiated after calibration of the hydrodynamic processes. For calibration purposes, the water quality model was operated for a four-year period from January 1995 through December 1998, the same as for the hydrodynamic model. Adjustments were made to input parameters until the resulting water quality conditions adequately matched the observed data. Once the initial calibration was made, model validation was carried out by operating the model for a second four year period from January 1999 through December 2002.

As part of the calibration and validation process, model results were compared to observed conditions mainly through graphical procedures. These consisted of time series plots of observed and simulated concentrations of the water quality constituents of interest. Comparison of the spatial profile was also conducted to determine if the observed trend of concentration levels decreasing in a downstream direction was replicated by the model.

Details of the water quality model calibration and validation procedures, including a presentation of results, are set forth in a memorandum report prepared by HydroQual, Inc. This memo is presented in Appendix F.

SUMMARY

Quantitative analyses of water quality in the study area under existing and alternative future conditions are essential to this regional water quality management planning effort. While existing conditions can be measured, the degree of assessment is usually limited in scope due to time and budget concerns. Moreover, evaluation of alternative future conditions cannot be achieved through measurement. To accomplish this, a series of computer simulation models were utilized. Those models were applied as appropriate to the components of the Greater Milwaukee Watersheds including at the watershed/stream level, within the MMSD sewage conveyance and inline storage system, and within the Milwaukee Harbor estuary and nearshore Lake Michigan area.

Simulation of water quantity and quality in the five major watersheds located in the planning area was carried out using the LSPC model that allows for long-term continuous simulation of the hydrologic, hydraulic, and water quality processes both on the land surface and within the receiving streams. The model can be used for both rural and urban land uses.

The principal function of the hydrologic portion of the watershed/watercourse model was to determine the volume and temporal distribution of flow from the land surface to a given lake or stream. The basic hydrologic conceptual unit on which the model operates is called a land segment. A land segment is defined as a unique combination of meteorological characteristics, such as precipitation and temperature; land characteristics, such as pervious or impervious surfaces; soil type; and slope. The model continuously and sequentially maintains a water balance within and between various hydrologic processes. Meteorological and land data constitute the two principal types of input for hydrologic simulation. The key output from the hydrologic phase of the model consists of a continuous series of runoff quantities for each land segment type identified.

The hydraulic portion of the model accepts as input the runoff generated by the hydrologic processes, along with any point source discharges, aggregates the two, and routes them through the stream system, producing a continuous series of discharge values at predetermined locations along the rivers and streams of the watershed. Application of the model requires the stream system to be divided into reach segments and their associated tributary drainage areas. Input for the hydraulic portion of the model consisted of a stage-discharge-cumulative storage table for each reach, as well as output from the hydrologic simulation.

In addition to hydrology and hydraulics, the watershed/watercourse model also includes water quality processes that simulate the time-varying unit loads and concentrations of the 15 water quality indicators selected for evaluation under the regional water quality management plan update. The water quality processes include both a land phase and a channel phase. The land phase operates on the same land segments as the hydrologic processes and includes the buildup and washoff of pollutants from the land surface. Utilizing the same stream reach segments as the hydraulic processes, the channel phase simulates the fate and transport of pollutants within the stream system. Input requirements for the water quality processes include the continuous runoff computations from the hydrologic phase of the model, meteorological data, land data, channel data, point sources of pollution, and diffuse sources of pollution.

Data base development for the watershed/watercourse models included the acquisition, verification, and coding of the data needed to operate, calibrate, validate, and apply the models. The model data base was composed of five distinct categories of information: meteorological conditions, land use and related conditions, channel conditions, diffuse sources of pollution, and point sources of pollution. The data base was assembled using data collected under other Commission and MMSD planning programs as well as data collected under the regional water quality management plan update itself.

The algorithms comprising the watershed/watercourse models are mathematical approximations of complex natural phenomena. Therefore, before the model could be used to simulate streamflow behavior and water quality conditions, it was necessary to calibrate the models. Calibration consists of comparing model results to actual measured historic data and, if significant differences were found, to make adjustments in the model parameters to enable the model to represent specific natural and man-made features of the watershed. Once the initial calibration was made, model validation was performed by simulating a monitoring period independent from the calibration data set. If the model did not properly fit the independent data set, additional adjustments were made until adequate validation was achieved. Calibration and validation of the hydrologic and hydraulic elements of the models was achieved by comparing simulated runoff volumes and discharges to streamflow measured at continuous recording stations operated by the U.S. Geological Survey. Calibration and validation of the water quality processes was achieved by comparing simulated pollutant loads and instream concentrations to data obtained as part of a bi-weekly sampling program carried out by the MMSD.

The MMSD conveyance system consists of the metropolitan interceptor system (MIS), the near surface collector system (NSCS), and the Inline Storage System (ISS) or deep tunnel. Simulation of this system operation was carried out using a suite of programs that were developed and maintained by the MMSD. In addition to simulating the volume of sewage flow and the ability of the conveyance system to deliver that sewage to the wastewater treatment plants, these models also simulated potential bypassing of flows to the rivers and Lake Michigan, which is an essential input to the water quality simulation models for those waterbodies.

The conveyance modeling system consists of two main model components, one that generates wastewater hydrographs from the tributary area and one that routes those hydrographs through the conveyance system. The Hydrological Simulation Program-Fortran (HSPF) and the Flow Forecasting System (FFS) models were used to generate wastewater hydrographs. The HSPF and FFS models were used in combination to compute wastewater discharge on a continuous basis as the sum of several components consisting of the base sanitary flow, dry and wet weather infiltration and inflow (I/I), and, in the case of the combined sewer service area, wet weather surface runoff that enters the combined sewers. Base sanitary flow is computed as a function of the specific land uses in the tributary area, those being residential, commercial, and industrial lands. Infiltration and inflow is computed by applying adjustment factors to simulated surface and subsurface runoff. Infiltration and inflow is computed by applying sewershed calibration factors to simulated surface and subsurface flow components.

The second model component characterizes the conveyance system hydraulics and operating procedures in order to identify hydraulic restrictions, estimate overflow frequencies and volumes for water quality assessment, and identify potential system improvements. Two versions of the model were used—Streamline-MOUSE and Mini-MOUSE—each representing a different level of system detail. Reducing the level of detail allowed for the practical simulation of longer time periods in a single model run.

Both versions of the hydraulic model represent the conveyance system as a series of links, nodes, and storage elements. An algorithm based on the MMSD operating procedures controls the simulated operations of the ISS gates and pumps. Using the hydrographs generated by the first model component, the hydraulic model computes both flows and stages throughout the system in order to help identify hydraulic restrictions and locations where critical elevations are exceeded. The model also simulates CSO and SSO discharges that in turn serve as input to the watershed/watercourse and estuary/lake models.

In addition to the sewage flow and system hydraulics models, a third model, MACRO, was used that allowed for testing the long-term impact of making systemwide changes or changes in operating procedures. This simple volumetric/operational model was used to quickly evaluate the overall response of the conveyance system to alternative system operations or new configurations.

The transport and mixing of pollutants in the Milwaukee Harbor estuary and nearshore Lake Michigan area are controlled by the circulation characteristics of those waterbodies. Those characteristics are influenced by both natural phenomena, such as surface wind stress, Lake Michigan-induced flows due to water level changes, and inflows from the tributary rivers, as well as man-made conditions, such as CSO and SSO events, the withdrawal and discharge of condenser cooling water, and intermittent flushing tunnel inflows. Simulation of these complex physical processes was carried out through the use of a continuous simulation, three-dimensional hydrodynamic model coupled with a water quality simulation model.

The purpose of the hydrodynamic model (ECOMSED) was to describe the movement and mixing of water due to input from tributary rivers, point source discharges, offshore lake effects, and meteorological conditions. Coupled with this turbulent mixing are heat exchange processes between the water column and the atmosphere. The model uses a system of curvilinear coordinates to represent the study area in the horizontal direction, allowing for representation of variable shoreline geometry. In the vertical direction, the model uses a transformed coordinate system known as the σ-coordinate transformation to permit representation of the bottom topography. The model calculates water surface elevation, water velocity and temperature, and water turbulence at points along the grid system based on input consisting of weather conditions, river inflow, and both water elevation and temperature at open water boundaries.

The aerial extent of the hydrodynamic model includes the Milwaukee River upstream to the former North Avenue dam site, the Menomonee River upstream to the former Falk Corporation dam site, the Kinnickinnic River upstream to S. 11th Street, the outer harbor, and the nearshore Lake Michigan area between Fox Point to the north and Wind Point to the south. Model coverage into the Lake extends easterly to about the 30-60 meter bathymetric contour, a distance that varies between four to six miles. The breakwall that protects the outer harbor was represented in the model as a series of thin wall dams to allow for the effective calculation of water transport and circulation between the harbor and Lake Michigan.

The estuary/lake water quality model (RCA) contains both bacteria and eutrophication routines and is capable of evaluating fate and transport of conventional and toxic pollutants in the surface waterbodies in one, two, or three dimensions. Eutrophication processes simulated for the regional water quality management plan update included simulation of one phytoplankton group, dissolved oxygen, and various organic and inorganic forms of nitrogen, phosphorus, and carbon or carbonaceous biochemical oxygen demand, while the bacteria submodel was used to simulate fecal coliform, as well as copper and zinc. The water quality model also includes a sediment submodel that was used to calculate the response of sediment fluxes to settling organic matter.

As with the watershed/watercourse models, the largest single work element in the preparation of the estuary/lake model is data base development. This included the acquisition, verification, and coding of the data that was composed of five distinct categories of information: meteorological data, bathymetric and channel data, model boundary conditions, diffuse sources of pollution, and point sources of pollution.

Similar to the watershed/watercourse models many of the algorithms comprising the estuary/lake model are mathematical approximations of complex natural phenomena. Therefore, before the model can be reliably used to simulate water circulation behavior and water quality conditions, it was necessary to calibrate the model. Since simulation of water quality is dependent on water movement, calibration and validation of the hydrodynamic model was carried out first.

Calibration of the hydrodynamic model consisted of two parts. The first part was to demonstrate the model's capability to reproduce the time variable water elevations. This was achieved through comparison of simulated water surface elevations to water level measurements obtained at a continuous recording gage operated by NOAA and located within the outer harbor near the U.S. Coast Guard station. The second part was to demonstrate adequate reproduction of the transport characteristics of the rivers and harbors. This was achieved by comparing simulated vertical temperature profiles to temperature measurements obtained by the MMSD as part of their bi-weekly sampling program. Additional evaluation was made through comparison of simulated flow to available flow measurements obtained at the USGS continuous recording station located at the mouth of the Milwaukee River. Calibration and validation of the water quality processes was achieved by comparing simulated pollutant concentrations to data obtained as part of a bi-weekly sampling program carried out by the MMSD.

Chapter VI

LEGAL STRUCTURES AFFECTING THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE

INTRODUCTION

In any sound planning effort, it is necessary to investigate the legal as well as the physical and economic factors affecting the problems under consideration. In developing water quality management plans on a watershed basis, the law can be as important as the benefits and costs of proposed water quality control facilities in determining the ultimate feasibility of a given watershed plan. If the legal constraints bearing on the planning problem are ignored during plan formulation, serious obstacles may be encountered during plan implementation. The regional water quality management plan update is intended to focus on water quality issues and problems and on the recommended water use objectives and standards for the greater Milwaukee watersheds (the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds and the Oak Creek watershed), the Milwaukee Harbor Estuary, and nearshore Lake Michigan areas comprising the study area. Thus, the focus of this chapter is on the legal structure relating to water quality. However, because of the importance of hydrologic and habitat conditions in watershed planning and their interrelationship with water quality, the chapter also describes legal structures related to water quantity and habitat conditions, including shoreland and wetland regulations.

Water constitutes one of the most important natural resources. It is essential not only to many of the primary economic activities of man but also to life itself. The available quantity and quality of this important resource are of concern to agricultural, commercial, manufacturing, conservation, and government interests. The rights to the availability and use of water are, accordingly, of vital concern to a host of public-interest and private-interest groups; the body of law regulating these rights is far from simple or static. Moreover, changes in this complex, dynamic body of law may be expected to take place even more rapidly as pressure on regional, State, and National water resources becomes more intense. For example, the Wisconsin Supreme Court has expressly overruled the historic common law doctrine on both groundwater[1] and diffuse surface water law,[2] finding the historic doctrines in these areas not to be applicable to modern water resource problems and conflicts.

In this chapter attention is focused first on those aspects of water law generally pertinent to the planning and management of the water resources of any watershed in Wisconsin. Included in this section are a discussion of the machinery for water quality management of the Federal, State, and local levels of government. Finally, more

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[1]State v. Michels Pipeline Construction, Inc., *63 Wis. 2d 278 (1974).*

[2]State v. Deetz, *66 Wis. 2d 1, 224 N.W. 2d 407 (1974).*

detailed consideration is given to those aspects of water law that relate more specifically to the problems of the regional water quality management plan update study area, including inventory findings on State water pollution abatement orders and permits.

WATER QUALITY MANAGEMENT

Because the regional water quality management plan update study is intended to deal primarily with problems of water quality and to recommend water use objectives and water quality standards for the greater Milwaukee watersheds, the Milwaukee Harbor Estuary, and nearshore Lake Michigan areas that comprise the study area, it is necessary to examine the existing and potential legal machinery through which attainment of water quality goals may be sought at various levels of government and through private action.

Federal Water Quality Management

The Federal government has long been involved in water quality management efforts, although it is only in recent years that the U.S. Congress has acted to secure the establishment of water use objectives and supporting standards for navigable waters. The 1899 Refuse Act prohibited the discharge of refuse matter of any kind, other than that flowing from streets and sewers, into any navigable waters of the United States or tributaries thereto without first obtaining a permit from the Secretary of the Army. The Secretary was directed to make a specific finding that the discharge of any refuse matter would not adversely affect anchorage and navigation; no finding on water quality was, however, required. This Act and the permits issued thereunder were largely ignored until enactment of the National Environmental Policy Act of 1969 (NEPA), which required all Federal agencies to consider environmental impact in the administration of all public laws, and the Water Quality Improvement Act of 1970, which required applicants for Federal permits to file a certification from the appropriate state that the proposed discharge would not violate any applicable state-adopted water quality standard.

A broader Federal approach to water quality management began with the passage of the Federal Water Pollution Control Act on June 30, 1948. With the passage of this Act, the Federal government began to take effective steps toward controlling and preventing pollution of the navigable waters of the United States. Initially, the Act was primarily directed at establishing a Federal grant-in-aid program for the construction of publicly owned waste treatment facilities. In the mid-1960s, requirements were added relating to the establishment of interstate water quality standards. The Act was substantially revised by the amendments of 1972, 1977, and 1987. The name of the statute was changed from the Federal Water Pollution Control Act to the Federal Clean Water Act at the time of the 1977 amendment. In general, the Act, as amended in 1972 and 1977, called for: 1) an increased emphasis on enhancing the quality of all of the navigable waters of the United States, whether interstate or intrastate, 2) an increased emphasis on planning and on examining alternative courses of action to meet stated water use objectives and supporting water quality standards, 3) waters of the United States to be made to the extent practicable “fishable and swimmable,” 4) the provision of substantial Federal financial assistance to construct publicly owned waste treatment works, and 5) the development and implementation of areawide waste treatment management planning processes to assure adequate control of sources of pollutants within each state. The requirements of the Act, as amended in 1972 and 1977, may be categorized under the following headings: water quality standards and effluent limitations, pollutant discharge permit system, continuing statewide water quality management planning processes, areawide waste treatment planning and management, and waste treatment works construction. The 1987 amendment to the Act called for 1) the development of control strategies for waters polluted by toxic substances, 2) a permitting program for stormwater discharges from municipalities of a certain size, certain industries, and construction sites, and 3) the establishment of a program ultimately to replace the Federal program of construction grants for sewage treatment facilities with revolving funds run by the states. In the following sections, attention is focused on the most relevant portions of the Federal Clean Water Act, as well as on the requirements of the NEPA of 1969.

Water Quality Standards and Effluent Limitations

Since 1965, the Federal Water Pollution Control Act, and, later, the Clean Water Act, have required states to adopt water use objectives and supporting water quality standards, or criteria, for all interstate waters.[3] The Act, as amended in 1972, incorporates by reference all existing interstate water quality standards and, for the first time, requires the adoption of intrastate water use objectives and supporting water quality standards, or criteria, and submittal of those objectives and standards for approval by the U.S. Environmental Protection Agency (USEPA). Wisconsin, through the Natural Resources Board and the Wisconsin Department of Natural Resources (WDNR), has adopted the required interstate and intrastate water use objectives and supporting water quality standards. These objectives and standards as related to streams and watercourses in the regional water quality management plan update study area are discussed in a subsequent section of this chapter.

In addition to water use objectives and standards, the Act requires the establishment of specific effluent limitations for all point sources of water pollution. Such limitations require the application of the best practicable water pollution control technology currently available, as defined by the USEPA Administrator. Also, any waste source which discharges into a publicly owned treatment works must comply with applicable pretreatment requirements, also established by the USEPA Administrator. The Act requires publicly owned treatment works to meet effluent limitations based upon a secondary level of treatment and through application of the best applicable waste treatment technology. In addition to these uniform or National effluent limitations, the Act provides that any waste source must meet any more stringent effluent limitations as required to implement any applicable water use objective and supporting standard established pursuant to any State law or regulation or any other Federal law or regulation.

Pollutant Discharge Permit System

The Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES). Under this system the USEPA Administrator or a state, upon approval of the USEPA Administrator, may issue permits for the discharge of any pollutant or combination of pollutants upon the condition that the discharge will meet all applicable effluent limitations or upon such additional conditions as are necessary to carry out the provision of the Act. All such permits must contain conditions to assure compliance with all of the requirements of the Act, including conditions relating to data collection and reporting. In essence, the Act stipulates that all discharges to navigable waters must obtain a Federal permit or, where a state is authorized to issue permits, a state permit. The intent of the permit system is to include in the permit, where appropriate, a schedule of compliance which will set forth the dates by which various stages of the requirements imposed in the permit shall be achieved. As set forth below, Wisconsin has an approved permit system operating under the NPDES.

The 1987 amendments to the Clean Water Act established Phase I of a Federal program for permitting of stormwater discharges from municipalities and specific industries. The Phase I program applies to the specified industries and to municipalities with populations of 100,000 or more. The stormwater discharge permitting program is administered by the USEPA and calls for the issuance of NPDES permits. Pollution from stormwater runoff is commonly characterized as diffuse, or nonpoint source, pollution. The Clean Water Act specifically exempts such pollution sources from the requirements of the NPDES program. However, because most urban stormwater runoff is discharged to receiving streams through storm sewers or other facilities which concentrate flows, the 1987 amendments designated urban stormwater pollution as a point source which could be regulated under the NPDES program. The Federal stormwater discharge permitting program requires: 1) control of industrial discharges utilizing the best available technology economically achievable, 2) control of construction site discharges using best management practices, and 3) municipal system controls to reduce the discharge of pollutants to the maximum extent practicable. As described in a later section of this report, the USEPA has delegated the administration of the stormwater discharge permitting program in the State of Wisconsin to the WDNR.

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[3]*Water quality criteria are continually being proposed and promulgated by the USEPA. Thus, the criteria set forth in this report can be expected to evolve over time.*

In October of 1999, the USEPA expanded the coverage of the stormwater discharge permitting regulations when it issued Phase II stormwater rules that apply to urbanized areas with populations between 50,000 and 100,000 persons and to construction sites that disturb from one to five acres. The Phase II program requires that regulated municipalities reduce nonpoint source pollution to the "maximum extent practicable" through implementations of a set of minimum control measures, including:

- Public education and outreach
- Public involvement and participation
- Illicit discharge detection and limitation
- Construction site stormwater runoff control
- Post-construction stormwater management for new development and redevelopment
- Pollution prevention and good housekeeping for municipal operations.

Ultimately, every separate municipal stormwater management system will be required to obtain a permit, regardless of the size of the municipality.

Continuing Statewide Water Quality Management Planning Processes

The Clean Water Act stipulates that each state must have a continuing planning process consistent with the objectives of the Act. States are required to submit a proposed continuing planning process to the USEPA Administrator for approval. The Administrator is prohibited from approving any state discharge permit program under the pollutant discharge elimination system if that state does not have an approved continuing planning program. The state continuing planning process must result in water quality management plans for the navigable waters within the state. Such plans must include at least the following items: effluent limitations and schedules of compliance to meet water use objectives and supporting water quality standards; the elements of any areawide wastewater management plan prepared for metropolitan areas; the total maximum daily pollutant load to all waters identified by the state for which the uniform or national effluent limitations are not stringent enough to implement the water use objectives and supporting water quality standards; adequate procedures for the revision of plans; adequate authority for intergovernmental cooperation; adequate steps for implementation, including schedules of compliance with any water use objectives and supporting water quality standards; adequate control over the disposition of all residual waste from any water treatment processing; and an inventory and ranking in order of priority needs for the construction of waste treatment works within the state. In effect, a state's planning process is designed to result in the preparation of comprehensive water quality management plans for natural drainage basins or watersheds. The Southeastern Wisconsin Regional Planning Commission and the Wisconsin Department of Natural Resources have cooperatively conducted a continuing water quality management planning program for the Southeastern Wisconsin Region since completion of the initial regional water quality management plan in 1979.

Areawide (Regional) Waste Treatment Planning and Management

Section 208 of the Clean Water Act provides for the development and implementation of areawide waste treatment management plans. The Act envisions that the Section 208 planning process would be most appropriately applied in the nation's metropolitan areas which, as a result of urban and industrial concentrations and other development factors, have substantial water quality control problems. Accordingly, the Act envisions the formal designation of a Section 208 planning agency for substate areas that are largely metropolitan in nature and the preparation of the required areawide water quality management plan by that agency.

Any areawide plan prepared under the Section 208 planning process must include the identification of both point and nonpoint sources of water pollution and the identification of cost-effective measures which will abate the pollution from those sources. The plans must also identify the appropriate management agency responsibilities for implementation.

On September 27, 1974, the seven-county Southeastern Wisconsin Region and the Southeastern Wisconsin Regional Planning Commission were formally designated as a Section 208 planning area and planning agency pursuant to the terms of the Clean Water Act. Following preparation of a detailed study design and after receiving a planning grant from the USEPA, the Commission started the planning program in July 1975. The program was continued through July 12, 1979, the date of formal adoption of the plan by the Commission. The plan adoption followed a series of public meetings and hearings and is fully documented in SEWRPC Planning Report No. 30, *A Regional Water Quality Management for Southeastern Wisconsin*, Volume One, *Inventory Findings*, Volume Two, *Alternative Plans*, and Volume Three, *Recommended Plan*. The plan was approved by the Wisconsin Natural Resources Board on July 25, 1979; by the Governor on December 3, 1979; and by the USEPA on April 30, 1980.

The original regional water quality management plan has been updated over time through an amendment and revision process. A status report on the plan as amended through 1993 is presented in SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995. That report also identifies issues which remain to be addressed in the continuing planning process.

The planning program documented in this report is intended to represent a formal update and amendment to the adopted regional water quality management plan.

Waste Treatment Works Construction

Prior to the 1987 amendments, one of the basic goals of the Clean Water Act was to provide for Federal funding of publicly owned waste treatment works. Such funding was based upon an approved areawide water quality management plan designed to provide for control of both point and nonpoint sources of pollution in a cost-effective manner. As noted above, the 1987 amendments to the Act revised this funding program by establishing the current program, which provides for revolving loan funds operated by the states.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 broadly declares that it is national policy to encourage a productive and enjoyable relationship between man and his environment, to promote efforts which will prevent or eliminate damage to the environment, and to enrich the understanding of the ecological systems and natural resources important to the nation. This Act has broad application to all projects in any way related to Federal action. The mechanism for carrying out the intent of the NEPA of 1969 is the preparation of an environmental assessment for each project. This document must include an exposition of the potential environmental impacts of the proposed project, any adverse environmental effects which cannot be avoided should the project be constructed, any alternative to the proposed project, the relationship between the local short-term uses of man’s environment and the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitments or resources which would be involved in the proposed action if it is implemented. As described below, Wisconsin has a similar environmental policy accompanying State governmental action of all kinds within the State, whether or not such action is federally aided.

U.S. Environmental Protection Agency Watershed Initiative

Watershed Planning

Since the early 1990s, the USEPA has encouraged watershed management approaches that address water quality problems. While such an approach has not yet been widely applied nationally as a planning tool, the Regional Planning Commission has long-practiced watershed planning approaches in its environmental planning work. As envisioned by the USEPA under its Watershed Initiative, the watershed management approach is directed toward attaining and maintaining state water quality standards. The watershed planning approach as put forth by the

USEPA[4] includes the following components, which are consistent with the regional water quality management planning process documented in this report:

- Identification of impaired waters and causes and sources of impairment,

- Identification of threats to other waters,

- Identification of point source and nonpoint source controls needed to attain and maintain water quality standards,

- Estimation of pollutant load reductions that will be achieved,

- Provision of an implementation program that identifies parties responsible for implementation of various plan components, an implementation schedule, and costs and funding sources,

- Identification of technical assistance and education needs, and

- Establishment of a monitoring plan.

The watershed approach to water quality management planning can employ several mechanisms related to plan implementation, including watershed-based permitting, establishment of total maximum daily load analysis, and water quality trading. Those are described below.

Watershed-Based Permitting
A January 2003 policy statement by the USEPA endorsed watershed-based National Pollutant Discharge Elimination System permitting, and implementation guidance for such permits was issued by the USEPA in December 2003.[5,6] The USEPA has identified the following types of watershed permits, although they note that other mechanisms may also be used:

- **Watershed-based General Permit - Common Sources.** A permitting authority "would develop and issue this type of general permit to a category of point sources within a watershed, such as all publicly owned treatment works (POTWs) or all confined animal feeding operations (CAFOs) or all storm water discharges from municipal separate storm sewer systems. This is similar to current general permits, except that the geographic area covered by the permit would correspond to the watershed boundary. The most significant difference between a traditional general permit and the watershed-based general permit for common sources would be permit requirements that reflect watershed-specific water quality standards."

- **"Watershed-based General Permit - Collective Sources.** Unlike the watershed based general permit described above, this type of permit would address all point sources within the watershed or alternatively, several subcategories of point sources within the watershed. This type of permit would be similar to the multi-sector general permit for storm water discharges associated with industrial activity with requirements being tied to categories and subcategories of discharges. Again, the

[4] *USEPA*, EPA's Commitment to the Watershed Management Approach, *presentation at the Water Environment Federation Annual Technical Exhibition and Conference (WEFTEC), October 14, 2003*.

[5] *U.S. Environmental Protection Agency*, Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Policy Statement, *January 7, 2003*.

[6] *U.S. Environmental Protection Agency*, Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation Guidance, *December 2003*.

distinguishing feature of this type of permit would be geographic coverage based on the watershed-boundaries and the permit requirements reflecting watershed-specific water quality standards."

- **"Watershed-based Individual Permit - Multiple Permittees.** Similar to the approach used for Phase I MS4s (municipal separate storm sewer systems) with multiple permittees, this type of permit would allow several point sources within a watershed to apply for and obtain permit coverage under an individual permit."

- **"Integrated Municipal NPDES Permit**. This type of permit would bundle all NPDES permit requirements for a municipality (e.g., storm water, combined sewer overflows, biosolids, pretreatment, etc.) into a single municipal permit. While this type of permit would focus on municipal boundaries rather than watershed boundaries, the analysis in developing permit requirements would reflect watershed-specific water quality standards."

The watershed-based permitting approach may be a useful tool in implementation of the recommendations of a watershed-based water quality management plan such as the regional update documented herein. Because the WDNR administers the pollutant discharge elimination system permitting program in Wisconsin, any watershed-based permits would be issued under the WPDES program. To the extent that nonpoint source of water pollution are regulated under WPDES stormwater discharge permits, it should be possible to consider such sources in developing watershed-based permits. New, innovative administrative and permitting frameworks may have to be developed to address nonpoint sources of pollution that are not currently covered by WPDES permits.

Total Maximum Daily Loads (TMDLs)
Under the Clean Water Act, Total Maximum Daily Loads (TMDLs) are to be established for waters that are not meeting their designated water quality standards and are, therefore, listed as impaired waters by the State under Section 303(d) of the Clean Water Act. The TMDLs are to be designed "to establish the 'total maximum daily load' of a pollutant that the waterbody can assimilate and still achieve water quality standards."[7] Mathematical water quality simulation models such as those used for this regional water quality management plan update (see descriptions in Chapter V of this report) may be useful in establishing TMDLs that consider point and nonpoint sources of pollution.

Water Quality Trading
The concept of water quality trading is based on the premise that the cost of controlling a given water pollutant may vary greatly, depending on the source of that pollutant. Thus, facilities with higher costs to meet the level of control required under their discharge permits may be able to purchase pollution reductions from other entities from which the control of the pollutant may be achieved at a lesser cost.[8] A typical example of this approach would be trading of reductions in a point pollution source for comparable, or greater, reductions in a nonpoint source.

In order for water quality trading to be possible, there must be a framework in place to enable evaluation of the effects on quality of the "trade." Such a framework could be a watershedwide water quality model, such as was developed for the regional water quality management plan update, or a TMDL, which may be based on such a model. The application of trading would be constrained or not feasible in watersheds where water quality standards cannot be met without controlling all pollution sources to the greatest degree practicable.

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[7]*Association of Metropolitan Sewerage Agencies,* Creating Successful Total Maximum Daily Loads, *2004.*

[8]*U.S. Environmental Protection Agency, www.epa.gov/OWOW/watershed/trading.htm*

Combined Sewer Overflow (CSO) Policy

The USEPA CSO Control Policy [9] is intended to provide a consistent approach to controlling CSOs through the National Pollutant Discharge Elimination System (NPDES) permitting program. The CSO Control Policy is comprised of four key principles that were implemented to meet the objectives of the Clean Water Act. These key principles are:

- Clear levels of control to meet health and environmental objectives,
- Flexibility to consider the site-specific nature of CSOs and find the most cost-effective way to control them,
- Phased implementation of CSO controls to accommodate a community's financial capability, and
- Review and revision of water quality standards during the development of CSO control plans to reflect the site-specific wet weather impacts of CSOs,

There are two other major components of the CSO Control Policy. The first is the implementation of minimum technology-based controls. These controls are referred to as the "nine minimum controls"[10] and are defined as "measures that can reduce the prevalence and impacts of CSOs and that are not expected to require significant engineering studies or major construction."

The nine minimum controls are as follows:

- Proper operation and regular maintenance programs for the sewer system and the CSOs
- Maximum use of the collection system for storage
- Review and modification of pretreatment requirements to assure CSO impacts are minimized
- Maximization of flow to the publicly owned treatment works for treatment
- Prohibition of CSOs during dry weather
- Control of solid and floatable materials in CSOs
- Pollution prevention
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

The CSO control measures implemented by MMSD as part of the Water Pollution Abatement Program essentially meet the nine minimum controls. This is documented in a report entitled *Documentation of the Implementation of the Nine Minimum Combined Sewer Overflow Controls,* which was submitted to the WDNR in September 2004. The other major component of the CSO Control Policy is the development of long-term CSO control plans (LTCP), which are to include the following elements:

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[9]*U.S. Environmental Protection Agency, Combined Sewer Overflow (CSO) Control Policy, April 19, 1994.*

[10]*U.S. Environmental Protection Agency*, Combined Sewer Overflows, Guidance for Nine Minimum Controls, *EPA 832-B-95-003, May 1995.*

- Characterization, monitoring, and modeling of the combined sewer system
- Public participation
- Consideration of sensitive areas
- Evaluation of alternatives to meet CWA requirements using either the "presumptive approach" or the "demonstration approach"
- Cost/performance considerations
- An operational plan
- Maximizing treatment at the existing Publicly Owned Treatment Works plant
- An implementation schedule
- A post-construction compliance monitoring program

All communities with combined sewer systems are expected to develop and implement LTCPs that will eventually afford full compliance with the Clean Water Act. The USEPA National CSO Control Policy calls for LTCPs to adopt one of the following approaches to CSO control:

"1) The 'presumptive approach' is a program that meets any of the criteria listed below and is presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA:

  - No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. …; or
  - The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the Combined Sewer Service Area during precipitation events on a systemwide annual average basis; or
  - The elimination or removal of no less than the mass of the pollutants, identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under the immediately preceding paragraph.

2) The 'demonstrative approach' allows a permittee to demonstrate that a selected control program is adequate to meet the water quality-based requirements of the CWA including attainment of water quality standards."[11]

As a result of the construction of the Inline Storage System (ISS) under the Water Pollution Abatement Program (WPAP), MMSD has met the required LTCP control level under the presumptive approach. However, the MMSD is now documenting its LTCP and integrating the development of its long-term CSO control plan document with the 2020 Facilities Planning process.

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[11]*Wisconsin Department of Natural Resources,* Sewer Overflows in Wisconsin-A Report to the Natural Resources Board, *March 15, 2001.*

Sanitary Sewer Overflow Policy
There is little definitive Federal guidance on SSOs beyond the Clean Water Act, which prohibits SSOs except under certain extreme conditions. Many State regulatory agencies have recognized that absolute prohibition of SSOs under any hydrologic conditions is impossible to achieve. This has led to the industry practice of sizing facilities for a defined level of protection against SSOs. The level of protection is typically defined in terms of a recurrence interval for a design rainfall event or a wastewater flow event recurrence interval.

Several years ago, the USEPA drafted a Sanitary Sewer Overflow Rule[12] that established requirements for standard permit conditions to be included in NPDES permits for POTWs and municipal sanitary sewer collection systems. The draft SSO rule provided guidance for sanitary sewer collection system capacity assessments and management practices, but no definitive guidance on facility sizing. The draft rule also provided a framework for regulating municipal satellite collection systems (collection systems that discharge to another collection system for eventual treatment) under the NPDES permit program. This draft rule was withdrawn from the rulemaking process some time ago and it is uncertain whether USEPA will resubmit it for consideration, or develop other guidance. Nevertheless, the draft rule has served as guidance for state regulatory agencies that are developing their own SSO rules, including the WDNR.

In the absence of definitive Federal or State criteria for sizing sanitary sewer systems, the regional water quality management plan update and the MMSD 2020 Facilities Plan approach sizing of sanitary sewer system facilities by evaluating wastewater facility needs over a range of levels of protection against sanitary sewer overflows from MMSD facilities. The level of protection to be used for sizing facilities will be determined in conjunction with the alternatives evaluation process. This process is intended to be carried out and determination of the level of protection will be based on water quality, cost, public goals and objectives, and other evaluation factors, in collaboration with the Wisconsin Department of Natural Resources.

Proposed Wet-Weather Policy
On December 19, 2005, the USEPA issued a draft memorandum regarding NPDES permit requirements for peak wet weather flow from POTW plants serving separate sanitary sewer systems.[13] The memorandum specifically notes that it does not apply to POTW plants serving combined sewer systems. The memo states that “EPA recognizes that peak wet weather flow diversions around secondary treatment units at POTW treatment plants serving separate sanitary sewer conveyance systems may be necessary in some circumstances to prevent temporary loss of function of secondary treatment units.” However, it also notes concerns that such diversions could have negative effects on the environment and public health. The memo indicates that peak wet weather diversions around secondary treatment units that are recombined with flows that have received secondary treatment, a procedure that is called “blending,” can be approved subject to meeting specific criteria set forth in 40 CFR 112.41(m)(4)(i)(A)-(C). If, based on a comprehensive analysis process specified in the memo, a POTW operator demonstrates that under certain conditions there would be no feasible alternative to such peak wet weather flow diversions, such diversions may be approved by the USEPA.

Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000
This Act (Public Law 106-284) is intended to protect public health at beaches. The Act amends the Federal Water Pollution Control Act to require that by April 10, 2004, states with coastal or Great Lakes recreation waters establish water quality criteria and standards for pathogens and pathogen indicators that are at least as stringent as

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[12]*U.S. Environmental Protection Agency, Notice of Proposed Rulemaking, Proposed for 40 CFR Parts 122 and 123, National Pollutant Discharge Elimination System (NPDES) Permit Requirements for Municipal Sanitary Sewer Collection Systems, Municipal Satellite Collection Systems, and Sanitary Sewer Overflows, January 4, 2001.*

[13]*U.S. Environmental Protection Agency, Draft Memorandum,* National Pollutant Discharge Elimination System Permit Requirements for Peak Wet Weather Discharges from Publicly Owned Treatment Works Treatment Plants Serving Separate Sanitary Sewer Collection Systems, *December 19, 2005*.

those set forth in the January 1986 USEPA report titled, *Ambient Water Quality Criteria for Bacteria-1986*. If a state did not adopt sufficiently restrictive standards and criteria by the 2004 deadline, the BEACH Act authorizes the USEPA to propose regulations for pathogens and pathogen indicators. The State of Wisconsin is in the process of adopting criteria, but had not adopted such criteria by the deadline. Thus, the USEPA has promulgated criteria for Wisconsin that call for an *Escherichia coli* (*E. coli*) geometric mean standard of 126 counts per 100 milliliters and single sample maxima ranging from 235 counts per 100 ml to 575 counts per 100 ml, depending on the frequency of use of the recreational waters. Also, an enterococci geometric mean standard of 33 counts per 100 ml and single sample maxima ranging from 61 to 151 counts per 100 ml were established. Within the study area for the current regional water quality management plan update, these USEPA standards only apply to Lake Michigan and recreational waters which are considered to be the open water Lake Michigan areas and the Milwaukee outer harbor.

The BEACH Act also requires states to develop and implement programs for water quality monitoring and public notification at coastal and great lakes recreational beaches. The State of Wisconsin has been implementing such a program since 2003.

State Water Quality Management

Responsibility for water quality management in Wisconsin is centered in the WDNR. Pursuant to the State Water Resources Act of 1965, the WDNR acts as the central unit of State government to protect, maintain, and improve the quality and management of the groundwater and surface waters of the State. The only substantive areas of water quality management authority not located in the WDNR, or shared with other agencies, are: 1) the authority to regulate private sanitary sewer systems, private septic tank sewage disposal systems, and construction site erosion control for single- and two-family residential building sites and commercial sites, which are the responsibility of the Wisconsin Department of Commerce, 2) the establishment of groundwater standards under Chapter NR 140 of the *Administrative Code*, which is shared with the Wisconsin Department of Health and Social Services, 3) the development by the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) of a model shoreland management ordinance and of regulations for drainage districts and county land and water resource management plans, and 4) the authority to regulate highway construction site erosion control for projects administered by the Wisconsin Department of Transportation (WisDOT), which is the responsibility of WisDOT. Attention in this section of the chapter will be focused on those specific functions of the WDNR which bear directly upon water quality management.

Water Resources Planning

Section 281.12(1) of the *Wisconsin Statutes* requires that the WDNR formulate a long-range comprehensive State water resources plan for each region in the State. The seven-county Southeastern Wisconsin Planning Region lies entirely within the eight-county Southeast Region of the Department. This section of the *Statutes* also stipulates that the Department should formulate plans and programs for the prevention and abatement of water pollution and for the maintenance and improvement of water quality. In addition, Section 281.13 of the *Wisconsin Statutes* authorizes the Department to conduct drainage basin surveys. This statutory authority enables the Department to conduct the continuing State water quality management planning process required by the Clean Water Act.

Water Use Objectives and Water Quality Standards/Criteria

Section 281.15(1) of the *Wisconsin Statutes* requires that the WDNR prepare and adopt water use objectives and supporting water quality standards, or criteria, that apply to all surface waters of the State. Such authority is essential if the State is to meet the requirements of the Clean Water Act. Water use objectives and supporting water quality standards were initially adopted for interstate waters in Wisconsin on June 1, 1967, and for intrastate waters on September 1, 1968. *Administrative Code* Chapters NR 102 through NR 105 comprise the water quality standards for the surface waters of the State. On October 1, 1973, the Wisconsin Natural Resources Board adopted revised water use objectives and supporting water quality standards which were set forth in *Wisconsin Administrative Code* Chapters NR 102 and 104. On October 1, 1976, *Administrative Code* Chapter NR 104 was repealed and a new chapter was created. Chapter NR 105, which establishes surface water quality criteria for toxic substances, took effect on March 1, 1989. Chapter NR 106, which also took effect on March 1, 1989, establishes procedures for calculating water quality-based effluent limitations for toxic and organoleptic substances discharged to surface waters. Such effluent limitations are essential to assure that the water quality standards set forth in Chapters NR 102 through NR 105 are attained. Chapter NR 103, which establishes water quality standards for wetlands, took effect on August 1, 1991.

Water quality standards, or criteria, have been promulgated by the Department for the following major water uses in Southeastern Wisconsin:

1. Great Lakes Communities: Streams classified under this category are those waters which drain to Lake Michigan and its bays, arms, and inlets, which serve as spawning areas for anadromous fishes.

2. Coldwater Biological Communities: Streams classified under this category are capable of supporting a community of coldwater fish and other aquatic life or serve as spawning areas for coldwater sport fish species. This category includes, but is not restricted to, surface waters identified as trout waters by the WDNR. Also included in this classification are coldwater streams which, although too small to support sport fish, are capable of supporting an abundant and diverse population of forage fish and macroinvertebrates which are intolerant of pollution.

3. Warmwater Sport Fish Communities: Streams placed under this classification are capable of supporting a warmwater sport fishery or they serve as spawning areas for warmwater sport fish species such as walleyed pike, bluegill, largemouth bass, and smallmouth bass. Also present are aquatic macroinvertebrates which are relatively intolerant of pollution.

4. Warmwater Forage Fish Communities: This category includes surface waters with natural water quality and habitat capable of supporting an abundant, usually diverse, community of forage fish (shiners, minnows) or aquatic macroinvertebrates (insects, clams, crayfish) which are relatively intolerant of pollution. These streams are generally too small to support sport fish species. Streams capable of supporting valuable populations of pollution-tolerant forage fish are also included in this classification.

5. Limited Forage Fish Communities (Intermediate Surface Waters): Streams within this classification are of limited capacity, naturally poor water quality, and deficient habitat. These intermediate surface waters are capable of supporting only a limited community of pollution-tolerant forage fish and aquatic macroinvertebrates.

6. Limited Aquatic Life (Marginal Surface Waters): Streams with this classification have a severely limited capacity, naturally poor water quality, and deficient habitat. These marginal surface waters are only capable of supporting a limited community of aquatic life.

As set forth in the following section, there are also minimum standards which apply to all waters. The existing water use objectives for all stream channels studied within the regional water quality management plan update study area, as adopted by the WDNR, are shown on Maps 51 through 56 in Chapter VII of this report, and applicable water quality standards for all water uses designated in Southeastern Wisconsin are set forth in Table 67.[14]

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[14]*The water quality standards adopted by the Wisconsin Department of Natural Resources are used for regulatory purposes. Additional standards adopted by the Regional Planning Commission for planning purposes are set forth in Chapter IV of SEWRPC Technical Report No. 39 (TR No. 39),* "Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds." *The Commission standards differ somewhat from the Department standards because of their application for planning, rather than regulatory, purposes. Chapter IV of TR No. 39 also presents human threshold and human cancer water quality criteria for public health and welfare, threshold concentrations for public health and welfare for substances causing taste and odor in water, wildlife criteria for surface water quality, acute and chronic toxicity criteria for aquatic life, and groundwater quality standards for substances of public health concern and public welfare.*

Table 67

APPLICABLE REGULATORY WATER USE OBJECTIVES AND WATER QUALITY STANDARDS, OR CRITERIA, FOR LAKES AND STREAMS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Water Quality Parameter	Combinations of Water Use Objectives Adopted for Planning Purposes[a]						Source
	Coldwater Community	Warmwater Sportfish and Forage Fish Communities	Limited Forage Fish Community (variance category)	Limited Aquatic Life (variance category)	Special Variance Category A[b]	Special Variance Category B[c]	
Recreational use	Full	Full	Full	Full	Limited	Limited	- -
Maximum Temperature (^{o}F)[d]	Background	89.0	89.0	- -	89.0[e]	89.0	NR 102.04 (4)[f]
Dissolved Oxygen (mg/l)[d]	6.0 minimum 7.0 minimum during spawning	5.0 minimum	3.0 minimum	1.0 minimum	2.0 minimum	2.0 minimum	NR 102.04 (4) NR 104.02 (3)
pH Range (S.U.)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0[e]	6.0-9.0[e]	NR 102.04 (4)[g] NR 104.02 (3)
Fecal Coliform (MFFCC)[h]	- -	- -	- -	- -	- -	- -	NR 102.04 (5) NR 104.06 (2)
Mean	200	200	200	200	1,000	1,000	- -
Maximum	400	400	400	400	2,000	- -	- -
Ammonia Nitrogen (mg/l)	- -[i]	- -[i]	- -[i]	- -[i]	- -[i]	- -[i]	NR 105 Tables 2c and 4b

[a]*NR 102.04(1) All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[b]*As set forth in Chapter NR 104.06(2)(a) of the* Wisconsin Administrative Code.

[c]*As set forth in Chapter NR 104.06(2)(b) of the* Wisconsin Administrative Code.

[d]*Dissolved oxygen and temperature standards apply to continuous streams and the upper layers of stratified lakes and to unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

[e]*Not specifically addressed within the* Wisconsin Administrative Code*. For planning purposes only, these values are considered to apply.*

[f]*NR 102.04(4) There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the natural temperature shall not exceed 5^{o}F for streams. There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[g]*The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[h]*NR 102.04(5)(a) The membrane filter fecal coliform count may not exceed 200 per 100 ml as a geometric mean based on not less than five samples per month, nor exceed 400 per 100 ml in more than ten percent of all samples during any month.*

[i]*J.E. McKee and M.W. Wolf,* Water Quality Criteria, 2nd edition, *California State Water Quality Control Board, Sacramento, California, 1963. The standards for ammonia nitrogen are set forth in Chapter IV of SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The water quality standards, or criteria, are statements of the physical, chemical, and biological characteristics of the water that must be maintained if the water is to be suitable for the specified uses. Chapter 281 of the *Wisconsin Statutes* recognizes that different standards may be required for different waters or portions thereof. According to the Chapter, in all cases the "standards of quality shall be such as to protect the public interest, which includes the protection of the public health and welfare and the present and prospective future use of such waters for public and private water supplies; propagation of fish and aquatic life and wildlife; domestic and recreational purposes; and agricultural, commercial, industrial and other legitimate uses."[15]

[15]Wisconsin Statute *Section 281.15(1).*

Chapter IV of SEWRPC Technical Report No. 39[16] lists additional water quality criteria for the following categories as set forth in the *Wisconsin Administrative Code* or the Code of Federal Regulations:

- Human threshold and human cancer water quality criteria for public health and welfare,
- Threshold concentrations for public health and welfare for substances causing taste and odor in water,
- Wildlife criteria for surface water quality,
- Acute and chronic toxicity criteria for aquatic life,
- The methodology for establishing preventive action limits for indicator parameters for groundwater quality,
- Groundwater quality standards for substances of public health concern, and
- Groundwater quality standards for substances of public welfare.

Minimum Standards, or Criteria
All surface waters must meet certain conditions at all times and under all flow conditions. Chapter NR 102 of the *Wisconsin Administrative Code* states that:

> "Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions:
>
> "(a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> "(b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> "(c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in the waters of the State.
>
> "(d) Substances in concentrations or combinations which are toxic or harmful to humans shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant or aquatic life."[17]

Recreational Use
Waters to be used for recreational purposes should be aesthetically attractive, free of substances that are toxic upon ingestion or irritating to the skin upon contact, and void of pathogenic organisms. The first two conditions are satisfied if the water meets the minimum standards for all waters as previously described, whereas the third condition requires that a standard be set to ensure the safety of water from the standpoint of health. The concentration of fecal bacteria is the indicator now used by the Wisconsin Department of Natural Resources for this purpose. Since the fecal coliform count is only an indicator of a potential public health hazard, the Wisconsin

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[16]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

[17]Wisconsin Administrative Code *Chapter NR 102.04.*

standards specify that a thorough sanitary survey to assure protection from fecal contamination be the chief criterion for determining recreational suitability.

Fish and Aquatic Life
The limited forage fish and limited aquatic life categories may be applied to streams with restricted use downstream from an area of intense urban development or where wastewater has a predominant influence, or they may be applied to streams with adequate water quality, but restrictions based on stream size and/or flow characteristics.

Application of the Water Use Objectives to the Regional Water Quality Management Plan Update Study Area
The application of the basic categories of water use objectives require specification of a design low flow at, or above, which the water quality standards commensurate with each water use objective are to be met. The water use objectives state that compliance with the supporting standards is to be evaluated on the basis of streamflow as low as the seven-day, 10-year low flow, which is defined as the minimum seven-day mean low flow expected to occur once on the average of every 10 years. That is, for a given water use objective, the stream water quality is to be such as to satisfy the supporting standards for all streamflow conditions at or above the seven-day, 10-year low flow. Based on changes in the quality of discharges to streams in the watershed, either from the addition or subtraction of point discharges (through the construction or abandonment of sewage treatment plants) and on selected specific stream evaluations, the WDNR has proposed revisions to the State-adopted water use objectives. Some of these proposed changes are documented in various WDNR "State of the Basin" reports. The proposed revisions are listed in Table 70 in Chapter VII of this report. The water use objectives that are considered under this regional water quality management plan are consistent with the revisions proposed by the WDNR.

Water Pollution Abatement Programs
Section 281.58 of the *Wisconsin Statutes* authorizes the WDNR to provide financial assistance through the Clean Water Fund Loan Program for the construction of point source pollution abatement facilities necessary for the protection of State waters. The rules governing the Clean Water Fund small loan interest rate subsidy program are set forth in Chapter NR 165 of the *Wisconsin Administrative Code*. Under this program, communities proposing eligible projects may receive loans at or below market interest rates. The program establishes three tiers of projects which may be eligible for loan interest rates ranging from 55 to 100 percent of the market rate.

Chapter Comm 87, which was created on February 1, 1999, pursuant to Section 145.245 of the *Wisconsin Statutes*, sets forth rules for the implementation and administration of the State financial assistance program for the replacement or rehabilitation of failing private sewage treatment systems. In order for residences or small commercial establishments to be eligible for State grants, the county, or in the case of Milwaukee County, the city or village, where the grant applicants are located must be designated as a participating governmental unit, as specified in Section 145.245. Dodge, Fond du Lac, Kenosha, Ozaukee, Racine, Sheboygan, Washington, and Waukesha Counties and the City of Franklin in Milwaukee County are participating governmental units in the regional water quality management plan update study area.

The Code identifies the following three categories of failing private systems:

Category 1: Private systems, the failure of which results in the discharge of sewage in surface water or groundwater; the introduction of sewage into saturation zones; or the discharge of sewage to a drain tile or into bedrock zones.

Category 2: Private systems discharging sewage to the ground surface.

Category 3: Private systems which fail to accept discharges of sewage, resulting in the backup of sewage into the structure served by the system.

Only principal residences or small commercial establishments constructed prior to July 1, 1978, are eligible for financial assistance for replacement or rehabilitation of failing systems. In addition, eligible principal residences must have annual family incomes of $45,000 or less, and eligible small commercial establishments must have annual gross revenues of $362,500 or less.

Effluent Reporting and Monitoring System

Section 299.15 of the *Wisconsin Statutes* directs the WDNR to require by rule that persons discharging industrial wastes, toxic and hazardous substances, or air contaminants submit a report on such discharges to the Department. The law further establishes an annual monitoring fee to provide for the cost of administering the program. In response to this statutory mandate, the Department prepared and adopted Chapter NR 101 of the *Wisconsin Administrative Code*, setting forth specific rules by which the reporting and monitoring program is to be conducted.

Pollutant Discharge Permit System

Sections 283.31(1) and 283.33 of the *Wisconsin Statutes* require a permit for the legal discharge of any pollutant into the waters of the State, including groundwaters. This State pollutant discharge permit system was established by the Wisconsin Legislature in direct response to the requirements of the Clean Water Act. While the Federal law envisioned requiring a permit only for the discharge of pollutants into navigable waters, in Wisconsin, permits are required for discharges from point sources of pollution to all surface waters of the State and, additionally, to land areas where pollutants may percolate or seep to, or be leached to, groundwater. The Wisconsin Pollutant Discharge Elimination System (WPDES) permitting program provides a major vehicle for achievement of the basic goal of meeting the water use objectives for the receiving waters to the extent that the permits are consistent with the water quality management plans prepared pursuant to the terms of the Clean Water Act.

Rules relating to the WPDES are initially set forth in Chapter NR 200 of the *Wisconsin Administrative Code*, the current version of which became effective on June 1, 1985 and has a most recent revision date of January 2000. The following types of discharges require permits under Chapter NR 200:

1. The direct discharge of any pollutant to any surface water.

2. The discharge of any pollutant, including cooling waters, to any surface water through any storm sewer system not discharging to publicly owned treatment works.

3. The discharge of pollutants other than from agricultural uses for the purpose of disposal, treatment, or containment on land areas, including land disposal systems such as ridge and furrow, irrigation, and ponding systems.

4. Discharge from an animal feeding operation where the operation causes the discharge of a significant amount of pollutants to waters of the State and the owner or operator of the operation does not implement remedial measures as required under a notice of discharge issued by the WDNR under Chapter NR 243, which deals with animal waste management.

Certain discharges are exempt from the permit system, as set forth under Chapter NR 200, including discharges to publicly owned sewerage works, discharges from vessels and properly functioning marine engines, and discharges of domestic sewage to septic tanks and drain fields, which are regulated under another chapter of the *Wisconsin Administrative Code*. Also exempted are the disposal of septic tank pumpage and other domestic waste, also regulated by another chapter of the *Wisconsin Administrative Code*; the disposal of solid wastes, including wet or semi-liquid wastes, when disposed of at a site licensed pursuant to another chapter of the *Wisconsin Administrative Code*; discharges from private alcohol fuel production systems; and discharges included under a general permit. The WPDES enables the accumulation of data concerning point sources of pollution and requires a listing of the treatment requirements and a schedule of compliance setting forth dates by which various stages of the requirements imposed by the permit shall be achieved.

As noted earlier in this chapter, the 1987 amendments to the Federal Clean Water Act established a Federal program for permitting stormwater discharges. The State of Wisconsin obtained certification from the USEPA which enabled the State to administer the stormwater discharge permitting program as an extension of the existing WPDES program. Section 283.33 of the *Statutes*, which provides authority for the issuance of stormwater discharge permits by the State, was enacted in 1993. The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216 of the *Administrative Code*, which took effect on November 1, 1994, and was most recently repealed and replaced effective August 1, 2004.

In general, the following entities are required to obtain discharge permits under Chapter NR 216:

1. An owner or operator of a municipal separate storm sewer system serving an incorporated area with a population of 100,000 or more.

2. An owner or operator of a municipal separate storm sewer system notified by WDNR prior to August 1, 2004, that they must obtain a permit.

3. An owner or operator of a municipal separate storm sewer system located within an urbanized area as defined by the U.S. Bureau of the Census.

4. An owner or operator of a municipal separate storm sewer system serving a population of 10,000 or more in a municipality with a population density of 1,000 persons or more per square mile as determined by the U.S. Bureau of the Census.

5. Industries identified in Section NR 216.21.[18]

6. Construction sites, except those associated with agricultural land uses, those for commercial buildings regulated by Chapters Comm 50 through 64 of the *Wisconsin Administrative Code*,[19,20] and Wisconsin Department of Transportation projects which are subject to the liaison cooperative agreement between the WDNR and WisDOT.

On January 19, 2006, the WDNR issued a general stormwater discharge permit[21] applicable to municipal separate storm sewer systems for areas that do not have individual permits and that are either:

- An urbanized area with a minimum population of 50,000 people as determined by the U.S. Bureau of the Census, or

- A municipality with a population of 10,000 or more and a population density of 1,000 persons or more per square mile, or

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[18]*Depending on the type of industry, a statewide general permit or an individual permit may be issued. A holder of a general or an individual permit must prepare and implement a stormwater pollution prevention plan. The requirements for such a plan are set forth in Section NR 216.27.*

[19]*Comm 50.115 describes procedures to be followed regarding filing a notice of intent for coverage under a WPDES General Permit for stormwater discharges associated with construction activities.*

[20]*Construction of one- and two-family dwellings is generally regulated by the Wisconsin Department of Commerce. Comm 21.125 sets forth erosion control procedures for construction of one- and two-family dwellings. Owners of properties on which such dwellings are to be constructed would only have to apply for a permit under Chapter NR 216 if the land disturbing activities associated with the development involved the disturbance of one or more acres.*

[21]General Permit to Discharge Under the Wisconsin Pollutant Discharge Elimination System, *WPDES Permit No. WI-S050075-1, January 19, 2006.*

- An area that drains to a municipal separate storm sewer system that is designated for permit coverage.

The general permit "specifies conditions under which stormwater may be discharged to waters of the state for the purpose of achieving water quality standards." It establishes conditions for discharges to State-designated outstanding or exceptional resources waters. When a municipal separate storm sewer system discharges to an impaired waterbody listed in Section 303(d) of the Clean Water Act, the following conditions must be met:

- The permittee's written stormwater management program must specifically identify control measures and practices that are to be applied in an attempt to reduce, with the goal of eliminating, the discharge of pollutants of concern that contribute to the impairment of the receiving water.

- The permittee may not initiate a new discharge of a pollutant of concern to an impaired waterbody, or increase the discharge of such a pollutant to an impaired waterbody unless receiving water quality standards will be met or WDNR has approved a total maximum daily load (TMDL) for the impaired waterbody.

- For discharges to a waterbody for which a TMDL has been established, the permittee must determine if additional stormwater runoff controls are required to meet the TMDL wasteload allocation.

The general stormwater discharge permit establishes requirements for:

- Public education and outreach,

- Public involvement and participation,

- Illicit discharge detection and elimination,

- Construction site pollutant control,

- Post-construction stormwater management, and a pollution prevention program.

The construction site pollutant control requirements and the post-construction control requirements are based on the standards for new development, redevelopment, and transportation facilities as set forth in Chapters NR 151 and NR 216.

State Performance Standards for Control of Nonpoint Source Pollution

Through 1997 Wisconsin Act 27, the State Legislature required the WDNR and DATCP to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[22] The performance standards are set forth in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code,* which became effective on October 1, 2002 and was revised in July 2004.

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[22]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *Additional Code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," and Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Stormwater Management Grant Program." Those chapters of the* Wisconsin Administrative Code *became effective in October 2002. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were repealed and recreated in October 2002. The Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) revised Chapter ATCP 50, "Soil and Water Resource Management," to incorporate changes in DATCP programs as required under 1997 Wisconsin Act 27.*

Agricultural Performance Standards
Agricultural performance standards cover the following areas:

- Cropland sheet, rill, and wind erosion control,
- Manure storage,
- Clean water diversions, and
- Nutrient management.

The following manure management prohibitions are set forth in Section NR 151.08.

A livestock operation:

- Shall have no overflow of manure storage facilities,
- Shall have no unconfined manure pile in a water quality management area,[23]
- Shall have no direct runoff from a feedlot or stored manure into the waters of the State, and
- May not allow unlimited access by livestock to waters of the State in a location where high concentrations of animals prevent the maintenance of adequate sod or self-sustaining vegetative cover.[24]

For existing land that does not meet the NR 151 standards and that was cropped or enrolled in the U.S. Department of Agriculture Conservation Reserve or Conservation Reserve Enhancement Programs as of October 1, 2002, agricultural performance standards are only required to be met if cost-sharing funds are available or if the best management practices and other corrective measures needed to meet the performance standards do not involve eligible costs. Existing cropland that met the standards as of October 1, 2002, must continue to meet the standards. New cropland must meet the standards, regardless of whether cost-share funds are available.

For existing livestock facilities that do not meet the NR 151 standards or prohibitions, the performance standards or prohibitions are only required to be met if cost-sharing funds are available or if the best management practices and other corrective measures needed to meet the performance standards or prohibitions do not involve eligible costs. Existing livestock facilities that met the standards as of October 1, 2002, must continue to meet the standards. New livestock facilities must meet the standards, regardless of whether cost-share funds are available.

Nonagricultural (urban) Performance Standards
The nonagricultural performance standards set forth in Chapter NR 151 encompass two major types of land management. The first includes standards for areas of new development and redevelopment and the second includes standards for developed urban areas. The performance standards address the following areas:

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[23]*A water quality management area is defined in Section NR 151.015(24) as "the area within 1,000 feet from the ordinary high water mark of navigable waters that consist of a lake, pond, or flowage, except that, for a navigable water that is a glacial pothole lake, the term means the area within 1,000 feet from the high water mark of the lake; the area within 300 feet from the ordinary high water mark of navigable waters that consist of a river or stream; and a site that is susceptible to groundwater contamination, or that has the potential to be a direct conduit for contamination to reach groundwater."*

[24]*This prohibition does not apply to properly designed, installed, and maintained livestock or farm equipment crossings.*

- Construction sites for new development and redevelopment,
- Post construction phase for new development and redevelopment,
- Developed urban areas, and
- Nonmunicipal property fertilizing.

Chapter NR 151 requires that municipalities with WPDES stormwater discharge permits reduce the amount of total suspended solids in stormwater runoff from areas of existing development that is in place as of October 2004 to the maximum extent practicable, according to the following standards:

- By March 10, 2008, the NR 151 standards call for a 20 percent reduction, and
- By October 1, 2013, the standards call for a 40 percent reduction.

Also, permitted municipalities must implement 1) public information and education programs relative to specific aspects of nonpoint source pollution control; 2) municipal programs for collection and management of leaf and grass clippings; and 3) site-specific programs for application of lawn and garden fertilizers on municipally controlled properties with over five acres of pervious surface. Under the requirements of Chapter NR 151, by March 10, 2008, incorporated municipalities with average population densities of 1,000 people or more per square mile that are not required to obtain municipal stormwater discharge permits must implement those same three programs.

In addition, regardless of whether a municipality is required to have a stormwater discharge permit under Chapter NR 216, Chapter NR 151 requires that all construction sites that have one acre or more of land disturbance must achieve an 80 percent reduction in the sediment load generated by the site. With certain limited exceptions, those sites required to have construction erosion control permits must also have post-development stormwater management practices to reduce the total suspended solids load from the site by 80 percent for new development, 40 percent for redevelopment, and 40 percent for infill development occurring prior to October 1, 2012. After October 1, 2012, infill development will be required to achieve an 80 percent reduction. If it can be demonstrated that the solids reduction standard cannot be met for a specific site, total suspended solids must be controlled to the maximum extent practicable.

Section NR 151.12 of the *Wisconsin Administrative Code* requires infiltration of post-development runoff from areas developed on or after October 1, 2004, subject to specific exclusions and exemptions as set forth in Sections 151.12(5)(c)5 and 151.12(5)(c)6, respectively. In residential areas, either 90 percent of the annual predevelopment infiltration volume or 25 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated. However, no more than 1 percent of the area of the project site is required to be used as effective infiltration area. In commercial, industrial and institutional areas, 60 percent of the annual predevelopment infiltration volume or 10 percent of the post-development runoff volume from a two-year recurrence interval, 24-hour storm, is required to be infiltrated. In this case, no more than 2 percent of the rooftop and parking lot areas are required to be used as effective infiltration area.

Section NR 151.12 also generally requires impervious area setbacks of 50 feet from streams, lakes, and wetlands. This setback distance is increased to 75 feet around Chapter NR 102-designated Outstanding or Exceptional Resource Waters or Chapter NR 103-designated wetlands of special natural resource interest. Reduced setbacks from less susceptible wetlands and drainage channels of not less than 10 feet may be allowed.

Transportation Facility Performance Standards
Transportation facility performance standards that are set forth in Chapter NR 151 and in Chapter TRANS 401, "Construction Site Erosion Control and Storm Water Management Procedures for Department Actions," of the *Wisconsin Administrative Code* cover the following areas:

- Construction sites,
- Post-construction phase, and
- Developed urban areas

The standards of TRANS 401 are applicable to Wisconsin Department of Transportation projects.

Soil and Water Resource Management Program
The current version of Chapter ATCP 50, "Soil and Water Resource Management Program," of the *Wisconsin Administrative* Code became effective on October 1, 2002, and was most recently revised in October 2004. The administrative rule relates specifically to agricultural programs and it establishes requirements and/or standards for:

- Soil and water conservation on farms,
- County soil and water programs, including land and water resource management plans,
- Grants to counties,
- Cost-share grants to landowners,
- Design certifications by soil and water professionals,
- Local regulations and ordinances, and
- Cost-share practice eligibility and design, construction, and maintenance.

Animal Feeding Operations
Chapter NR 243, "Animal Feeding Operations," of the *Wisconsin Administrative Code* sets forth rules for concentrated animal feeding operations and other animal feeding operations for the purpose of controlling the discharge of pollutants to waters of the State. Concentrated animal feeding operations are defined as livestock and poultry operations with more than 1,000 animal units. Animal units are calculated for each different type and size class of livestock and poultry. For example, facilities with 1,000 beef cattle, 700 milking cows, or 200,000 chickens each would be considered to have the equivalent of 1,000 animal units. All concentrated animal feeding operations and certain types of other animal feeding operations must obtain WPDES permits. In general, animal feeding operations are defined as feedlots or facilities, other than pastures, where animals are fed for a total of 45 days in any 12-month period.

Sanitary Sewerage System Plans
Under Wisconsin law and administrative rules, the State of Wisconsin is required to review and take action to approve or reject plans for proposed sewerage facilities. The review and action is guided by the adopted areawide water quality management plan. Under Chapter 281 of the *Wisconsin Statutes*, the State must find certain actions to be in accordance with the adopted and endorsed plan. These actions by the State include, among others, approval of locally proposed sanitary sewer extensions. In addition, the water quality management plan recommends that important natural resources, including surface waters and associated floodlands and shorelands, wetlands, woodlands, wildlife habitat, and areas of steep slope and rough topography, be preserved in natural, open uses.

Chapters NR 110 and Comm 82 of the *Wisconsin Administrative Code* require that the WDNR, with respect to public sanitary sewers, and the Wisconsin Department of Commerce, with respect to private sanitary sewers, make a finding that all proposed sanitary sewer extensions be in conformance with adopted areawide water quality management plans. These Departments, in carrying out their responsibilities, require that the Southeastern

Wisconsin Regional Planning Commission, as the designated areawide water quality management planning agency for the Southeastern Wisconsin Region, review and comment on each proposed sewer extension as to its relationship to the approved water quality management plan.

More specifically, with respect to the granting of a public sanitary sewer service extension permit, under Sections NR 110.08(4) and NR 121.05, the WDNR must make a finding that the area proposed to be served is located 1) within an approved sewer service area, and 2) outside of areas having physical or environmental constraints which, if developed, would have adverse water quality impacts. Areas having such physical or environmental constraints may include wetlands, shorelands, floodways and floodplains, steep slopes, highly erodible soils and other limiting soil types, and groundwater recharge areas.

With respect to the granting of a private sewer connection permit, under Section Comm 82.20(4), the Wisconsin Department of Commerce, like the WDNR as described above, must make a finding that the buildings proposed to be served through a private sewer connection are located 1) within an approved sewer service area and 2) outside of areas having physical or environmental constraints which, if developed, would have adverse water quality impacts.

In order to properly reflect local, as well as areawide, planning concerns in the execution of this review responsibility, the Regional Planning Commission, in adopting the original areawide water quality management plan, recommended that steps be taken to refine and detail each of the sanitary sewer service areas delineated in the plan. The preparation of refined sanitary sewer service area plans and sewerage facilities plans is intended to provide the means to adjust the recommended sewer service areas to meet local needs and objectives within the framework of the regional plans.

Private Sewage System Regulation
The Wisconsin Department of Commerce is charged with the responsibility of regulating the installation of private sewage systems, including septic tank, mound, aerobic, and sand filter sewage disposal systems. Such systems often contribute to the pollution of surface water and groundwater. Pursuant to Chapter 236 of the *Wisconsin Statutes*, the Department of Commerce reviews plats of all land subdivisions not served by public sanitary sewerage systems and may object to such plats if sanitary waste disposal facilities are not properly provided for in the plat layout. Basic regulations governing the installation of private sewage systems are set forth in Chapter Comm 83 of the *Wisconsin Administrative Code*, dated January 2004.

Section NR 113.07 (1)(e) of the *Wisconsin Administrative Code* requires that large commercial, industrial, or residential development sewage holding tank systems that singly, in combination, or as increased by successive additions, generate 3,000 gallons of holding tank waste per day or more must have a contract with a public wastewater treatment facility for the treatment of the waste. The sewer service area attendant to the wastewater treatment facility must include the commercial, industrial, recreational, or residential development. The WDNR may not indicate sufficient disposal capacity to the Department of Commerce until the needed sewer service area adjustments have been completed and approved.

Wisconsin Environmental Policy Act
In April 1972, the Wisconsin Legislature created Section 1.11 of the *Wisconsin Statutes* concerning governmental consideration of environmental impact. In many ways, the State legislation parallels the NEPA of 1969 discussed earlier in this chapter. Under this legislation, all agencies of the State must include an environmental assessment in every recommendation or report on proposals for legislation or other major actions which would significantly affect the quality of the human environment. The required contents of this assessment parallel the contents required in the Federal environmental assessments. The effect of the State legislation is, therefore, to extend the environmental assessment concept to all State action not already covered under the Federal action.

The Act requires that an assessment be prepared on: 1) the environmental impact of a proposed action, 2) any adverse environmental effects which cannot be avoided should a proposal be implemented, 3) alternatives to a proposed action, 4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, 5) any irreversible and irretrievable commitments of resources which would be involved in a proposed action should it be implemented, and 6) the details of the beneficial aspects of a proposed project, both short-term and long-term, and the economic advantages of the proposal. As such, the Wisconsin Environmental Policy Act has been designed to encourage more environmentally sensitive decisions by State agencies and to encourage a broader citizen participation in the decision-making process.[25]

Chapter NR 150 of the *Wisconsin Administrative Code* sets forth the general policy concerning actions by State agencies and the effects of these actions on the environment, sets forth the criteria for determining whether an environmental assessment or impact statement must be prepared, and establishes guidelines for the preparation and review of any required environmental evaluation of State actions.

Under Chapter NR 150, the WDNR specifies its intention to encourage productive and enjoyable harmony among people and their environment, to promote efforts that minimize harm to the environment, and to promote the understanding of the important ecological systems and natural resources of the State. The Department also recognizes its responsibilities as the State environmental agency for evaluating, coordinating, and communicating information on all actions by State and Federal agencies which may affect natural resources and overall environment for life in the State.

Under Chapter NR 150, the Department identifies potential actions by State and Federal agencies and establishes categories for those actions, importantly including regulatory actions, for which environmental impact evaluations would be required.[26]

Type I actions are "major" actions which would significantly affect the quality of the human environment. The preparation of an environmental impact statement is required for any Type I action by a State or Federal agency. Examples of Type I actions include establishment of land acquisition projects over 1,000 acres in size involving a proposed change in land use, State regulatory action involving a new hazardous waste disposal facility over 80 acres in size, and State regulatory action involving new large electric generating facilities.

Type II actions are actions which have the potential to have significant environmental effects and may involve unresolved conflicts in the use of available resources. The preparation of an environmental assessment is generally required for Type II actions. Examples of Type II actions include approvals to change the course of more than 500 feet of stream; permits to divert water for nonagricultural purposes; permits to enclose navigable waterways; establishment of land acquisition projects less than 1,000 acres in size or those acquisition projects larger than 1,000 acres in size not resulting in a land use change; habitat management activities involving filling or draining of wetlands; draining or filling affecting wetlands greater than five acres in size; acquisition of parcels located outside of established project boundaries where the total area planned for acquisition exceeds 160 acres; and stocking or introduction of fish or wildlife species that are not native to, or established in, the State.

Type III actions are actions which normally do not have the potential to have significant environmental effects, normally do not significantly affect energy usage, and normally do not involve unresolved conflicts in the use of available resources. Type III actions generally require the issuance of a news release and may require the preparation of an environmental impact report providing information on the proposed action. Examples of Type III actions include approvals to change the course of 500 feet or less of a stream, draining or filling affecting wetlands less than five acres in size, permits to divert water for agricultural and irrigation purposes, acquisition and development of public sites for access to public waters, acquisition of parcels less than 160 acres in size

[25]A Citizen Guide to the Role of the Wisconsin Environmental Policy Act in DNR Decision-Making*, Madison, Wis., Wisconsin Department of Natural Resources, 1993.*

[26]*Section NR 150.02 defines "action" as "any final decision by the Department to commence, engage in, fund, approve, disapprove, conditionally approve, or otherwise carry out any activity, pursuit, or procedure, including proposals for legislation, which may affect the quality of the human environment."*

located outside of established project boundaries, prescribed burning affecting less than 60 acres within State property, and silvicultural harvesting involving less than 160 acres within State property during a calendar year.

Type IV actions include enforcement activities; emergency activities to protect public health, safety, and welfare; and other actions which do not significantly affect the quality of the human environment, do not significantly affect energy usage, and do not involve unresolved conflicts in the use of available resources. Type IV actions generally do not require an environmental impact statement, an environmental assessment, or a news release, and are generally exempt from requirements under Chapter NR 150. Examples of Type IV actions include authority to construct bridges and roadway culverts across navigable waterways, approval of priority watershed plans, approval of floodplain zoning ordinances and amendments, nonpoint source pollution abatement grants, acquisition of parcels within established project boundaries, lake and stream habitat improvement, and trail construction for wildlife management purposes.

Under Chapter NR 150, guidelines for issue identification are set forth; the required contents of environmental impact statements, assessments, and reports are identified; procedures for statement, assessment, and report review are established; and public review and comment procedures are set forth.

Certain actions recommended in the regional water quality management plan update could be classified as actions for which an environmental assessment or environmental impact report must be prepared.

Statewide Strategy for Separate Sewer Overflows and Combined Sewer Overflows

The Wisconsin statewide strategy for separate sewer overflows (SSOs) and combined sewer overflows (CSOs) was set forth in a 2001 report from the WDNR staff to the Natural Resources Board.[27] In that report the WDNR identified the following components of the statewide strategy:

- Upgrading the reporting system for identification and inventory of all SSOs,
- Reissuance of the general permit for SSOs from sewage collection systems,[28]
- Consideration of issuance of system-specific permits to municipalities with frequently occurring SSOs,
- Review and revision of existing SSO enforcement guidance,
- Communication and outreach activities by WDNR staff to inform municipalities regarding SSO requirements in permits,
- Continued monitoring by MMSD of water quality conditions in area waterways,
- Completion by MMSD of an investigation of microbial pathogens in the Milwaukee River and environs,[29]

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[27]*Wisconsin Department of Natural Resources, 2001*, op. cit.

[28]*This permit was reissued on March 1, 2006. WPDES Permit No. WI-0047341-04-0, State of Wisconsin Department of Natural Resources General Permit to Discharge Under the Wisconsin Pollutant Discharge Elimination System-Sanitary Sewer Overflows (SSO) from Sewage Collection Systems.*

[29]*Such an investigation has been completed and is documented in a draft bacterial fate and transport study prepared by MMSD.*

- Evaluation of applying a watershed approach to managing CSOs, SSOs, stormwater runoff, and other sources of impairment to water quality,[30]

- Incorporation of USEPA regulatory requirements regarding SSOs into State rules,[31]

- Creation of a single rule, or cross referenced set of rules regarding separate sanitary sewer overflows, integrating the requirements of Chapters NR 110, NR 205, NR 208, and NR 210 of the *Wisconsin Administrative Code*,[32]

- Expansion of the NR 208 compliance maintenance program requiring owners of publicly owned treatment systems to annually evaluate whether their operation and maintenance avoids degradation of water quality and prevents WPDES permit violations, and

- Incorporation of the Federal Compliance, Management, Operation and Maintenance (CMOM) concept into the State program.

The statewide strategy also sets forth recommendations regarding specific system operational adjustments and upgrades, including consideration of infiltration and inflow, to be undertaken by MMSD and the communities it serves to establish the feasibility of reducing the frequency and volume of SSOs and CSOs.[33]

Local Water Quality Management

All towns, villages, and cities in Wisconsin have, as part of the broad grant of authority by which they exist, sufficient police power to regulate by ordinance any condition or set of circumstances bearing upon the health, safety, and welfare of the community. Presumably, the water quality of a receiving stream or the polluting capability of effluent generated within the municipal unit would fall within the regulative sphere by virtue of its potential danger to health and welfare. Such local ordinances could not, however, conflict with Federal and State legislation.

Special Units of Government

In addition to providing broad grant of authority to general-purpose units of local government, the *Wisconsin Statutes* currently provide for the creation of six types of special-purpose units of government through which water pollution can be abated and water quality protected. These are: 1) metropolitan sewerage districts, 2) utility districts, 3) inland lake protection and rehabilitation districts, 4) town sanitary districts, 5) joint sewerage systems, and 6) cooperative action by contract.

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[30]*The regional water quality management plan update for the Greater Milwaukee Watersheds and the MMSD 2020 Facilities Plan are applying a watershed approach.*

[31]*As noted above in the section on Federal water quality management, a USEPA draft SSO rule was issued in 2001 and later withdrawn from the rulemaking process. At this time, it is uncertain whether USEPA will resubmit it for consideration, or develop other guidance. To date, the draft rule has served as guidance for state regulatory agencies that are developing their own SSO rules, including the WDNR.*

[32]*In 2003, the WDNR formed a technical advisory committee to draft revisions to Chapters NR 110, 205, and 210. The revisions are narrowly targeted to address SSO permitting requirements and design issues related to SSOs and bypasses. It is anticipated that the rulemaking process will be completed in 2009.*

[33]*On its own initiative, and in response to the WDNR infiltration and inflow recommendations, the MMSD is in the process of adopting a policy related to development of a wet weather peak flow management program as documented in the MMSD report entitled* Wet Weather Peak Flow Management Program: Strategic Plan.

Metropolitan Sewerage Districts
The Milwaukee Metropolitan Sewerage District (MMSD) is a special-purpose unit of government directed by an appointed Commission. Sections 200.21 through 200.65 of the *Wisconsin Statutes* set forth the enabling legislation for the establishment of metropolitan sewerage districts which include first class cities. The only such district in the regional water quality management plan update study area is the MMSD. The MMSD includes all municipalities in Milwaukee County, except for portions of the City of Franklin and all of the City of South Milwaukee. The District also provides sewage conveyance, storage, and treatment services for portions of Ozaukee, Milwaukee, Racine, and Washington Counties. Contract services are provided to the following municipalities or special units of government outside Milwaukee County:

- Ozaukee County: City of Mequon, Village of Thiensville
- Racine County: Caddy Vista Sanitary District
- Washington County: Village of Germantown
- Waukesha County: Villages of Butler, Elm Grove, and Menomonee Falls and Cities of Brookfield, Muskego, and New Berlin

The 11-member Metropolitan Sewerage Commission of the MMSD was created in 1982 through reorganization of the Metropolitan Sewerage District of the County of Milwaukee and the City of Milwaukee Sewerage Commission. Seven members of the MMSD Commission are appointed by the Mayor of the City of Milwaukee and four members are appointed by an executive council consisting of the chief elected official of each city and village in Milwaukee County (except the Cities of Milwaukee and South Milwaukee). The District has the authority to levy taxes to fund its capital improvement programs and operation and maintenance of its facilities.

The District has a number of important responsibilities in the area of water resources management, including the provision of floodland management programs for most of the major streams within the District and the collection, transmission, storage, and treatment of domestic, industrial, and other sanitary sewage generated in the District and its contract service areas.

The District's Milwaukee Water Pollution Abatement Program (MWPAP) was begun in 1977. Under that program, a master facilities plan was prepared, adopted by the MMSD Commission in 1980, and approved by the WDNR and the USEPA in 1981. Construction of the wastewater conveyance, storage, and treatment facilities called for under the MWPAP was completed in 1996. Following completion of the MWPAP, the District issued its 2010 facilities plan in 1998. The 2020 District Facilities Plan was prepared in coordination with the regional water quality management plan for the greater Milwaukee watersheds that is documented in this report.

Sections 200.01 through 200.15 of the *Wisconsin Statutes* set forth the enabling legislation for the creation of metropolitan sewerage districts which do not include first class cities. These sections of the *Statute* only apply to those portions of the study area outside the MMSD. This legislation stipulates that proceedings to create a metropolitan sewerage district may be initiated by resolution of the governmental body of any municipality. Such resolution, which is submitted to the WDNR, must set forth a description of the territory proposed to be included in the district and a description of the functions proposed to be performed by the district. Upon receipt of the resolution, the Department is required to schedule a public hearing for the purpose of permitting any persons to present information relating to the matter of the proposed metropolitan sewerage district. Within 90 days of the hearing, the Department must either order or deny the formation of the proposed district. The Department must order the formation of the district if it finds that the district consists of at least one municipality in its entirety and all or part of other municipalities; if the district is determined to be conducive to management of a unified system of sewage collection and treatment; if the formation of the district will promote sound sewerage management policies and operation and is consistent with adopted plans of municipal, regional, and State agencies; and if the formation of the district will promote the public health and welfare and effect efficiency and economy in sewerage management. No territory of a city or village jointly or separately owning or operating a sewage collection or disposal system may be included in the district, however, unless it has filed with the WDNR a certified copy of a resolution of its governing body consenting to the inclusion of its territory within the proposed district. As of 2006, there were no metropolitan sewerage districts in the regional water quality management plan study area outside of the MMSD.

Utility Districts

Section 66.0827 of the *Wisconsin Statutes* permits towns, villages, and cities of the third and fourth class to establish utility districts for a number of municipal improvement functions, including the provision of sanitary sewer service. Funds for the provision of services within the district which are not paid for through special assessments are provided by levying a tax upon all property within the district. The establishment of utility districts requires a majority vote in towns and a three-fourths vote in cities and villages. Prior to establishing such a district, the local governing bodies are required to hold a formal public hearing.

The Caledonia East and West Utility Districts, Mt. Pleasant Sewer Utility District No. 1, and Town of Yorkville Utility District No. 1 are the only utility districts which provide sanitary sewer service within the regional water quality management plan update study area.[34]

Inland Lake Protection and Rehabilitation Districts

Inland lake protection and rehabilitation districts are special-purpose units of government created pursuant to Chapter 33 of the *Wisconsin Statutes*. There are three such districts in the study area, all of which are located in the Milwaukee River watershed in Washington County. They include the Big Cedar Lake District, the Little Cedar Lake District, and the Silver Lake District.[35]

Town Sanitary Districts

Town sanitary districts may be created, pursuant to Section 60.70 of the *Wisconsin Statutes*, to plan, construct, and maintain sanitary and storm sewers and sewage treatment and sewage disposal systems. A town sanitary district may offer its services outside its jurisdictional area on a reimbursable basis. In addition, Section 60.71(5) of the *Wisconsin Statutes*, indicates that town sanitary districts may be created to provide auxiliary sewer construction in unincorporated areas of metropolitan sewerage districts. Town sanitary districts are usually created by the town board upon petition of 51 percent of the property owners or the owners of 51 percent of the property within the proposed district. The WDNR may, however, upon finding that private sewage disposal or water supply systems constitute a public health menace and that there is no local action evident to correct the situation, order the creation of such districts. Town board members may serve as sanitary district commissioners, the commissioners may be appointed by a town board, the commissioners may be elected by the residents of the district, or, if the town board does not take timely action to appoint or provide for the election of commissioners, the WDNR may appoint commissioners.

There are five sanitary districts in the regional water quality management plan study area. These are the Waubeka Area Sanitary District in Ozaukee County, the Lake Ellen Sanitary District and Town of Scott Sanitary District

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[34]*Following incorporation of the Town of Caledonia as the Village of Caledonia, the former Caddy Vista Sanitary District and Caledonia Utility District No. 1 were combined into the Caledonia West Utility District and the former Crestview Sanitary District and the former North Park Sanitary District were combined into the Caledonia East Utility District.*

[35]*In addition to the inland lake protection and rehabilitation districts listed there are other lake-related organizations in the study area, including the Church Lake Citizens League and the Crystal Springs Park Association in the Milwaukee River watershed in Ozaukee County; the Silver Lake Sanitary District, the Wallace Lake Sanitary District, the Big Cedar Lake Property Owners Association, the Green Lake Property Owners Association of Washington County, and the Silver Lake Protective Association, all in the Milwaukee River watershed in Washington County; and the Kelly Lake Association, Inc. in the Root River watershed in Milwaukee and Waukesha Counties.*

No. 1 in Sheboygan County, and the Wallace Lake Sanitary District and Silver Lake Sanitary District, both in Washington County. As noted above in the Utility Districts subsection of this report, upon incorporation of Caledonia as a Village, the Caddy Vista Sanitary District was dissolved and brought under the jurisdiction of the Caledonia West Utility District. The Crestview Sanitary District and the North Park Sanitary District were combined into the Caledonia East Utility District.

Joint Sewerage Systems
Section 281.43 of the *Wisconsin Statutes* provides the authority for a group of governmental units, including cities, villages, and town sanitary or utility districts, to construct and operate a joint sewerage system following a hearing and approval by the WDNR. The Statute stipulates that when one governmental unit renders such service as sewage conveyance and treatment to another unit under this section, reasonable compensation is to be paid. Such reasonable charges are to be determined by the governmental unit furnishing the service. If the governmental unit receiving this service deems the charge unreasonable, the *Statutes* provide for either binding arbitration by a panel of three reputable and experienced engineers or judicial review in the circuit court of the county of the governmental unit furnishing the service. As an alternative, the jointly acting governmental units may create a sewerage commission to plan, construct, and maintain in the area sewerage facilities for the collection, transmission, and treatment of sewage. Such a commission becomes a municipal corporation and has all the powers of a common council and board of public works in carrying out its duties. However, all bond issues and appropriations made by such a commission are subject to approval by the governing bodies of the units of government which initially formed the commission. The *Statutes* stipulate that each governmental unit must pay its proportionate share of constructing, operating, and maintaining the joint sewerage system. Grievances concerning the same may be taken to the circuit court of the county in which the aggrieved governmental unit is located. There are two joint sewerage systems which provide sewage service to a portion of the regional water quality management plan update study area. One sewerage system is the Onion River Sewerage Commission which serves the Village of Adell, which lies within the study area. The Commission also serves the Hingham Sanitary District which is located outside the study area. The treatment plant serving both sewer systems is located outside the study area. The other joint sewerage system is the Underwood Creek interceptor which is jointly operated by the City of Brookfield and the Village of Elm Grove.

Cooperative Action by Contract
Section 66.0301 of the *Wisconsin Statutes* permits the joint exercise by municipalities, broadly defined to include the State or any department or agency thereof or numerous other units of government, including, but not limited to, any city, village, town, county, public inland lake protection and rehabilitation district, sanitary district, farm drainage district, metropolitan sewerage district, sewer utility district, water utility district, or regional planning commission, of any power or duty required of, or authorized to, individual municipalities by Statute. To exercise any such power jointly, such as the transmission, treatment, and disposal of sanitary sewage, municipalities would have to create a commission by contract.

Farm Drainage Districts
Pursuant to Sections 88.11 and 93.07(1) of the *Wisconsin Statutes*, the Department of Agriculture, Trade and Consumer Protection promulgated rules regarding farm drainage districts under Chapter ATCP 48 of the *Wisconsin Administrative Code* on July 1, 1995. Those rules were amended effective September 1, 1999. The rules establish procedures for assessing drainage district costs and benefits, inspecting drainage districts, construction and maintenance projects, landowner actions affecting drainage districts, drainage district records, and enforcement and variances.

Stormwater Drainage Districts
Wisconsin Act 53, which was enacted on December 19, 1997, amended and expanded Section 66.0821 of the *Wisconsin Statutes* to specifically grant municipalities the legal authority to assess service charges to users of a stormwater and surface water sewerage system. This legislation granted municipalities essential authorities for the establishment of stormwater utilities.

Regulation of Private Onsite Wastewater Treatment Systems
Sections 59.70 and 145.01(5) of the *Wisconsin Statutes* require that all Wisconsin counties, except counties with a population of 500,000 or more, adopt and administer an ordinance regulating private onsite wastewater treatment systems (POWTS) within the County. In accordance with Chapters 59 and 145 of the State statutes, all counties in the regional water quality management plan study area, with the exception of Milwaukee County which is excluded from this requirement, have enacted regulations applying to POWTS. The codes regulate the location, construction, installation, design, use, and maintenance of POWTS in the Counties. Regulations in the ordinance pertaining to POWTS apply throughout each County, including cities and villages as well as unincorporated areas. The County sanitary codes establish site requirements for soil absorption sewage disposal systems, including percolation rates and minimum allowable depth to groundwater and bedrock, and other POWTS that may be permitted under Chapter Comm 83 of the *Wisconsin Administrative Code*.

Shoreland Regulation
The State Water Resources Act of 1965 provides for the regulation of shoreland uses along navigable waters to assist in water quality protection and pollution abatement and prevention. In Section 59.692(1) of the *Wisconsin Statutes*, the Legislature defines shorelands as the area lying within the following distances from the ordinary high water mark of all natural lakes and of all streams, ponds, sloughs, flowages, and other waters which are navigable under the laws of the State of Wisconsin: 1,000 feet from a lake, pond, flowage, or glacial pothole lake, and 300 feet from a stream or to the landward side of the floodplain, whichever is greater.[36]

Section 281.31 of the *Wisconsin Statutes* specifically authorizes municipal zoning regulations for shorelands. This Statute defines municipality as a county, city, or village. The shoreland regulations authorized by this Statute have been defined by the WDNR to include land subdivision controls and sanitary regulations. The purposes of zoning, land subdivision, and sanitary regulations in shoreland areas include the maintenance of safe and healthful conditions in riverine areas; the prevention and control of water pollution; the protection of spawning grounds, fish, and aquatic life; the control of building sites, placement of structures, and land use; and the preservation of shore cover and natural beauty.

The standards and criteria for county shoreland ordinances are set forth in Chapter NR 115 of the *Wisconsin Administrative Code*. Chapter NR 117 of the *Wisconsin Administrative Code* sets forth rules regarding shoreland-wetland zoning for cities and villages. The WDNR retains oversight responsibility for the implementation and enforcement of Chapters NR 115 and NR 117. In addition, the Department must review and approve all shoreland and shoreland-wetland zoning ordinances, determine compliance, and monitor the rule.

County General and Floodland-Shoreland Zoning Ordinances
Zoning ordinances represent one of the most important means available to county and local units of government for managing land use in the public interest. In Wisconsin, counties, in cooperation with the towns, may enact a general, or comprehensive, zoning ordinance applicable to all unincorporated areas of the county. Such a general county zoning ordinance, however, becomes effective only in those towns which act to ratify the county ordinance.

In addition to the general zoning ordinance, counties are required, under the State Water Resources Act of 1965 and Section 59.692 of the *Wisconsin Statutes*, to adopt a shoreland zoning ordinance and Section 87.30 requires the adoption of a floodland zoning ordinance. These ordinances are intended to promote public safety and health by discouraging the location of flood-damage-prone land uses in areas subject to flood hazard and help preserve important natural resources in the floodland-shoreland area, thereby protecting and enhancing water quality. Town ratification of floodland and shoreland ordinances is not required and, indeed, towns have no zoning jurisdiction in shoreland areas.

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[36]*Definitive determination of navigability and location of the ordinary high water mark on a case-by-case basis is the responsibility of the Wisconsin Department of Natural Resources.*

The standards and criteria for county shoreland ordinances as set forth in Chapter NR 115 of the *Wisconsin Administrative Code* include restrictions on lot sizes, including a minimum average width of 65 feet and minimum area of 10,000 square feet for lots served by public sanitary sewer and a minimum average width of 100 feet and a minimum area of 20,000 square feet for lots not served by public sanitary sewer; on building setbacks, including a typical minimum setback of 75 feet from the ordinary high water mark of any surface waterbody; on the cutting of trees and shrubbery; and on filling, grading, and dredging.

Under Chapter NR 115, counties are also required to place all wetlands as shown on the final Wisconsin Wetland Inventory Maps and located in the statutory shoreland zoning jurisdictional area into a shoreland-wetland zoning district, to establish land division regulations, and to establish sanitary regulations under a County private sewage system ordinance.

Permitted uses within the shoreland-wetland zoning district include hiking, fishing, hunting, trapping, harvest of wild crops, silviculture, pasturing of livestock, cultivation of crops provided that such "cultivation can be accomplished without filling, flooding, or artificial drainage of the wetland," repair of existing drainage systems, construction of certain utility lines, and construction and maintenance of duck blinds, piers, docks and walkways "provided that no filling, flooding, dredging, draining, ditching, tiling, or excavating is done."[37]

Counties are required to keep their regulations current and effective in order to remain in compliance with the statutes and minimum standards established by the WDNR. Chapter NR 115 of the *Administrative Code* requires that any rezoning of wetlands within the shoreland area meets specific criteria. A rezoning, as well as a conditional use or variance, may not take place if the development permitted by the proposed rezoning would result in a significant adverse impact upon any of the following characteristics of the shoreland area:

1. Stormwater and floodwater storage capacity;

2. Maintenance of dry season streamflow, the discharge of groundwater to a wetland, the recharge of groundwater from a wetland to another area, or the flow of groundwater through a wetland;

3. Filtering or storage of sediments, nutrients, heavy metals, or organic compounds that would otherwise drain into navigable waters;

4. Shoreline protection against soil erosion;

5. Fish spawning, breeding, nursery, or feeding grounds;

6. Wildlife habitat; or

7. Areas of special recreational, scenic, or scientific interest, including scarce wetland types.

The county zoning agency must notify the WDNR of the proposed rezoning, hold a public hearing, and submit findings and recommendations to the county board. The Department must review and approve any proposed amendment of the zoning ordinance text or district map. If the county board approves the proposed zoning amendment and the Department determines, after review against the criteria set forth above, that the proposed rezoning would no longer comply with State requirements, the WDNR, after notice and hearing, must act to adopt a complying ordinance for the county.

Regulations related to floodland zoning for counties, cities, and villages are set forth in Chapter NR 116 of the *Wisconsin Administrative Code*. Those regulations are described in more detail in a subsequent section of this chapter.

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[37]*See Chapter NR 115.05 (2)(c)* Wisconsin Administrative Code.

City and Village Shoreland-Wetland Zoning
Shoreland-wetland zoning is also required by State law for cities and villages. The two sections of the *Wisconsin Statutes* applying to shoreland-wetlands in incorporated territory are 62.231 for cities and 61.351 for villages. Both sections require cities and villages to zone protectively those wetlands shown on the Wisconsin Wetland Inventory maps that are five acres or larger in size and located within the shoreland zone.

Chapter NR 117 of the State *Administrative Code* sets forth rules regarding shoreland-wetland zoning for cities and villages. The criteria concerning permitted uses, functional values and uses, and State review and oversight are, for the most part, the same as for county shoreland-wetland zoning, although cities and villages may be more restrictive than State requirements with regard to the uses they allow in shoreland-wetlands. However, the rules regarding minimum lots sizes, building setbacks, and cutting of trees and shrubbery established in Chapter NR 115 for counties do not apply to cities and villages.

Shoreland Zoning Regulations in Annexed Lands
According to Section 59.692(7)(a) of the *Wisconsin Statutes*, county shoreland zoning regulations remain in effect in areas which are annexed by a city or village after May 7, 1982, or for a town which incorporates as a city or village after April 30, 1994, unless the ordinance requirements of the annexing or incorporating city or village are at least as stringent as those of the county. The only exception to this condition is if, after annexation, the annexing municipality requests the county to amend the county ordinance to delete or modify provisions that establish specified land uses or requirements associated with those uses. In such a situation, stipulations regarding land uses or requirements may be amended only if the amendment does not provide less protection to navigable waters than was provided prior to the amendment.

Wisconsin Wetland Inventory
To facilitate the protection of shoreland wetlands, the State Legislature in 1978 mandated the mapping of all wetlands in the State. The wetlands mapping program, officially known as the Wisconsin Wetland Inventory, resulted in the preparation by the Regional Planning Commission for the WDNR of wetland maps covering each U.S. Public Land Survey township in the seven-county Region.[38] The Wisconsin Department of Natural Resources prepared these maps in Dodge, Fond du Lac, and Sheboygan Counties. The maps enable identification of the general location of wetlands; however, the determination of actual wetland boundaries related to activities which are to be located or conducted in the vicinity of wetlands requires a field identification and survey.

The Wisconsin Wetland Inventory maps serve as the basis for the identification of those wetlands to be regulated under Chapters NR 115 and NR 117. Under the procedures established by the WDNR to implement provisions of Chapters NR 115 and NR 117, preliminary wetland maps for each survey township within each respective county and for the affected cities and villages are provided by the State to the county zoning administrator or the appropriate city or village officials for review. Chapter NR 115 also requires that the county zoning committee hold a public hearing to receive comments on the accuracy and completeness of the preliminary maps, that hearing notices be mailed to all town clerks, and that hearing notices be published as class one notices. Chapter NR 117 allows for a similar hearing and notice procedure with the exception that the public hearing is not mandatory. Under both Chapters NR 115 and NR 117, following the review period and hearing, the final wetland maps are prepared and each county is required to amend, within six months of receiving the final maps, its shoreland-wetland zoning ordinance to protect all mapped wetlands within the shoreland areas.

State and County Land and Water Conservation Programs
Chapter 92 of the *Wisconsin Statutes* designates the Department of Agriculture, Trade and Consumer Protection as the State agency responsible for "setting and implementing Statewide soil and water conservation policies and administering the State's soil and water conservation program." Chapter 92 also provides the authority for the

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[38]*The Regional Planning Commission is updating wetland delineations for the entire seven-county Region in cooperation with the WDNR. That inventory is expected to be completed in early 2008, and it will be available for use in updating local shoreland wetland zoning maps.*

establishment of the State Land and Water Conservation Board and requires the establishment of County Land Conservation Committees. The county committees carry out programs to control erosion, sedimentation, and nonpoint source water pollution. Those programs include the distribution of Federal, State, and county funds for soil and water conservation programs; the construction of facilities for flood control and water conservation, development, and utilization; the preparation and administration of a county erosion control plan; the monitoring of farmland preservation agreements to ensure that such agreements include soil and water conservation plans; the establishment of soil and water conservation standards; the enactment of ordinances to promote soil and water conservation and the abatement of nonpoint source pollution; and the establishment of a soil and water resource management program.

As a result of passage of Wisconsin Act 27 in 1997, Chapter 92 was revised, leading to the requirement that each county in Wisconsin develop a land and water resource management plan to address both rural and urban nonpoint source problems. All of the Counties in the study area completed their land and water resource management plans, as required under Chapter ATCP 50 of the *Wisconsin Administrative Code.* In addition, Fond du Lac, Sheboygan, Washington, and Waukesha Counties have adopted stormwater management and construction erosion control ordinances and Dodge County has adopted a construction erosion control ordinance.

Private Steps for Water Pollution Control

The foregoing discussion deals exclusively with the water pollution control and water quality preservation regulations available to units and agencies of government. However, direct action may also be taken by private individuals or organizations effectively to abate water pollution. There are two legal categories of private individuals who can seek direct action for water pollution control: riparians, or owners of land along a natural body of water, and nonriparians.

Riparians

It is not enough for a riparian proprietor seeking an injunction to show simply that an upstream riparian is polluting the stream and thus he, the downstream riparian, is being damaged. Courts will often inquire as to the nature and the extent of the defendant's activity; its worth to the community; its suitability to the area; and its present attempts, if any, to treat wastes. The utility of the defendant's activity is weighed against the extent of the plaintiff's damage within the framework of reasonable alternatives open to both. On the plaintiff's side, the court may inquire into the size and scope of his operations, the degree of water purity that he actually requires, and the extent of his actual damages. This approach may cause the court to conclude that the plaintiff is entitled to a judicial remedy. Whether this remedy will be an injunction or merely an award of damages depends on the balance which the court strikes after reviewing all the evidence. For example, where a municipal treatment plant or industry is involved, the court, recognizing equities on both sides, might not grant an injunction stopping the defendant's activity but might compensate the plaintiff in damages. In addition, the court may order the defendant to install certain equipment or to take certain measures designed to minimize the future polluting effects of his waste disposal.

This balancing is not simply a test of economic strengths. If it were, the rights of small riparians would never receive protection. The balance that is struck is one of reasonable action under the circumstances; small riparians can be, and have been, adequately protected by the courts. Riparians along waterbodies in the Southeastern Wisconsin Region are not prevented by Federal, State, or local pollution control efforts from attempting to assert their common law rights in courts. The court may ask the WDNR to act as its master in chancery, especially where unbiased technical evidence is necessary to determine the rights of litigants. A master in chancery or a "master in litigation" is a person or agency brought into court as a technical expert to supply expertise on a particular issue or topic. The important point, however, is that nothing in the *Wisconsin Statutes* can be found which expressly states that, in an effort to control pollution, all administrative remedies must first be exhausted before an appeal to the courts may be had or that any derogation of common law judicial remedies is intended. Thus, the courts are not prevented from entertaining an original action brought by a riparian owner to abate pollution.

Nonriparians
The rights of nonriparians to take direct action through the courts are less well defined than the rights of riparians. The Wisconsin Supreme Court set forth a potentially far-reaching conclusion in *Muench v. Public Service Commission*[39] when it concluded that:

> "The rights of the citizens of the State to enjoy our navigable streams for recreational purposes, including the enjoyment of scenic beauty, is a legal right that is entitled to all the protection which is given financial rights."

This language, however, was somewhat broader than necessary to meet the particular situation at hand, since the case involved an appeal of a State agency ruling. The more traditional view would be that a nonriparian citizen must show special damages in a suit to enforce his public rights.

It should be noted that Section 299.91 of the *Wisconsin Statutes* enables six or more citizens, whether riparian or not, to file a complaint leading to a full-scale public hearing by the WDNR on alleged or potential acts of pollution. The Clean Water Act also provides for citizen suits. Under this law, any citizen, meaning a person or persons having an interest which is, or may be, adversely affected, may commence a civil action on his or her own behalf against any person, including any governmental agency, alleged to be in violation of any effluent standard, limitation, or prohibition of any pollution discharge permit or condition thereof, or against the USEPA Administrator when there is alleged failure by the Administrator to duly carry out any nondiscretionary duty or to act under the Clean Water Act. Prior to bringing such action, however, the citizen commencing the action must give notice to the alleged violator. When issuing final orders in any action under this section, the courts may award the costs of litigation to any party.

STATE LAWS AND REGULATIONS RELATED TO NAVIGABLE WATERS

The Public Trust Doctrine and Public Waters
Wisconsin's "public trust doctrine" is based upon an original concept of English common law under which the Crown held tidal waters in trust for the public. This concept was advanced in the Northwest Ordinance of 1787, under Article IV, where it was held that "the navigable waters leading into the Mississippi and St. Lawrence [Rivers], and the carrying places between the same shall be common highways, and forever free . . . ." The Wisconsin Enabling Act of 1836 admitted Wisconsin as a territory. That Act, under Section 3, incorporated the Northwest Ordinance language concerning navigable waters. Later, in 1848, the Territorial Convention acted to adopt the Wisconsin Constitution. The public trust with respect to navigable waters was carried forward under Section 1, titled "Jurisdiction on Rivers and Lakes; Navigable Waters," of Article IX, "Eminent Domain and Property of the State," of the Wisconsin Constitution. Section 1 states that "the state shall have concurrent jurisdiction on all rivers and lakes bordering on this state . . . and the navigable waters leading into the Mississippi [River] and St. Lawrence [River] and the carrying places between the same, shall be common highways and forever free . . . ."

The Wisconsin courts have construed the public trust doctrine liberally and noted in *Diana Shooting Club v. Husting* (1914)[40] that the "wisdom of the policy which steadfastly and carefully preserved to the people the full and free use of public waters cannot be questioned. Nor should it be limited by narrow constructions." This ruling further affirmed the State as ". . . a trustee of the people charged with the faithful execution of the trust created for their benefit."

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[39] *261 Wis. 492, 53 N.W. 2d 514 (1952).*

[40] Diana Shooting Club v. Husting, *156 Wis. 261 (1914).*

The Wisconsin courts have also expanded the public trust doctrine in recognition of changes in public needs and uses. For example, the court held, in *Muench v. Public Service Commission* (1952),[41] that the enjoyment of scenic beauty is a public right. Later, in *Claflin v. Department of Natural Resources* (1973),[42] the State Supreme Court upheld an order for the removal of a boathouse based upon its adverse aesthetic impacts. The Court stated that ". . . the natural beauty of our northern lakes is one of the most precious heritages Wisconsin citizens enjoy."

The ownership of navigable waters and their beds have been established under case law. *Diedrich v. Northwestern Union Railroad Co.* (1877)[43] established that the beds of navigable lakes are owned by the State, while *Munninghoff v. Wisconsin Conservation Commission* (1949)[44] established that the beds of navigable streams are owned by the riparian owner. Noted, however, was the concept that the water over the streambed was held in the public trust. The navigable waters of Wisconsin include the entire area of the lakes and ponds that are located below the ordinary high water mark of such waterbodies.[45] In addition, such waters must have a well-defined bed and banks.

Several court cases have addressed what, in effect, amounts to a definition of a lake and pond. In *Ne-pee-nauk Club v. Wilson* (1897), *Ne-pee-nauk Club v. Wilson*, 96 Wisc 290 (1897),[46] the Court distinguished between a lake and stream, stating that a stream has natural motion, a current, while a lake, in its natural state, is substantially at rest. The Court went on to state that the difference between lakes and streams is independent of the size of the waterbody. The Court further recognized that navigable lakes could be properly called a marsh or swamp as a result of low water conditions in which large expanses of mud or vegetation are exposed. This latter condition was further supported in *Illinois Steel Co. v. Bilot*,[47] in which the Court declared:

> "The mere fact that the water was very shallow, so that marsh grass appeared above the surface, that it was called a marsh, and that the water was not deep enough to admit navigation, or that the surface was not at all times wholly submerged, does not preclude its being, in fact, a lake."

This fact was further supported in *State v. Trudeau*,[48] in which the Court held that a lakebed need not be navigable in fact: "if land is part of a navigable lake, then the fact that the specific area cannot be navigated is irrelevant."[49]

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[41]Muench v. Public Service Commission*, 261 Wisc. 492 (1952).*

[42]Claflin v. DNR*, 58 Wisc. 2D 182 (1973).*

[43]Diedrich v. Northwestern Union Railroad Co.*, 42 Wis 248 (1877).*

[44]Munninghoff v. Wisconsin Conservation Commission*, 255 Wis 252 (1949).*

[45]*Navigable waters of the State are defined in s.144.26(2)(d). Also, the ordinary high water mark was defined in* Diana Shooting Club v. Husting*, 156 Wis. 261 (1914).*

[46]Ne-pee-nauk Club v. Wilson*, 96 Wisc 290 (1897).*

[47]Illinois Steel Co. v. Bilot, *109 Wisc 418 (1901).*

[48]State v. Trudeau*, 139 Wisc 2d 91 (1987).*

[49]*Cain, Michael, and Roberta Borchardt,* Topical List of Water Law Cases*, Madison, Wis., Wisconsin Department of Natural Resources, 1992.*

Navigable waters in Wisconsin also include streams and flowages. Specifically, navigable streams have clearly been defined in case law. *DeGaynor and Company, Inc., v. Department of Natural Resources* (1975)[50] expanded the definition of navigability from the old saw log test (see *Olson v. Merrill* [1877][51])to:

> "any stream is `navigable in fact' which is capable of floating any boat, skiff, or canoe, of the shallowest draft used for recreational purposes . . . ."

> ". . . [further] the test [for navigability] is whether the stream has periods of navigable capacity which ordinarily recur from year to year, e.g. spring freshets, or has continued navigability long enough to make it useful as a highway for recreation or commerce."

In addition, a navigable stream must have a bed and banks, as well as a direction of flow.

Chapter 30, Navigable Waters, Harbors, and Navigation

Under Chapter 30 of the *Wisconsin Statutes*, the WDNR has the authority to regulate the deposition of materials upon the bed of any navigable body of water, the straightening or altering of the courses of a stream, the dredging of material from the bed of a lake or river, the enlargement of any navigable waterway, and diversions from any body of water. Navigable waters include those wetland areas below the ordinary high water mark of an adjacent navigable lake or stream. The issuance of a Chapter 30 permit for any of the abovementioned activities in navigable waters would be subject to the policies and standards stipulated in Chapters NR 1.95 and NR 103 of the *Wisconsin Administrative Code* and to the provisions of the Wisconsin Environmental Policy Act.

One of the initial steps in the issuance of any Chapter 30 permit is the determination of navigability of the affected surface waterbody or adjacent wetland. Section 30.10 of the *Wisconsin Statutes* indicates that "all lakes . . . which are navigable in fact are declared to be navigable and public waters . . . ." Section 30.10 also indicates that "all streams, sloughs, bayous, and marsh outlets, which are navigable in fact for any purpose whatsoever, are declared navigable . . . ." The Wisconsin Supreme Court, in its decision on *Muench v. Public Service Commission* in 1952, pointed out that, in Wisconsin since 1911, navigable waters had been defined as those which are navigable in fact for any purpose whatsoever. In addition, as noted above, the Court, in its decision on *DeGayner and Company, Inc., v. Department of Natural Resources* in 1975, indicated that this test of navigability does not require that the surface waters be capable of floating a recreational boat or canoe on every day of the year or for every rod of its length or surface area. If it is determined that a surface waterbody is not navigable, the State may not have jurisdiction over the surface waterbody.

The determination of navigability is made on a case-by-case basis by the staff of the WDNR. Because of budgetary constraints, no jurisdictional maps of the navigable waters of the State have been prepared. The navigability or nonnavigability of a surface waterbody may change over the years as urban development; agricultural practices, including conversion of agricultural lands to natural open use; or other natural causes affect the amount of water flowing through the surface water system. Under Section 30.10(4)(c) of the *Wisconsin Statutes*, "farm drainage ditches are not navigable . . . unless it is shown that the ditches were navigable streams before ditching."

Chapter 31, Regulation of Dams and Bridges Affecting Navigable Waters

Dams have a significant impact on water quality, wildlife, public safety, water rights issues, and land use in Wisconsin. Under Chapter 31 of the *Wisconsin Statutes*, which was created in 1917 under the Water Power Law, the WDNR has authority to regulate the location, construction, permitting, safety, operation, and maintenance of dams and bridges affecting a navigable body of water. Chapter 31 also addresses alteration or repair of dams, dam transfer and removal, and water level and flow control.

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[50]DeGaynor and Co., Inc. v. DNR, *70 Wisc 2d 936, 236 N. W. 2d 217 (1975).*

[51]Olson v. Merrill, *42 Wis. 203 (1877).*

Administrative rules governing dam design and construction standards are set forth in Chapter NR 333 of the *Wisconsin Administrative Code*. Chapter NR 335 covers the administration of the Municipal Dam Repair and Removal Grant Program and Chapter NR 330 provides standards for warning signs and portages for dams.

The issuance of a Chapter 31 permit would be subject to the policies stipulated in Chapter NR 1.95 and the standards set forth in Chapter NR 103 of the *Wisconsin Administrative Code* and to the provisions of the Wisconsin Environmental Policy Act. Section 31.19 of the *Wisconsin Statutes* requires that the WDNR perform safety inspections of large dams on navigable waterways once every 10 years.[52] In general, the Department does not inspect dams that are regulated by a Federal agency.

FLOODLAND REGULATION AND CONSTRUCTION OF FLOOD CONTROL FACILITIES

While water quality improvement is not the primary purpose of flood control facilities, the planning and design of such facilities will often include features that directly affect water quality and terrestrial and aquatic habitat, and certain facilities may be designed to meet multiple objectives including flood control, stream rehabilitation/restoration, habitat improvement, and water quality improvement. Also, such facilities must be constructed within the regulatory framework described above. Floodland regulations and zoning can be useful tools in preserving riparian lands in open space uses and in moderating streamflows with an attendant benefit for stream channel morphology. Thus, it is appropriate to include information on floodland regulations and flood control facilities in the water quality management plan update.

Effective abatement of flooding can be achieved only through a comprehensive approach to the problem. That approach ideally strikes a balance between preserving existing undeveloped floodlands in open space uses; providing physical protection from flood hazards in areas of existing or committed development through the construction of dams, flood control reservoirs, levees, channel modifications, and other water control facilities; and implementing nonstructural flood control measures where such measures are feasible. As urbanization proceeds within a watershed, it becomes increasingly necessary to develop an integrated program of land use regulation of the floodlands within the entire watershed to supplement required water control facilities if efforts to provide such facilities are not to be self-defeating.

Definition of Floodlands and Description of Floodplain Components

The precise delineation of floodlands is essential to the sound, effective, and legal administration of floodland regulation. This is particularly true in such rapidly urbanizing areas as portions of the regional water quality management plan update study area. Chapter NR 116 of the *Wisconsin Administrative Code* defines the floodplain as “that land which has been or may be covered by flood water during the regional flood.”[53,54]

In planning for the proper use of floodlands, it is useful to subdivide the total floodland area on the basis of the hydraulic or hydrologic functions which the various subareas perform, as well as on the basis of the differing degrees of flood hazard that may be present in those subareas. Floodlands may be considered as consisting of two components: 1) a floodway, which effectively conveys the 100-year recurrence interval flood discharge, and 2) a floodplain fringe, which does not effectively convey flow, but which is inundated during floods and which temporarily stores floodwaters.

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[52]*A large dam is defined as having a structural height of over six feet and impounding 50 acre-feet or more, or having a structural height of 25 feet or more and impounding more than 15 acre-feet.*

[53]*The regional flood is defined as the 100-year recurrence interval flood, or that flood which has a 1 percent probability of occurring in any given year.*

[54]*This definition is consistent with the definition of a floodplain which has been applied by the Regional Planning Commission in its comprehensive watershed plans and other floodland management efforts.*

Under ideal conditions, the entire natural floodplain would be maintained in an open, essentially natural state, and, therefore, would not be filled and utilized for incompatible, intensive urban land uses. Conditions permitting an ideal approach to floodland regulation, however, generally occur only in rural areas. In areas which have already been developed for intensive urban use without proper recognition of the flood hazard, a practical regulatory approach may have to incorporate the concept of a floodway. Land use controls applied to the floodway should recognize that the designated floodway area is not suited for human habitation and should essentially prohibit all fill, structures, and other development that would impair floodwater conveyance by adversely increasing flood stages or velocities. Normally, filling and urban development may be permitted in the floodplain fringe, subject to restrictions which will minimize flood damages, including the provision of compensatory floodwater storage. Under actual conditions, the floodplain fringe may include buildings constructed in natural floodlands prior to the advent of sound floodland regulations. The delineation of the limits of the floodland regulatory area should be based upon careful hydrologic and hydraulic studies such as have been conducted for major portions of the watercourse system of the study area under SEWRPC watershed studies, Federal flood insurance studies, studies by communities, and studies associated with private developments.

Land Use Regulations in Floodlands

The following section summarizes the various land use regulatory powers available to State, county, and local units of government for use in regulating floodland development.

Channel Regulation

Sections 30.11, 30.12, and 30.16 of the *Wisconsin Statutes* establish rules for the placement of material and structures on the bed of any navigable water and for the removal of material and structures illegally placed on such beds. With the approval of the WDNR, pursuant to Section 30.11 of the *Wisconsin Statutes*, any town, village, city, or county may establish bulkhead lines along any section of the shore of any navigable water within its boundaries. Where a bulkhead line has been properly established, material may be deposited and structures built out to the line, consistent with the appropriate floodway zoning ordinance. A WDNR permit is required for the deposit of material or the erection of a structure beyond the bulkhead line. Where no bulkhead line has been established, it is unlawful to deposit any material or build any structure upon the bed of any navigable water unless a WDNR permit has first been obtained.

Regulation of Floodway and Floodplain Fringe

The regulation of floodlands in Wisconsin is governed primarily by the rules and regulations adopted by the WDNR pursuant to Section 87.30 of the *Wisconsin Statutes*.[55] In addition, the enactment of floodland regulation in Wisconsin is further governed by rules promulgated by the Federal Emergency Management Agency (FEMA). In essence, floodland regulation in Wisconsin is a partnership between the local, State, and Federal levels of government.

State Floodplain Management Program

The Wisconsin Legislature long ago recognized that the regulation of stream channel encroachments was an areawide problem transcending county and municipal boundaries and, therefore, provided for State regulation. However, it was not until passage of the State Water Resources Act in August 1966 that a similar need was recognized for floodway and floodplain-fringe regulation. In that Act, the Legislature created Section 87.30 of the *Wisconsin Statutes*. This section authorizes and directs the WDNR to enact floodland zoning regulations where it finds that a county, city, or village has not adopted reasonable and effective floodland regulations. The cost of the necessary floodplain determination and ordinance promulgation and enforcement by the State must, under the Statute, be assessed and collected as taxes by the State from the county, city, or village.

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[55]*Section 87.30(1m) of the* Wisconsin Statutes *stipulates that "a floodplain zoning ordinance. . .does not apply to lands adjacent to farm drainage ditches if: 1) such lands are not within the floodplain of a natural navigable stream or river, 2) those parts of the drainage ditches adjacent to these lands were nonnavigable streams before ditching, and 3) such lands are maintained in nonstructural agricultural use."*

Chapter NR 116 of the *Wisconsin Administrative Code* sets forth the general criteria for counties, cities, and villages to follow in enacting reasonable and effective floodland regulations. The current version of that chapter of the State *Administrative Code* took effect on March 1, 1986 and was most-recently revised in August 2004. The version of the Code now in effect establishes stringent requirements regarding the permissible increase in the 100-year recurrence interval flood stage resulting from activities in the floodplain and sets forth criteria for regulating floodplains in reaches downstream from dams.

State Agency Coordination

On November 26, 1973, Governor's Executive Order No. 67 was issued. It was designed to promote a unified State policy of comprehensive floodplain and shoreland management. The key provisions of the executive order are as follows:

1. State agencies are required to consider flooding and erosion dangers in the administration of grant, loan, mortgage insurance, and other financing programs.

2. All State agencies involved in land use planning are required to consider flooding and erosion hazards when preparing and evaluating plans. In addition, all State agencies directly responsible for new construction of State facilities, including buildings, roads, and other facilities, are required to evaluate existing and potential flood hazards associated with such construction activities.

3. All State agencies that are responsible for the review and approval of subdivision plats, buildings, structures, roads, and other facilities are required to evaluate the existing or potential flood hazards associated with such construction activities.

The provisions of this executive order are important in that they require all State agencies to utilize the flood-hazard data that have been, and are being, developed. Thus, the provisions assist in assuring that State-aided action, such as highway construction, will not contribute to increasing flooding and erosion hazards or to changing the character of the flooding. The order also assures that State agency actions will be consistent with local floodland regulations.

State and Federal Policies Relating to Floodland Management and to the Construction of Flood Control Facilities

Sound physical planning principles dictate that a watershed be studied in its entirety if practical solutions are to be found to water-related problems and that plans and plan implementation programs, possibly including the construction of flood control facilities, be formulated to deal with the interrelated problems of the watershed as a whole. A watershed, however, typically is divided in an irregular fashion by a complex of man-made political boundaries: county, city, village, town, and special-district. When such public works projects as flood control works, covering and serving an entire watershed, are required, these artificial demarcations become important because they limit the jurisdiction, the physical area, within which any one particular arm of county or local government may act.

This limitation may be overcome by delegation of the planning tasks to a regional planning agency and attendant designation of the plan implementation tasks to various existing units of government.

Historic channel modification projects in the study area, including channel deepening, widening, and straightening, have generally been carried out by legally constituted farm drainage districts or riparian landowners for the purpose of improving agricultural drainage, by municipalities or the Milwaukee Metropolitan Sewerage District to resolve flooding or erosion problems, or by the Wisconsin Department of Transportation in conjunction with highway construction projects. Specific information on the physical characteristics of stream channels is set forth in Chapter V through IX of SEWRPC Technical Report No. 39.[56]

[56]*SEWRPC Technical Report No. 39,* op. cit.

State of Wisconsin Guidelines Regarding Channel Modifications

In November 1987, the Secretary of the Wisconsin Department of Natural Resources established a policy on the regulation of stream channelization projects for urban flood control. The policy enumerated Department concerns regarding channel modification as follows:

1. Loss of aquatic habitat.

2. Adverse impacts on public rights and interests, including boating, fishing, swimming, maintenance of environmental quality, and enjoyment of scenic beauty.

3. Loss of floodplain storage volume and decrease in the time for runoff to travel through the channelized reaches, with attendant increases in downstream flood flows and flood stages. The Department policy recognizes, however, that such problems are attributable to the implementation of channel modification without an areawide systems approach which deals with a watershed as a whole.

4. Creation of safety problems due to increases in flow velocities, particularly when the modified channel is lined with concrete.

5. The implementation of single-purpose channel modification projects for flood control in cases where multiple objective projects utilizing detention storage for the control of both water quantity and quality could be used.

In light of the Department concerns listed, the 1987 policy document calls upon Department staff involved in the review of channel modification projects to:

1. Presume that stream channelization is not the best overall solution to flooding or stormwater runoff problems.

2. Require consideration of alternative approaches, including stormwater management practices and nonstructural flood control measures.

3. Issue permits only for, or recommend not opposing, channelization projects when there are no other reasonable alternatives to solving a recognized flooding problem, the adverse impacts of channelization have been minimized to the extent practicable, and the project meets all other legal requirements.

INTERBASIN WATER DIVERSION

The traditional common-law riparian doctrine forbade the transfer of water between watersheds. However, states by legislative action, can create, and have created, exceptions to this general doctrine. In contemplating a stream diversion, two major groups of individuals may be in a position, depending upon the quantity of water involved and the duration of the diversion, to assert their private property rights against the private or municipal agencies carrying out the diversion. The first group consists of those riparians along the stream from which the diversion is made. The reasonableness of the diversion, the "taking" of private property involved, and the issue of compensation are all legal factors to be considered. The second group of individuals who may be in a position to assert legal rights are those whose lands abut the streams or lakeshore into which the diversion is made. Again, the diverter is liable to these riparians for land taken or damages caused as a consequence of the unnaturally increased flow.

Wisconsin Statutes Section 30.18, dealing with water diversions, stipulates that ". . . no water shall be so diverted to the injury of public rights in the streams . . . ." The Statute also states that only "surplus water," i.e., any water of a stream which is not being beneficially used, can be diverted and such diversions can be made only for the purpose of maintaining normal stream or lake levels in other watercourses. The only apparent exception to this section applies to agricultural and irrigation purposes, for which water other than "surplus water" may be diverted, but only with the consent of all of the riparians who would be injured by the diversion. To effect even these limited types of diversions, hearings would have to be held and permits issued by the WDNR. The Wisconsin Supreme Court case of *Omernik v. State*[57] stated that Section 30.18 applied to nonnavigable streams from which water was diverted as well as to navigable streams. If the anticipated use of diverted water is other than for one of the categories stipulated under Section 30.18 of the *Wisconsin Statutes*, then the common-law test of reasonableness will be invoked.

The Great Lakes–St. Lawrence River Basin Water Resources Compact is an agreement among the States of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin and the Commonwealth of Pennsylvania. The Great Lakes–St. Lawrence River Basin Sustainable Water Resources Agreement is an agreement among those States and the Canadian Provinces of Ontario and Quebec. Those documents, which are collectively referred to as "Annex 2001" and were signed by the Great Lakes Governors and Premiers on December 13, 2005, are intended to protect, conserve, restore, improve, and manage the waters of the Great Lakes basin.[58]

The agreements are intended to accomplish the following:

- With limited exceptions, ban new or increased diversions of water to areas outside the Great Lakes-St. Lawrence River Basin,

- Establish a new standard for the States and Provinces to apply in reviewing proposed uses of Great Lakes water,

- Improve the collection and distribution of technical data between the States and Provinces, and

- Require the implementation of water conservation programs.

Key provisions of the agreements include:

- In general, new or increased diversions of water from the Basin are prohibited.

- Exception for Straddling Communities: An exception to the prohibition on diversion may be granted for transfers of water from the Basin to areas of any city, village, or, town that is located partially within and partially outside the Basin (straddling community) if the diverted water is used for public water supply purposes, is returned to the Basin less an allowance for consumptive uses, and is managed and regulated by the State in which the community is located. Additional requirements set forth under an "Exception Standard" must be met if the new or increased withdrawal consists of an average of 100,000 gallons per day or more over any 90-day period. Regional review by the State and Provinces is not required, unless the proposal calls for a new or increased average consumptive use of five million gallons per day or more.

- Exception for Communities in Straddling Counties: An exception to the prohibition on diversion may be granted for transfers of water from the Basin to areas of any city, village, or, town that is located in a county that is partially within and partially outside the Basin (straddling county) if: the diverted water is used for public water supply purposes; meets the Exception Standard and maximizes the portion of the water returned to the source watershed; there is no reasonable water supply alternative within the basin in which the community is located; the diversion will not endanger the Basin ecosystem; the diversion is managed and regulated by the State in which the community is located, the proposal undergoes Regional Review by the States and Provinces; and the proposal is approved by the Great Lakes-St. Lawrence River Basin Water Resources Council, consisting of the Governors of the States.

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[57] *64 Wis. 2d 6, 218 N.W. 2d 734 (1974).*

[58] *Full implementation of Annex 2001 will require further legislative action at the State and Federal levels.*

Annex 2001 also sets forth requirements for intra-basin transfers from the watershed of one Great Lake into the watershed of another Great Lake.

Diversion of water across the subcontinental divide between the Lake Michigan and Upper Mississippi River Basins is an issue that can be related to the provision of sanitary sewerage facilities and water supply facilities to certain municipalities. However, given that the entire study area is in the Lake Michigan drainage basin, these issues are not expected to be of specific concern in this planning effort.

RELATIONSHIP BETWEEN FEDERAL, STATE, AND LOCAL REGULATORY PROGRAMS FOR WETLANDS

The wetland water quality standards which are set forth in Chapter NR 103 of the *Wisconsin Administrative Code* are related primarily to the shoreland-wetland regulations in Chapters NR 115 and 117 of the *Wisconsin Administrative Code*; Chapters 30, 31, 281, 283, and 299 of the State Statutes; and Sections 401 and 404 of the Federal Clean Water Act.

The determination of permissible, or potentially permissible, activities in wetlands within the study area may involve shoreland-wetland regulations as administered by the counties, cities, and villages, all under the oversight of the WDNR; wetland water quality standards set forth by the WDNR in Chapter NR 103 of the *Wisconsin Administrative Code*; and regulations administered by the U.S. Army Corps of Engineers (USCOE) under Section 404 of the Federal Clean Water Act regarding the discharge of dredged or fill materials to wetlands. U.S. Department of Agriculture (USDA) policies and programs regarding benefits to farmers may also be of concern.

Federal Wetland Regulatory Program

The U.S. Congress has provided for the regulation of certain wetlands of the Nation. Section 404 of the Clean Water Act, as amended, provides the principal Federal authority in the regulation of wetland use. That statute requires the U.S. Department of the Army Corps of Engineers (USCOE), working in cooperation with the USEPA, to regulate the discharge of dredged and fill materials into waters of the United States, including lakes, rivers, and wetlands. All interstate wetlands, regardless of size, are regulated under the provisions of the *Statutes*. The USEPA maintains a permit veto and enforcement authority under the Act should a particular application be judged to have adverse environmental consequences.

In carrying out this regulatory responsibility, the USCOE identifies interstate waters of the United States, including wetlands, and determines when permits are required for the discharge of dredged and fill materials. The USCOE may permit a project either through the issuance of a general permit, letter of permission, or through a specific individual permit, depending upon the scope and potential consequences of the project. For example, wetland fill or excavation projects which involve more than two acres of a wetland would typically require an individual permit. Similar projects involving filling or excavating of less than two acres of a wetland would require notification to the USCOE, and would be handled under the general permit or letter of permission procedure (GP/LOP).[59] There are four categories to the GP/LOP, which include the following:

- General Permitting–Non Reporting;
- General Permitting–Provisional;
- Letter of Permission–Provisional; and
- General Permitting–Programmatic.

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[59]*The GP/LOP permitting process replaced the nationwide permit in Wisconsin in April of 2000.*

The nonreporting option of the general permit is for very small scale projects that are anticipated to have a negligible effect on the resource and include practices such as streambank stabilization and boat ramp construction. Projects that fall under the nonreporting option do not require notification to the USCOE. It is the landowner or project manager's responsibility to ensure that the USCOE criteria are satisfied. The provisional option of the general report is suited for projects that primarily involve discharges into Federal waters which could be related to utility lines, bridge construction, or hydropower plants, or other discharges into wetlands or Federal waters that involve less than up to one-tenth of an acre. The letter of permission is issued for larger projects that impact between one-tenth and two acres of wetlands, or up to five acres for projects administered by the Wisconsin Department of Transportation (WisDOT) that are subject to the WDNR/WisDOT cooperative agreement. Finally, the programmatic option of the general permit is also for larger projects that impact up to two acres, and for projects that are not covered by one of the previous options. The USCOE maintains a discretionary authority under which it may override any permit on a case-by-case basis, as it deems appropriate.

Silvicultural and agricultural activities in waters of the United States and adjacent wetlands are exempt from the permitting process provided that they do not cause a release of toxic contaminants and do not change the use of the waters. Certain minor activities, such as sand blankets, boat ramp construction, and shore stabilization activities, may be undertaken under a nonreporting general permit.

The USCOE has limited jurisdiction for areas of isolated wetlands. In a case that was decided by the Supreme Court on January 9, 2001, "Solid Waste Association of Northern Cook County v. U.S. Army Corps of Engineers," the Court ruled that the USCOE has no jurisdiction over nonnavigable (i.e., not connected to Federal waters), isolated, intrastate waters. The USCOE determines whether or not an isolated wetland is ultimately connected to Federal waters. This ruling removed significant areas of wetland from regulation, and it prompted the State of Wisconsin to pass legislation extending State authority over isolated wetlands, as described below.

Under the provisions of Section 401 of the Clean Water Act, the issuance of Federal permits must be consistent with State water quality policies and standards. The State of Wisconsin has established procedures to review all activities which may involve the discharge of dredged or fill material into the waters of the State, including wetlands. The procedures for the review of Federal permits are set forth in Chapter NR 299 of the *Wisconsin Administrative Code*, which requires the WDNR to deny certification for any discharge which does not meet the guidelines set forth in Chapters 30, 31, and 281 of the State statutes, to grant certification if such guidelines are met, or to waive certification if such guidelines do not apply. In cases where State certification is denied, the U.S. Department of the Army permit would also be denied.

State of Wisconsin Wetland Regulatory Program Related to Wetlands

The Wisconsin wetlands preservation, protection, and management policies are set forth generally in Section NR 1.95 of Chapter NR 1 of the *Wisconsin Administrative Code* (most recently revised in November 2005); the Wisconsin water quality standards for shoreland and nonshoreland wetlands, prepared pursuant to Chapter 281 of the State statutes, are set forth in Chapter NR 103 of the *Wisconsin Administrative Code* (most recently revised in March 2005). Chapters NR 1 and 103 were both updated in 2002 to provide for the administration of a compensatory wetland mitigation program.

Section NR 1.95 establishes the policy by which the WDNR administers its regulatory and management authorities regarding wetlands. Such policy require the Department to evaluate all reasonable alternatives, including the alternative of no action, in making regulatory decisions concerning such processes requiring permits as sanitary sewer extensions, dredging and filling, the construction of dams and bridges, and streamcourse alterations where adverse impacts to wetlands may occur as a result of such activities. In addition, Section NR 1.95 indicates that State land acquisition programs should emphasize acquisition of high-value wetlands; that State enforcement activities regarding unlawfully altered wetlands should, to the extent practicable, require restoration; and that the avoidance or minimal use of wetlands should be advocated in liaison activities with Federal, State, and local units and agencies of government. Under Section NR 1.95, administrative rules and legislation aimed at protecting and enhancing wetland values and ecology, and at providing education about wetlands, may be promulgated by the Department.

Prior to the January 2001, Supreme Court ruling, "Solid Waste Association of Northern Cook County v. U.S. Army Corps of Engineers," the Department had limited jurisdictional authority regarding isolated nonshoreland wetlands. Since that ruling, the Wisconsin Legislature passed Wisconsin Act 6, which became effective on May 8, 2001. Wisconsin Act 6 amends Chapter 23 and more significantly Chapter 281 of the *Wisconsin Statutes.* The Department now has the jurisdictional authority to regulate fill placement into nonfederal wetlands. Fill placement into a nonfederal wetland requires water quality certification under Chapter NR 299 of the *Wisconsin Administrative Code.* There are some exemptions to Wisconsin Act 6, which primarily involve silvicultural and agricultural activities.

Wisconsin Act 6 provides for the issuance of general water quality certifications for types of discharges, instead of individual certifications, subject to a Department finding of minimal individual and cumulative adverse environmental effects.

Chapter NR 103 establishes water quality standards for wetlands. These standards, like the more general policies set forth for wetlands protection under Section NR 1.95, are applied by the WDNR in the exercise of State authority and in State review of applications for permits under Section 404 of the Federal Clean Water Act. Chapter NR 103 applies to all wetlands and these standards are applied when a State permit or State water quality certification is required. The water quality standards for wetlands are intended to provide protection of all waters of the State, including wetlands, for all present and potential future uses, such as for public and private water supply; for use by fish and other aquatic life, as well as wild and domestic animals; for preservation of natural flora and fauna; for domestic and recreational uses; and for agricultural, commercial, industrial, and other uses.

Under Chapter NR 103, the WDNR is responsible for the protection of the functions of wetlands. The functional values of wetlands include stormwater and floodwater storage and retention and the moderation of water level fluctuation extremes; hydrologic functional values, such as maintenance of dry season streamflow, the discharging and recharging of groundwater and maintenance of groundwater flow; filtration or storage of sediments, nutrients, or toxic substances which might otherwise adversely affect other waters of the State; shoreline protection against erosion; habitat for aquatic organisms; habitat for resident and transient wildlife; and all other recreational, cultural, educational, scientific, aesthetic, and natural values.

The rules set forth in Chapter NR 103 consist of two parts: 1) alternatives analysis, and 2) a set of standards intended to protect the functional values of wetlands.

A project would not be in compliance with the provisions of Chapter NR 103 if it is not a wetland dependent use, meaning that it does not necessarily require location in or adjacent to wetlands to fulfill its basic purpose, and if a practicable alternative to the project exists that does not involve the filling of wetlands. Under a practicable alternatives analysis, the proposed project would be compared to other alternatives considering relative monetary costs, logistical limitations, technological limitations, and other pertinent positive or negative aspects. If there is an alternative to the project which is practicable, will not adversely impact wetlands, and will not have other significant adverse environmental consequences, that alternative may be selected.

If, following the analysis of practicable alternatives, no suitable alternative is identified, an assessment of the potential significant impacts of the project on the functional values of the wetland must be made. Those impacts would then be considered by the Department in making a determination whether the basic requirements of Chapter NR 103 are satisfied.

Considerations Related to Federal and State Approval of Urban and Agricultural Drainage Projects Involving Wetlands

Installation of agricultural drain tiles, sanitary sewers, or urban storm sewers, and construction of urban or agricultural drainage channels through wetlands could involve the temporary discharge of fill material and would, therefore, require a Federal Section 404 permit and/or water quality certification by the State of Wisconsin under Chapter NR 103. In considering a permit application to discharge dredged or fill material to wetlands, the USCOE and/or the WDNR may also consider other impacts (secondary impacts) of the proposed project, such as whether the project would result in draining of wetlands. As part of the permit issuance, the use of special construction techniques may be required. Such requirements may include providing for agricultural drain tiles or storm sewer pipes to be sealed so that the wetland would not be drained, covering the trench with six inches of native soil, and restoring the original grade and vegetation. Thus, such agricultural drain tile lines could, under such a conditional permit, be used only for improving drainage from upstream areas, not for restoring drainage to the areas which have reverted to wetlands.

U.S. Natural Resources Conservation Service Involvement in Wetland Issues

Involvement in wetland matters by the Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service, is primarily related to the administration of programs distributing USDA benefits as mandated under the Federal Food, Agriculture, Conservation and Trade Act of 1990, commonly referred to as the 1990 Farm Bill.[60]

Land Classifications

The NRCS has established four land classification categories which relate to the status of agricultural lands as wetland or cropland. These classifications are defined as follows:

1. Prior Converted Cropland: Land that may contain wetlands that were cleared, drained, filled, or otherwise manipulated to make them cropable prior to December 23, 1985. These lands are flooded for no more than 14 consecutive days during the growing season. If prior converted cropland is not cropped, managed, or maintained for agricultural production for five consecutive years and the land reverts to wetland, the land would be regulated by the USCOE under Section 404. Reversion to wetland requires that the land exhibit the three mandatory wetlands criteria set forth under the USCOE and USEPA wetland definition: hydric soils, wetland vegetation, and hydrologic characteristics associated with wetlands. Also, prior converted cropland that is located in a shoreland jurisdictional zone, as designated in Chapters NR 115 or 117 of the *Wisconsin Administrative Code*, is regulated as a shoreland wetland.

2. Farmed Wetland: Land that was cleared or drained or filled and cropped prior to December 23, 1985, and, in many years, still floods or ponds in the spring or fall. These lands are flooded for 15 or more consecutive days during the growing season or for 10 percent of the length of the growing season, whichever time is shorter. These wetlands are regulated under Section 404, but normal farming of these lands is allowed.

3. Wetland: Land that has wet, saturated soils and would support wetland vegetation if not tilled or mowed.

4. Not Inventoried: Land that may contain wetlands but has not been designated, either because the existing vegetation makes wetland designation difficult or because the area has low potential for use as cropland.

The NRCS periodically obtains aerial photographs at a scale of one inch equals 660 feet and those photographs are used to identify saturated soils and to document land use practices, including determinations of the number of consecutive years for which land has not been cropped. Conversions of wetlands which occur after December 23, 1985, can affect the eligibility of landowners to receive U.S. Department of Agriculture subsidies. If a drainage

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[60]*The Wisconsin Wetland Inventory maps are described in Chapter III of this report. The U.S. Natural Resources Conservation Service has also prepared wetland maps on one inch equals 660 foot scale and on one inch equals 1,000 foot scale aerial photographs. Those maps are used by the NRCS in administering programs mandated under the Food, Agriculture, Conservation and Trade Act of 1990, commonly referred to as the 1990 Farm Bill. The NRCS wetland maps and the Wisconsin Wetland Inventory maps are used by the USCOE in administering its regulatory program for wetlands.*

district converts wetland to cropland, the landowner of the converted wetland who is assessed by the drainage district and who uses the conversion to increase agricultural production could lose his rights to Federal subsidies. If a drainage district implements measures which convert wetland areas after November 28, 1990, and the conversion is beyond the control of the landowner of the property containing the wetland, Federal subsidies would not be lost if no agricultural commodities are planted or if no hay or forage crops are harvested.

If a wetland conversion began prior to December 23, 1985, and attempts to improve drainage have occurred since 1985, the project may be classified as a commenced conversion and the landowner or farmer may be able to produce an agricultural commodity on the land without losing Federal subsidies. When a drainage district is involved in a conversion, it is necessary that: 1) a detailed drainage plan was officially adopted, 2) the installation of drainage measures began before December 23, 1985, or that contracts were executed before December 23, 1985, for the purchase of materials for the conversion of the wetlands, and 3) the landowner or farmer was assessed for the project or legally obligated to pay such an assessment before December 23, 1985.

Decisions by an NRCS field office regarding the wetland status of a particular parcel of land may be appealed by the landowner. The initial appeal would be made to the field office, the staff of which would make a field determination in response to the appeal. Further appeals would be made to the NRCS area, State, and Washington, D.C., offices.

DIFFUSED WATER LAW

This area of the law relates to what is commonly termed stormwater, which consists of runoff from rain, snowmelt, and springs prior to collection in a watercourse or lake. Under the "common enemy" doctrine which was enforced in the State of Wisconsin until 1974, "a landowner could drain diffused surface water onto another's property regardless of the harm caused."[61]

In 1974, the "common enemy" doctrine was replaced by the "reasonable use" rule as a result of the findings of the Wisconsin Supreme Court in the case of *State v. Deetz*.[62] This rule permits the reasonable discharge of diffused surface water. An unreasonable discharge is defined as one which results in an intentional invasion of another's land and either: "1) the gravity of the harm caused by the discharge outweighs the utility of the conduct of the discharge or 2) the harm caused by the discharge is substantial and the financial burden of compensating for the harm does not render the conduct causing the discharge infeasible."[63]

An example of the application of the "reasonable use" rule is the case of *Crest Chevrolet v. Willemsen*.[64] In this case the court applied the reasonable use rule and ruled in favor of the plaintiff, who claimed that the raising of the grade of the defendant's property obstructed the discharge of runoff from the plaintiff's property, flooding the plaintiff's parking lot.

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[61]*University of Wisconsin-Extension Environmental Resources Center and the University of Wisconsin Law School,* Wisconsin Water Law Handbook: A Guide to Water Rights and Regulations*, draft, Madison, April 1994.*

[62]State v. Deetz*, 66 Wis. 2d 1, 224 N.W. 2d 407 (1974).*

[63]Ibid.

[64]Crest Chevrolet v. Willemsen*, 129 Wis. 2d 129, 144-45, 384 N.W. 2d 692 (1986).*

SPECIFIC LEGAL CONSIDERATIONS AND INVENTORY FINDINGS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Inventories were conducted of State water pollution abatement orders and permits and other applicable local water-related regulatory matters. A discussion of these legal considerations and how they apply to the regional water quality management plan update study area is presented below.

State Water Pollution Abatement Permits

As noted earlier in this chapter, the Wisconsin Pollutant Discharge Elimination System permit structure was established by the WDNR pursuant to Chapter 283 of the *Wisconsin Statutes*. A permit is required for all industrial and municipal wastewater discharges and for certain specified municipal and industrial stormwater discharges. The inventory conducted for the regional water quality management plan update identified the industrial wastewater and stormwater discharge permits that were issued through February 2003. Those permits are listed in Chapters V through IX and Appendix G of SEWRPC Technical Report No. 39. An inventory of WPDES permit information for public and private sewage treatment facilities in the study area, including effluent limits, is set forth in Table 68.

Current MMSD WPDES Permit Requirements

The MMSD 2003 WPDES Permit (Permit) lists the requirements that MMSD must adhere to in order to remain in compliance with WDNR and USEPA regulations. Sections 3 and 4 of the Permit focus on CSO and SSO requirements. In addition, there are certain elements of the Schedules of Compliance, Permit Section 8, that also address CSO and SSO requirements.

Under Section 3 of the Permit, a CSO LTCP must be developed and submitted to WDNR for approval in accordance with the terms of the Compliance Schedule. MMSD may not discharge from CSO points during dry weather and must provide records to verify that no discharges are occurring from outfalls where the gate to the corresponding dropshaft is open, unless the capacity of the near surface collector associated with the dropshaft has been exceeded.

Wet-weather discharges are not permitted except to prevent the ISS capacity from being exceeded or to relieve the associated near surface collector sewers when their capacities have been exceeded.

The ISS must be operated and maintained to meet *either* of the following two presumptive approach performance standards relative to CSOs:

- No more than six combined sewer overflow discharge events per year; **or**

- The capture and delivery of no less than 85 percent by volume of the combined sewage collected in the combined sewer system resulting from precipitation events on a systemwide annual average basis to either the Jones Island or South Shore wastewater treatment plants.

MMSD must notify, by telephone, the WDNR Southeast Regional Office of a CSO occurrence and its anticipated duration within 24 hours of initiating discharge from listed CSO outfalls. A written report including the following information must be submitted to the Southeast Regional Office within five days of initiating discharge from listed CSO outfalls:

- Estimated duration

- Estimated volume

- Reason for discharge

- Operational actions taken to maximize capture and treatment

- Measures being taken to prevent another discharge

Table 68

WPDES PERMIT INFORMATION FOR PUBLIC AND PRIVATE SEWAGE TREATMENT FACILITIES

	WPDES Permit			Effluent Limits													
				BOD_5		$CBOD_5$[a]		Total Suspended Solids		Total Phosphorus	Ammonia Nitrogen			Total Chlorine (residual)		Fecal Coliform
Facility Name	Number	Effective Date	Expiration Date	Weekly Average	Monthly Average	Weekly Average	Monthly Average	Weekly Average	Monthly Average	Monthly Average	Daily Maximum	Weekly Average	Monthly Average	Daily Maximum	Weekly Average	Geo Mean
Public Facilities																
Milwaukee Metropolitan Sewerage District Jones Island Treatment Plant	- -	04/01/03	3/31/08	45 mg/l	30 mg/l	- -	- -	45 mg/l	30 mg/l	1.0 mg/l	- -	- -	- -	38 µg/l	36 µg/l	400 cells/ 100 ml
Milwaukee Metropolitan Sewerage District South Shore Treatment Plant	- -	04/01/03	3/31/08	45 mg/l	30 mg/l	- -	- -	45 mg/l	30 mg/l	1.0 mg/l	- -	Variable[b]	- -	38 µg/l	80 µg/l	400 cells/ 100 ml
City of Cedarburg	0020222	07/01/03	06/30/08	10 mg/l (229 lbs/day) , 15 mg/l (344 lbs/day)[c]	10 mg/l, 15 mg/l[c]	- -	- -	15 mg/l (344 lbs/day)	15 mg/l	1.0 mg/l	- -	2.0 mg/l, 4.0 mg/l[c]	- -	- -	- -	400 cells/ 100 ml[d]
City of Racine	0025194	04/01/03	03/31/08	45 mg/l	30 mg/l	- -	- -	45 mg/l	30 mg/l	1.0 mg/l	- -	- -	- -	38 µg/l	80 µg/l	400 cells/ 100 ml
City of South Milwaukee	0028819	01/01/06	12/31/10	45 mg/l	30 mg/l	- -	- -	45 mg/l	30 mg/l	1.0 mg/l	- -	- -	- -	- -	- -	400 cells/ 100 ml[d]
City of West Bend	0025763	10/01/05	06/30/10	10 mg/l	10 mg/l	- -	- -	10 mg/l	10 mg/l	1.0 mg/l	9.4 mg/l	4.8 mg/l[e], 3.6 mg/l[f], 6.9 mg/l[g], 11.1 mg/l[h]	2.1 mg/l[e], 1.9 mg/l[f], 3.0 mg/l[g], 5.0 mg/l[h]	38 µg/l	8.0 µg/l	400 cells/ 100 ml
Village of Campbellsport	0020818	07/01/02	06/03/07	10 mg/l	- -	- -	- -	10 mg/l	- -	- -	- -	0.77 mg/l[i], 4.0 mg/l[j]	- -	- -	- -	400 cells/ 100 ml
Village of Cascade	0031372	10/01/05	09/30/10	45 mg/l[j]	30 mg/l[j]	40 mg/l[i]	25 mg/l[i]	60 mg/l	60 mg/l	3.8 mg/l[k], 1.0 mg/l[l]	6.4 mg/l[l]	20 mg/l[m], 32 mg/l[n]	12 mg/l[m], 16 mg/l[o], 19 mg/l[n]	38 µg/l	23 µg/l	400 cells/ 100 ml
Village of Fredonia	0020800	01/01/05	12/31/09	- -	- -	40 mg/l	25 mg/l	45 mg/l	30 mg/l	1.0 mg/l[p]	17 mg/l[q]	- -	26 mg/l[q]	38 µg/l[r]	- -	400 cells/ 100 ml[d]
Village of Grafton	0020184	07/01/02	06/30/07	35 mg/l, 45 mg/l [c]	30 mg/l	- -	- -	35 mg/l, 45 mg/l[c]	30 mg/l	1.0 mg/l	- -	2.1 mg/l, 9.8 mg/l[c]	37 lbs/day, 175 lbs/day[c]	38 µg/l[r]	20 µg/l[r]	400 cells/ 100 ml[c]
Village of Jackson	0021806	10/01/05	09/30/10	12 mg/l, 17 mg/l [c]	- -	- -	- -	12 mg/l	- -	1.0 mg/l	14 mg/l	8.5 mg/l, 7.4 mg/l, 5.0 mg/l, 8.4 mg/l, 14 mg/l[s]	4.3 mg/l, 5.7 mg/l, 3.9 mg/l, 7.0 mg/l[t]	38 µg/l[r]	7.7 µg/l[r]	400 cells/ 100 ml[d]
Village of Kewaskum	0021733	01/01/05	12/31/09	10 mg/l (63 lbs/day), 18 mg/l (113 lbs/day)[c]	10 mg/l, 18 mg/l[c]	- -	- -	10 mg/l (63 lbs/day), 18 mg/l (113 lbs/day)[c]	10 mg/l, 18 mg/l[c]	1.0 mg/l	24 mg/l	6.4 mg/l, 14.3 mg/l, 8.8 mg/l[u]	8.1 mg/l, 11.5 mg/l, 7.1 mg/l[u]	- -	- -	400 cells/ 100 ml[d]
Village of Newburg	0024911	10/01/02	09/30/07	45 mg/l	30 mg/l	- -	- -	45 mg/l	30 mg/l	- -	- -	- -	- -	- -	- -	400 cells/ 100 ml[d]

Table 68 (continued)

Facility Name	WPDES Permit Number	WPDES Permit Effective Date	WPDES Permit Expiration Date	Effluent Limits: BOD_5 Weekly Average	BOD_5 Monthly Average	$CBOD_5$[a] Weekly Average	$CBOD_5$[a] Monthly Average	Total Suspended Solids Weekly Average	Total Suspended Solids Monthly Average	Total Phosphorus Monthly Average	Ammonia Nitrogen Daily Maximum	Ammonia Nitrogen Weekly Average	Ammonia Nitrogen Monthly Average	Total Chlorine (residual) Daily Maximum	Total Chlorine (residual) Weekly Average	Fecal Coliform Geo Mean
Public Facilities (continued)																
Village of Random Lake	0021415	12/29/95	12/31/00	30 mg/l	15 mg/l	- -	- -	30 mg/l	20 mg/l	1.0 mg/l	- -	3.0 mg/l[i], 6.0 mg/l[j]	- -	37 µg/l	8.1 µg/l	400 cells/ 100 ml
Village of Saukville	0021555	01/01/04	12/31/08	35 mg/l (470 lbs/day), 45 mg/l [c]	30 mg/l	- -	- -	35 mg/l (470 lbs/day), 45 mg/l[c]	30 mg/l	1.0 mg/l	- -	18 mg/l (242 lbs/day), 4.7 mg/l (63 lbs/day), 8.1 mg/l (109 lbs/day)[v]	- -	- -	- -	400 cells/ 100 ml[d]
Village of Union Grove	0028291	01/01/04	12/31/09	30 mg/l	15 mg/l	- -	- -	30 mg/l	20 mg/l	1.0 mg/l	11.4 mg/l	31 mg/l[h], 5.6 mg/l[w]	12.5 mg/l[h], 2.3 mg/l[w]	- -	- -	- -
Town of Scott[x]	0036684	7/1/03	06/30/08	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Town of Yorkville	0029831	1/1/05	12/31/09	30 mg/l	20 mg/l	- -	- -	30 mg/l	20 mg/l	- -	- -	- -	- -	- -	- -	- -
Private Facilities																
Fonks Mobile Home Park	0026689	01/01/06	12/31/10	30 mg/l	20 mg/l	30 mg/l	20 mg/l	- -	- -	- -	- -	- -	- -	- -	- -	- -
Kettle Moraine Correctional Institution	0060721	07/01/03	06/30/08	- -	50 mg/l	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Long Lake Recreation Area	0060356	04/01/06	03/31/11	- -	50 mg/l	- -	- -	- -	- -	- -	- -	- --	-	- -	- -	2,000,000 MPN/g TS[y]

[a]*Carbonaceous biochemical oxygen demand.*

[b]*Weekly limitations on total ammonia nitrogen in mg/l at the MMSD South Shore Treatment Plant are as follows:*

Month	*pH 7.0*	*pH 7.1*	*pH 7.2*	*pH 7.3*	*pH 7.4*	*pH 7.5*
June	*16.7*	*16.7*	*13.1*	*13.1*	*13.1*	*13.1*
July..................................	*11.3*	*8.8*	*8.8*	*8.8*	*6.8*	*6.8*
August.............................	*11.1*	*8.7*	*8.7*	*6.7*	*6.7*	*6.7*
September	*12.7*	*12.7*	*10.0*	*10.0*	*10.0*	*10.0*

[c]*May-October, November-April.*

[d]*May-September only.*

[e]*April-May.*

[f]*June-September.*

[g]*October.*

[h]*November-March.*

[i]*May-October.*

[j]*November-April*

[k]*Effective through December 2009.*

[l]*Effective January 1, 2010.*

Table 68 Footnotes (continued)

[m]*Effective for April, after January 1, 2010.*

[n]*Effective for November-March, after January 1, 2010.*

[o]*Effective for May-September, after January 1, 2010.*

[p]*Limit effective starting March 1, 2005; monitoring begins January 1, 2005.*

[q]*Limit effective starting January 1, 2008. Alternate daily maximum limit may be reached if pH adjustment is chosen.*

[r]*May-September or whenever chlorinating.*

[s]*April, May, June-September, October, November-March.*

[t]*April and October, May, June-September, November-March.*

[u]*May-October, November-March, April.*

[v]*March-May, June-August, September-November.*

[w]*April-October*

[x]*The Scott Sanitary District provides treatment through an absorption pond. Thus, the following limits apply to grab samples collected from eight monitoring wells.*

Parameter	Units	Preventative Action Limit	Enforcement Standard	Frequency
Nitrogen, Nitrite + Nitrate (as N) Dissolved	mg/l	3.4	10	Quarterly
Chloride Dissolved	mg/l	125.0	250	Quarterly
pH (Lab and Field)	Standard Units (su)	8.2	N/A	Quarterly
Nitrogen, Ammonia Dissolved	mg/l	2.1	N/A	Quarterly
Nitrogen, Organic Dissolved	mg/l	2.2	N/A	Quarterly
Solids, Total Dissolved	mg/l	568.0	N/A	Quarterly

[y]*Monitor only during operating season, May 1st- October 31st.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

A quarterly report must be submitted detailing all discharges that took place that quarter. Technology-based requirements for CSOs are also listed in Section 3.2.6 of the Permit; these requirements are identical to the Nine Minimum Controls set out in the USEPA National CSO Control Policy.

MMSD is required to provide a quarterly bypass report for the SSOs listed in the WPDES permit. Quarterly reports must be filed within 45 days from the calendar quarter end and must describe the bypass events for that quarter, including all sanitary sewer overflows and bypasses, and the listed SSO discharge points. All discharges reported for each quarter must be accompanied by a description including the following information:

- Approximate duration
- Estimated volume per incident
- The reason for the discharge

WPDES Permit Requirements Regarding Sanitary Sewer Overflows
The Wisconsin Pollutant Discharge Elimination System (WPDES) permit for MMSD sewerage system and wastewater treatment facilities specifically states that, "Bypasses and overflows of wastewater from the permittee's sanitary sewerage system are prohibited and are not authorized by this permit, the Department may initiate legal action regarding such occurrences as authorized by § 283.89, Wis. Stats."

The WPDES permit for each municipal wastewater treatment facility in the study area, including the MMSD system, has an "Unscheduled Bypassing" subsection that lists the following conditions regarding enforcement actions related to sanitary sewer overflows:

"Any unscheduled bypass or overflow of wastewater at the treatment works or from the collection system is prohibited, and the Department may take enforcement action against a permittee for such occurrences under § 283.89, Wis. Stats., unless:

- The bypass was unavoidable to prevent loss of life, or severe property damage;
- There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and
- The permittee notified the Department as required in this Section (of the discharge permit).

WPDES Stormwater Discharge Permits
The communities in the study area that currently have obtained, or have applied for, a stormwater discharge permit under Chapter NR 216 are listed in Table 19 in Chapter II of this report. According to Section NR 216.02(3), all counties within the study area, except for Dodge County, and the cities, villages, and towns listed in Table 69 have been identified as being in urbanized areas that will be required to obtain stormwater discharge permits unless they receive exemptions.

WPDES Permits for Concentrated Animal Feeding Operations
There are six concentrated animal feeding operations (CAFO) in the regional water quality management plan update study area, five in the Milwaukee River watershed and one in the Root River watershed. The CAFOs in the Milwaukee River watershed include the Abel Dairy in the Town of Eden, which rears about 1,700 cattle and calves; the Clover Hill Dairy in the Town of Ashford, which rears about 850 cattle and calves; the Opitz Dairy Farm in the Town of Saukville, which rears about 1,800 cattle and calves; the R&J Partnership in the Town of

Table 69

COUNTIES AND COMMUNITIES IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA WITH MUNICIPAL SEPARATE STORM SEWER SYSTEMS IN URBANIZED AREAS: 2004[a]

Counties
Fond du Lac
Kenosha
Milwaukee
Ozaukee
Racine
Sheboygan
Washington
Waukesha
Cities
Brookfield
Cedarburg
Cudahy
Franklin
Glendale
Greenfield
Mequon
Milwaukee
Muskego
New Berlin
Oak Creek
Port Washington
Racine
South Milwaukee
St. Francis
Wauwatosa
West Allis
West Bend
Villages
Bayside
Brown Deer
Butler
Villages (continued)
Caledonia
Elm Grove
Fox Point
Germantown
Grafton
Greendale
Hales Corners
Menomonee Falls
Mt. Pleasant
North Bay
River Hills
Saukville
Shorewood
Sturtevant
Thiensville
West Milwaukee
Whitefish Bay
Wind Point
Towns
Brookfield
Cedarburg
Empire
Germantown
Grafton
Holland
Lisbon
Richfield
Saukville
Scott
Special Districts
Southeast Wisconsin Professional Baseball Park District

[a]*These counties and communities are listed in Section NR 216.02(3) and they have obtained, or will be required to obtain, WPDES permits, unless they receive exemptions.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Kewaskum, which rears up to 400,000 chickens; and Vorpahl Farms in the Town of Sherman, which rears about 2,050 cattle and calves. The CAFO in the Root river watershed is Maple Leaf Farms in the Town of Yorkville, which rears about 500,000 ducks.

Local Water-Related Regulatory Matters

Authority to enact construction site erosion control and stormwater management ordinances are granted to counties, cities, villages, and towns under Sections 59.693, 62.234, 61.354, and 60.627, respectively, of the *Wisconsin Statutes*.[65] Selected information on construction erosion control and stormwater management ordinances in the study area are listed in Chapters V through IX of SEWRPC Technical Report No. 39.

[65]*Sections 101.65 and 101.653 of the* Wisconsin Statutes *establish the authority for county, city, village, or town regulation of construction site erosion for single- and two-family residential construction. Such programs are generally administered by local building inspectors, with review of each local program by the Wisconsin Department of Commerce.*

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Chapter VII

PLANNING OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

The formulation of plan development objectives and supporting standards is one of the most important steps in the water resources planning process. Soundly conceived water resources plan development objectives should incorporate the knowledge of many people who are informed about the watersheds involved. As much as possible, such objectives should be established by duly elected or appointed public officials legally assigned this task, assisted as necessary, not only by planners and engineers, but also by interested and concerned citizens as well. This is particularly important because of the value judgments inherent in any set of development objectives. The active participation of duly elected public officials and citizen leaders in the overall regional planning program is implicit in the composition of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) itself. As described in a later section, input on the objectives was obtained from a number of public and watershed officials advisory committees and related venues prior to presentation to the Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds.

One of the important functions of the Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds is to assist in the formulation of a set of watershed development objectives and standards which can provide a sound basis for watershed plan design, testing, and evaluation. This chapter sets forth the set of planning objectives and supporting principles and standards approved by the Committee. Some of these objectives, principles, and standards were originally adopted by the Commission under related regional planning programs but were deemed relevant to formulation of the regional water quality management plan update. Others were formulated specifically for the regional water quality management plan update, and to a large extent were the result of advice generated during the public involvement process.

The development of the planning activities has been coordinated with the development of objectives for the Milwaukee Metropolitan Sewerage District (MMSD) 2020 facilities plan. Since the alternative plans being considered are integrated in many aspects, the plan objectives must be consistent.

BASIC CONCEPTS AND DEFINITIONS

The basic concepts and definitions utilized herein have been coordinated with the MMSD 2020 facilities planning program since the development of such concepts should be similar as the alternative plans being considered are, in some cases, integrated.

The term "objective" is subject to a wide range of interpretation and application and is closely linked to other terms often used in planning work which are similarly subject to a wide range of interpretation and application. The following definitions have, therefore, been adopted in order to provide a common frame of reference:

1. **Goal:** A desired future condition, usually defined in broad terms interpreted differently from a variety of perspectives.

2. **Objective:** A more specific desired future condition, toward which the attainment of plans and policies are directed.

3. **Principle:** A fundamental, primary, or generally accepted tenet used to support objectives and prepare standards and plans.

4. **Planning Standard:** A statement of a condition or criterion used as a basis for determining the adequacy of a plan to attain objectives.

5. **Wisconsin Department of Natural Resources (WDNR) Regulatory Water Quality Standard, Criteria, and Designated Uses:** A water quality goal that is established to guide water quality protection efforts for lakes, rivers, and streams. A standard is built upon the principle of identifying the appropriate designated use(s) of a waterbody, setting water quality criteria to protect that use, and preserving the water quality with an anti-degradation policy.[1] In Wisconsin, standards are set for different categories of designated uses, such as: public health and welfare, wildlife, recreation, and fish and other aquatic life. For instance, some waterbodies may be able to support a coldwater fish community (i.e., trout and salmon) whereas others may be better suited to support warmwater fish (i.e., walleye and bass). In order to maintain a healthy fishery in each of these two communities, pollution management activities should not allow the dissolved oxygen to drop below six mg/L for the coldwater community or five mg/L for the warmwater community. This reflects the different sensitivities and needs of the fish species that typically occupy these very different systems. Incorporation of the anti-degradation policy would ensure that human activity would not be allowed to result in lower quality water that could jeopardize the cold or warmwater communities defined by the designated use. Water quality criteria are also developed for several other pollutants, including: heat, ammonia, nutrients, toxic substances, etc.

6. **Plan:** a design which seeks to achieve the agreed-upon objectives.

7. **Policy:** a rule or course of action used to ensure plan implementation.

8. **Program:** a coordinated series of policies and actions to carry out a plan.

Although this chapter deals primarily with the second, third, and fourth of these terms, an understanding of the interrelationship of the foregoing definitions and the basic concepts which they represent is essential to the explanation of watershed development objectives, principles, and standards.

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[1]*In this context, the term "anti- degradation policy" is intended to mean the anti-degradation policy referred to in Section NR 102.05(1) of the* Wisconsin Administrative Code *and the associated implementation procedures set forth in Chapter NR 207 of the* Wisconsin Administrative Code. *That policy states that 'No waters of the state shall be lowered in quality unless it has been affirmatively demonstrated to the department that such a change is justified as a result of necessary economic and social development, provided that no new or increased effluent interferes with or becomes injurious to any assigned uses made of or presently possible in such waters.' In practice, this policy applies to formally proposed increases in existing discharges or to new discharges to the surface waters. As such, the policy does not typically apply to any changes in currently approved discharges due to incremental changes in land uses or point source connections which are anticipated in the current permitted levels of discharge.*

PRELIMINARY OBJECTIVE DEVELOPMENT

The formulation of plan objectives followed a fairly rigorous and extended period of public involvement. This featured initial public input by the Citizens Advisory Council, followed by supplementary contributions and review by that group, and the Watershed Officials Forum.[2] The process was designed to obtain input on objectives for both the MMSD 2020 facilities plan and the regional water quality management plan update and was led by the MMSD staff and its consultant.

In April 2004, the Citizens Advisory Council was convened on sequential evenings in the Cities of Milwaukee and West Bend to begin the process of setting goals and objectives for MMSD's 2020 facilities plan and the regional water quality management plan update. Council members were invited to attend the meeting of their choice to discuss their vision for the future of water resources in the greater Milwaukee watersheds. This early discussion, by way of brainstorming, was part of a multi-step process toward creating plan objectives with numerous opportunities for public contributions and refinement.

Based upon meeting attendance, two citizen subgroups in Milwaukee and one in West Bend were asked to formulate answers to the following question:

"*What do we, as a region, need to do so that current and future generations have improved rivers, streams and lakes in the greater Milwaukee watersheds?*"

By design, the question was intended to elicit action ideas via asking about what needed to be done. This approach was believed necessary to generating a wealth of responses—more so than might be possible by directly seeking suggestions for bigger picture objectives relating to an expected future state. The process generated some 400 comments, issues, actions, and measures. That input from these meetings was then refined in subsequent meetings and the planning process to reflect the desired condition of land and water resources, the types of impediments observed that require correction, and the perceived means toward water quality improvement and public use.

Commission staff sought to utilize the citizen input in a manner which would both respect the contributions of past and current advisory plan development committees, and the development of objectives for the current planning process. The 400 comments, issues, actions, and measures offered as ideas presented by the Citizen Advisory Council were, thus, considered in light of objectives developed in comprehensive watershed management and land use planning programs that have been reviewed by advisory committees attendant to planning programs in the past.

Another step in the process included review of Wisconsin Department of Natural Resources watershed and basin planning objectives, as well as those from other relevant studies, to determine if any major area was not covered by the process noted above. This process of comparing, contrasting, and integrating the Citizens Advisory Council ideas with existing plan objectives, with which the regional water quality management plan update would need to be consistent, resulted in each of the citizen ideas being assigned a discrete reference number and being slotted under a preliminary objective for consistency.

Five preliminary objectives not utilized previously by the Regional Planning Commission were added to the preliminary/potential objectives researched, based upon the Citizens Advisory Council visioning in order to fully cover all of the citizen input. One of these additional objectives relates to economic development and job creation, three others relate to plan structure and monitoring, and one relates to educational and informational programming, all in support of land and water resource planning and management.

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[2]*For more information on the make up of the advisory committees involved in the planning process, see Appendix A.*

OBJECTIVE REVIEW AND REFINEMENT

The preliminary objectives were reviewed by the Watershed Officials Forum and compared with statement lists generated to summarize the Citizen Advisory Council input. Two companion meeting dates and times were offered in June 2004, respectively in rural Newburg and the City of Greenfield, to provide a convenient option for attendees. Likewise, the Citizens Advisory Council was convened during two evenings in July 2004, in the Cities of Franklin and Mequon respectively, on these occasions to address watershed-specific rather than regional action needs.

Interestingly, though variable locations based upon watershed areas were selected for meetings, and the citizens particularly were approached about discussing individual watershed issues or more localized comments, the broadly applicable/regional comments continued to emerge. Even the ideas initially envisioned for a specific watershed were by and large expanded by the contributors to encompass the entire greater Milwaukee watersheds.

During August 2004, the Citizens Advisory Council again met in Milwaukee; and in September 2004 the Watershed Officials Forum met in companion afternoon and evening meetings in the City of Oak Creek and rural Newburg, respectively. Attendees were offered another opportunity to comment on the preliminary objectives for the regional water quality management plan update. Additionally, the preliminary objectives were explained to attendees and distributed for review at four public information meetings held in September 2004 by MMSD and attended by SEWRPC staff. These meetings were conducted during evenings in the Village of Bayside and the Cities of Milwaukee and Wauwatosa, respectively, and during the morning in a second Milwaukee location.

In general, the preliminary objectives received support, with only minor additions and rearrangement occurring beyond their initial development. This included comparing and seeking to accommodate all additional ideas and comments, in like fashion to those initially considered from the Citizens Advisory Council. Thus, numerous opportunities for input complemented the extensive early contributions toward developing objectives, prior to their initial distribution at a meeting of the Technical Advisory Committee during October 2004.

The recommended objectives for use in development of the regional water quality management plan update are set forth in the following report section. The listing includes broad categorical headings followed by one or more objectives in each category. Each objective is stated in abbreviated form in bold, followed by a complete objective statement which is needed for planning purposes in order to properly develop and evaluate alternative plans. It may be noted that such categorization was itself a product of the public involvement process and interagency cooperation in the planning effort. In addition, previous SEWRPC water quality management plan wording of objectives has been augmented where appropriate to accommodate the phrase, ". . .water quality control facilities, programs, operational improvements, and policies. . .," to enhance consistency with the MMSD 2020 facilities planning program.

PLANNING OBJECTIVES

In order to be useful in the watershed planning process, objectives not only must be logically sound and related in a demonstrable and measurable way to alternative physical development proposals, but also must be consistent with, and grow out of, regionwide development objectives. This is essential if the watershed water resources plans are to comprise integral elements of a comprehensive plan for the physical development of the Region and if sound coordination of regional and watershed development is to be achieved.

SEWRPC has, in its planning efforts to date, adopted, after careful review and recommendation by various advisory and coordinating committees, a number of regional development objectives relating to land use, housing, transportation, sewerage, water quality management, air quality management, flood control, and recreation and open space preservation. These objectives, together with their supporting principles and standards, are set forth in previous SEWRPC planning reports. Some of these objectives and standards are directly applicable to the current watershed water resources planning effort and are hereby recommended for adoption as development objectives for the watershed. Some of these objectives have been refined based upon the aforenoted processes of obtaining broader input on the plan objectives. In addition, that broader input resulted in the creation of five new objectives. The recommended plan objectives are described as follows:

Land Use Development Objectives

Four land use development objectives similar to those adopted by SEWRPC under its regional land use planning program are directly applicable to the regional water quality management plan update effort. It should be noted that the land use development objectives set forth herein and the associated principles and standards set forth in Appendix G are intended to be utilized for defining the recommended regional land use plan as a framework at the watershed level. These objectives, principles, and standards are expected to be refined during subsequent county and local land use and comprehensive plan development and, thus, represent a point of departure for such planning. This is especially true for planning in Dodge, Fond du Lac, and Sheboygan Counties. Additionally, previous county and local planning will be incorporated into the recommended plan, where available. These land use development objectives are:

1. **Achievement of a Balanced Land Use Allocation**
   A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population, while protecting water resources.

2. **Protection and Wise Use of Natural Resources**
   A geographic distribution of the various land uses which results in the protection and wise use of the natural resources of the watersheds involved, including its soils, inland lakes and streams, including floodwater storage areas, groundwater, wetlands, woodlands, prairies, wildlife habitat, and natural areas and critical species habitat.

3. **Land Use Compatible with Economical Provision of Public Services**
   A geographic distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems, including stormwater management and sewerage, in order to provide these systems in as economical a manner as practical.

4. **Preservation of Land for Agriculture, Habitat, and Orderly Development**
   The preservation of land areas to provide for agriculture, to enable a reserve or holding area for future urban and rural needs, and to ensure the preservation of those rural areas which provide wildlife habitat and which are essential to orderly urban development.

Water Quality Management Objectives

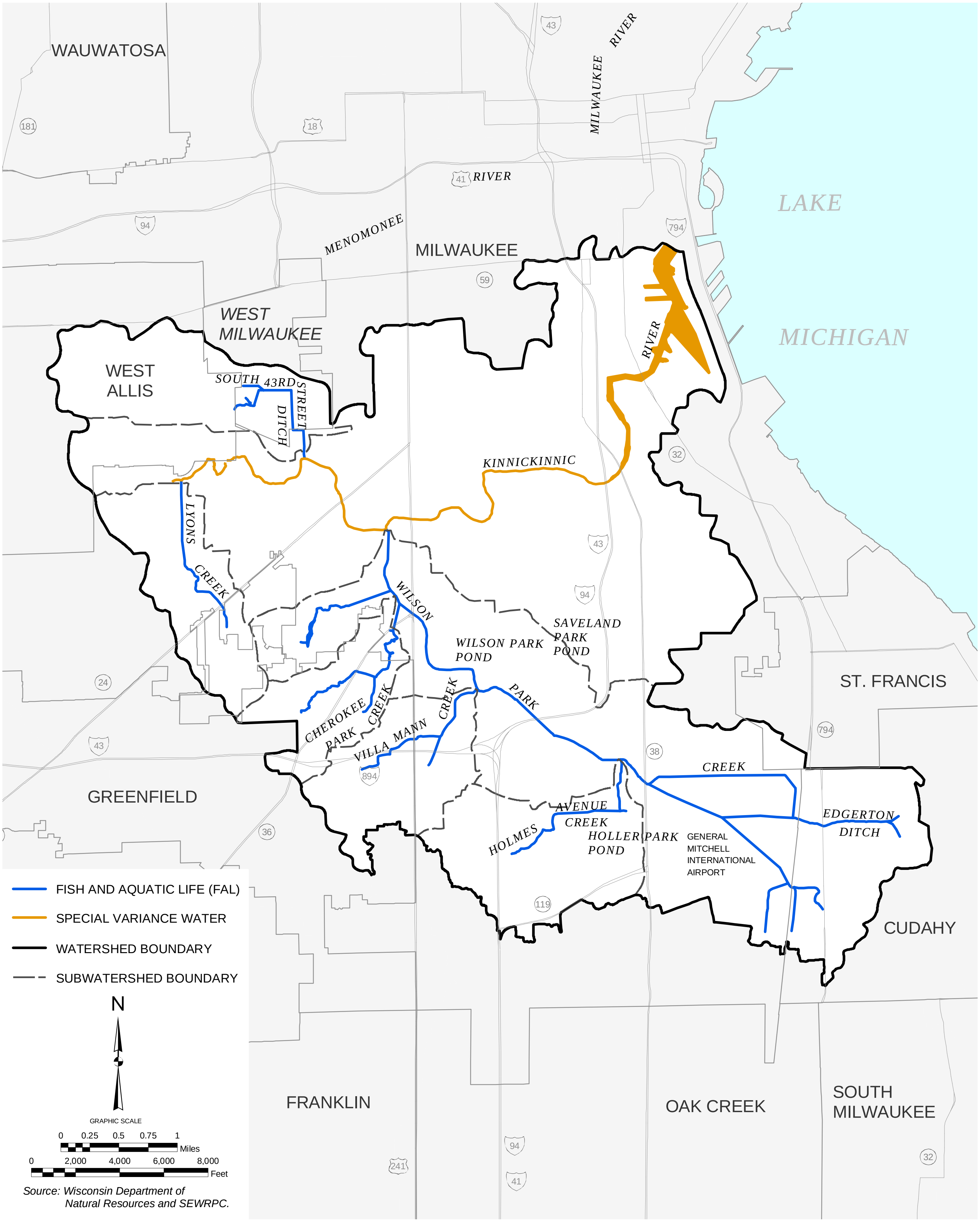
Four water quality management objectives similar to those adopted by SEWRPC under its comprehensive watershed and regional water quality management planning program are directly applicable to the regional water quality management plan update effort. These are:

1. **Development of Facilities, Programs, and Policies to Serve the Regional Development Pattern**
   The development of water quality control facilities, programs, operational improvements, and policies, including land management and nonpoint pollution controls, which will effectively serve the existing and planned future regional development pattern and meet sanitary and industrial wastewater disposal, and stormwater runoff control needs.

2. **Development of Policies and Practices to Meet Water Use Objectives**
   The development of land management and water quality control facilities, programs, operational improvements, policies and practices, so as to meet the recommended water use objectives or use classification supporting water quality criteria as set forth on Maps 51 through 56 and Table 70.

Map 51

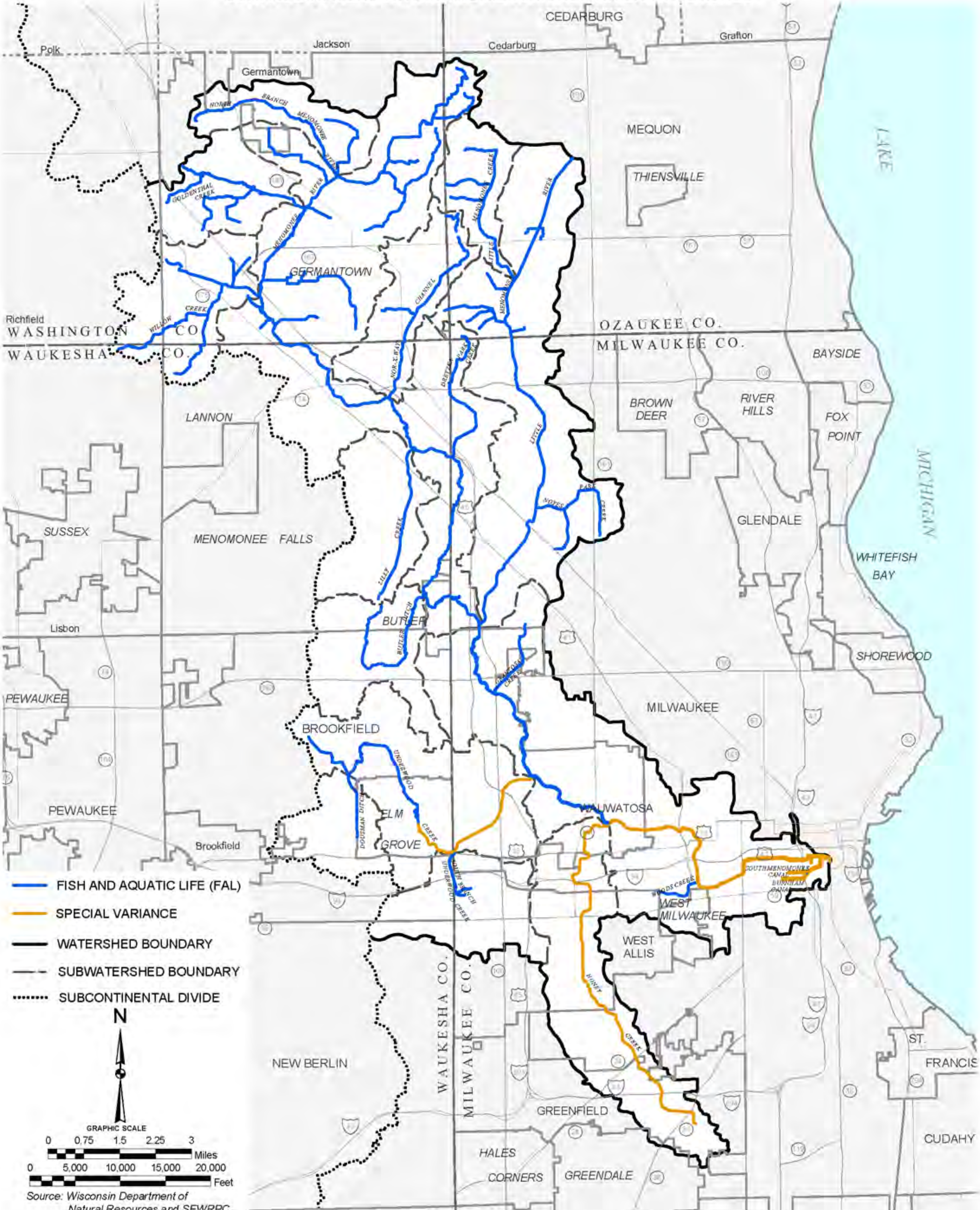
CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE KINNICKINNIC RIVER WATERSHED



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 52

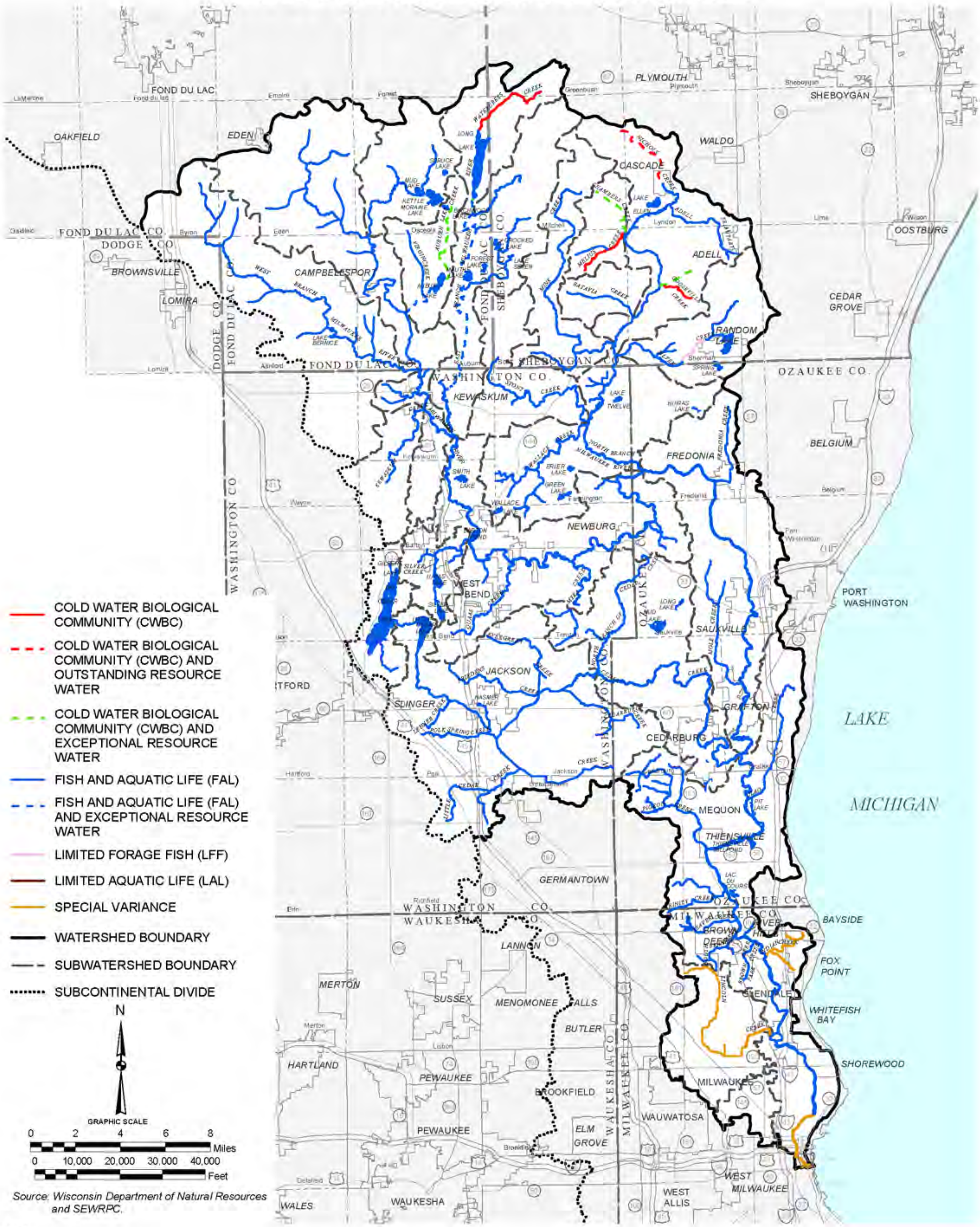
CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE MENOMONEE RIVER WATERSHED



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 53

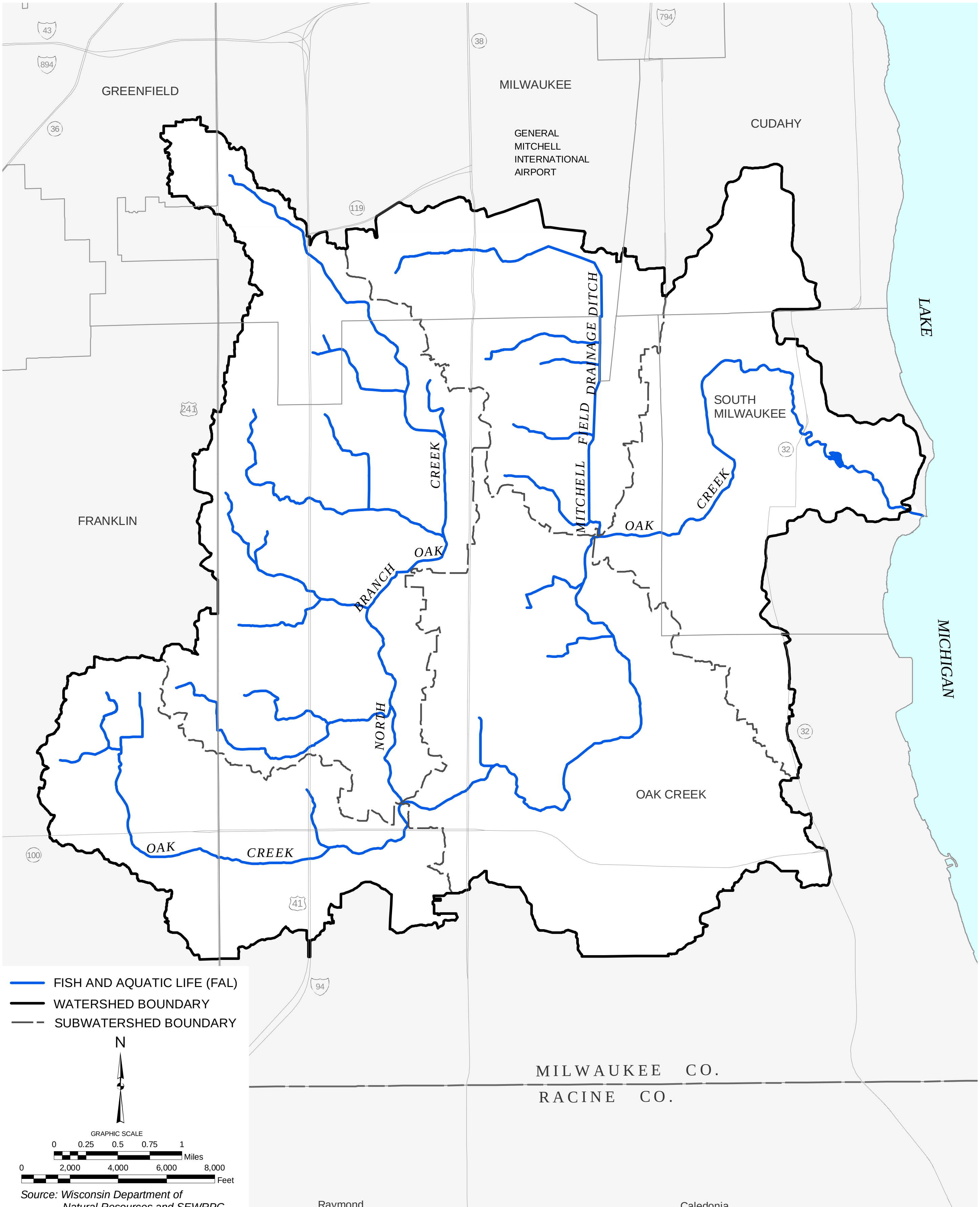
CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE MILWAUKEE RIVER WATERSHED



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 54

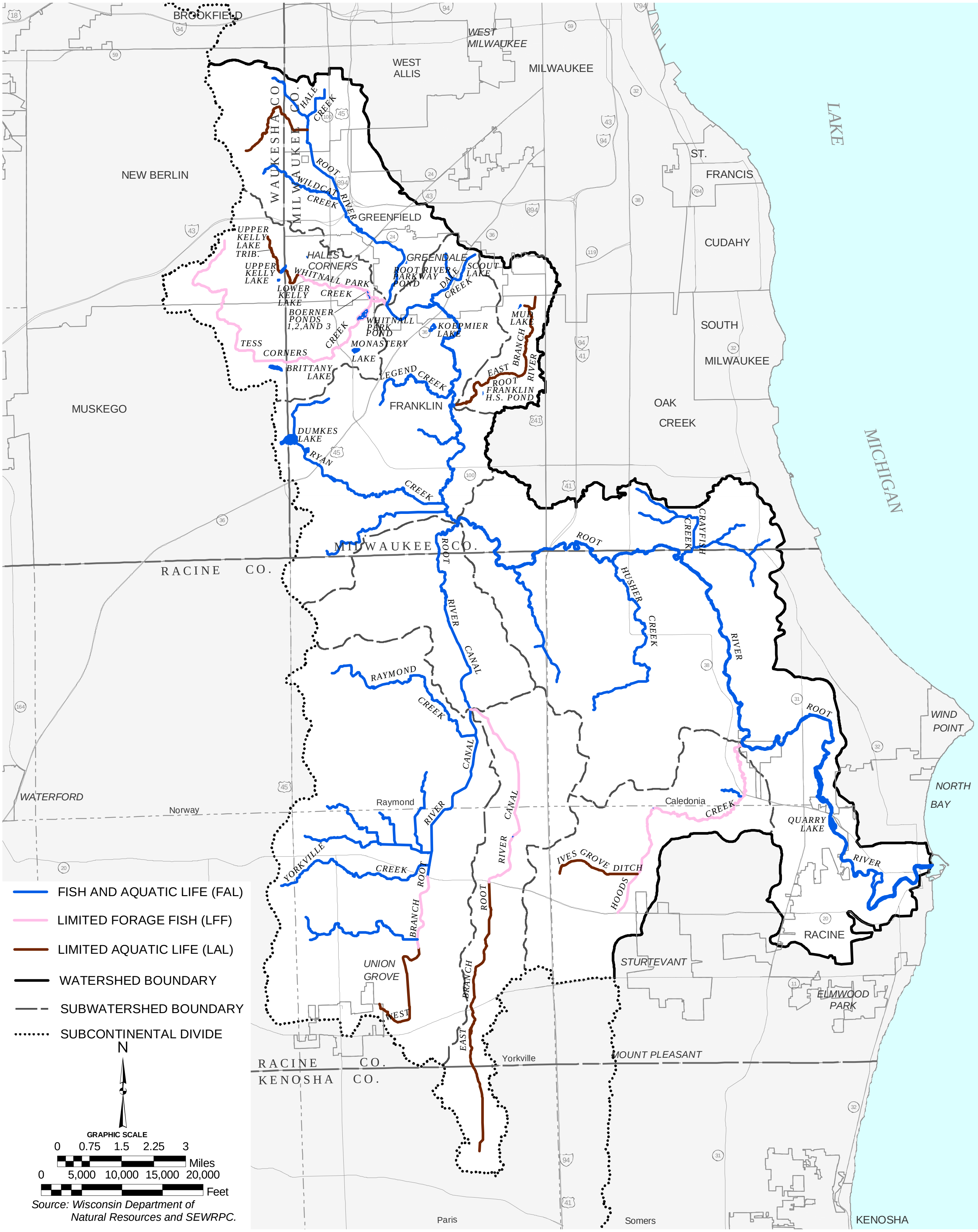
CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE OAK CREEK WATERSHED



Source: Wisconsin Department of Natural Resources and SEWRPC.

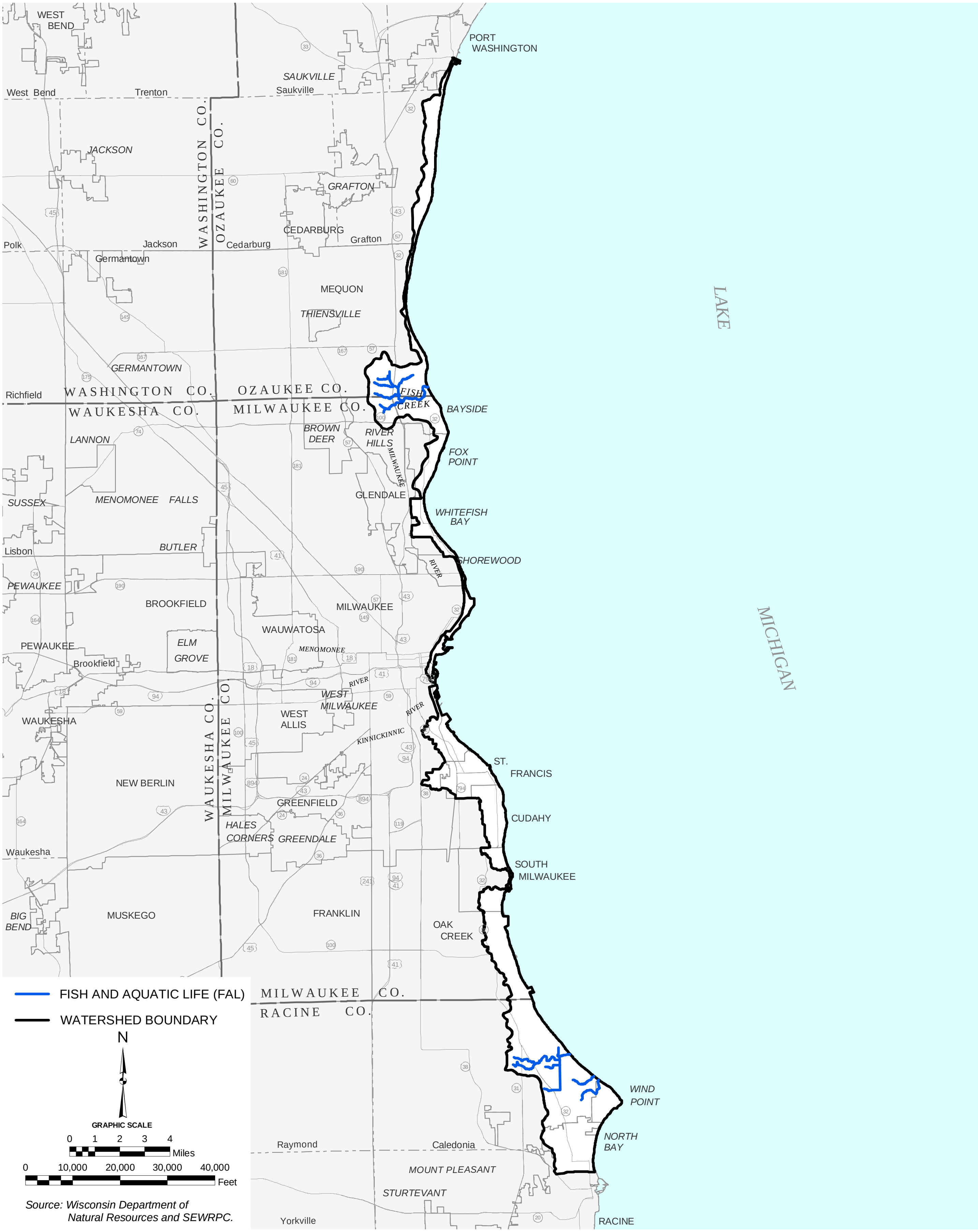
Map 55

CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE ROOT RIVER WATERSHED



Map 56

CURRENT REGULATORY WATER USE CLASSIFICATIONS FOR SURFACE WATERS WITHIN THE AREA TRIBUTARY TO LAKE MICHIGAN



Source: Wisconsin Department of Natural Resources and SEWRPC.

Table 70

REGULATORY AND AUXILIARY FISH AND AQUATIC LIFE WATER AND RECREATIONAL USE OBJECTIVES/DESIGNATED USES TO BE CONSIDERED FOR STREAMS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
KINNICKINNIC RIVER WATERSHED			
Kinnickinnic River Natural/Earthen Channel Reaches from Confluence with Milwaukee River to S. 6th Street (T6N R22E NE SW 8)	Variance Water[f] (NR 104.06(2)(a)(8))	**Variance Water** *FAL*[d]	Variance applies to all of the Kinnickinnic River
Kinnickinnic River Concrete Channel Reaches Upstream of S. 6th Street (T6N R22E NE SW 8) to Headwaters	Variance Water[f] (NR 104.06(2)(a)(8))	**Variance Water**	Variance applies to all of the Kinnickinnic River
Unnamed Creek (Cherokee Park Creek) (T6N R21E SE NE 13)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Edgerton Ditch) (T6N R22E SW NE 28)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Holmes Avenue Creek) (T6N R22E SE SE 20)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Lyons Park Creek) (T6N R21E SW NW 11)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (S. 43rd Street Ditch) (T6N R21E NW NW 12)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Villa Mann Creek) (T6N R22E NW NE 19)	FAL (DEF)[a]	**FAL**	- -

NOTES: 1. Text in italics = Auxiliary use objective to be considered as potential for management purposes.

2. FAL means Fish and Aquatic Life; DEF means no specific use classification is set forth in Chapter NR 102 of the *Wisconsin Administrative Code*; and COLD I indicates waters which have sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity; COLD II indicates waters which have some natural reproduction of trout, but require stocking to maintain a desirable sport fishery; COLD is used as an auxiliary use for planning purposes and may indicate either COLD I or COLD II; LFF means Limited Forage Fish Community; LAL means Limited Aquatic Life.

3. All streams are classified as “Full Recreational Use,” except that those designated as having a “variance water” designation are classified as “Limited Recreational Use.”

Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
KINNICKINNIC RIVER WATERSHED (continued)			
Unnamed Creek (Wilson Park Creek) Concrete or Enclosed Channel Reaches from Confluence with Unnamed Creek (Edgerton Ditch) (T6N R22E SE NW 27) to S. 6th Street (T6N R22E SW SE 20)	FAL (DEF)a	**FAL**	- -
Unnamed Creek (Wilson Park Creek) Natural/Earthen Channel Reaches from S. 6th Street (T6N R22E SW SE 20) to 20th Street (T6N R22E NW NE 19)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Wilson Park Creek) All Existing Concrete-Lined or Enclosed Reaches from S. 20th Street in the NW NE T6N R22E to the Confluence with the Kinnickinnic River in the SE SE T6N R21E 12	FAL (DEF)[a]	**FAL**	- -
MENOMONEE RIVER WATERSHED			
Burnham Canal (T7N R22E SW SE 29)	Variance Water[g] (NR 104.06(2)(b)(2))	**Variance Water** *FAL*[d]	- -
Honey Creek Natural Channel from Confluence with Menomonee River (T7N R21E NW NW 27) to Concrete Channel at Honey Creek Parkway (T7N R21E SW SE 28)	Variance Water[f] (NR 104.06(2)(a)(6))	**Variance Water** *FAL*[d]	Variance applies to all of Honey Creek

NOTES: 1. Text in italics = Auxiliary use objective to be considered as potential for management purposes.

2. FAL means Fish and Aquatic Life; DEF means no specific use classification is set forth in Chapter NR 102 of the *Wisconsin Administrative Code*; and COLD I indicates waters which have sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity; COLD II indicates waters which have some natural reproduction of trout, but require stocking to maintain a desirable sport fishery; COLD is used as an auxiliary use for planning purposes and may indicate either COLD I or COLD II; LFF means Limited Forage Fish Community; LAL means Limited Aquatic Life.

3. All streams are classified as “Full Recreational Use,” except that those designated as having a “variance water” designation are classified as “Limited Recreational Use.”

Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
MENOMONEE RIVER WATERSHED (continued)			
Honey Creek Concrete or Enclosed Channel at Honey Creek Parkway (T7N R21E SW SE 28) to Natural Channel at IH 894 (T6N R21E SW SW 23)	Variance Water[f] (NR 104.06(2)(a)(6))	**Variance Water**	Variance applies to all of Honey Creek
Honey Creek Natural Channel from IH 894 (T6N R21E SW SW 23) to Headwaters	Variance Water[f] (NR 104.06(2)(a)(6))	**Variance Water** *LFF*[d]	Variance applies to all of Honey Creek
Lilly Creek	FAL (DEF)[a]	**FAL**	- -
Little Menomonee Creek	FAL (DEF)[a]	**FAL**	- -
Little Menomonee River	FAL (DEF)[a]	**FAL**	- -
Menomonee River from Confluence with Honey Creek (T7N R21E NW NW 27) to Confluence with Milwaukee River (T7N R22E SE SE 29)	Variance Water[f] (NR 104.06(2)(a)(7))	**Variance Water** *FAL*[d]	- -
Menomonee River Main Stem Upstream from Confluence with Honey Creek	FAL (DEF)[a]	**FAL**	- -
Nor-X-Way Channel Concrete Channel Reach	FAL (DEF)[a]	**FAL**	- -
Nor-X-Way Channel/ All-Natural Channel Reaches	FAL (DEF)[a]	**FAL**	- -
South Menomonee Canal (T7N R22E NE NW 32)	Variance Water[g] (NR 104.06(2)(b)(2))	**Variance Water** *FAL*[d]	- -

NOTES: 1. Text in italics = Auxiliary use objective to be considered as potential for management purposes.

2. FAL means Fish and Aquatic Life; DEF means no specific use classification is set forth in Chapter NR 102 of the *Wisconsin Administrative Code*; and COLD I indicates waters which have sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity; COLD II indicates waters which have some natural reproduction of trout, but require stocking to maintain a desirable sport fishery; COLD is used as an auxiliary use for planning purposes and may indicate either COLD I or COLD II; LFF means Limited Forage Fish Community; LAL means Limited Aquatic Life.

3. All streams are classified as “Full Recreational Use,” except that those designated as having a “variance water” designation are classified as “Limited Recreational Use.”

Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
MENOMONEE RIVER WATERSHED (continued)			
Southbranch of Underwood Creek from Confluence with Underwood Creek (T7N R21E NW SW 30) to Headwaters	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Butler Ditch) (T8N R20E SE NW 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Goldenthal Creek) (T9N R20E NW NW 22)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T7N R20E SE SE 15)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Wood Creek) (T7N R21E SW NW 36)	FAL (DEF)[a]	**FAL**	- -
Underwood Creek Concrete Channel from Confluence with Menomonee River (T7N R21E NW NE 20) to Juneau Boulevard (T7N R20E NE NW 25)	Variance Water[f] (NR 104.06(2)(a)(1))	**Variance Water** *FAL*[l]	- -
Underwood Creek from Juneau Boulevard (T7N R20E SE SW 24) to Headwaters	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Underwood Creek from T6N R21E S6 to Confluence with Underwood Creek	FAL (DEF)[a]	**FAL**	- -
Willow Creek	FAL (DEF)[a]	**FAL**	- -
Cedar Creek Subwatershed			
Cedar Creek	FAL (DEF)[a]	**FAL**	- -
Cedarburg Creek	FAL (DEF)[a]	**FAL**	- -
Evergreen Creek	FAL (DEF)a	**FAL**	- -

NOTES: 1. Text in italics = Auxiliary use objective to be considered as potential for management purposes.

2. FAL means Fish and Aquatic Life; DEF means no specific use classification is set forth in Chapter NR 102 of the *Wisconsin Administrative Code*; and COLD I indicates waters which have sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity; COLD II indicates waters which have some natural reproduction of trout, but require stocking to maintain a desirable sport fishery; COLD is used as an auxiliary use for planning purposes and may indicate either COLD I or COLD II; LFF means Limited Forage Fish Community; LAL means Limited Aquatic Life.

3. All streams are classified as “Full Recreational Use,” except that those designated as having a “variance water” designation are classified as “Limited Recreational Use.”

Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Cedar Creek Subwatershed (continued)			
Friedens Creek	FAL (DEF)[a]	**FAL**	- -
Jackson Creek	FAL (DEF)[a]	**FAL**	- -
Kressin Creek	FAL (DEF)[a]	**FAL**	- -
Lehner Creek	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Little Cedar Creek	FAL (DEF)[a]	**FAL**	- -
North Branch Cedar Creek	FAL (DEF)[a]	**FAL**	- -
Polk Spring Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T10N R19E NW NE 5)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T10N R20E NE NE 1)	FAL (DEF)[a]	**FAL**	- -
Milwaukee River East and West Branches Subwatershed			
Auburn Lake Creek (Lake Fifteen Creek) Downstream of Auburn Lake	FAL (DEF)[a]	**FAL**	Code lists as exceptional resource water (NR 102.11(1)(d) (8))
Auburn Lake Creek (Lake Fifteen Creek) Upstream of Auburn Lake	COLD II (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD II** *COLD I*[d]	Cold II designation in Wisconsin Trout Streams applies only to portions in S2-3 of T13N R19E Code lists as exceptional resource water (NR 102.11(1)(d) (8))
Kewaskum Creek	FAL (DEF)[a]	**FAL**	- -
Milwaukee River East Branch from Long Lake (T14N R19E NW SW 25) to STH 28 (T12N R21E SE NE 10)	FAL (DEF)[a]	**FAL**	Code lists as exceptional resource water (NR 102.11(1)(d) (39))
Milwaukee River East Branch from STH 28 (T12N R21E SE NE 10) to Confluence with Milwaukee River West Branch (T12N R19E SE SW 14)	FAL (DEF)[a]	**FAL**	- -

NOTES: 1. Text in italics = Auxiliary use objective to be considered as potential for management purposes.

2. FAL means Fish and Aquatic Life; DEF means no specific use classification is set forth in Chapter NR 102 of the *Wisconsin Administrative Code*; and COLD I indicates waters which have sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity; COLD II indicates waters which have some natural reproduction of trout, but require stocking to maintain a desirable sport fishery; COLD is used as an auxiliary use for planning purposes and may indicate either COLD I or COLD II; LFF means Limited Forage Fish Community; LAL means Limited Aquatic Life.

3. All streams are classified as “Full Recreational Use,” except that those designated as having a “variance water” designation are classified as “Limited Recreational Use.”

Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River East and West Branches Subwatershed (continued)			
Milwaukee River Main Stem	FAL (DEF)[a]	**FAL**	- -
Milwaukee River West Branch	FAL (DEF)[a]	**FAL**	- -
Myra Creek	FAL (DEF)[a]	**FAL**	- -
Quaas Creek	FAL (DEF)[a]	**FAL**	- -
Silver Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E SW NE 28)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Lake Seven outlet)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Riveredge Creek)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T11N R19E NE NW 14)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T11N R20E SW SE 17)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T12N R19E NW NE 9)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T12N R19E SE NE 4)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T12N R20E NE SW 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R18E NW NE 26)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E NW NE 06)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E NW NE 17)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E NW SE 33)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E NW SE 6)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E SE NE 16)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E SE NW 18)	FAL (DEF)[a]	**FAL**	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River East and West Branches Subwatershed (continued)			
Unnamed Creek (T13N R19E SE SW 34)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E SW NE 10)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R19E SW NE 14)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R17E SE NE 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E NW NE 27)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E NW SE 22)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E NW SW 14)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E SE NW 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R18E SE SE 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R19E NW NE 36)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R19E SE NW 36)	FAL (DEF)[a]	**FAL**	- -
Virgin Creek	FAL (DEF)[a]	**FAL**	- -
Watercress Creek	COLD II (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD II** *COLD I*[d]	- -
Milwaukee River North Branch Subwatershed			
Adell Tributary	FAL (DEF)[a]	**FAL**	- -
Batavia Creek	FAL (DEF)[a]	**FAL**	- -
Chambers Creek	COLD I (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD I**	Cold I designation in Wisconsin Trout Streams applies down to Hwy W Code lists as exceptional resource water (NR 102.11(1)(a))
Gooseville Creek (South Branch)	COLD II (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD II** *COLD I*[d]	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River North Branch Subwatershed (continued)			
Gooseville Creek (North Branch and Main Stem to Milwaukee River)	COLD I (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD I**	Code lists as exceptional resource water (NR 102.11(1)(a))
Melius Creek	COLD II (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD II** *COLD I*[d]	- -
Mink Creek	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
North Branch Milwaukee River	FAL (DEF)[a]	**FAL**	- -
North Branch Milwaukee River (Nichols Creek)	COLD I (NR 102.04(3)(a) Wisconsin Trout Streams (1980)[b])	**COLD I**	Cold I designation in Wisconsin Trout Streams applies down to Hwy 28 in Cascade Code lists as outstanding resource water (NR 102.10(1)(d))
Silver Creek from Random Lake Sewage Treatment Plant Downstream to First Crossing of Creek Road	LFF (NR 104.07(2) Table 5 (40))	**LFF**	- -
Silver Creek, Except from Random Lake Sewage Treatment Plant Downstream to First Crossing of Creek Road	FAL (DEF)[a]	**FAL**	- -
Stony Creek	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Unnamed Creek (T13N R20E NW NE 11)	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Unnamed Creek (T12N R20E SE SE 2)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T12N R20E SW NW 8)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T12N R20E SW SW 3)	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Unnamed Creek (T13N R20E SE NE 34)	FAL (DEF)a	**FAL** *COLD*[d]	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River North Branch Subwatershed (continued)			
Unnamed Creek (T13N R21E NE NW 11)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R21E NE NW 32)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R21E NW SE 27)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T13N R21E SE NE 23)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (T14N R21E SW NE 31)	FAL (DEF)[a]	**FAL**	- -
Wallace Creek	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Milwaukee River South Branch Subwatershed			
Indian Creek Concrete Channel Upstream of IH 43 (T8N R22E S8 NE SW 8) to Headwaters	Variance Water[f] (NR 104.06(2)(a)(5))	**Variance Water** *FAL*[d]	Variance applies to all of Indian Creek
Indian Creek Natural Channel from Confluence with Milwaukee River (T8N R22E NW NE 18) to IH 43 and Concrete Channel (T8N R22E S8 NE SW 8)	Variance Water[f] (NR 104.06(2)(a)(5))	**Variance Water** *FAL*[d]	Variance applies to all of Indian Creek
Lincoln Creek Natural Channel from Confluence with Milwaukee River (T8N R22E NE SE 31) to Former Concrete Channel at Teutonia Avenue (T8N R22E NE SE 36)	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water** *FAL*[d]	Variance applies to all of Lincoln Creek
Lincoln Creek Former Concrete Channel at Teutonia Avenue (T8N R22E NE SE 36) to Natural Channel at N. 32nd Street (T7N R21E NW NE 1)	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water** *FAL*[k]	Variance applies to all of Lincoln Creek

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River South Branch Subwatershed (continued)			
Lincoln Creek Natural Channel at N. 32nd Street (T7N R21E NW NE 1) to Former Concrete Channel at W. Hampton Avenue (T8N R21E SE SE 34)	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water** *LFF*[e]	Variance applies to all of Lincoln Creek
Lincoln Creek Former Concrete Channel at W. Hampton Avenue (T8N R21E SE SE 34) to Natural Channel Upstream of W. Silver Spring Drive (T8N R21E SW SW 26)	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water** *LFF*[k]	Variance applies to all of Lincoln Creek
Lincoln Creek Natural Channel Upstream of W. Silver Spring Drive (T8N R21E SW SW 26) to Concrete Channel Upstream of Brynwood Country Club Pond (T8N R21E NE SW 15)	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water** *LFF*[e]	Variance applies to all of Lincoln Creek
Lincoln Creek Concrete or Enclosed Channel Upstream of Brynwood Country Club Pond (T8N R21E NE SW 15) to Headwaters	Variance Water[f] (NR 104.06(2)(a)(9))	**Variance Water**	Variance applies to all of Lincoln Creek
Milwaukee River from Abandoned North Avenue Dam (T7N R22E NW NE 21) to Confluence with Lake Michigan	Variance Water[g] (NR 104.06(2)(b)(1))	**Variance Water** *FAL*[d]	- -
Milwaukee River from River Mile 47.5 to Abandoned North Avenue Dam (T7N R22E NW NE 21)	FAL (DEF)[a]	**FAL**	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River South Branch Subwatershed (continued)			
Pigeon Creek (T9N R21E SW NW 23)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Beaver Creek) Natural Channel from Confluence with Milwaukee River (T8N R21E SE SW 1) to Concrete Channel (T8N R21E NW SW 1)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Beaver Creek) Concrete Channel Reach (T8N R21E SE SW 1) to North Ridge Lake Dam (T8N R21E SE SW 3)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Brown Deer Creek) (T8N R22E SW NW 7)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Fredonia Creek) T12N R21E NW NE 34)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Mole Creek) (T10N R21E NE NE 13)	FAL (DEF)[a]	**FAL** *COLD*[d]	- -
Unnamed Creek (Southbranch Creek) Natural Channel from Confluence with Milwaukee River (T8N R21E SW NW 12) to Concrete Channel at Churchill Road (T8N R21E NE SE 11)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Southbranch Creek) Concrete Channel Reaches (T8N R21E SE NW 12) to Headwaters	FAL (DEF)[a]	**FAL**	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
Milwaukee River South Branch Subwatershed (continued)			
Unnamed Creek (Trinity Creek) (T9N R21E SE NE 35)	FAL (DEF)[a]	**FAL**	- -
Unnamed Creek (Ulao Creek) (T9N R21E NE NE 12)	FAL (DEF)[a]	**FAL**	- -
MINOR STREAMS AND DIRECT DRAINAGE AREA TRIBUTARY TO LAKE MICHIGAN			
Fish Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Lake Michigan T9N R22E 33	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Lake Michigan T4N R23E NW SW 22	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Lake Michigan T4N R23E NE SE 17	FAL (DEF)[a]	**FAL**	- -
OAK CREEK WATERSHED			
Oak Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Oak Creek (Mitchell Field Drainage Ditch) T5N R22E SW NW 10	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Oak Creek (North Branch Oak Creek) T5N R22E SW SE 20	FAL (DEF)[a]	**FAL**	- -
ROOT RIVER WATERSHED			
Root River	FAL (DEF)[a]	**FAL**	- -
Hoods Creek	LFF (NR 104.06(1) Table 4 (20))	**LFF** *FAL*[h]	LFF applies from STH 20 downstream to confluence with Root River
Unnamed Tributary to Hoods Creek (Ives Grove Ditch) T3N R22E SW NW 9	LAL (NR 104.06(1) Table 4 (20))	**LAL** **LFF**[e]	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
ROOT RIVER WATERSHED (continued)			
Unnamed Tributary to Root River T5N R22E SW SE 34	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Root River T4N R22E NW NW 3	FAL (DEF)[a]	**FAL**	- -
Husher Creek T4N R22E NE SW 5	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Root River T4N R21E NW SE 1	FAL (DEF)[a]	**FAL**	- -
Root River Canal	FAL (DEF)[a]	**FAL**	- -
East Branch Root River Canal Upstream from STH 20	LAL (NR 104.06(1) Table 4 (5))	**LAL**	- -
East Branch Root River Canal from STH 20 Downstream to West Branch Root River Canal	LFF (NR 104.06(1) Table 4 (5))	**LFF**[e]	- -
West Branch Root River Canal	LFF & LAL (NR 104.06(1) Table 4 (30))	**LAL**[i]	Code lists 1. LAL from 67th Drive downstream to CTH C 2. LFF from CTH C downstream to STH 20
Unnamed Tributary to West Branch Root River Canal T3N R21E NW SW 10	FAL (DEF)[a]	**FAL**	- -
Ryan Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Root River T5N R21E SE NE 15	LAL (NR 104.06(1) Table 4 (21))	**LAL** *FAL*[h]	LAL applies from the former Rawson Homes Sewage Treatment Plant to the Root River
Dale Creek	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to Root River (Tess Corners Creek) T5N R21E NW NE 4	LFF (NR 104.06(1) Table 4 (10))	**LFF** *FAL*[h]	Code lists sections upstream and downstream from STH 45 separately

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
ROOT RIVER WATERSHED (continued)			
Unnamed Tributary to Root River (Whitnall Park Creek, also known as Hales Corners Tributary) T5N R21E NW NW 4 Upstream from the Former Hales Corners Sewage Treatment Plant (except for Upper Kelly Lake)	LAL (NR 104.06(1) Table 4 (7))	**LAL** *FAL*[h]	- -
Unnamed Tributary to Root River (Whitnall Park Creek, also known as Hales Corners Tributary) T5N R21E NW NW 4 from the Former Hales Corners Sewage Treatment Plant Downstream to Whitnall Park Pond	LFF (NR 104.06(1) Table 4 (7))	**LFF** *FAL*[h]	- -
Unnamed Tributary to West Branch Root River Canal (Yorkville Creek) T3N R21E SW SW 3	FAL (DEF)[a]	**FAL**	- -
Unnamed Tributary to West Branch Root River Canal (Raymond Creek) T4N R21E NW SE 26	FAL (DEF)[a]	**FAL**	- -
Diffuse Surface Drainage from the Former New Berlin Memorial Hospital Sewage Treatment Plant to Root River Tributary (T6N R20E 12)	LAL (NR 104.06(1) Table 4 (12))	**LAL** *FAL*[j]	- -
Tributary to Root River Downstream from the Former New Berlin Memorial Hospital Sewage Treatment Plant (T6N R20E S12)	LAL (NR 104.06(1) Table 4 (12))	**LAL** **FAL**[j]	- -

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Table 70 (continued)

Watershed or Subwatershed and Stream Reach	Codified Use[a,b]	RWQMPU/2020 Facilities Plan Designated and Auxiliary Uses to Be Considered for Planning Purposes[c]	Comments
ROOT RIVER WATERSHED (continued)			
Unnamed Tributary to West Branch Root River Canal from Wastewater Treatment Plant in T4N R21E NE SW 34 to Confluence with West Branch Root River Canal	FAL (DEF)[a]	**FAL**	- -

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[a]*When no specific use classification is identified (DEF), FAL applies as the default classification, as defined in NR 102.13.*

[b]*Codified use is identical in the 2002 edition of Wisconsin Trout Streams.*

[c]*Pending further public input which may result in some revisions.*

[d]*Based upon: Wisconsin Department of Natural Resources,* The State of the Milwaukee River Basin: August 2001, *PUBL WT-704-2001.*

[e]*Considered by WDNR in 2001.*

[f]*These waters shall meet the standards for fish and aquatic life except that the dissolved oxygen shall not be lowered to less than 2 mg/L at any time, nor shall the membrane filter fecal coliform count exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 2,000 per 100 ml in more than 10 percent of all samples in any month. This is interpreted to mean the current use is being achieved.*

[g]*These waters shall meet the standards for fish and aquatic life except that the dissolved oxygen shall not be lowered to less than 2 mg/L at any time, nor shall the membrane filter fecal coliform count exceed 1,000 per 100 ml as a monthly geometric mean based on not less than five samples per month nor exceed 89°F at any time at the edge of the mixing zones established by the WDNR under s. NR 102.05(3).*

[h]*Based upon Wisconsin Department of Natural Resources,* The State of the Root-Pike River Basin: May 2002, *PUBL WT-700-2002.*

[i]*Recommended for the reach from CTH C to Southern Colony.*

[j]*Based upon best professional judgment of fisheries biologist.*

[k]*Based upon modifications in channel type completed or committed to by MMSD.*

[l]*Based upon resource objectives developed by WDNR and MMSD for use in the Milwaukee County Grounds Detention Basin Design Program.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

3. **Enhancement of the Quality of Natural and Man-Made Environments**
   The development of land management and water quality control facilities, programs, operational improvements, and policies, including use of nonstructural practices and management changes, that will enhance the overall quality of the natural and man-made environments.

4. **Reduction of Sedimentation, Other Water Pollution, and Eutrophication**
   The attainment of soil and water conservation practices and urban stormwater management practices which reduce stormwater runoff and control nonpoint source pollution in the form of soil erosion, nutrient enrichment, stream and lake sedimentation, other pollution, and resulting eutrophication.

Outdoor Recreation and Open Space Preservation Objectives
Two outdoor recreation and open space preservation objectives similar to those adopted by SEWRPC under its regional park and open space planning program and under county planning programs are directly applicable to the regional water quality management plan update planning program. These are:

1. **Provision of Outdoor Recreation Sites**
   The provision of an integrated system of public general-use outdoor recreation sites and related open space areas, including environmental corridors encompassing water resources, which will allow the resident population of the watersheds involved adequate opportunity to participate in a wide range of outdoor recreation activities, while respecting private property rights.

2. **Preservation of Open Space**
   The preservation of sufficient high-quality open space lands for the protection of the underlying and sustaining natural resource base, to give form and sustainability to urban development and to enhance the social and economic well-being and environmental quality of the watersheds involved.

Water Control Facility Development Objective
One water control facility development objective similar to that adopted by SEWRPC in its watershed planning program has been adopted for use in the current plan. It is:

1. **Development of a System to Reduce Flood Damage**
   The development of an integrated system of stormwater management and flood control facilities, programs, operational improvements, and policies which will efficiently and cost-effectively reduce flood damage and stormwater drainage problems under the existing and future land use patterns and promote the implementation of land use and comprehensive plans in the Region's watersheds involved.

Plan Structure and Monitoring Objectives
Six plan structure and monitoring objectives have been developed for use in the current planning program. The first two of these objectives are similar to an objective adopted by SEWRPC under its comprehensive watershed and regional water quality management planning programs. The other four objectives were developed in response to the public input received under the current planning program. These objectives are:

1. **Development of Economical and Efficient Programs**
   The development of land management and water quality control facilities, programs, operational improvements, and policies, that are both economical and efficient, meeting all other objectives at the lowest practical cost, considering both long-term capital and operation and maintenance costs.

2. **Development of Strong Institutions for Plan Implementation**
   The development or use of land management and water quality management institutions, inclusive of the governmental units and their responsibilities, authorities, policies, procedures, and resources, and supporting revenue-raising mechanisms which are effective and locally acceptable, allowing the flexibility to provide a sound basis for plan implementation.

3. **Support of Economic Development and Job Creation**
   The development of land management and water quality control facilities, programs, operational improvements, and policies which are consistent with regional economic development and attendant job creation.

4. **Responsiveness of Adaptive and Flexible Plans**
The development of land management and water quality facilities, programs, operational improvements, and policies which are flexible, adaptive, and robust in response to changing conditions.

5. **Improvement of Assessment and Management**
Improvement of the abilities to assess the state of water resources, to detect changes in these states, to evaluate the overall environmental and economic impacts of these changes, and to prescribe remedies for improving undesirable states.

6. **Support of a Collaborative Approach to Water Quality Management**
The development of mechanisms for fostering cooperation and collaboration among governmental units, organizations, the public, and other parties concerned with the quality of the land and water resources in the Region, in support of the other objectives.

Educational and Informational Programming Objectives
One educational and informational programming objective has been developed for use in the current planning program in response to the public input received under the current planning program. It is:

1. **Support of an Informed and Educated Public**
The development of informational and educational mechanisms which will inform and educate the public and decision makers on water quality problems, needs, policies, and corrective actions, in support of the objectives above.

PRINCIPLES AND STANDARDS

Complementing each of the foregoing plan development objectives are one or more planning principles, which support the objective and assert its inherent validity, and a set of planning standards, which can be used to evaluate the relative or absolute ability of alternative plan designs to meet the stated objective. These principles and standards, as they apply to water resources planning, are set forth in Appendix G and serve to facilitate quantitative application of the objectives during plan design, test, and evaluation.

It should be noted that the planning standards set forth herein fall into two groups: comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. Absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values to the extent practical. The standards should serve as aids, not only in the development, test, and evaluation of watershed land use and water resources plans, but also with optional local refinement, in the development, test, and evaluation of local land use and community facility plans and in the development of plan implementation policies and programs.

Water Use Objectives/Classification and Water Quality Standards/Criteria
As described in Chapter VI, the WDNR currently has developed standards, or criteria, for the following water use objectives or classifications relating to fish and aquatic life for the study area watershed stream and lake system: 1) Great Lakes communities, 2) coldwater communities, 3) warmwater sport fish community, 4) warmwater forage fish community, 5) limited forage fish, and 6) limited aquatic life. In addition, the WDNR has developed standards, or criteria, for two recreational use classifications: 1) full recreational use and 2) limited recreational use; and it has developed standards, or criteria, for public health and welfare and for wildlife protection. The standards, or criteria, associated with each classification are documented in Chapter VI. The objectives or classifications for fish and aquatic life for all of the streams in the study area are set forth on Maps 51 through 56 and in Table 70. All of the fish and aquatic life categories are considered to be in the full recreational use category, except where a special variance is noted.

The fish and aquatic life and the recreational use objectives or classifications are those most directly related to the regional water quality management plan update. All streams are expected to meet the wildlife standards, or criteria. The public health and welfare standards, or criteria, vary only depending upon whether or not the surface water is used for public drinking water supply. Thus, there is no variation in the public health and welfare objectives or category for all of the surface waters in the study area, except Lake Michigan. The standards and criteria supporting the classifications are set forth in Chapter VI.

For selected surface waters in the study area, the regional water quality management plan update has evaluated the potential for achieving a higher objective or classification than currently codified. This evaluation is being made to assist in future planning and management strategies and is not intended to be directed as a change to the current regulatory framework. Those surface waters where an auxiliary upgraded water use objective or classification has been evaluated in the planning process and the basis for the auxiliary recommendations are set forth in Table 70. The evaluation of alternative classifications are largely being done in response to changes in conditions since the last relevant *Administrative Code* sections were promulgated.

The WDNR has also applied special-use designation to selected surface waters. These uses are “outstanding resource waters” and “exceptional resource waters,” as set forth in Chapter NR 102 of the *Wisconsin Administrative Code*. The classification of “outstanding resource waters” applies to designated national and scenic rivers. The classification of “exceptional resource waters” applies to surface water which provide valuable fisheries or other unique features. All Class I trout waters are included in the “exceptional resource waters” classification. Selected streams with the “exceptional resource waters” classification are located in the Upper Milwaukee River watershed.

As noted in Chapter VI of this report, Chapter NR 103 of the *Wisconsin Administrative Code* establishes water quality-related rules for wetlands. The rules consist of 1) a set of standards intended to protect the water quality-related functions of wetlands and 2) implementation procedures for application of the water quality standards. Because the application of the rules set forth in Chapter NR 103 is site-specific and requires consideration of the specific activity proposed within or adjacent to a wetland, wetland water quality standards are not specifically addressed in this report. The procedures documented in Chapter NR 103 must be applied by the WDNR on a site-specific, case-by-case basis.

Overriding Considerations

When applying the water resources development objectives, principles, and standards to the watershed plan elements, several overriding considerations must be recognized. First, it must be recognized that any recommended/proposed water quality management facility, program, operational improvement, or policy must constitute integral parts of a total system. It is not possible through application of these objectives and standards alone, however, to assure such system integration, since the objectives and standards cannot be used to determine the effect of individual facilities and controls on each other or on the system as a whole. This requires the application of planning and engineering techniques developed for this purpose, such as water quality simulation, to test quantitatively the performance of the proposed facilities as part of a total system, thereby permitting adjustment of the spatial distribution and capacities of the facilities to the existing and future runoff and waste loadings derived from the land use plan. Second, it must be recognized that it is unlikely that any one plan proposal will meet all the objectives and standards completely. Thus, the extent to which each objective and standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan proposal to achieve the plan objectives. Third, it must be recognized that certain objectives may be in conflict and that such conflict will require resolution through compromise; such compromise is an essential part of any design effort. The degree to which the recommended regional water quality management plan update meets the adopted objectives and standards is discussed in Chapter X of this report.

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Chapter VIII

FUTURE SITUATION: ANTICIPATED GROWTH AND CHANGE

INTRODUCTION

In any planning effort, forecasts are required of those future events and conditions on which the plan design and implementation are based. The future impacts on surface water quality and the future requirements for water quality infrastructure are, in part, determined by the size and spatial distribution of future population, land use, and economic activity in the greater Milwaukee watersheds. In preparation of this update to the regional water quality management plan, future populations and land use conditions had to be forecast. These forecasts were important because population and land use directly influence the demands placed upon land, water, and other important elements of the natural resource base. In addition, the population and land use forecasts are significant elements in determining future sewerage needs. These forecasts are important in order to estimate future wastewater flows, needed wastewater conveyance and treatment capacity, and loads related to point and nonpoint pollution sources.

For the development and modeling of screening alternatives and alternative water quality management plans as described in Chapter IX of this report, the design year 2020 regional land use plan,[1] supplemented by community-supplied estimates for municipalities in the MMSD planning area, served as a basis for the forecasts of population and land use and for the land use pattern envisioned in this update of the regional water quality management plan. However, as was anticipated when the work plan for the water quality plan update was developed, over the course of the planning process, projections became available from the design year 2035 regional land use plan,[2] facilitating updating of some 2020 forecasts to account for changing trends in population and land use within the study area as reflected by the 2035 land use plan.

BASIS OF POPULATION AND LAND USE FORECASTS

Population and land use forecasts presented in this chapter are based upon forecasts prepared for and used in other regional plan elements, including the regional land use plan. The use of forecasts prepared for comprehensive, areawide planning purposes helps to assure consistency between the regional water quality management plan update and other long-range, regional plan elements.

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[1]*SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

[2]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2005.*

Within the MMSD planning area, as shown on Map 1 in Chapter I of this report, 2020 and buildout population and land use estimates were initially developed by the SEWRPC staff by sewershed for 27 of the 28 MMSD member or contract communities based on future land use information provided by those communities. City of Milwaukee staff developed 2020 and buildout population and land use estimates by sewershed for the City, using the same methodology employed by the SEWRPC staff for the other communities served by the MMSD. Planned land use data from the SEWRPC 2020 regional land use plan was applied for communities in the study area that are not served by MMSD. Those initial year 2020 population and land development assessments were applied for developing and evaluating the screening alternatives and the alternative water quality management plans, providing a consistent basis for comparison of the screening alternatives and the alternative plans.

When data from the 2035 regional land use plan became available, 2020 land use and population estimates for the MMSD communities were revised using those data and the revised data were used to develop the regional sewerage system components called for under the recommended MMSD 2020 facilities plan, including components related to the Inline Storage System (ISS) and wastewater treatment plants. Similarly, refined population estimates were used for the 2020 condition evaluation of all of the other public wastewater treatment plants in the study area. Conveyance components of the MMSD system were still sized based on the original year 2020 population and land use estimates. The revised 2020 industrial and commercial land use estimates were also applied for the development of revised nonpoint source pollution loads within the MMSD planning area.

The rationale for using the original year 2020 population and land use estimates provided by the MMSD communities to size and evaluate conveyance components of the MMSD system under the preliminary and final recommended plans and using the revised year 2020 projections based on the 2035 regional land use plan to evaluate and size regional MMSD facilities under those plans was based on the possibility that, while the community-projected growth could occur in any given sewershed or community, it would not be likely to occur throughout the entire MMSD planning area. Thus, applying sewage flow estimates based on the original 2020 population and land use data would provide for adequate conveyance facilities, while applying sewage flow estimates based on the revised 2020 projections (which would more likely represent the overall conditions in the MMSD planning area tributary to the MMSD wastewater treatment plants), would enable facilities associated with those plants and the ISS to be appropriately sized, rather than oversized.

In order to provide a sound, long-term basis for sizing the potential Metropolitan Interceptor Sewers (MIS) that are conditionally called for under both the MMSD 2020 facilities plan and the recommended regional water quality management plan as described in Chapter X of this report, buildout population and commercial and industrial land use estimates were applied to evaluate the adequacy of those sewers. It was found that, except for the Ryan Road MIS relief sewer in the City of Oak Creek, all of the potential MIS projects as sized for revised 2020 baseline conditions would also have adequate capacity to convey the wastewater flows under buildout conditions. The MMSD 2020 facilities plan recommends additional study and flow monitoring prior to constructing the potential MIS relief sewers. The additional study would consider buildout conditions, but, depending on the results of the study and the monitoring, the Ryan Road relief sewer size may ultimately fall between the 48-inch-diameter pipe required under revised 2020 land use conditions and the 72-inch-diameter pipe required under buildout conditions.

MMSD Planning Area

Existing 2000 Data

For communities in the MMSD planning area, 2000 U.S. Census data were used by SEWRPC staff to determine existing year 2000 population and land use data sets by sewershed. These sewershed data were then aggregated into community estimates. In addition, existing 2000 population and land use were estimated using U.S. Public Land Survey quarter section boundaries to approximate community and watershed boundaries. These estimates were used for constructing revised 2020 baseline population and land use conditions.

Original 2020 Baseline and Buildout Forecasts

The 2020 baseline and buildout populations were based upon forecasts from the 2020 regional land use plan and current (1990-2000) growth trends within each community. Future land uses were based on a review of community land use plans and zoning classifications. Planned land uses were only identified on open lands and were designated for specific land use types. Planned redevelopment areas were identified during the community review process.

To make these estimates, projections of population and land use were developed for each community within the MMSD planning area based on the 2000 census and planned 2020 population and commercial and industrial land use areas. Commission staff and staff from MMSD's consultant team then met with representatives from each of the communities in MMSD's planning area to discuss the existing and planned 2020 and buildout population and land use data. All communities with the exception of the Village of River Hills met with Commission and consultant team staff.[3] These meetings typically involved:

- Providing the community representatives with background information on the regional water quality management plan update and MMSD facilities planning efforts.

- Reviewing the existing population and land use data.

- Reviewing the community's estimated population and planned land use.

During the process of refining demographic data and planned land use maps, Commission staff conducted 44 meetings and had numerous telephone conversations and considerable electronic and postal correspondence with staff from the communities. As necessary, Commission staff revised the 2020 baseline planned land use for each community based on comments received from community representatives.

After considering the communities' input, Commission staff compiled the 2020 baseline and buildout population and land use projections. Commission staff then provided this information to each community for final review and comment. Commission staff further refined the data sets based on additional community comments.

Updated Original 2020 Baseline and Buildout Forecasts
After the draft of MMSD's recommended 2020 Facilities Plan was completed, five municipalities provided comments and proposed revisions to the planned population and commercial and industrial land use forecasts. These communities were the Cities of Greenfield, Mequon, and Wauwatosa and the Villages of Brown Deer and Greendale. The following revisions were proposed by the municipalities:

- City of Greenfield—Increase original 2020 baseline population by about 20 percent, increase buildout population by about 31 percent, increase original 2020 baseline and buildout commercial land uses by 2 percent, and decrease original 2020 baseline and buildout industrial land uses by 20 percent.

- City of Mequon—Increase original 2020 baseline and buildout populations by about 5 percent, increase original 2020 baseline and buildout commercial land uses by 5 percent, and decrease original 2020 baseline and buildout industrial land uses by 2 percent.

- City of Wauwatosa—Increase original 2020 baseline populations by 17 percent, increase buildout population by about 4 percent, increase original 2020 baseline commercial land use by 31 percent, decrease buildout commercial land use by 1 percent, decrease original 2020 baseline industrial land use by 13 percent, and increase buildout industrial land use by 12 percent.

- Village of Brown Deer—Increase original 2020 baseline and buildout populations by about 10 percent and increase original 2020 baseline and buildout commercial land uses by 6 percent.

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[3]*River Hills is an essentially builtout community. Staff from River Hills indicated to Commission staff that no meeting was necessary.*

- Village of Greendale-Increase original 2020 baseline and buildout populations by about 11 percent, increase original 2020 baseline and buildout commercial land uses by 3 percent, and decrease original 2020 baseline and buildout industrial land uses by 39 percent.

Commission staff met with the five communities and conducted a detailed review of the proposed changes. Based on its review, Commission staff concluded that the requested revisions appeared reasonable considering each community's proposed development and redevelopment plans.[4]

Revised 2020 Baseline Forecasts

When the original 2020 baseline population and land use forecasts for the municipalities in the MMSD planning area were compiled and analyzed collectively, it became apparent that the total estimates were unrealistically high. The sum of all the community forecasts for the original 2020 baseline exceeded the projections that were developed for the 2035 land use plan.[5] For example, based upon estimates from the communities, the total of the original 2020 baseline industrial land area totaled 15,600 acres, exceeding the projected year 2035 estimate of 10,800 acres.[6] Similarly, the total of the community-based estimates for 2020 baseline projected a population of 1,269,100 persons for the MMSD planning area. This exceeded the year 2035 projection which estimated 1,200,000 persons.[7] While the community-based forecasts for 2020 represent a 17 percent increase over existing 2000 populations, the 2035 land use plan forecasts a 4 percent increase by 2020 and a 9.5 percent increase by 2035.

Upon review of the aggregate 2020 population and land use for the MMSD planning area based upon community estimates, it was recognized that while the community-projected growth could occur in any given sewershed or community, it would not be likely to occur throughout the entire MMSD planning area. Thus it was considered necessary to consider revisions to the 2020 baseline population and land use estimates.

Methods Used to Revise 2020 Baseline Population and Land Use

The general method used to compute the revised 2020 baseline community population estimates was linear interpolation between existing 2000 population and estimated future 2035 population from the 2035 land use plan. For each community, an annual growth rate was calculated from the existing 2000 population and estimated 2035 population, both based on the quarter section analysis. The revised 2020 baseline population estimate was then calculated by applying this rate to the existing 2000 population, as based on the 2000 census, to determine 20 years growth and adding it to the existing 2000 population.

The equation used to calculate the growth rate (r) is:

$$r = \left(\frac{P_{35qs} - P_{00qs}}{P_{00qs}} \right) \div 35,$$

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[4]*For the regional water quality management plan update, these population and land use changes are included directly in the "original 2020 baseline" condition. The MMSD facilities plan refers to the revised information as the "updated 2020 baseline" condition.*

[5]*SEWRPC Planning Report No. 48*, op. cit.

[6]Ibid.

[7]Ibid.

Where P_{35qs} designates estimated 2035 population based on the SEWRPC quarter section analysis and P_{00qs} designates existing 2000 population based on the SEWRPC quarter section analysis. The equation used to calculate the revised 2020 baseline population estimate (P_{20rev}) was:

$$P_{20rev} = P_{00cen} + (r \times P_{00cen} \times 20),$$

Where P_{00cen} designates the existing 2000 population as based on U.S. Census boundaries.

Similar procedures were used to calculate revised estimates of 2020 commercial and industrial land use.

This general procedure to estimate the revised 2020 baseline community population was suitable for most communities; however, a number of special adjustments needed to be made.

Adjustments to Revised 2020 Baseline Population

When the calculated estimate indicated that the revised 2020 baseline population was within 5 percent of the original 2020 baseline population, then the original 2020 baseline value was retained. This was done because the calculated growth rate is not sufficiently accurate to merit a change in the 2020 baseline value unless the change is more than 5 percent of the original value.

For the City of Glendale and the Villages of Shorewood and Whitefish Bay, the disaggregated 2000 data based on the quarter section analysis needed to be evaluated as a group. Therefore, these three communities were analyzed together as a single unit by summing the population numbers. The growth rate for the group was applied to the sum of the existing 2000 population values to determine the overall growth in population as a group. Then the overall growth was partitioned between the three communities based in proportion to the growth in the 2020 baseline values. This resulted in 66 percent of the growth being given to Glendale, 5 percent of the growth being given to Shorewood, and 29 percent of the growth being given to Whitefish Bay. This adjustment produced a substantial change for Glendale and minor changes for Shorewood and Whitefish Bay. The revised 2020 baseline population estimate for Glendale was determined by this special adjustment. For Shorewood and Whitefish Bay, the calculated values were within 5 percent of the original 2020 baseline values. Thus, the original 2020 baseline estimates were also used as the revised 2020 baseline values for these two communities.

Adjustments to Revised 2020 Baseline Community Commercial Land Use

As noted above, revised 2020 baseline community commercial land use estimates were computed using equations similar to those used to calculate the revised 2020 population estimates. Two special adjustments were made to the revised 2020 baseline community commercial land use estimates.

As with revised 2020 baseline population, when the calculated revised 2020 baseline commercial area was within 5 percent of the original 2020 baseline commercial area, the calculated estimate was not used. Instead, the original 2020 baseline estimate was used for consistency. This was done because the calculated growth rate is not sufficiently accurate to merit a change in the 2020 baseline value unless the change is more than 5 percent of the original value.

For the purposes of estimating revised 2020 baseline commercial area, the City of Brookfield and the Village of Elm Grove commercial areas were grouped together. The growth rate of the combined commercial area of the two communities was used to estimate the increase in the commercial area. This area was then partitioned between the two communities based on the relative distribution in the original 2020 baseline values. This resulted in 88 percent being assigned to Brookfield and 12 percent being assigned to Elm Grove.

Adjustments to Revised 2020 Baseline Community Industrial Land Use

Revised 2020 baseline community industrial land use values were computed using a method similar to that for population and commercial area as described above. When the result of the calculation was between the existing 2000 value and the original 2020 baseline value, the result was used as the revised 2020 baseline industrial land use value. The revised 2020 baseline industrial land use value was calculated for most communities using this method.

For those communities where the original 2020 baseline values showed growth, but the revised 2020 baseline values showed a decrease, the existing 2000 industrial area values were used as the revised 2020 baseline values. This was done because MMSD's conveyance system must operate for existing wastewater flows as well as future flows. Even if less flow is expected in the future, the system must meet the current needs. This approach was used to calculate revised 2020 baseline industrial area for the Cities of Brookfield, Greenfield, and Glendale and the Villages of Brown Deer, Greendale, and Shorewood.

For those communities where the original 2020 baseline values showed a decrease from the existing 2000 value and the revised 2020 baseline values showed an even larger decrease, the likelihood of a reduction in industrial area is high; only the degree of reduction is in question. In these cases, the revised 2020 baseline industrial area estimates were set equal to the original 2020 baseline industrial area values, in order to generate a conservative estimate. This method was used to calculate revised 2020 baseline industrial area for the Cities of Wauwatosa and West Allis and the Village of West Milwaukee.

An additional adjustment was performed to the revised 2020 baseline industrial area for the Village of Elm Grove. The disaggregated 2000 industrial area from the quarter section analysis indicated no industrial area in Elm Grove in the future. Because the 2020 baseline data showed 0.4 acres of industrial area, this value was used as the revised 2020 baseline industrial area for the Village.

Outside the MMSD Planning Area
Planned land use data from the SEWRPC 2020 regional land use plan was applied for communities in the study area that are not served by MMSD. Those initial year 2020 population and land development assessments were applied for developing and evaluating the screening alternatives, the alternative water quality management plans, and the recommended water quality management plan.

POPULATION

Table 71 shows the existing 2000, original 2020 baseline, and revised 2020 baseline population projections for communities in the regional water quality management plan update study area. The estimates given in the table include those portions of the Fox River watershed in the Cities of Brookfield, Franklin, Muskego, and New Berlin and the Village of Menomonee Falls that are located within the MMSD planning area. Planned condition wastewater flows from those areas were included in the analysis of year 2020 MMSD sewerage system needs.

Existing 2000 Data
The population of the regional water quality management plan update study area in 2000 was 1,312,566 persons (Table 71). About 82 percent of the population of the study area, or 1,072,950 persons, were located in the MMSD planning area, with the remaining 18 percent of the population, or 239,616 persons, located in those portions of the study area outside the MMSD planning area. The majority of the population of the study area, 71.7 percent, resided in Milwaukee County. The portions of the study area in Waukesha, Racine, Washington, and Ozaukee Counties accounted for 8.3 percent, 7.4 percent, 6.1 percent, and 5.1 percent, respectively, of the population of the study area. The portions of the study area in Dodge, Fond du Lac, Kenosha, and Sheboygan Counties each accounted for less than 1 percent of the population of the study area.

Original 2020 Baseline Forecasts
The original 2020 baseline population forecast envisions that the population of the regional water quality management plan update study area would increase by about 17 percent to 1,538,230 persons in 2020 (Table 71). This projection envisions that about 83 percent of the population of the study area, or 1,267,113 persons, would be located in the MMSD planning area, with the remaining 18 percent of the population, or 271,117 persons, projected to be located in those portions of the study area outside the MMSD planning area. The majority of the population of the study area, 70 percent, is projected to reside in Milwaukee County. The portions of the study

Table 71

EXISTING 2000 AND FORECAST 2020 POPULATION IN THE GREATER MILWAUKEE WATERSHEDS

Civil Division	Existing 2000 Population[a]	Original 2020 Baseline Population Forecast[a,b]	Revised 2020 Baseline Population Forecast[a,c]
Dodge County			
Village of Lomira	155	147	- -
Town of Lomira	132	125	- -
Subtotal	287	272	- -
Fond du Lac County			
Village of Campbellsport	1,913	2,115	- -
Town of Ashford	1,773	2,030	- -
Town of Auburn	2,075	2,496	- -
Town of Byron	375	428	- -
Town of Eden	778	718	- -
Town of Osceola	1,779	2,074	- -
Subtotal	8,693	9,861	- -
Kenosha County			
Town of Paris	56	60	- -
Subtotal	56	60	- -
Milwaukee County			
City of Cudahy	18,429	20,599	18,681
City of Franklin[d]	29,494	45,314	40,411
City of Glendale	13,367	14,607	13,532
City of Greenfield	35,476	46,534[e]	36,899
City of Milwaukee	596,974	645,888	601,327
City of Oak Creek	28,456	49,291	41,474
City of South Milwaukee	21,256	22,351	22,351
City of St. Francis	8,662	14,299	10,505
City of Wauwatosa	47,271	56,484[e]	48,278
City of West Allis	61,254	79,522	63,866
Village of Bayside	4,507	4,490	4,490
Village of Brown Deer	12,170	14,490[e]	12,470
Village of Fox Point	7,012	7,001	7,001
Village of Greendale	14,405	16,043[e]	14,396
Village of Hales Corners	7,765	10,021	9,062
Village of River Hills	1,631	1,667	1,667
Village of Shorewood	13,763	13,853	13,853
Village of West Milwaukee	4,201	4,632	4,632
Village of Whitefish Bay	14,163	14,707	14,707
Subtotal	940,267	1,081,813	979,622
Ozaukee County			
City of Cedarburg	10,906	14,890	- -
City of Mequon	22,601	29,666[e]	25,231
Village of Bayside	11	20	20
Village of Fredonia	1,863	2,307	- -
Village of Grafton	11,090	13,295	- -
Village of Saukville	4,088	5,236	- -
Village of Thiensville	3,254	3,811	3,529
Town of Cedarburg	5,703	5,894	- -
Town of Fredonia	1,955	2,155	- -
Town of Grafton	3,421	3,595	- -
Town of Port Washington	414	414	- -
Town of Saukville	1,852	2,018	- -
Subtotal	67,158	83,301	78,584[f]

Table 71 (continued)

Civil Division	Existing 2000 Population[a]	Original 2020 Baseline Population Forecast[a,b]	Revised 2020 Baseline Population Forecast[a,c]
Racine County			
City of Racine	55,696	54,493	- -
Village of Caledonia[g]	23,438	26,304	- -
Village of Mt. Pleasant	5,925	8,344	- -
Village of North Bay	- -[h]	- -[h]	- -[h]
Village of Union Grove	2,528	3,222	- -
Village of Wind Point	1,941	1,863	- -
Town of Dover	552	619	- -
Town of Raymond	3,348	3,547	- -
Town of Yorkville	2,834	3,125	- -
Caddy Vista Sanitary District[g]	756	1,371	1,002
Subtotal	97,018	102,888	102,519[f]
Sheboygan County			
Village of Adell	517	510	- -
Village of Cascade	666	671	- -
Village of Random Lake	1,551	1,776	- -
Town of Greenbush	1,389	1,620	- -
Town of Lyndon	939	1,117	- -
Town of Mitchell	1,098	1,480	- -
Town of Scott	1,804	2,072	- -
Town of Sherman	1,459	1,512	- -
Subtotal	9,423	10,758	- -
Washington County			
City of West Bend	27,652	38,039	- -
Village of Germantown	18,260	25,459	22,541
Village of Jackson	4,944	5,419	- -
Village of Kewaskum	3,185	4,312	- -
Village of Newburg	1,046	1,564	- -
Town of Barton	2,543	2,656	- -
Town of Farmington	3,239	3,417	- -
Town of Germantown	205	189	- -
Town of Jackson	3,541	3,834	- -
Town of Kewaskum	1,211	1,267	- -
Town of Polk	3,088	3,249	- -
Town of Richfield	1,893	1,957	- -
Town of Trenton	4,591	4,806	- -
Town of Wayne	438	460	
Town of West Bend	4,459	5,010	
Subtotal	80,295	101,638	98,720[f]
Waukesha County			
City of Brookfield[d]	17,176	21,075	18,227
City of Muskego[d]	20,066	34,125	25,340
City of New Berlin[d]	34,324	43,349	38,145
Village of Butler	1,881	1,908	1,908
Village of Elm Grove	6,249	8,113	6,347
Village of Menomonee Falls[d]	29,372	38,774	32,196
Town of Brookfield	278	270	- -
Town of Lisbon	13	25	- -
Subtotal	109,359	147,639	122,458[f]
Total	1,312,556	1,538,230	1,402,854[f]

Table 71 Footnotes

[a]*For communities in the MMSD planning area, actual civil division and watershed boundaries were used. For communities outside the MMSD planning area, civil division and watershed boundaries were approximated by U.S. Public Land Survey one-quarter sections.*

[b]*Based upon projections in the 2020 land use plan within the study area, but outside the MMSD planning area. Based upon projections by local communities within the MMSD planning area.*

[c]*For communities in the MMSD planning area, based upon linear interpolation between existing 2000 population and projected 2035 population in the 2035 regional land use plan. The original 2020 baseline forecasts were used for those communities in the study area, but outside of the MMSD planning area.*

[d]*Includes the portion of the community within the Fox River watershed that is within the MMSD planning area.*

[e]*Updated original 2020 projection based on additional data submitted by community.*

[f]*Represents the sum of original 2020 forecast for communities outside of the MMSD planning area and revised 2020 forecasts for communities in the MMSD planning area.*

[g]*Village of Caledonia population does not include the portion of the Village comprising the Caddy Vista Sanitary District.*

[h]*Because the Village of North Bay covers a relatively small land area, that does not lend itself to quantification on an U.S. Public Land Survey one-quarter section basis, the Village population is not specified separately in this table, but it is included in the population estimates for the City of Racine.*

Source: Wisconsin Department of Administration and SEWRPC.

area in Waukesha, Racine, Washington, and Ozaukee Counties are projected to account for 9.6 percent, 6.7 percent, 6.6 percent, and 5.4 percent, respectively, of the population of the study area. The portions of the study area in Dodge, Fond du Lac, Kenosha, and Sheboygan Counties are each projected to account for less than 1 percent of the population of the study area.

Revised 2020 Baseline Forecasts

To produce areawide totals for the study area corresponding to the revised 2020 baseline population forecasts, the revised 2020 population estimates for the communities in the MMSD planning area were added to the original 2020 baseline estimates for those communities outside the MMSD planning area.

The revised 2020 baseline population forecast envisions that the population of the regional water quality management plan update study area would increase by about 7 percent to 1,402,854 persons in 2020 (Table 71). This projection envisions that about 81 percent of the population of the study area, or 1,131,737 persons, would be located in the MMSD planning area, with the remaining 19 percent of the population, or 271,117 persons, projected to be located in those portions of the study area outside the MMSD planning area. The majority of the population of the study area, 69.6 percent, is projected to reside in Milwaukee County. The portions of the study area in Waukesha, Racine, Washington, and Ozaukee Counties are projected to account for 8.7 percent, 7.3 percent, 7.0 percent, and 5.6 percent, respectively, of the population of the study area. The portions of the study area in Dodge, Fond du Lac, Kenosha, and Sheboygan Counties are each projected to account for less than 1 percent of the population of the study area.

Buildout Population Forecasts

Buildout population forecasts were only developed for communities within the MMSD planning area. The buildout population forecast envisions that the population of the MMSD planning area would increase by 31 percent to 1,433,169 persons (Table 72). The majority of the population of the planning area, 83.3 percent, is projected to reside in Milwaukee County. The portions of the planning area in Waukesha, Racine, Washington, and Ozaukee Counties are projected to account for 12.1 percent, 0.1 percent, 2.0 percent, and 2.5 percent, respectively, of the population of the planning area.

Table 72

POPULATION COMPARISON IN THE MMSD PLANNING AREA

Civil Division	Existing 2000 Population	Original 2020 Baseline Population Forecast[a]	Revised 2020 Baseline Population Forecast[b]	Buildout Population[a]
City of Brookfield[c]	17,176	21,075	18,227	26,124
City of Cudahy	18,429	20,599	18,681	21,621
City of Franklin[c]	29,494	45,314	40,411	57,015
City of Glendale	13,367	14,607	13,532	15,269
City of Greenfield[d]	35,476	46,534	36,899	50,926
City of Mequon[d]	22,601	29,666	25,231	31,350
City of Milwaukee	596,974	645,888	601,327	685,023
City of Muskego[c]	20,066	34,125	25,340	49,413
City of New Berlin[c]	34,324	43,349	38,145	44,156
City of Oak Creek	28,456	49,291	41,474	58,225
City of South Milwaukee	21,256	22,351	22,351	22,959
City of St. Francis	8,662	14,299	10,505	15,310
City of Wauwatosa[d]	47,271	56,484	48,278	82,140
City of West Allis	61,254	79,522	63,866	96,999
Village of Bayside	4,518	4,510	4,510	4,510
Village of Brown Deer[d]	12,170	14,490	12,470	15,045
Village of Butler	1,881	1,908	1,908	1,908
Village of Elm Grove	6,249	8,113	6,347	9,217
Village of Fox Point	7,012	7,001	7,001	7,001
Village of Germantown	18,260	25,459	22,541	27,950
Village of Greendale[d]	14,405	16,043	14,396	16,043
Village of Hales Corners	7,765	10,021	9,062	10,350
Village of Menomonee Falls[c]	29,372	38,774	32,196	43,294
Village of River Hills	1,631	1,667	1,667	1,667
Village of Shorewood	13,763	13,853	13,853	14,005
Village of Thiensville	3,254	3,811	3,529	3,811
Village of West Milwaukee	4,201	4,632	4,632	5,130
Village of Whitefish Bay	14,163	14,707	14,707	14,707
Caddy Vista Sanitary District	756	1,371	1,002	2,001
Total	1,094,206	1,289,464	1,154,088	1,433,169

[a] *Based upon projections by communities.*

[b] *Based upon linear interpolation between the existing 2000 population and projected 2035 population in the 2035 regional land use plan.*

[c] *Includes the portion of the community within the Fox River watershed that is within the MMSD planning area.*

[d] *Updated original 2020 baseline and buildout projections based on additional data submitted by the community.*

Source: SEWRPC.

LAND USE

Table 73 shows the existing 2000, original 2020 baseline, revised 2020 baseline, and buildout industrial and commercial land use projections for communities in the MMSD planning area. The estimates given in the table include those portions of the Fox River watershed in the Cities of Brookfield, Franklin, Muskego, and New Berlin and the Village of Menomonee Falls that are located within the MMSD planning area.

In 2000, commercial land uses occupied 9,529.4 acres in the MMSD planning area. The original 2020 baseline projection envisions that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by commercial land uses will increase by 34 percent to 12,808.7 acres in 2020. The revised 2020 baseline projection envisions that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by commercial land uses will increase by 18 percent to 11,215.3 acres in 2020. The buildout projection envisions

Table 73

EXISTING 2000 AND FORECAST 2020 COMMERCIAL AND INDUSTRIAL LAND USE IN THE MMSD PLANNING AREA

Civil Division	Commercial Land Use (acres)				Industrial Land Use (acres)			
	Existing 2000	Original 2020 Baseline[a]	Revised 2020 Baseline[b]	Buildout[a]	Existing 2000	Original 2020 Baseline[a]	Revised 2020 Baseline[b]	Buildout[a]
City of Brookfield[c]	477.8	596.4	525.4	596.4	187.1	220.2	187.1	220.2
City of Cudahy	146.2	209.9	178.5	254.4	343.0	455.5	344.3	535.8
City of Franklin[c]	382.2	702.5	623.5	1,010.8	349.0	740.2	474.5	1,671.9
City of Glendale	317.0	392.2	364.6	448.2	319.6	352.3	319.6	352.3
City of Greenfield	491.2	639.2[d]	544.6	639.2	20.0	22.4[d]	20.0	22.4
City of Mequon	316.9	467.0[d]	382.7	467.0	272.4	1,007.0[d]	317.8	1,007.0
City of Milwaukee	3,473.3	3,718.9	3,718.9	3,718.9	4,045.6	5,219.5	4,092.9	5,220.1
City of Muskego[c]	163.6	358.5	201.1	358.5	139.6	237.0	147.8	237.0
City of New Berlin[c]	489.2	733.8	640.7	733.8	697.8	1,405.6	808.6	1,476.3
City of Oak Creek	424.5	757.0	653.7	1,135.8	763.0	1,259.3	829.3	1,890.6
City of South Milwaukee	85.4	106.3	91.9	106.3	158.0	141.0	141.0	134.2
City of St. Francis	69.6	114.6	82.9	114.6	86.5	143.5	86.5	143.5
City of Wauwatosa	512.7	806.1[d]	613.4	1,077.0	497.2	426.8[d]	491.4	275.6
City of West Allis	580.6	662.8	614.8	662.8	522.0	434.3	434.3	367.3
Village of Bayside	34.5	35.8	35.8	35.8	0.0	0.0	0.0	- -
Village of Brown Deer	232.0	287.5[d]	242.7	287.5	113.5	126.2 [d]	113.5	126.2
Village of Butler	48.8	49.3	49.3	49.3	154.8	165.0	155.3	165.0
Village of Elm Grove	59.8	76.5	66.5	105.0	14.1	0.4	0.4	0.4
Village of Fox Point	33.6	33.4	33.4	33.4	0.0	0.0	0.0	- -
Village of Germantown	275.3	799.0	417.3	973.4	425.7	1,352.8	491.5	1,655.9
Village of Greendale	140.0	153.1[d]	148.3	153.1	51.2	34.5[d]	51.2	34.5
Village of Hales Corners	115.8	126.3	126.3	126.3	2.2	6.2	2.2	6.2
Village of Menomonee Falls[c]	522.1	797.2	673.6	797.2	970.5	1,494.5	1,068.1	1,666.3
Village of River Hills	0.0	0.0	0.0	- -	0.0	0.0	0.0	- -
Village of Shorewood	36.2	35.3	35.3	35.3	0.0	0.0	0.0	- -
Village of Thiensville	52.7	54.2	54.2	54.2	5.0	1.9	4.0	1.9
Village of West Milwaukee	29.2	74.4	74.4	118.9	289.1	264.2	264.2	251.8
Village of Whitefish Bay	19.2	21.5	21.5	21.5	0.0	0.0	0.0	- -
Caddy Vista Sanitary District	0.0	0.0	0.0	- -	0.0	0.0	0.0	- -
Total	9,529.4	12,808.7	11,215.3	14,114.6	10,426.9	15,510.3	10,845.5	17,462.4

[a]*Based upon projections by communities.*

[b]*Based upon linear interpolation between the existing 2000 land use and projected land use in the SEWRPC 2035 land use plan.*

[c]*Includes the portion of the community within the Fox River watershed that is within the MMSD planning area.*

[d]*Updated original 2020 baseline projection based on additional data submitted by the community.*

Source: SEWRPC.

that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by commercial land uses will increase by 48 percent to 14,114.6 acres.

In 2000, industrial land uses occupied 10,426.9 acres in the MMSD planning area (Table 73). The original 2020 baseline projection envisions that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by industrial land uses will increase by 49 percent to 15,510.3 acres in 2020. The revised 2020 baseline projection envisions that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by industrial land uses will increase by 4 percent to 10,845.5 acres in 2020. The buildout projection envisions that, relative to 2000 conditions, the amount of land in the MMSD planning area occupied by industrial land uses will increase by 67 percent to 17,462.4 acres.

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Chapter IX

DEVELOPMENT OF ALTERNATIVE PLANS: DESCRIPTION AND EVALUATION

INTRODUCTION

The inventory and analysis phase of the regional water quality management plan update identified certain water resource problems, including water pollution from both point and nonpoint sources. As stated in Chapter I, the primary purpose of this plan update is to develop a sound and workable plan for the abatement of water pollution in the greater Milwaukee watersheds so as to meet the plan objectives that are set forth in Chapter VII. More specifically, the planning program is intended to set forth a framework plan for the management of surface water for the greater Milwaukee watersheds incorporating measures to abate existing pollution problems and to prevent future pollution problems.

This chapter presents alternative plans for water pollution abatement and evaluates those plans in order to provide a basis for the selection of the best water quality management elements for incorporation into the comprehensive water quality management plan. More specifically, this chapter analyzes the extent to which various alternative water pollution abatement measures may be expected to achieve the agreed-upon water use objectives, and, based on evaluation of the technical, economic, and environmental performance of the alternatives considered, recommends an integrated preliminary set of water quality management measures for incorporation into the regional water quality management plan update.

The material presented in this chapter is organized as follows. First, the relationships are described between the regional water quality management plan update and:

- The Milwaukee Metropolitan Sewerage District (MMSD) 2020 facilities planning program,
- The Wisconsin Department of Natural Resources (WDNR) Milwaukee River and Pike and Root River basin planning programs, and
- The Regional land use planning program.

Next, a discussion of plan design criteria and procedures is presented, followed by a review and evaluation of potential water quality management options, including screening alternatives. Water pollution abatement alternatives are then advanced and evaluated. Based upon the evaluation of these alternatives, a preliminary recommended set of water quality management measures is presented. Finally, a summary of the chapter is provided.

RELATIONSHIP TO MILWAUKEE METROPOLITAN SEWERAGE DISTRICT 2020 FACILITIES PLANNING PROGRAM

The MMSD has defined a series of interrelated projects which are designed to carry out its sewage management responsibilities, and which are collectively referred to as the Milwaukee water pollution abatement program. These projects were developed through facility planning programs which were subregional in nature, the latest of which was completed in 1998 and had a design year of 2010. The present MMSD initiative seeks to amend and extend its sewerage facilities plan to a design year of 2020. As stated in Chapter I, the regional water quality management plan update for the greater Milwaukee watersheds was carried out in a cooperative manner with the ongoing MMSD 2020 facility planning program, with both projects being conducted as separate, but coordinated and cooperative, work efforts. These two planning efforts were coordinated for many of the work elements and selected work elements were jointly carried out, including the development and evaluation of a single set of alternative water quality management plans.

In carrying out the update to its facility planning program, the MMSD advanced the notion of taking a watershed-based approach that includes evaluation of water quality impacts of receiving waters impacted by its facilities, as opposed to simply considering end-of-pipe conditions. As such, this approach correlates with the type of evaluation adopted under the original regional water quality management plan and the current update to that plan, which also are based on evaluations of instream and in-lake water quality on a watershedwide basis.

RELATIONSHIP TO MILWAUKEE RIVER AND PIKE AND ROOT RIVER BASIN PLANNING PROGRAMS

The WDNR currently carries out program management and planning for the Milwaukee River basin, comprised of the Kinnickinnic, Menomonee, and Milwaukee River watersheds, and the Root-Pike basin, which includes the Root River and Oak Creek watersheds.[1] The Department has prepared state-of-the-basin plans for each of these basins.[2] These plans include resource management recommendations related to WDNR programmatic activities, including surface water quality objectives (classifications), sewerage system management, and related water resources programs.

The regional water quality management plan update planning program has included review and coordination with the WDNR basin planning. This includes incorporation of the current regulatory surface water use classifications as well as potential higher use classifications that were presented in the state-of-the-basin reports. Those higher use classifications are largely being considered in response to changes in conditions since the regulatory uses were last promulgated. Both the current regulatory and auxiliary water use classifications are presented in Chapter VII of this report. The development and evaluation of the alternative water quality management plan elements presented in this chapter focused on the degree to which those alternative plans achieve these use objectives.

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[1]*The Root-Pike basin also includes the Pike River watershed located in Kenosha and Racine Counties and the portion of the Lake Michigan direct drainage area extending from the mouth of Oak Creek south to the Wisconsin-Illinois state line. The Pike River watershed and the portion of the Lake Michigan direct drainage area south of the mouth of the Root River are not part of the greater Milwaukee watersheds that are the subject of this regional water quality management plan update.*

[2]*Wisconsin Department of Natural Resources,* The State of the Milwaukee River Basin, *August 2001; and Wisconsin Department of Natural Resources,* The State of the Root-Pike River Basin, *May 2002.*

Between 1979 and 1990, seven portions of the greater Milwaukee watersheds were designated as priority watersheds under the Wisconsin Nonpoint Source Pollution Abatement Program.[3] These priority watersheds included all of the greater Milwaukee watersheds, except for the Oak Creek watershed and the Lake Michigan direct drainage area. Plans were prepared for these priority watershed projects which identified the need for reductions in pollutant loadings to the streams of the watersheds in order to meet water quality objectives. While the needs identified varied among the priority watersheds, they typically included reductions in loads of sediment, phosphorus, heavy metals, and total pollutants delivered to the streams of the watershed.[4] In addition, these plans recommended a number of management actions and practices to be implemented over the project period for both rural and urban lands. Implementation of these plans was intended to be achieved by a program of educational activities and a funding program which provided cost-share agreements with eligible municipalities, landowners, and operators for the installation of land management practices. This program provided funding for a variety of activities related to abatement of nonpoint source water pollution. In the greater Milwaukee watersheds, these projects were completed between 1989 and 2001.

RELATIONSHIP TO LAND USE PLANNING

One of the major elements of the regional water quality management plan update is the incorporation of updated land use information, including both an inventory of existing (2000) development and the identification of planned year 2020 development. A summary of existing development is presented in Chapter II, while a discussion of planned future development is set forth in Chapter VIII.

Evaluations of water quality conditions within the greater Milwaukee watersheds were carried out for both existing and planned year 2020 land use conditions. For the existing land use condition, application of the water quality models included existing point sources and current operating procedures for the MMSD Inline Storage System. Nonpoint source loadings were simulated assuming the current level of urban and rural best management practices. For the planned year 2020 land use evaluation, application of the water quality models included consideration of point sources under expected 2020 conditions, and committed MMSD projects, including wastewater conveyance and storage system expansion and watercourse flood management projects, such as the Milwaukee County Grounds floodwater storage basin. Implementation of practices for the control of nonpoint source pollutants and stormwater runoff as required under current regulations including Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* and Chapter 13, "Surface Water and Storm Water," of the MMSD Discharge Regulations and Enforcement Procedures was also accounted for.

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[3]*SEWRPC Community Assistance Planning Report No. 37,* A Nonpoint Source Water Pollution Control Plan for the Root River Watershed, *March 1980; Wisconsin Department of Natural Resources,* Nonpoint Source Control Plan for the Cedar Creek Priority Watershed Project, *August 1993; Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the East and West Branches of the Milwaukee River Priority Watershed Project, *February 1989; Wisconsin Department of Natural Resources,* Nonpoint Source Control Plan for the Kinnickinnic River Priority Watershed Project, *October 1994; Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Menomonee River Priority Watershed Project, *March 1992; Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the Milwaukee River South Priority Watershed Project, *December 1991; Wisconsin Department of Natural Resources,* A Nonpoint Source Control Plan for the North Branch Milwaukee River Priority Watershed Project, *July 1989.*

[4]*The pollutant loading analyses conducted for the priority watershed studies did not include simulation modeling of instream water quality under existing, planned, alternative, and recommended plan conditions.*

The planned year 2020 condition also served as the baseline condition for comparison of the alternative water quality management plans that are presented in this chapter.[5] That condition is described in greater detail later in this chapter in the section describing Alternative A–Baseline Alternative.

WATER QUALITY MANAGEMENT PLANNING CRITERIA AND ANALYTIC PROCEDURES

Certain planning criteria and analytic procedures were utilized in designing alternative plan elements, in testing the technological feasibility of those elements, and in making the necessary economic comparisons. The procedures used in the development of the point and nonpoint source pollution control measures are described in the following sections of this chapter. Also described are the procedures used in the economic analyses.

Basis for Development and Analysis of Alternative Water Quality Management Plans

The alternative water quality management plan elements presented in this chapter are the result of the collaborative planning process between the MMSD 2020 Facilities Plan and the regional water quality management plan update. That process included consideration of the public and stakeholder input that was obtained as part of these planning efforts. A description of the program for public involvement in the planning process was provided in Chapter I.

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[5]*As described in Chapter VIII, 2020 and buildout population and land use estimates by sewershed for 27 of the 28 MMSD member or contract communities were initially developed by the SEWRPC staff based on future land use information provided by those communities. City of Milwaukee staff developed 2020 and buildout population and land use estimates by sewershed for the City, using the same methodology employed by the SEWRPC staff for the other communities served by the MMSD. Planned land use data from the SEWRPC 2020 Regional land use plan was applied for communities in the study area that are not served by MMSD. Those initial year 2020 population and land development assessments were applied for developing and evaluating the screening alternatives and the alternative water quality management plans. That approach provided a consistent basis for comparison of the screening alternatives and the alternative water quality plans.*

The work plan for the regional water quality management plan update anticipated the SEWRPC 2035 regional land use plan would be completed during the course of preparing the regional water quality plan. Thus, when data from the 2035 plan became available, 2020 land use and population estimates for the MMSD communities were revised using those data and the revised data were used to develop the wastewater treatment components called for under the recommended MMSD 2020 Facilities Plan, which is incorporated in the preliminary and final recommended regional water quality management plans. Similarly, refined population estimates were used for the 2020 condition evaluation of all of the other public sewage treatment plants in the study area. As described in Chapter VIII of this report, conveyance components of the MMSD system were still sized based on the original year 2020 population and land use estimates. The revised 2020 industrial and commercial land use estimates were also applied for the development of revised nonpoint source pollution loads used in the preliminary recommended water quality management plan described at the end of this chapter.

The rationale for using the original year 2020 population and land use estimates provided by the MMSD communities to size and evaluate conveyance components of the MMSD system under the preliminary and final recommended plans and using the revised year 2020 projections based on the 2035 regional land use plan to evaluate and size regional MMSD treatment facilities under those plans was based on the possibility that, while the community-projected growth could occur in any given sewershed or community, it would not be likely to occur throughout the entire MMSD planning area. Thus, applying sewage flow estimates based on the original 2020 population and land use data would provide for adequate conveyance facilities, while applying sewage flow estimates based on the revised 2020 projections (which would more likely represent the overall conditions in the MMSD planning area tributary to the MMSD wastewater treatment plants), would enable facilities associated with those plants to be appropriately sized, rather than oversized.

Surface water use objectives (classifications) and supporting water quality standards were the primary basis for plan design and evaluation. For the purposes of the water quality analyses, the water use objectives and supporting standards used were those set forth in Chapter VII of this report. The water quality standards specify maximum or minimum levels for certain substances indicative of water quality conditions that are required to support recreational uses in the water, and desired healthy populations of fish and other aquatic life.

Combined and Separated Sewer Overflow Abatement Measures
Under the regional water quality management plan update, consideration of measures to abate overflows from both the combined and separate sanitary sewer systems was a multi-step process. The first step was the development of a state-of-the-art report on pollution abatement technologies which is discussed below. Using the information presented in that report regarding costs and effectiveness in reducing pollutant loading for the various technologies, further evaluations were carried out through the development of screening alternatives. Both the state-of-the-art report and the screening alternative analyses were then used to help guide the selection of the most favorable measures to be included in the water quality management alternative plans presented later in this chapter. Evaluation of an alternative's ability to reduce overflows was based on application of the conveyance system simulation models that were described in Chapter V. Model simulation was carried out for a 64.5-year period from January 1940 through June 2004 using recorded precipitation values from Milwaukee General Mitchell International Airport.

Other Point Source Abatement Measures
The adopted regional water quality management plan included recommendations for the abatement of pollutants from point sources. This included a recommendation regarding the level of phosphorus removal for wastewater treatment plants that discharge directly to streams or lakes. Under the adopted plan, it was recommended that these plants implement conventional phosphorus removal measures to achieve a phosphorus concentration of 1.0 mg/l or less in the effluent. Current operating rules enforced by the WDNR call for effluent phosphorus levels not to exceed 1.0 mg/l for those treatment plants located within the planning area. Therefore, it was assumed under this planning effort that the recommendation set forth in the previously adopted water quality plan will be met for the design year 2020 condition. Additionally, consideration was given to the achievement of the water use objectives (classifications) and supporting standards as described above.

Nonpoint Source and Stormwater Management Abatement Measures
Development and evaluation of various measures to abate nonpoint source pollution was carried out in the same manner as the CSO and SSO abatement measures. That is, an initial inventory and evaluation of available technologies was included in the development of the state-of-the-art report that was prepared as part of this planning effort. Using the results of that report as a guide, further evaluations were carried out during the screening alternative analysis. Finally, both the state-of-the-art report and the results from the screening alternatives were used to guide the development of the alternative water quality management plans.

Economic Evaluation
The concepts of economic analysis and economic selection are vital to the public planning process. Sound economic analysis should be an important guide to planners and decision makers in the selection of the most suitable plan from an array of alternatives. With respect to water quality management planning, the cost-effectiveness of a given control measure refers to the cost of that measure relative to the attendant water quality improvements that may be expected. Therefore, the most cost-effective measure provides the most water quality benefits at the lowest cost.

The costs presented in this report are sufficiently accurate for systems level planning, but should be refined during facilities planning and project engineering. At the systems level of planning, the cost information is used primarily to compare alternatives on a consistent basis.

Planning Period and Economic Life
The physical life of a facility is that period between its original construction and final disposal of the facility. The economic life is defined as the period after which the incremental benefits from continued use no longer exceed

the incremental cost of operation. In the economic analyses conducted under the regional water quality management plan update, the time period over which the facility is totally depreciated was made equal to the economic life.

Although the plan design year for the regional water quality management plan update is 2020, the economic life of certain planned facilities will extend beyond this design year. Accordingly, a salvage value was assigned to those facilities with an economic life extending beyond the end of the economic analysis period. For purposes of the economic analyses, an economic life of 50 years was assumed for sewers; certain stormwater best management practices, such as wet detention basins and modular sedimentation/flotation/filtering devices; major structural facilities and land. An economic life of 20 years was assumed for pumps and other major electrical and mechanical equipment and for stormwater infiltration facilities. While the plan design period or planning period used was 14 years, from 2007 to 2020, the economic analysis period used was 2007 through 2056. All costs are expressed in 2007 dollars. An interest rate of 6 percent and analysis period of 50 years was used in all of the economic analyses under the regional water quality management plan update planning program.

Following sound principles of engineering economic analyses, no escalation over time of construction, operation, maintenance, or replacement costs was considered. In the economic evaluations, provisions for the replacement of shorter-lived components were incorporated into the total economic costs through the selection of an economic life as described above. The economic analyses of alternatives assume replacement of facilities at specific life intervals. As already noted, a salvage value was credited to facilities whose economic life extended beyond the year 2056.

Construction Capital Costs

Construction costs used in this planning effort were estimated using 2007 unit prices, which reflect the type and size of facility or control measure, location, and regional labor and material costs. These construction costs were multiplied in the economic analyses by a factor of 1.35 to obtain total project capital costs. The 35 percent was added to account for contingencies, engineering and legal fees, administrative costs, and financing costs.[6]

Present Worth and Annual Costs

Four terms are commonly used in preparing economic analyses of important engineering projects: the single payment present worth factor (PWF), the uniform series present worth factor (SPWF), the gradient series present worth factor (GPWF), and the capital recovery factor (CRF). For this study, the PWF, the SPWF, and the CRF were applied. The gradient series present worth factor was not used, since the annual costs were developed as the average of the annual costs over the planning period.

The single payment present worth factor converts the cost of a single expenditure at some future time to an equivalent present value. The uniform series present worth factor converts a series of future uniform annual payments to an equivalent present worth value. The present worth of future single or uniform annual series payments is always less than the absolute value of the single payment or the sum of the annual payments. The capital recovery factor converts a lump payment at the beginning of a period, or a present worth value, into a series of uniform annual payments over the length of the period. The sum of these uniform annual payments is always greater than the lump payment.

It should be noted that, given the same interest rate and the same estimated series of costs, comparisons by annual cost lead to the same conclusions as comparisons by present worth. The economic analysis utilizing present worth and annual costs allows alternatives to be compared in monetary terms. This enables public officials to evaluate

[6]*The capital costs presented in this report for the MMSD facilities were obtained from the MMSD 2020 Facilities Plan. Those costs included an additional 25 percent adjustment for contingencies over and above the 35 percent used herein. In order to avoid confusion over the costs of those measures, no adjustment was made to the MMSD capital costs under the regional water quality management plan update.*

more objectively and explicitly the benefits and costs of alternative plans to assure that the public will receive the greatest possible benefits from limited monetary resources.

REVIEW AND EVALUATION OF POTENTIALLY APPLICABLE WATER QUALITY MANAGEMENT OPTIONS

It was important that the regional water quality management plan update and assessments of pollution control costs and effectiveness be based upon the best current technology. Therefore, one of the early work elements of the planning effort was the development of a state-of-the-art report on available pollution abatement technologies. That report included the inventory and review of water quality management measures in the subareas of sewage collection, conveyance, and treatment; rural runoff control; and urban stormwater runoff control.

In addition to the state-of-the-art report, a sensitivity study was conducted through which a set of screening alternatives was developed and analyzed to address extreme "what-if" situations or "bookends." These scenarios were not necessarily intended to be feasible solutions, but rather were intended to provide background data for development of alternative plans and to answer some common questions raised during the planning process, such as: "What if the combined sewers were separated?" Selection of technologies considered viable for use in the screening alternatives was based on information developed for the state-of-the-art report.

State-of-the-Art Report

The purpose of the state-of-the-art report was to provide a systematic evaluation of the costs and effectiveness of varying water pollution control technologies. In order to accomplish this, the concept of production theory was employed. Under this theory, each technology is described by a cost function, a production function, a cost-benefit relationship, and its interaction with other control technologies. Using this information, technologies that address similar water quality indicators are compared. Also, combinations of technologies working in series or in parallel can be evaluated. Finally, the combination of technologies that maximizes pollution reduction benefits and minimizes costs is determined. Production theory was felt to be the most logical way to analyze multiple technologies with varied inputs, such as point source and nonpoint source water pollution, and outputs, such as reduction in sewer overflow volume and/or pollutants.

A total of 169 water pollution abatement technologies were identified for consideration as part of the state-of-the-art report. These technologies underwent an initial screening process whereby they were ranked according to a set of factors developed through collaboration between the SEWRPC staff, the MMSD staff, the project engineering consultants, and various stakeholder committees. After the initial screening process, the technologies were organized into six categories: a) technologies to be analyzed using production theory; b) sewer separation technologies; c) technologies that the MMSD was already evaluating as part of active projects; d) existing policies or programs; e) beneficial technologies that were not analyzed using production theory since there were insufficient data available for them or their reported effectiveness was too variable; and f) technologies eliminated in the screening process. In some cases, similar technologies that address the same water quality indicators were combined. A more detailed presentation of the technology assessment can be found in the state-of-the-art report.[7]

Screening Alternatives

The screening alternatives considered in the planning process were designed to address two basic issues: upgrades to the MMSD sewage conveyance, storage, and treatment system to eliminate overflows, and widespread implementation of best management practices (BMPs) for treatment of nonpoint source pollution. A total of four screening alternatives addressing separate and combined sewer overflow reductions were evaluated. One screening alternative was evaluated that addressed implementation of a high level of BMP controls. The five screening alternatives were each developed by adding to a baseline alternative that is described in the following major section entitled "Description of Alternative Water Quality Management Plans." Components of the

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[7]*MMSD 2020 Facilities Plan*, State of the Art Report, *June 2007*.

individual screening alternatives, along with their associated costs, are set forth in Table 74. In addition, Table 74 also indicates if implementation of components of the screening alternatives might require new or modified regulations or changes in enforcement of existing regulations.

All of the screening alternatives include a set of future baseline condition measures that are described in detail later in this chapter in the section on the alternative water quality management plans. The baseline condition measures include certain committed projects and regulatory programs. Costs related to the baseline condition elements are included in Table 74.

Tabular comparisons of pollutant loading for the screening alternatives are presented in Appendix H. Appendix I includes tabular comparisons of water quality conditions. Assessment of the water quality impact of the screening alternatives was made through comparison to the future 2020 land use baseline condition presented later in this chapter in the discussion of alternative plans. For informational purposes, the modeled existing condition loads and water quality statistics are also presented and compared in the appendices. The locations of the receiving water assessment points are shown on Maps 57 through 62. Many of the assessment points also correspond with the location of MMSD water quality sampling sites that were included in the water quality assessment presented in Chapter III. A cross-reference between the assessment point designations shown on the maps and the MMSD sampling site designations is provided in Table 75.

Screening Alternative 1A: Elimination of Separate Sewer Overflows (SSOs) and Combined Sewer Overflows (CSOs) Using Sewer Separation

This screening alternative assumes elimination of SSOs and CSOs through sewer separation within the MMSD combined sewer area to the maximum extent practicable, supplemented with enhanced wastewater treatment, storage, and pumping. A total of 89 percent of the combined sewer area would be converted into a separate sewer area with separate collection systems for sanitary sewage and stormwater runoff. The remaining 11 percent, located within the central portion of the combined sewer area, would remain unchanged.[8] Within the area to be separated, the existing combined sewers would be used to convey stormwater runoff only, while new sewers would be laid to convey sanitary sewage.

With the current combined sewer system, stormwater runoff is captured along with the sanitary sewage and sent to the wastewater treatment plants. By separating the sewer system, stormwater runoff would normally be sent to the rivers or Lake Michigan. It was assumed under this screening alternative that the more heavily polluted “first flush” of stormwater from the separated area, which comprises a significant portion of the annual stormwater runoff pollutant loading, would continue to be diverted to the Inline Storage System (ISS), from which it would be pumped to the wastewater treatment plants (WWTP). That approach would maintain a portion of the current water quality benefit from treating stormwater runoff from the combined sewer area. Excess stormwater runoff would overflow to the receiving streams or Lake Michigan.

In order to achieve the goal of eliminating SSOs and CSOs, this screening alternative would also require additional wastewater treatment capacities of 200 million gallons per day (mgd) and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 234 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Hydraulic restrictions were also identified at 42 locations within the Metropolitan Interceptor System (MIS). In order to avoid SSOs it was assumed that parallel relief sewers would be constructed at these locations. These 42 relief sewers are a common element of screening alternatives 1A through 1C.

As noted in a previous section, the ability of this screening alternative to eliminate SSOs and CSOs was based on an evaluation of recorded precipitation for a 64.5-year period between 1940 and 2004. While it is possible that

[8]*That area comprises the central business district of the City of Milwaukee. Sewer separation in that area was considered to potentially be too disruptive to include in the screening alternative.*

Table 74

PRINCIPAL FEATURES AND COSTS OF THE SCREENING ALTERNATIVES USED TO AID IN THE DEVELOPMENT OF THE WATER QUALITY MANAGEMENT PLAN ALTERNATIVES

Screening Alternative								
Designation	Name	Description	Component	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
1A	Elimination of SSOs and CSOs Using Sewer Separation	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components[d]	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes all components of the future baseline condition alternative[d]	Sewer Separation	2,740,000	0	2,740,000	173,716	- -
		Separate combined sewers in 89 percent of combined sewer service area	200 million gallons per day (MGD) additional treatment capacity at South Shore WWTP	193,000	3,700	300,090	19,026	- -
		Additional conveyance, storage, and treatment (CST) measures for elimination of SSOs	100 MGD additional treatment capacity at Jones Island WWTP	124,000	2,300	184,849	11,719	- -
			100 MGD additional pumping capacity from ISS to Jones Island WWTP	115,000	921	144,791	9,180	- -
			234 million gallons (MG) additional storage in ISS	580,000	0	569,502	36,106	- -
			MIS relief sewers at 42 locations	350,000	0	350,000	22,190	- -
			Total Cost	$5,136,624	$ 74,966	$6,407,940	$406,289	
1B	Elimination of SSOs and CSOs Using Enhanced Treatment and Storage	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components[d]	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes all components of the future baseline condition alternative[d]	200 MGD additional treatment capacity at South Shore WWTP	193,000	3,700	300,090	19,026	- -
		Additional conveyance, storage, and treatment (CST) measures for elimination of SSOs and CSOs	100 MGD additional treatment capacity at Jones Island WWTP	124,000	2,300	184,849	11,719	- -
			100 MGD additional pumping capacity from ISS to Jones Island WWTP	115,000	921	144,791	9,180	- -
			1,622 MG additional storage in ISS	3,990,000	0	3,917,781	248,387	- -
			MIS relief sewers at 42 locations	350,000	0	350,000	22,190	- -
			Total Cost	$5,806,624	$ 74,966	$7,016,219	$444,854	

Table 74 (continued)

Screening Alternative								
Designation	Name	Description	Component	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
1C	Elimination of SSOs Using Enhanced Treatment and Storage	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components[d]	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes all components of the future baseline condition alternative[d]	200 MGD additional treatment capacity at South Shore WWTP	193,000	3,700	300,090	19,026	- -
		Additional conveyance, storage, and treatment (CST) measures for elimination of SSOs only	100 MGD additional treatment capacity at Jones Island WWTP	124,000	2,300	184,849	11,719	- -
		Provides some incidental CSO volume reduction benefits	100 MGD additional pumping capacity from ISS to Jones Island WWTP	115,000	921	144,791	9,180	- -
			153 MG additional storage in ISS	400,000	0	392,760	24,901	- -
			MIS relief sewers at 42 locations	350,000	0	350,000	22,190	- -
			Total Cost	$2,216,624	$ 74,966	$3,491,198	$221,368	
1D	Elimination of SSOs through Infiltration and Inflow (I/I) Reduction	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components[d]	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes all components of the future baseline condition alternative[d]	I/I reduction in 90 percent of separate sewer system area	6,670,000	0	6,670,000	422,878	- -
		Reduce I/I within sanitary sewer system area (MMSD service area) so as to limit the five-year recurrence interval wastewater inflow rate to 2,000 gallons per acre per day						- -
		Provides some incidental CSO volume reduction benefits						- -
			Total Cost	$7,704,624	$ 68,045	$8,788,708	$577,230	
2	Implementation of a High Level of BMPs to Control Nonpoint Source Pollution	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components[d]	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes selected components of the future baseline condition alternative[d]	Rural nonpoint source measures:					
		Assumes full compliance with Chapter NR 151 rules for control of both urban and rural nonpoint source pollution	1. Manure management for all livestock operations	245,995	16,060	499,137	31,645	- -
		Expanded level of nonpoint source pollution control beyond that required for Chapter NR 151, including expanded control of runoff volumes in urban areas	2. Fencing along 50 percent of pastures adjacent to waterways	330	16	590	37	- -
			3. Expand buffers to 50 feet for all cropland and pasture adjacent to streams	1,654	368	7,425	471	X

Table 74 (continued)

Screening Alternative								
Designation	Name	Description	Component	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
2 (continued)	Implementation of a High Level of Stormwater BMPs (continued)		4. Expand level of septic system inspections	$ 109,800	$ 641	$ 119,898	$ 7,601	X
			5. Fertilizer management education program	40	8	166	10	- -
			Additional urban nonpoint source measures in separate sewer areas:					
			1. Extend infiltration to include all existing institutional and commercial development and redeveloped well-drained institutional and commercial land. Provide enhanced infiltration for all new institutional, commercial, and residential development and for redeveloped, poorly-drained institutional and commercial development	107,037	5,215	230,104	14,589	X
			2. Double implementation of end-of-pipe water quality treatment devices over levels assumed for NR 151 implementation	259,679	7,095	371,513	23,554	X
			3. Downspout disconnection with rain barrels at 15 percent of homes in study area	38,207	723	49,601	3,145	- -
			4. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 3)	97,967	3,711	156,458	9,919	- -
			5. Stormwater trees	- -[e]	- -[e]	- -[e]	- -[e]	- -
			6. Chloride reduction program modeled after programs in Cities of Brookfield and Madison (apply to 50 percent of roads, 25 percent of existing water softeners, 100 percent of new water softeners)	394	1,183	19,186	1,216	- -
			7. Pet litter management programs	- -[f]	- -[f]	- -[f]	- -[f]	X
			8. Waterfowl control programs for all Lake Michigan beaches	0	125	1,966	125	- -
			9. Litter control programs	0	6,204	97,787	6,204	- -

Table 74 (continued)

Screening Alternative									
Designation	Name	Description	Component	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
2 (continued)	Implementation of a High Level of Stormwater BMPs (continued)		Urban nonpoint source measures in combined sewer service area:					
			1. Extend infiltration to all existing and redeveloped institutional and commercial land. Provide enhanced infiltration for all new industrial, commercial, and institutional development.	$ 4,671	$ 255	$ 10,475	$ 664	X
			2. Downspout disconnection with rain barrels at 15 percent of homes in study area.	10,618	201	13,784	874	- -
			3. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 2)	27,225	1,031	43,479	2,757	- -
			4. Stormwater trees	- -[e]	- -[e]	- -[e]	- -[e]	- -
			5. Rooftop storage equaling 14 MG to 50 percent of buildings from MMSD downspout disconnection study.	24,800	0	34,270	2,173	- -
			6. Storm sewer inlet restrictors to provide 15 MG of street storage	32,500	650	42,745	2,710	- -
			7. Sewer separation for seven parking lots identified in MMSD stormwater disconnection study	7,330	0	7,330	465	- -
			8. Pet litter management programs	- -[f]	- -[f]	- -[f]	- -[f]	X
			9. Waterfowl control programs for all Lake Michigan beaches	- -[g]	- -[g]	- -[g]	- -[g]	- -
			10. Litter control programs	- -[g]	- -[g]	- -[g]	- -[g]	- -
			11. Skimmer boat operation within inner and outer harbor	1,000	150	3,364	213	- -
			Total Cost	$2,003,871	$111,681	$3,827,986	$242,724	- -

[a] *Costs are based on an annual interest rate of 6 percent and a 50-year amortization period.*

[b] *The mechanism for implementing components that may require new or modified regulations or changes in enforcement would be established at the Federal, State, or local government levels. Many of those components might also be implemented voluntarily.*

[c] *Original 2020 land use and population projections based on information provided by communities served by the MMSD and on the SEWRPC land use plan in areas outside the MMSD planning area. See Chapter VIII of this report for additional information.*

[d] *Components of the future baseline condition alternative are presented under Alternative A in Table 76.*

[e] *Included in costs for downspout disconnection.*

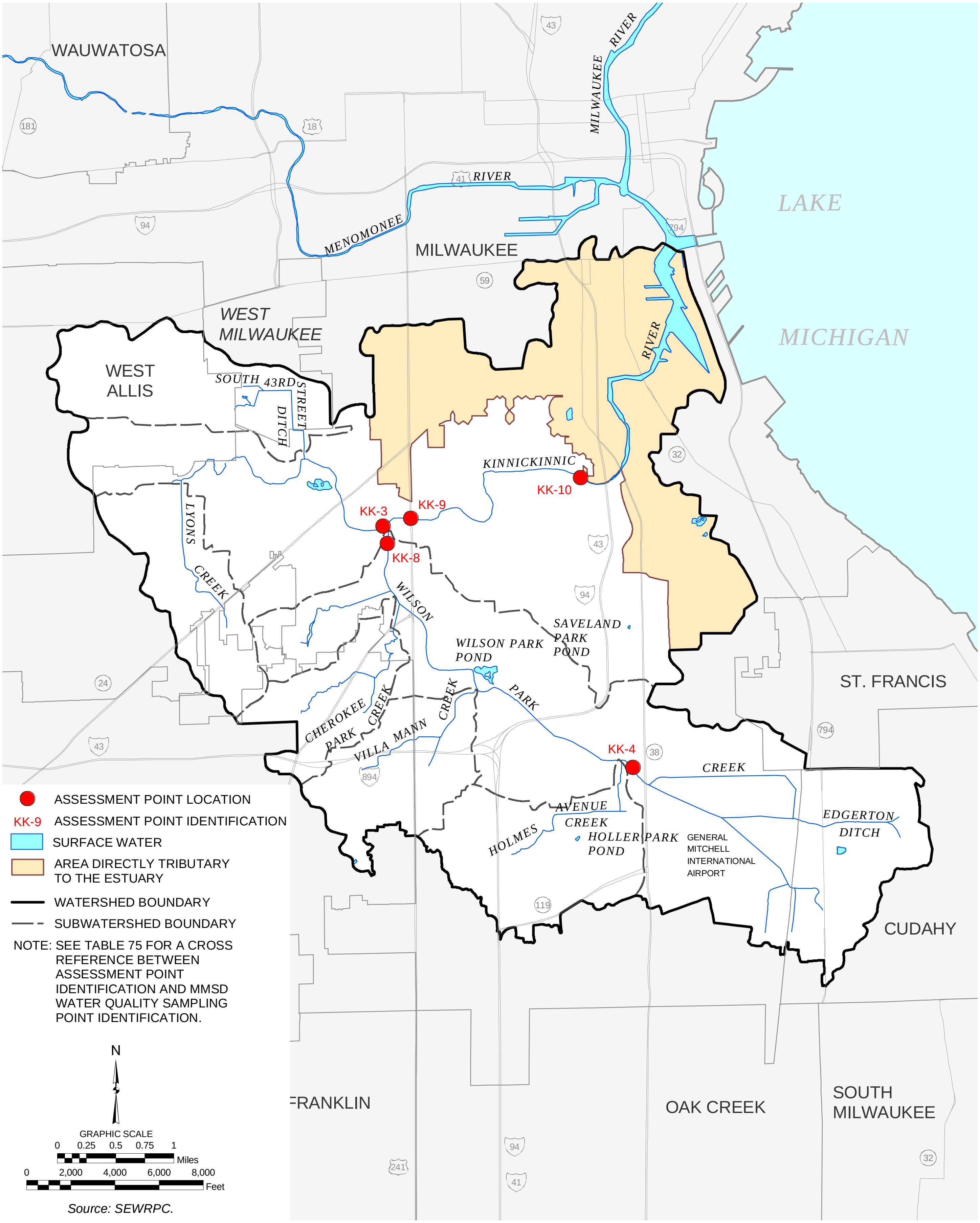
[f] *No cost assigned. Assumed to be covered under cost of compliance with Chapter NR 151 rules.*

[g] *Included above in cost for separate sewer area.*

Source: Milwaukee Metropolitan Sewerage District, HNTB, and SEWRPC.

Map 57

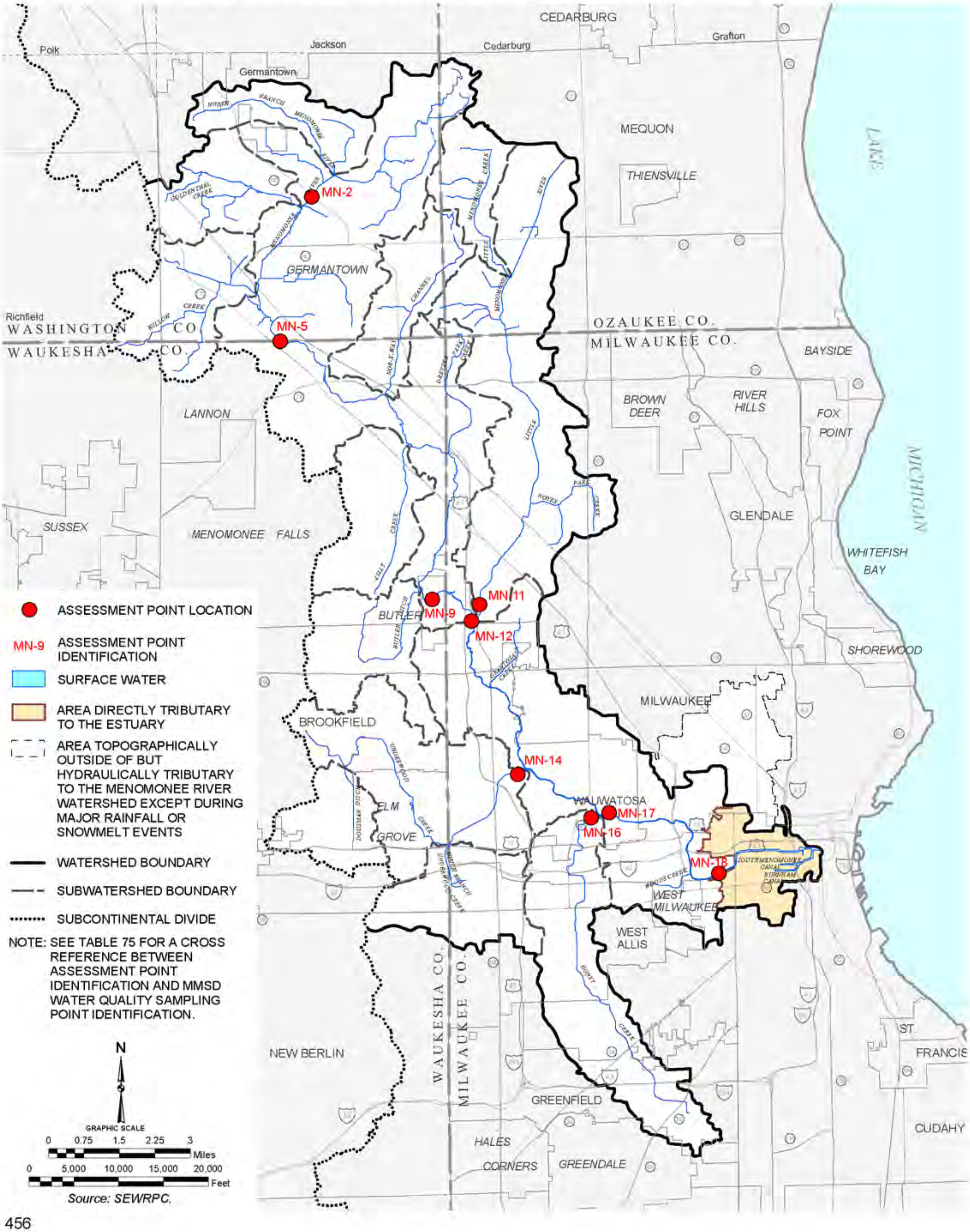
ASSESSMENT POINTS WITHIN THE KINNICKINNIC RIVER WATERSHED FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS



Source: SEWRPC.

Map 58

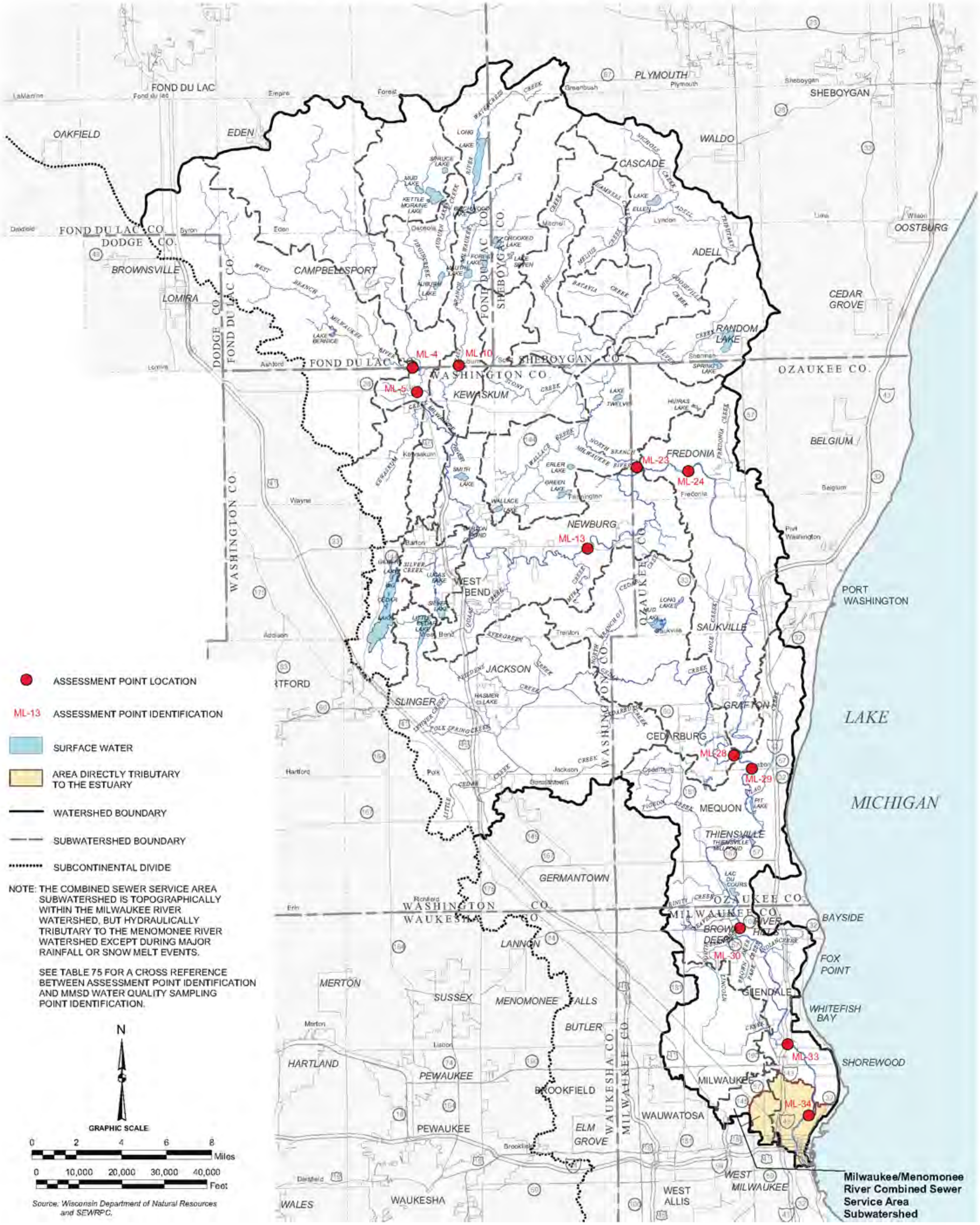
ASSESSMENT POINTS WITHIN THE MENOMONEE RIVER WATERSHED FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS



Source: SEWRPC.

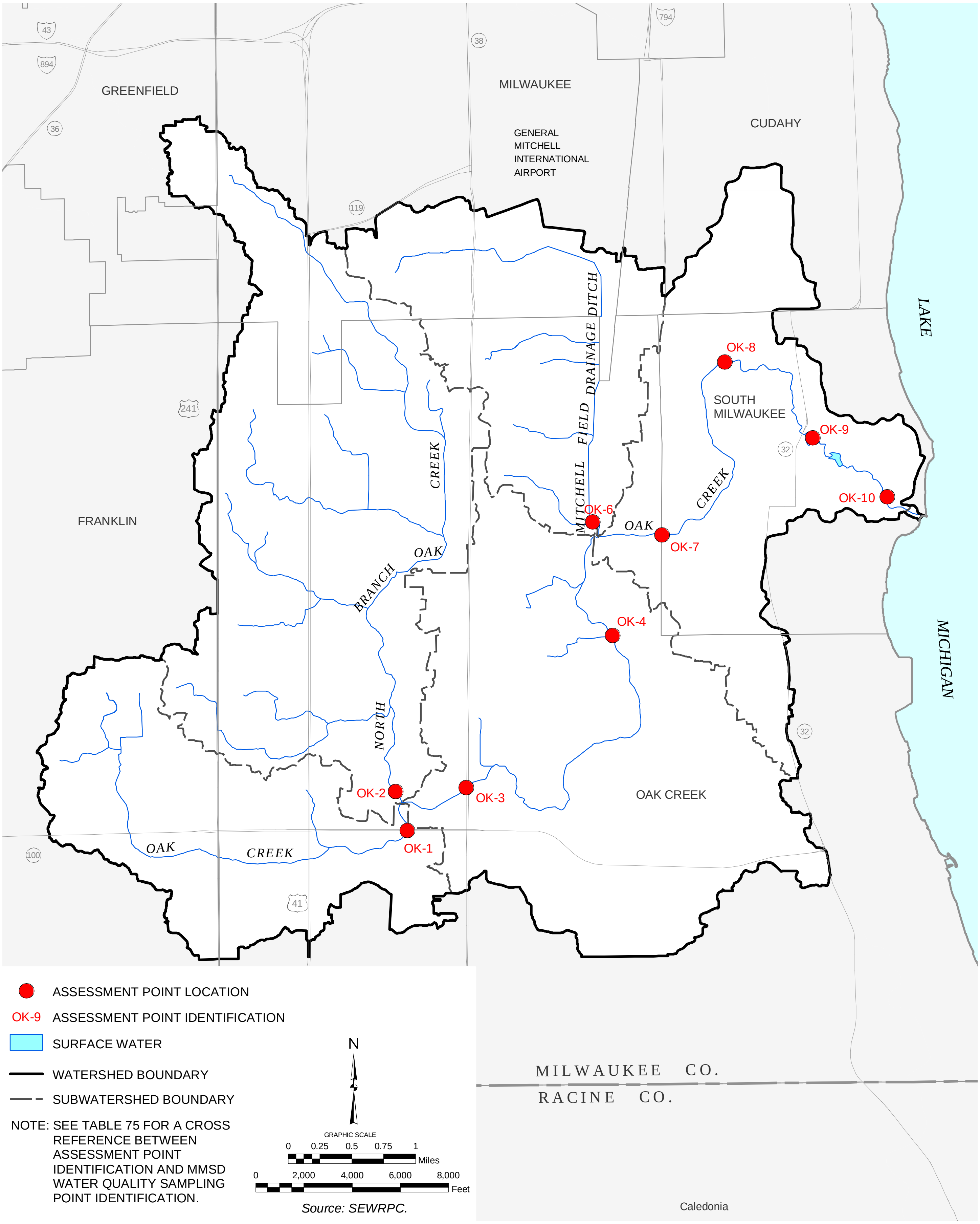
Map 59

ASSESSMENT POINTS WITHIN THE MILWAUKEE RIVER WATERSHED FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS



Map 60

ASSESSMENT POINTS WITHIN THE OAK CREEK WATERSHED FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS

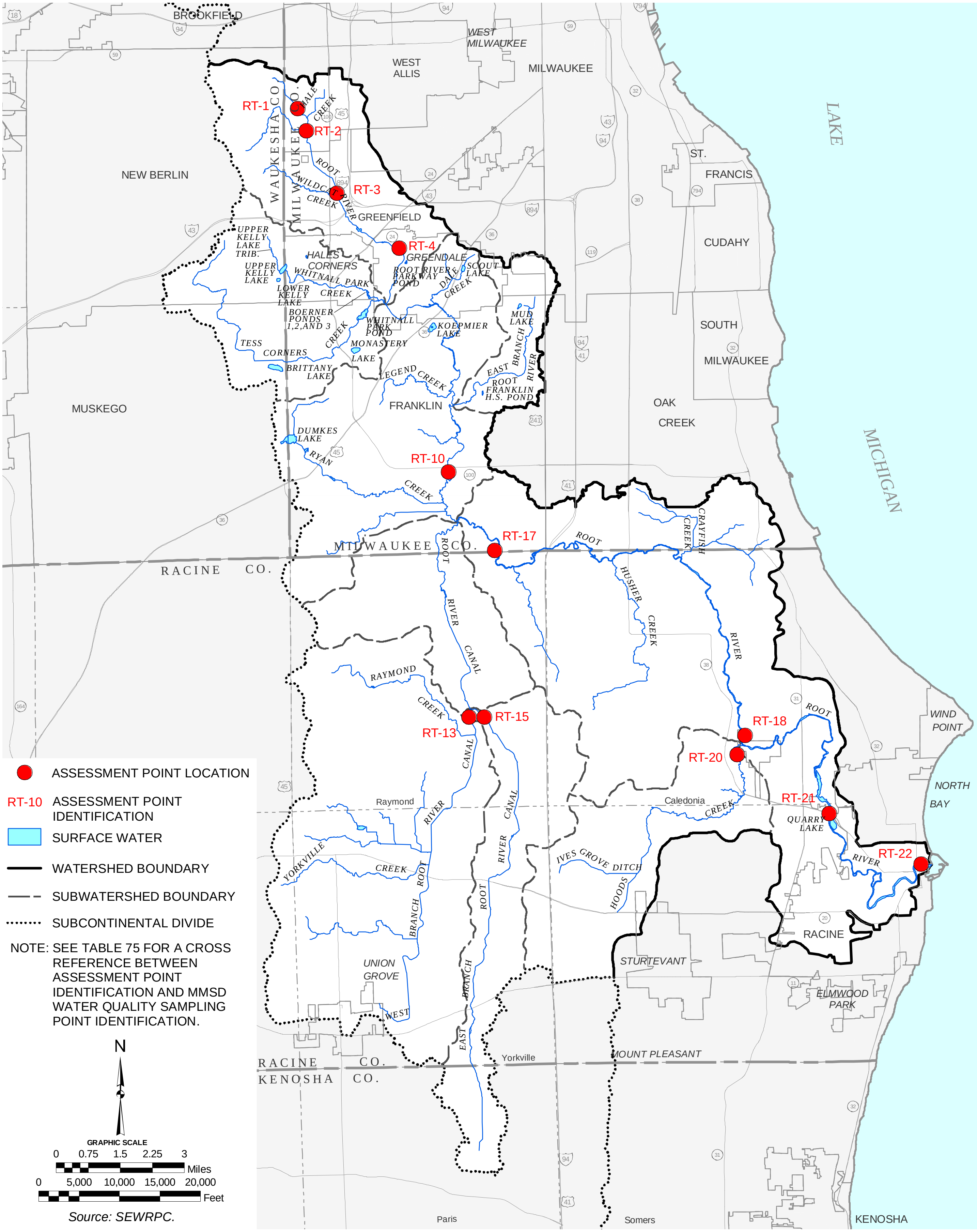


NOTE: SEE TABLE 75 FOR A CROSS REFERENCE BETWEEN ASSESSMENT POINT IDENTIFICATION AND MMSD WATER QUALITY SAMPLING POINT IDENTIFICATION.

Source: SEWRPC.

Map 61

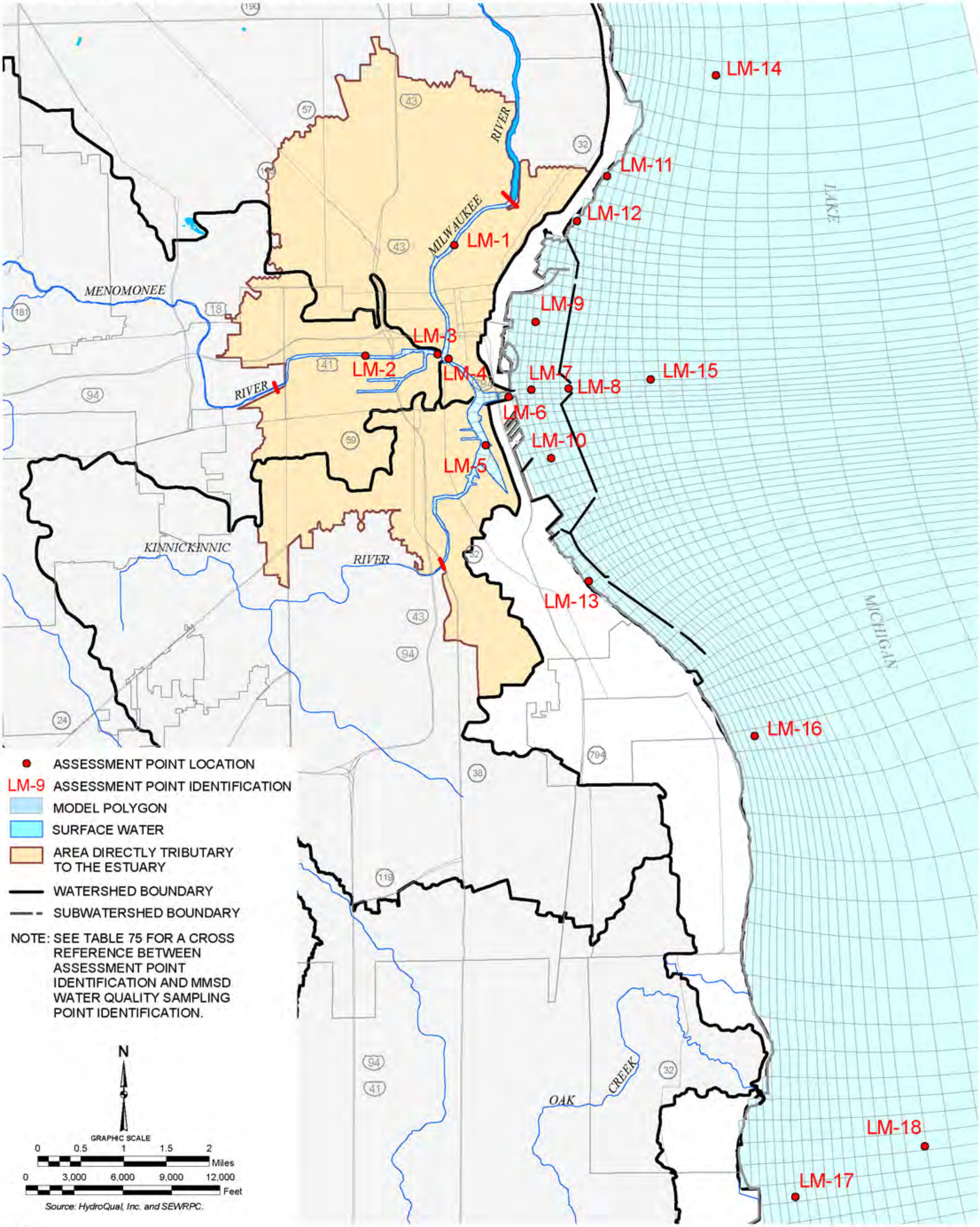
ASSESSMENT POINTS WITHIN THE ROOT RIVER WATERSHED FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS



Source: SEWRPC.

Map 62

ASSESSMENT POINTS WITHIN THE MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN AREA FOR SCREENING ALTERNATIVES AND ALTERNATIVE WATER QUALITY PLANS



Source: HydroQual, Inc. and SEWRPC.

Table 75

CROSS-REFERENCE BETWEEN WATER QUALITY ASSESSMENT POINT IDENTIFICATION NUMBERS AND MMSD SAMPLING STATION IDENTIFICATION

		Assessment Point Identification		MMSD Sampling
Watershed	Map Number	Screening Alternatives	Alternatives	Station ID
Kinnickinnic River	57	- -	KK-3	- -
		- -	KK-4	- -
		- -	KK-8	- -
		KK-9	KK-9	RI-12
		KK-10	KK-10	RI-13
Menomonee River	58	- -	MN-2	- -
		MN-5	MN-5	RI-16
		MN-9	MN-9	RI-21
		- -	MN-11	- -
		MN-12	MN-12	RI-22
		- -	MN-14	- -
		- -	MN-16	- -
		MN-17	MN-17	RI-09
		MN-18	MN-18	RI-10
Milwaukee River	59	- -	ML-4	- -
		- -	ML-5	- -
		- -	ML-10	- -
		- -	ML-13	- -
		- -	ML-23	- -
		- -	ML-24	- -
		- -	ML-28	- -
		ML-29	ML-29	RI-01
		ML-30	ML-30	RI-02
		ML-33	ML-33	RI-04
		ML-34	ML-34	RI-05
Oak Creek	60	OK-1	OK-1	OC-01
		- -	OK-2	- -
		OK-3	OK-3	OC-02
		0K-4	OK-4	OC-03
		- -	OK-6	- -
		OK-7	OK-7	OC-04
		OK-8	OK-8	OC-05
		OK-9	OK-9	OC-06
		OK-10	OK-10	OC-07
Root River	61	RT-1	RT-1	RR-01
		RT-2	RT-2	RR-02
		RT-3	RT-3	RR-03
		RT-4	RT-4	RR-04
		RT-10	RT-10	RR-05
		- -	RT-13	- -
		- -	RT-15	- -
		RT-17	RT-17	RR-06
		- -	RT-18	- -
		- -	RT-20	- -
		- -	RT-21	- -
		RT-22	RT-22	- -
Lake Michigan/Estuary	62	LM-1	LM-1	RI-06
		LM-2	LM-2	RI-11
		LM-3	LM-3	RI-17
		LM-4	LM-4	RI-08
		LM-5	LM-5	RI-18
		LM-6	LM-6	OH-01
		LM-7	LM-7	OH-03

Table 75 (continued)

Watershed	Map Number	Assessment Point Identification		MMSD Sampling
		Screening Alternatives	Alternatives	Station ID
Lake Michigan/Estuary (continued)	62	LM-8	LM-8	OH-07
		LM-9	LM-9	OH-04
		LM-10	LM-10	OH-11
		LM-11	LM-11	- -
		LM-12	LM-12	- -
		LM-13	LM-13	- -
		LM-14	LM-14	NS-07
		LM-15	LM-15	NS-14 (OH-14)
		LM-16	LM-16	NS-04
		LM-17	LM-17	NS-27
		LM-18	LM-18	NS-02

Source: SEWRPC.

more extreme conditions than those observed during that period could occur, such events would be extremely rare, making additional enhancements to handle such events very costly while only rarely being utilized to their full capacity.

The effects of this screening alternative on pollutant loading is summarized in the tables presented in Appendix H. Appendix I includes a summary of statistical measures of receiving water quality at representative locations within the regional water quality management plan update study area. Also included is an indication of the percentage of time that any relevant water quality standards are met. For comparison, the same information is presented in these tables for existing conditions and for the baseline 2020 condition alternative that is described in the next section of this chapter.

This screening alternative has an estimated capital cost of $5.136 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $406.3 million.

Screening Alternative 1B: Elimination of SSOs and CSOs Using Enhanced Treatment and Storage

This screening alternative assumes elimination of SSOs and CSOs solely through a combination of enhanced wastewater treatment, storage, and pumping. The most cost effective combination of these measures calls for additional wastewater treatment capacities of 200 million gallons per day (mgd) and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 1,622 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Parallel relief sewers would also be required at 42 locations along the MIS in order to avoid SSOs during the more extreme wet weather events.

The effect of this screening alternative on pollutant loading is summarized in the tables presented in Appendix H. A summary of statistical measures of receiving water quality at representative locations within the regional water quality management plan update study area is included in Appendix I.

This screening alternative has an estimated capital cost of $5.807 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $444.9 million.

Screening Alternative 1C: Elimination of SSOs Using Enhanced Treatment and Storage

This screening alternative was designed to eliminate SSOs only, using a combination of enhanced wastewater treatment, storage, and pumping. The major difference from Screening Alternative 1B is in the level of enhancements needed, since this screening alternative is not designed to reduce CSOs. Under this screening alternative, the most cost effective combination of measures calls for additional wastewater treatment capacities of 200 mgd and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 153 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Parallel relief sewers would also be required at 42 locations along the MIS in order to avoid SSOs during the more extreme wet weather events.

Although designed to eliminate only SSOs, this screening alternative does have some incidental benefits in reducing the anticipated volume of CSOs as well. This benefit results from the increased treatment capacity and is most effective during wet weather events that are characterized by extended periods of runoff, such as those related to snowmelt or extended periods of moderate rainfall. Events characterized by intense runoff of shorter duration, such as that resulting from thunderstorms, are not affected. Those types of events are impacted more by increasing storage capacity. Although the total volume of the ISS is increased under this alternative, all of the additional new capacity would be reserved solely for inflow from the separate sewer service area and, therefore, would not serve to reduce CSOs.

The effect of this screening alternative on pollutant loading is summarized in the tables presented in Appendix H. A summary of statistical measures of receiving water quality at representative locations within the regional water quality management plan update study area is included in Appendix I.

This screening alternative has an estimated capital cost of $2.217 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $221.4 million.

Screening Alternative 1D: Elimination of SSOs through Infiltration and Inflow Reduction

This screening alternative was designed to eliminate SSOs by reducing infiltration and inflow (I/I) to sanitary sewers within the separate sewer area. In order to achieve this, a multi-step process was followed in which the sewersheds that were identified as having the highest levels of I/I were targeted first. Progressive expansion of the I/I removal was carried out within the separate sewer area until all SSOs were eliminated based on the 64.5-year model simulation period.

In order to eliminate all SSOs, reduction efforts would need to reduce I/I so that the wastewater flow rates from all sewersheds would be less than 2,000 gallons per acre per day for the five-year recurrence interval peak wastewater flow. This would require I/I reduction efforts within about 93 percent of the separate sewer area that would exist under planned year 2020 land use conditions. These reduction efforts would focus mainly on disconnection of foundation drains and lateral rehabilitation on private properties.

In addition to achieving elimination of SSOs, this screening alternative would also have some effect on reducing the number and volume of CSOs that may be expected to occur. This reduction would be the result of having less inflow from the separate sewer area to store and treat, freeing up capacity for the storage and treatment of inflow from the combined sewer area. For the entire 64.5-year simulation period, it is anticipated that CSO volume would be reduced by about 12 percent, while the number of actual CSO events would be reduced by about 3 percent.

The effect of this screening alternative on pollutant loading is summarized in the tables presented in Appendix H. A summary of statistical measures of receiving water quality at representative locations within the regional water quality management plan update study area is presented in Appendix I.

This screening alternative has an estimated capital cost of $7.705 billion and an annual operation and maintenance cost of $68.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $577.2 million.

Screening Alternative 2: Implementation of a High Level of Best Management Practices to Control Nonpoint Source Pollution

In contrast to the previous four screening alternatives that looked at reducing or eliminating sanitary sewage overflows, this screening alternative was designed to test the impact on water quality of solely implementing a high level of best management practices (BMP) aimed at reducing urban and rural nonpoint source pollutant loads. Under this alternative it was assumed that there would be no further measures involving enhanced treatment, storage, or I/I reduction to limit the number and volume of separate and combined sewer overflows beyond those included under the future 2020 land use baseline condition. The level of BMP implementation assumed, while deemed achievable, would be well above that which would be anticipated to be implemented under the current regulatory and institutional frameworks.

In selecting the BMPs to be included and assigning their levels of implementation, an initial consideration was given to those measures that were used to represent compliance with State and local requirements governing nonpoint source runoff, as described below for the baseline condition alternative. Using the information developed for the state-of-the-art report, additional technologies and increased levels of compliance were then added to the baseline condition to make up this screening alternative. The choice of the additional technologies is not meant to exclude the use of other technologies where appropriate, nor is it implied that they are likely to be implemented exactly in the manner assumed here. Rather, they are merely intended to represent a reasonable distribution of actions that could be taken.

The technologies applied under this screening alternative and their assumed levels of implementation are listed in Table 74. They include technologies specific to both rural and urban land uses. Rural measures include those intended to address agricultural loadings including manure and livestock management, nutrient management, and expansion of riparian buffers. Also included is an expanded program of inspection and replacement of failing septic systems. Urban land use measures would further reduce or manage stormwater runoff volume over and above that currently called for under Chapter NR 151 of the *Wisconsin Administrative Code*. These measures include increased application of infiltration techniques, rooftop storage, inlet restrictors, downspout disconnection, rain barrels, and rain gardens.

The effect of this screening alternative on pollutant loading is summarized in the tables presented in Appendix H. A summary of statistical measures of receiving water quality at representative locations within the regional water quality management plan update study area is presented in Appendix I.

This screening alternative has an estimated capital cost of $2.004 billion and an annual operation and maintenance cost of $111.7 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $242.7 million.

Comparison and Evaluation of Screening Alternatives

The relative equivalent annual costs and water quality effects of the five screening alternatives were compared to provide guidance on the most effective components to include in the next step of the plan development process—synthesis of alternative water quality management plans. Comparison of the cost information set forth in Table 74 and the water quality data in Appendix I indicates that Screening Alternative 1C: Eliminate SSOs Using Enhanced Treatment and Storage has the lowest estimated equivalent annual cost while providing water quality benefits similar to Screening Alternatives 1A, 1B, and 1D. Screening Alternative 2: High Level of Implementation of Best Management Practices to Control Nonpoint Source Pollution has the second lowest estimated equivalent annual cost and would result in achievement of the best instream water quality conditions. Screening Alternatives 1A, 1B, and 1D have significantly higher equivalent annual costs compared to Screening Alternatives 1C and 2. The alternative plans described in the next section of this report were developed in consideration of both the regulatory requirements regarding SSOs and CSOs and the potential for achieving the largest improvements in water quality through implementation of controls on nonpoint source pollution.

DESCRIPTION OF ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Five alternative water quality management plans were considered to abate the existing water quality problems described in Chapter III of this report, and to meet the water use objectives and supporting standards presented in Chapter VII. The first plan considered was used as a baseline condition, against which to assess the effectiveness of the other four plans. This baseline, or alternative future situation, included the effect of implementing projects that are already committed, including current regulatory programs, while also taking into account future population and land development projections. The remaining four plans—as well as the five screening alternatives described above—each included the components of the baseline alternative and were grouped into two distinct categories: regulatory-based alternatives and water quality-based alternatives. A description of each alternative plan is presented below. Individual features of the plans are set forth in Table 76. Table 76 also indicates if implementation of components of the alternative water quality management plans might require new or modified regulations or changes in enforcement of existing regulations.

Alternative A: Baseline Alternative

This alternative includes only those measures that are already committed by various agencies within the study area, particularly those projects committed to be carried out by the MMSD by the design year of 2020. Also included are actions required under current regulatory programs, including State and local rules governing nonpoint pollutant runoff.

This alternative has an estimated capital cost of $1.035 billion and an annual operation and maintenance cost of $68.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $134.4 million.

The components of this alternative are described in the following subsections.

Land Use

As noted previously in this chapter, the screening alternatives, the baseline alternative, and the alternative water quality management plans reflect planned year 2020 land use conditions throughout the study area. Within the MMSD planning area, 2020 population and land use estimates were developed by the SEWRPC staff based on detailed consultation with officials and staff of the MMSD communities. Specific, anticipated future land use conditions were identified by each community and the SEWRPC staff translated those conditions to household and population projections and land use distributions by sewershed. Outside of the MMSD planning area, information developed under the SEWRPC 2020 land use plan was used to obtain household, population, and land use projections.[9]

Following development of the screening alternatives and the alternative water quality plans, the regional land use plan for the year 2035 was completed.[10] The water quality planning process as initially established recognized that completion of the 2035 plan would offer an opportunity to revise year 2020 population and land use projections based on the 2035 estimates. Such revisions were made and that information was used in evaluating possible study area sewage treatment plant needs and MMSD system storage and treatment components to be included in this plan. Sewage flows based on the original 2020 population and land use information as developed from community estimates were used to size MMSD conveyance facilities under all aspects of the planning process—screening alternatives, alternative water quality plans, and the recommended plan. To distinguish between the two 2020 land use and population conditions, the community-determined condition applied for the screening alternatives and the alternative water quality plans is referred to as the "**original 2020 baseline**

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[9]*SEWRPC Planning Report No. 45*, A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

[10]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

Table 76

PRINCIPAL FEATURES AND COSTS OF THE ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
A	Future Baseline Condition	Assumes future year 2020 planned land use conditions[c]	MMSD committed facilities[d]	$ 842,000	$ 0	$ 842,000	$ 53,383	- -
		MMSD committed facilities as reflected in MMSD 2006 Capital Budget	Maintain current levels of I/I for MMSD and community sewer systems	0	36,493	575,198	36,493	- -
		Implementation of *Wisconsin Administrative Code* Chapter NR 151 rules governing urban nonpoint source runoff and partial implementation of rules governing rural nonpoint source runoff	Rural nonpoint source measures:					
			1. Conservation tillage	0	0	0	0	- -
		Implementation of MMSD Chapter 13 rules governing stormwater runoff volume from new development	Urban nonpoint source measures:					
			1. Infiltration systems	8,970	439	19,318	1,225	- -
		Assumes increase in WWTP discharge based on future development while maintaining current effluent characteristics	2. Stormwater treatment systems	86,560	26,813	509,175	32,282	- -
			3. Wet detention basins	75,767	3,788	135,479	8,589	- -
		Assumes current level of industrial source discharges[e]	4. Vacuum sweeping of roadways	21,327	512	37,538	2,380	- -
		Assumes current level of pollutant loadings from POWTs						
			Total Cost	$1,034,624	$ 68,045	$2,118,708	$134,352	
B1	Regulatory-Based	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes components of the future baseline condition alternative	185 MGD additional treatment capacity at South Shore WWTP	182,200	3,437	282,062	17,883	- -
		Maintain current MMSD operating procedures to limit occurrence of CSOs and SSOs	100 MGD additional pumping capacity from ISS to Jones Island WWTP	115,000	921	144,791	9,180	- -
		Additional conveyance, storage, and treatment (CST) measures to provide a five-year level of protection (LOP) for SSOs	40 MG additional storage in ISS	100,000	0	98,190	6,225	- -
			Upgrade MIS conveyance capacity at identified hydraulic restrictions	115,000	0	115,000	7,291	- -

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
B1 (continued)	Regulatory-Based (continued)	Additional stormwater volume controls for the combined sewer service area	Rural nonpoint source measures:					
		Full implementation of Chapter NR 151 urban and rural nonpoint source rules	1. Manure management for all livestock operations	$ 245,995	$ 16,060	$ 499,137	$ 31,645	- -
			2. Fencing along 50 percent of pastures adjacent to waterways	330	16	590	37	- -
			3. Expand buffers to 50 feet for all cropland and pasture adjacent to streams	1,654	368	7,425	471	X
			4. Expand level of septic system inspections, and, if necessary, replacement	109,800	641	119,898	7,601	X
			5. Fertilizer management education program	40	8	166	10	- -
			Urban nonpoint source measures in combined sewer service area:					
			1. Downspout disconnection with rain barrels at 15 percent of homes in study area	9,900	165	12,501	793	- -
			2. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 1)	27,225	1,031	43,479	2,757	- -
			3. Rooftop storage equaling 14 MG to 50 percent of buildings from MMSD downspout disconnection study	24,800	0	34,270	2,173	- -
			4. Storm sewer inlet restrictors to provide 15 MG of street storage	32,500	650	42,745	2,710	- -
			Total Cost	$1,999,068	$ 91,342	$3,518,962	$223,128	
B2	Regulatory-Based, with Revised ISS Operating Procedure[f]	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes components of the future baseline condition alternative	185 MGD additional treatment capacity at South Shore WWTP	182,200	3,437	282,062	17,883	- -
		Revise MMSD operating procedures to provide zero reserve storage in ISS for SSO control, thereby maximizing use of available storage	100 MGD additional pumping capacity from ISS to Jones Island WWTP	115,000	921	144,791	9,180	- -
		Additional conveyance, storage, and treatment (CST) measures to provide a five-year level of protection (LOP) for SSOs	40 MG additional storage in ISS	100,000	0	98,190	6,225	- -
			Upgrade MIS conveyance capacity at identified hydraulic restrictions	115,000	0	115,000	7,291	- -

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
B2 (continued)	Regulatory-Based, with Revised ISS Operating Procedure[f] (continued)	Additional stormwater volume controls for the combined sewer service area	Rural nonpoint source measures:					
		Full implementation of Chapter NR 151 urban and rural nonpoint source rules	1. Manure management for all livestock operations	$ 245,995	$ 16,060	$ 499,137	$ 31,645	- -
			2. Fencing along 50 percent of pastures adjacent to waterways	330	16	590	37	- -
			3. Expand buffers to 50 feet for all cropland and pasture adjacent to streams	1,654	368	7,425	471	X
			4. Expand level of septic system inspections, and, if necessary, replacement	109,800	641	119,898	7,601	X
			5. Fertilizer management education program	40	8	166	10	- -
			Urban nonpoint source measures in combined sewer service area:					
			1. Downspout disconnection with rain barrels at 15 percent of homes in study area	9,900	165	12,501	793	- -
			2. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 1)	27,225	1,031	43,479	2,757	- -
			3. Rooftop storage equaling 14 MG to 50 percent of buildings from MMSD downspout disconnection study	24,800	0	34,270	2,173	- -
			4. Storm sewer inlet restrictors to provide 15 MG of street storage	32,500	650	42,745	2,710	- -
			Total Cost	$1,999,068	$ 91,342	$3,518,962	$223,128	
C1	Water Quality-Based	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes components of the future baseline condition alternative	Rural nonpoint source measures:					
		Maintain current MMSD operating procedures to limit occurrence of CSOs and SSOs	1. Manure management for all livestock operations	245,995	16,060	499,137	31,645	- -
		Expanded level of nonpoint source pollutant control beyond that required for Chapter NR 151, including expanded control of runoff volumes in urban areas	2. Fencing along 50 percent of pastures adjacent to waterways	330	16	590	37	- -
			3. Expand buffers to 50 feet for all cropland and pasture adjacent to streams	1,654	368	7,425	471	X

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
C1 (continued)	Water Quality-Based (continued)		4. Expand level of septic system inspections	$ 109,800	$ 641	$ 119,898	$ 7,601	X
			5. Fertilizer management education program	40	8	166	10	- -
			Urban nonpoint source measures in separate sewer areas:					
			1. Extend infiltration to include all existing institutional and commercial development. Provide enhanced infiltration for all redeveloped institutional and commercial development and all new residential development	57,725	2,826	124,320	7,882	X
			2. Double implementation of end-of-pipe water quality treatment devices over levels assumed for NR 151 implementation (100 percent of parking lots)	259,679	7,095	371,513	23,554	X
			3. Targeted stormwater disinfection (high rate chlorination (bleach) and dechlorination units at storm sewer outfalls)	616,941	7,652	926,011	58,709	X
			4. Downspout disconnection with rain barrels at 15 percent of homes in study area	35,625	594	44,983	2,852	- -
			5. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 4)	97,967	3,711	156,458	9,919	- -
			6. Chloride reduction program modeled after Madison and Brookfield programs. (apply to 25 percent of roads, 25 percent of existing water softeners, 100 percent of new water softeners)	394	1,183	19,186	1,216	- -
			7. Pet litter management programs	- -[g]	- -[g]	- -[g]	- -[g]	X
			8. Waterfowl control programs for all Lake Michigan beaches	0	125	1,966	125	- -
			9. Litter control programs	0	6,204	97,787	6,204	- -

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
C1 (continued)	Water Quality-Based (continued)		Urban nonpoint source measures in combined sewer service area:					
			1. Provide enhanced infiltration for new well-drained industrial, commercial, and institutional development	$ 400	$ 20	$ 861	$ 55	X
			2. Downspout disconnection with rain barrels at 15 percent of homes in study area	9,900	165	12,501	793	- -
			3. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 2)	27,225	1,031	43,479	2,757	- -
			4. Sewer separation for seven parking lots identified in MMSD stormwater disconnection study	7,330	0	7,330	465	- -
			5. Stormwater trees	- -[h]	- -[h]	- -[h]	- -[h]	- -
			6. Rooftop storage equaling 14 MG to 50 percent of buildings from MMSD downspout disconnection study	24,800	0	34,270	2,173	- -
			7. Storm sewer inlet restrictors to provide 15 MG of street storage	32,500	650	42,745	2,710	- -
			8. Pet litter management programs	- -[g]	- -[g]	- -[g]	- -[g]	X
			9. Waterfowl control programs for all Lake Michigan beaches	- -[i]	- -[i]	- -[i]	- -[i]	- -
			10. Litter control programs	- -[i]	- -[i]	- -[i]	- -[i]	- -
			11. Skimmer boat operation within inner and outer harbor	1,000	150	3,364	213	- -
			Total Cost	$2,563,929	$116,544	$4,632,698	$293,743	
C2	Water Quality-Based, with Green Measures	Assumes future year 2020 planned land use conditions[c]	Future baseline condition components	$1,034,624	$ 68,045	$2,118,708	$134,352	- -
		Includes components of the future baseline condition alternative	Rural nonpoint source measures:					
		Maintain current MMSD operating procedures to limit occurrence of CSOs and SSOs	1. Manure management for all livestock operations	245,995	16,060	499,137	31,645	- -
		Expanded level of nonpoint source pollutant control beyond that required for Chapter NR 151, including expanded control of runoff volumes in urban areas	2. Fencing along 50 percent of pastures adjacent to waterways	330	16	590	37	- -

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
C2	Water Quality-Based, with Green Measures (continued)	Incorporate "green" best management practices	3. Expand buffers to 50 feet for all cropland and pasture adjacent to streams	$ 1,654	$ 368	$ 7,425	$ 471	X
			4. Expand level of septic system inspections	109,800	641	119,898	7,601	X
			5. Fertilizer management education program	40	8	166	10	- -
			6. Convert 5 percent of existing cropland and pasture to wetland (target less productive lands)	104,454	10,443	267,159	16,938	- -
			7. Convert 5 percent of existing cropland and pasture to prairie vegetation (target less productive lands)	23,331	6,957	132,568	8,405	- -
			Urban nonpoint source measures in separate sewer areas:					
			1. Extend infiltration to include all existing institutional and commercial development. Provide enhanced infiltration for all redeveloped institutional and commercial development and all new residential development	57,725	2,826	124,320	7,882	X
			2. Double implementation of end-of-pipe water quality treatment devices over levels assumed for NR 151 implementation (100 percent of parking lots)	259,679	7,095	371,513	23,554	X
			3. Targeted stormwater disinfection (ultraviolet light treatment units at storm sewer outfalls)	152,100	6,868	306,814	19,452	X
			4. Downspout disconnection with rain barrels at 15 percent of homes in study area	35,625	594	44,983	2,852	- -
			5. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 4)	97,967	3,711	156,458	9,919	- -
			6. Chloride reduction program modeled after Madison and Brookfield programs (apply to 25 percent of roads, 25 percent of existing water softeners, 100 percent of new water softeners)	394	1,183	19,186	1,216	- -

Table 76 (continued)

Alternative				Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Present Worth Cost[a] (thousands)	Equivalent Annual Cost[a] (thousands)	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Designation	Name	Description	Component					
C2 (continued)	Water Quality-Based, with Green Measures (continued)		7. Pet litter management programs	- -[g]	- -[g]	- -[g]	- -[g]	X
			8. Waterfowl control programs for all Lake Michigan beaches	$ 0	$ 125	$ 1,966	$ 125	- -
			9. Litter control programs	0	6,204	97,787	6,204	- -
			10. LEED development for 50 percent of new commercial and industrial development in areas with suitable soils	- -[j]	- -[j]	- -[j]	- -[j]	- -
			Urban nonpoint source measures in combined sewer service area:					
			1. Provide enhanced infiltration for new well-drained industrial, commercial, and institutional development	400	20	861	55	X
			2. Downspout disconnection with rain barrels at 15 percent of homes in study area	9,900	165	12,501	793	- -
			3. Downspout disconnection with rain gardens at 15 percent of homes in study area. (different homes than Item 2)	27,225	1,031	43,479	2,757	- -
			4. Sewer separation for seven parking lots identified in MMSD stormwater disconnection study	7,330	0	7,330	465	- -
			5. Stormwater trees	- -[h]	- -[h]	- -[h]	- -[h]	- -
			6. Rooftop storage equaling 14 MG to 50 percent of buildings from MMSD downspout disconnection study	24,800	0	34,270	2,173	- -
			7. Storm sewer inlet restrictors to provide 15 MG of street storage	32,500	650	42,745	2,710	- -
			8. Pet litter management programs	- -[g]	- -[g]	- -[g]	- -[g]	X
			9. Waterfowl control programs for all Lake Michigan beaches	- -[i]	- -[i]	- -[i]	- -[i]	- -
			10. Litter control programs	- -[i]	- -[i]	- -[i]	- -[i]	- -
			11. Skimmer boat operation within inner and outer harbor	1,000	150	3,364	213	- -
			Total Cost	$2,226,873	$133,160	$4,413,228	$279,829	- -

Table 76 Footnotes

[a]*Costs are based on an annual interest rate of 6 percent and a 50-year amortization period.*

[b]*The mechanism for implementing components that may require new or modified regulations or changes in enforcement would be established at the Federal, State, or local government levels. Many of those components might also be implemented voluntarily.*

[c]*Original 2020 land use and population projections based on information provided by communities served by the MMSD and on the SEWRPC land use plan in areas outside the MMSD planning area. See Chapter VIII of this report for additional information.*

[d]*Includes facilities as reported in MMSD 2006 Capital Budget. The facilities and costs are for a six-year period, beginning in 2006, as reflected in the six-year capital improvements program. Capital costs account for inflation over six-year period. No operation and maintenance costs were provided in the budget report.*

[e]*Does not include discharge from LeSaffre Yeast plant in City of Milwaukee. That plant closed in 2005.*

[f]*Implementation of this alternative plan would require a change in Federal law with regard to sanitary sewer overflows.*

[g]*No costs assigned. Assumed to be covered under cost of compliance with Chapter NR 151 rules.*

[h]*Included in costs for downspout disconnection.*

[i]*Included above in cost for separate sewer area.*

[j]*No cost assigned. Assumed higher initial capital costs compensated for in long-term energy savings.*

Source: Milwaukee Metropolitan Sewerage District, HNTB, and SEWRPC.

population and land use condition." The year 2020 condition derived from the 2035 regional land use plan data and applied for the recommended plan and extreme measures condition as described in Chapter X is referred to as the "**revised 2020 baseline population and land use condition.**" A detailed explanation of the land use plan element is provided in Chapter VIII.

Urban Stormwater Management

As described in detail in Chapter VI, Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* sets forth rules for the control of nonpoint pollution from agricultural and nonagricultural areas, construction sites, and transportation projects. For new development and redevelopment, these include both construction and post-construction performance standards intended to limit the volume of stormwater runoff and the sediment load from a given site. Standards are also included for the reduction of sediment loading from areas of existing development. Additional rules regarding public information and education programs, leaf and grass clipping collection and management, and fertilizer management programs are also included. The baseline alternative assumes compliance with all of the nonagricultural performance standards.

In addition to the performance standards set forth in Chapter NR 151, the MMSD has adopted rules aimed at limiting the increase in runoff due to new development within its service area. These rules are set forth in Chapter 13, "Surface Water and Storm Water," of the MMSD Discharge Regulations and Enforcement Procedures. Although these rules are aimed at avoiding increased flooding problems, the associated limits on stormwater runoff and the attendant control measures necessary to achieve them may also serve to reduce nonpoint source pollutant loadings to the receiving waters in the study area. The baseline alternative includes consideration of these rules and their impact on reducing stormwater runoff and associated pollutant loads within the MMSD planning area.

Rural Land Management

The performance standards governing control of nonpoint pollution from agricultural lands that are set forth in Chapter NR 151 cover the areas of cropland sheet, rill, and wind erosion control, manure storage, clean water diversions, and nutrient management. For existing land that does not meet the NR 151 standards and that was cropped or enrolled in the U.S. Department of Agriculture Conservation Reserve or Conservation Reserve Enhancement Programs as of October 1, 2002, agricultural performance standards are only required to be met if cost sharing funds are available. Given the current lack of public cost share funding, it is unlikely that compliance with the standards will be achieved by the plan design year of 2020. Inventories carried out during this planning effort indicate that the majority of croplands in the study area already meet the standards for cropland sheet, rill, and wind erosion control. Thus, a level of soil erosion control consistent with all cropland being in compliance by the design year 2020 was assumed. This partial level of implementation of the NR 151 agricultural performance standards is considered to be consistent with the anticipated level of funding, assuming no change in the structure of the current grant program.

Sewerage Systems (Committed Facilities)

The basis of the specific committed sewerage system facilities included in the baseline condition alternative was the MMSD 2006 Capital Budget and Six-Year Capital Improvements Program.[11] Major projects incorporated under the baseline condition include improving the wet weather flow capacity at the Jones Island and South Shore WWTPs, constructing the Jones Island Inline Pump Station and the Harbor Siphons, and additional storage capacity projects including the recently completed Northwest Side Relief Sewer, and the West Wisconsin Avenue relief sewer, the Port Washington Road relief sewer, and the Range Line Road relief sewer.[12]

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[11]*Milwaukee Metropolitan Sewerage District*, 2006 Annual Budget.

[12]*Subsequent to the adoption of the MMSD 2006 Capital Budget, the West Wisconsin Avenue and Port Washington Road relief sewer projects were dropped in favor of the North 27th Street ISS, which was found to provide the same level of relief.*

Under this baseline condition, it was also assumed that effluent characteristics of all public and private wastewater treatment plants within the project area would remain the same as under existing conditions. The volume of effluent from these plants was adjusted, however, to reflect the increased contributions due to future development as set forth in the year 2020 land use plan. Therefore, future system upgrades that may be implemented to handle the increase in loading from new development are accounted for. It was also assumed that the level of SSOs for sewerage systems outside of the MMSD service area would remain at the current levels.

For the baseline condition it was assumed that the current MMSD operating procedures for the ISS would be maintained. Currently the ISS has a storage capacity of 432 million gallons. During wet weather, a certain amount of that storage is reserved for inflow from the separate sewer area, with the remaining volume being used to store inflow from the combined sewer area. The actual amount of storage that is reserved varies by event depending on weather forecasts and the amount of available storage in the ISS at the time. For purposes of alternative plan evaluation under the regional water quality management plan update, it was assumed that 177 million gallons of the ISS storage would be reserved for separate sewer inflow, while the remaining 255 million gallons would be available to store inflow from the combined sewer service area. The 177 million gallons reserved storage was found to be the optimum value in terms of minimizing the occurrence of CSOs, based on application of the MMSD conveyance system model that was described in Chapter V.[13]

Under certain circumstances, MMSD uses blending to prevent basement backups, raw sewage overflows, and damage to the Jones Island WWTP. When blending becomes necessary, up to 20 percent of the total flow coming out of primary treatment is blended back together with flow that received secondary treatment and the combined flow is then disinfected. Under the baseline condition, it was assumed that the current rate of blending would continue at the Jones Island WWTP. No additional blending was assumed for the Jones Island WWTP and no blending was assumed at the South Shore WWTP.

Management of Infiltration and Inflow

One of the assumptions of the future baseline condition is that conveyance system I/I will be maintained at current levels. In order to achieve this, it was assumed that the MMSD and all communities that contribute to the MMSD system will continue their current level of sanitary sewer system maintenance so as not to allow any further increase in system I/I. Measures to further reduce I/I below current levels are not included in the baseline condition alternative, but were investigated as part of Screening Alternative 1D.

Other Point and Nonpoint Sources of Pollution

In addition to public and private wastewater treatment plants and separate and combined sewer overflows, the water quality assessment also considered point source contributions from industrial sources. As described in Chapter V, loading information for these sources was obtained from Discharge Monitoring Reports that are required under the WDNR Wisconsin Pollutant Discharge Elimination System permitting program. Under the future baseline condition, it was assumed that the existing industries would continue to discharge at the current rates. One exception is the LeSaffre Yeast plant that discharged to the Menomonee River in the City of Milwaukee. That plant closed in 2005 and, thus, was not included in the future condition analyses.

Although not explicitly represented in the water quality simulation models used, discharges from malfunctioning private onsite waste treatment systems (POWTs) was accounted for through an increase in pollutant concentrations associated with groundwater. Under the future baseline condition, it was assumed that the current level of pollutant contribution from POWTs would be maintained.

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[13]*The reserve storage value of 177 million gallons was derived using the original 2020 population and land use assumptions. As described in Chapter VIII, those assumptions were later revised based on the SEWRPC 2035 Regional land use plan. Application of the revised 2020 population and land use within the MMSD conveyance model results in an optimum reserve storage of 197 million gallons for separate sewer system inflow. This revised storage value was assumed in the evaluation of the preliminary recommended plan.*

Watercourse Management

In addition to construction and maintenance of facilities for the conveyance and treatment of wastewater, the MMSD also has discretionary authority to maintain waterways within the watersheds located within its service area. In 1990, SEWRPC completed a storm water drainage and flood control system plan for the MMSD that identified specific measures for relieving flooding problems within the District service area. Following severe flooding problems experienced in 1997 and 1998, the MMSD updated this plan and initiated a series of projects aimed at alleviating flood problems along the streams for which it has assumed jurisdiction. Many of these projects include structural measures that could affect the hydraulic characteristics and/or flow regime of these waterways, including channel modification, floodplain lowering, floodwater storage, and flood walls and levees.

The baseline alternative assumes that all of the MMSD watercourse projects that have either been completed or are committed to be completed by the year 2020 will be implemented. Committed projects are those outlined in the MMSD 2006 Capital Budget.

No other specific watercourse management projects were identified in the study area.

Continued Dredging of Bottom Sediments for Maintenance of Navigation

Maintenance dredging is carried out for that portion of the Milwaukee Harbor estuary used for waterborne commerce through the combined efforts of the Federal government, the City of Milwaukee, and private riparian property owners. The U.S. Army Corps of Engineers (USCOE) conducts dredging in the major navigation waterways within the inner and outer harbor. The current USCOE dredging program is focused on the outer harbor where a 28-foot depth below the established low water datum is maintained, the main gap from the outer harbor into Lake Michigan where a 30-foot depth is maintained, a short reach of the Milwaukee River downstream of E. Buffalo Street where a 21-foot depth is maintained, the Menomonee River from N. 20th Street extended to its confluence with the Milwaukee River where an 18-foot depth is maintained, the South Menomonee Canal where an approximately 16-foot depth is maintained, and the Kinnickinnic River from S. Kinnickinnic Avenue to the Union Pacific Railroad swing bridge (21-foot depth) and from the swing bridge to the confluence with the Milwaukee River (27-foot depth).including the Milwaukee River downstream of E. Buffalo Street, the Menomonee River downstream of S. 25th Street, and the Kinnickinnic River downstream of S. Kinnickinnic Avenue.

The Port of Milwaukee dredges within the municipal mooring basin along the Kinnickinnic River (27-foot-depth) and in the ship slips in the outer harbor, while the slips in the inner harbor are maintained by private concerns.

As part of the baseline and all subsequent alternative water quality management plans, it was assumed that maintenance dredging for commercial navigation would continue to be conducted as needed.

Alternative B1: Regulatory-Based Alternative

Under this alternative it was assumed that all current regulations governing discharge from municipal sanitary sewer overflows and control of nonpoint source pollution would be met. This alternative was built on baseline Alternative A and includes the same features regarding future committed projects and the common package.

Currently, the MMSD operating permit incorporates the presumptive approach under which the MMSD’s level of CSO control is presumed to be meeting water quality standards if:

- There are no more than six combined sewer overflow discharge events per year; or
- No less than 85 percent by volume of the combined sewage collected in the combined sewer system from precipitation events on a systemwide annual average basis is captured and delivered to the Jones Island and South Shore WWTPs.

Application of the conveyance system models that were described in Chapter V indicates that the MMSD would be expected to meet these criteria under the future 2020 land use conditions, assuming that current system operating conditions are maintained. Under this alternative, the MMSD would maintain the current operating procedures of its conveyance, storage, and treatment facilities so as to meet the CSO requirements.

The Wisconsin Pollutant Discharge Elimination System (WPDES) permit for MMSD sewerage system and wastewater treatment facilities specifically states that, “Bypasses and overflows of wastewater from the permittee’s sanitary sewerage system are prohibited and are not authorized by this permit, the Department may initiate legal action regarding such occurrences as authorized by § 283.89, *Wis. Stats*.”

The WPDES permit for each municipal wastewater treatment facility in the study area, including the MMSD system, has an “Unscheduled Bypassing” subsection that lists the following conditions regarding enforcement actions related to sanitary sewer overflows:

“Any unscheduled bypass or overflow of wastewater at the treatment works or from the collection system is prohibited, and the Department may take enforcement action against a permittee for such occurrences under § 283.89, *Wis. Stats*., unless:

- The bypass was unavoidable to prevent loss of life, or severe property damage;

- There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

- The permittee notified the Department as required in this Section (of the discharge permit).”

Under this alternative plan, a five-year recurrence interval level of protection (LOP) from SSOs was assumed. This level of occurrence is tied to the frequency of overflow events, and not to rainfall frequency. In order to meet the five-year LOP SSO restriction, this alternative includes the following additional measures:

- Add 100 mgd of pumping capacity from the MMSD Inline Storage System (ISS) to the Jones Island WWTP.

- Add 185 mgd of treatment capacity to the South Shore WWTP.

- Add 40 million gallons of storage capacity to the ISS.

- Upgrade the Metropolitan Interceptor System (MIS) conveyance capacity at identified hydraulic restrictions.

Assessment of the ability of this alternative to achieve compliance with the SSO requirement was carried out using the MMSD conveyance system models described in Chapter V. The simulation modeling was based on recorded rainfall conditions for the 64.5-year period from 1940 to 2004. Facility upgrades required under this alternative were sized to accommodate the critical storms during that period.

In addition to the CSO and SSO control measures noted above, this alternative also includes full compliance with both the urban and rural nonpoint source control performance standards as outlined in Chapter NR 151 of the *Wisconsin Administrative Code*. This is a departure from Alternative A, which assumed only partial implementation of the NR 151 agricultural standards due to funding constraints. Under Alternative B1, it was assumed that adequate funding would be made available.

Additional measures aimed at reducing the volume of stormwater runoff from within the combined sewer service area would also be implemented. These include downspout disconnection with rain barrel installation at

15 percent of homes in the area, downspout disconnection with rain gardens at a different 15 percent of homes in the area, provision of 14 million gallons of rooftop storage in the City of Milwaukee central business district, provision of 15 million gallons of street storage through installation of storm sewer inlet restrictors, and provision of stormwater trees.

This alternative has an estimated capital cost of $1.999 billion and an annual operation and maintenance cost of $91.3 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $223.1 million.

Alternative B2: Regulatory-Based Alternative with Revised ISS Operating Procedure

This alternative is similar in concept to Alternative B1, with the exception of a change in the operation of the ISS so that volume does not always need to be reserved for wastewater from the separate sewer systems. In this way, the use of the ISS may be maximized, with the intent of reducing the total volume of overflows from both combined and separate sewers.

As previously stated, current regulations do not allow for separate sewer overflow discharges except in special situations. The change in operating procedures under this alternative would result in a reduction in the number and volume of CSOs at the expense of an increase in the number and volume of SSOs. Thus, implementation of this alternative would require a change in Federal law with regard to SSOs.

In order to provide a consistent basis of comparison with Alternative B1 in terms of water quality impacts, this alternative also includes the same system improvements as that alternative, namely an increase of 100 mgd in pumping capacity from the ISS to the Jones Island WWTP, an increase of 185 mgd in the treatment capacity at the South Shore WWTP, an increase of 40 million gallons in the ISS capacity, and upgrades to the MIS conveyance capacity to relieve identified hydraulic restrictions.

In addition to the CSO and SSO control measures noted above, this alternative also includes full compliance with both the urban and rural nonpoint source control performance standards as outlined in Chapter NR 151. As with Alternative B1, it was assumed that adequate funding would be made available to implement the agricultural performance standards of that program.

Additional measures aimed at reducing the volume of stormwater runoff from within the combined sewer service area would also be implemented. These include downspout disconnection with rain barrel installation at 15 percent of homes in the area, downspout disconnection with rain gardens at a different 15 percent of homes in the area, provision of 14 million gallons of rooftop storage in the City of Milwaukee central business district, provision of 15 million gallons of street storage through installation of storm sewer inlet restrictors, and provision of stormwater trees.

This alternative has an estimated capital cost of $1.999 billion and an annual operation and maintenance cost of $91.3 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $223.1 million.

Alternative C1: Water Quality-Based Alternative

This alternative and Alternative C2 were developed with an emphasis on maximizing compliance with water quality standards and criteria, rather than meeting regulatory requirements. To this end, both of these alternatives emphasized control of nonpoint source pollution. The main difference between these two is that C1 addresses nonpoint source reductions with more traditional measures, while Alternative C2 incorporates more innovative "green" measures. As with Alternatives B1 and B2, these two alternatives were built on Alternative A and includes the same features regarding future committed projects and the common package.

The measures that make up Alternative C1 are identified in Table 76. Under this alternative, it was assumed that the current MMSD operational measures to control the occurrence of SSOs and CSOs would be maintained.

There would be no further measures employed to reduce the level of SSOs and CSOs over and above the committed actions that were assumed under the future baseline condition (Alternative A).

Alternative C1 assumes the application of nonpoint source control measures that would exceed those required to meet the current performance standards as identified in Chapter NR 151. For rural areas, these measures include providing buffer strips with a minimum width of 50 feet on existing crop and pasture lands along each side of streams, implementation of manure management programs for all livestock operations, and increased inspections of privately owned wastewater treatment systems. For urban areas, measures to be employed include extending the infiltration standards set forth in Chapter NR 151 to include all existing institutional and commercial development and providing enhanced infiltration for all redeveloped institutional and commercial development and all new residential development. Other urban area measures include increasing the application of modular end-of-pipe water quality treatment devices; installing storm sewer outfall disinfection units; implementing chloride reduction programs; downspout disconnections in conjunction with either rain barrels or rain gardens; pet litter management; waterfowl control; litter control; continued skimmer boat operation within the inner and outer harbors; selective sewer separation in the combined sewer service area; providing enhanced infiltration of stormwater from new well-drained industrial, commercial, and institutional development in the combined sewer area; and applying street and rooftop storage within the combined sewer area.

This alternative has an estimated capital cost of $2.564 billion and an annual operation and maintenance cost of $116.5 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $293.7 million.

Alternative C2: Water Quality-Based Alternative with Green Measures

As previously noted, this alternative differs from Alternative C1 in that it includes more emphasis on “green” technologies that more directly address reduction of sources of pollution. The measures that make up Alternative C2 are identified in Table 76. As seen in that table, all of the measures set forth in Alternative C1 would also be included under Alternative C2. One exception is in the application of storm sewer outfall disinfection units. Under Alternative C1, it was assumed that the units would utilize a chlorine-based system for disinfection. For Alternative C2, disinfection would be achieved utilizing ultraviolet light.

For rural areas, additional measures that would be employed are the conversion of a total of 10 percent of existing crop or pasture land to either wetland or prairie. A 50-50 split was assumed, with 5 percent of the land being converted to wetland and 5 percent to prairie. Marginally productive farmland would be targeted for such conversion.

Within urban areas, this alternative assumes that 50 percent of new industrial and commercial development would employ Leadership in Energy and Environmental Design (LEED) features. The LEED Green Building Rating System is a voluntary, consensus-based national standard for developing high performance, sustainable buildings, with an emphasis on state-of-the-art strategies for sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. While many of the LEED standards relate to building design, energy conservation, material reuse and recycling, and indoor environmental quality, a number of standards are stormwater-related. Standards that could affect the quantity and quality of stormwater runoff include: erosion and sediment control, reduced site disturbance, stormwater management, and water efficient landscaping.

This alternative has an estimated capital cost of $2.227 billion and an annual operation and maintenance cost of $113.2 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $279.8 million.

COMPARATIVE EVALUATION OF WATER QUALITY MANAGEMENT ALTERNATIVE PLANS

The preceding section of this chapter describes water quality management plan alternatives for the greater Milwaukee watersheds. This section compares the major features of those alternative plans, including economic considerations and water quality benefits. The following evaluation and comparison serves as the basis for the development of the preliminary recommended water quality management plan.

Pollutant Loading Analysis

Tabular comparisons of the various point and nonpoint source pollutant loadings for the alternative water quality management plans are presented in Appendix B. Also shown for comparative purposes are loads based on existing land use with current wastewater conveyance, storage, and treatment systems in place.

The information presented in Appendix B shows that the expected pollutant loadings under Alternative A, the future year 2020 baseline condition, are generally similar to existing conditions. The largest loading differences are in fecal coliform bacteria, which are anticipated to drop by about 21 percent relative to existing conditions, and total suspended solids, which are anticipated to increase by about 10 percent relative to existing conditions. The other indicator pollutants listed show modest differences of ±3 percent relative to existing conditions. Although there is more development under the future condition, and thus more potential for pollutant loads, this is offset by construction of the additional committed MMSD and community facilities and implementation of the Chapter NR 151 nonpoint source pollution control rules, all of which are assumed under the future condition.

Among the remaining water quality management plan alternatives, Alternatives B1 and B2 provide similar results to one another. The major difference is in the allocation of fecal coliform point source loadings between SSOs and CSOs. Alternative B2, which calls for a change in operating procedure for the ISS, shows a lower loading from CSOs than Alternative B1, but a higher loading from SSOs. Overall, the total combined CSO and SSO fecal coliform bacteria load is higher under Alternative B2 than for Alternative B1. For the other pollutants listed, the difference between these two alternatives is negligible.

In terms of overall pollutant load reduction, Alternative C1 provides results that are similar to Alternatives B1 and B2. Alternative C2, which includes the highest level of nonpoint source controls, provides the highest overall level of pollutant load reduction among the alternative plans. For all of the alternative plans, the highest percent reductions occur for total suspended solids and fecal coliform bacteria, while the lowest percent reductions occur for total nitrogen and copper.

Water Quality Conditions and Ability to Meet Water Use Objectives

The water quality benefits of the alternative plans were evaluated by comparing the effects of the plan alternatives, as predicted using the mathematical simulation modeling techniques described in Chapter V of this report, upon a number of water quality indicators. Tabular comparisons of water quality conditions among alternative plans are presented in Appendix J (revised). In general, the anticipated differences in water quality conditions among alternatives are small.

Methodology for Comparing Alternative Plans

The effects of the alternative plans on water quality indicators were compared at 64 water quality assessment points. The locations of these assessment points are shown on Maps 57 through 62. Many of the assessment points also correspond with the location of MMSD water quality sampling sites. A cross-reference between the assessment point designations shown on the maps and the MMSD sampling site designations is provided in Table 75. A series of comparisons were made at each site using 20 indicators related to concentrations of the following six water quality parameters: fecal coliform bacteria, dissolved oxygen, total phosphorus, total nitrogen, total suspended solids, and copper. These indicators are listed in Table 77. A variety of indicators were compared for these parameters. For all six parameters, comparisons were made among the arithmetic mean concentrations predicted for each alternative plan. Similarly, comparisons were made among the median concentrations predicted for each alternative plan for all parameters except fecal coliform bacteria, where the geometric mean

Table 77

WATER QUALITY INDICATORS USED TO COMPARE ALTERNATIVE PLANS

Parameter	Indicator
Fecal Coliform Bacteria over Entire Year	Arithmetic mean concentration of fecal coliform bacteria
	Proportion of time fecal coliform bacteria concentration is equal to or below single sample standard
	Geometric mean concentration of fecal coliform bacteria
	Days per year geometric mean of fecal coliform bacteria is equal to or below geometric mean standard
Fecal Coliform Bacteria from May to September	Arithmetic mean concentration of fecal coliform bacteria
	Proportion of time fecal coliform bacteria concentration is equal to or below single sample standard
	Geometric mean concentration of fecal coliform bacteria
	Days per year geometric mean of fecal coliform bacteria is equal to or below geometric mean standard
Dissolved Oxygen	Mean concentration of dissolved oxygen
	Median concentration of dissolved oxygen
	Proportion of time dissolved oxygen concentration is equal to or above applicable standard
Total Phosphorus	Mean concentration of total phosphorus
	Median concentration of total phosphorus
	Proportion of time total phosphorus concentration is equal to or below the recommended planning standard
Total Nitrogen	Mean concentration of total nitrogen
	Median concentration of total nitrogen
Total Suspended Solids	Mean concentration of total suspended solids
	Median concentration of total suspended solids
Copper	Mean concentration of copper
	Median concentration of copper

Source: SEWRPC.

concentrations were applied. For those water quality parameters for which there are regulatory or planning water quality criteria and standards (see Chapter VII of this report), comparisons were also made of the proportion of time that the parameter would be in compliance with the criteria and standards.[14] Where special use or variance waters were identified, the applicable standards were used. All comparisons involving fecal coliform bacteria were performed both on a full-year basis and for the May to September period when the potential for body contact would be greater.

For each indicator at each assessment point, the four alternative plans other than the future baseline condition (Alternative A) were compared to one another. Alternative A was not included in the comparison since it served as the basis of the remaining four alternatives, and, thus, should always reflect the worst water quality conditions

[14]*The proportion of time in compliance estimates are based on the results of the water quality model simulation that utilized a 10-year simulation period.*

among all of the alternative plans. The comparison among the remaining four alternatives was made by computing the relative deviation of the value of the indicator associated with that alternative plan from the mean value of the indicator for all four alternatives. This was computed by subtracting the mean value of the indicator for all alternatives at a given site from the value of the indicator for the alternative and dividing the result by the mean value that was subtracted. The sign of the relative deviation was adjusted for some indicators so that a positive relative deviation indicated better water quality and a negative relative deviation indicated poorer water quality.[15] For each water quality parameter, the relative deviations from all indicators were totaled. Subtotals were also computed for each watershed. An overall score was computed by totaling the scores from each water quality parameter. Prior to totaling, the scores were adjusted to give each water quality parameter equal weight in the overall total.[16]

It is worth commenting on two properties of this method. First, this method compares the effects of alternative plans relative to one another. A higher value in the final total for an alternative plan indicates better water quality relative to the other alternative plans. Similarly, a lower value in the final total for an alternative plan indicates poorer water quality relative to the other alternatives. It is important to note that because only the alternative plans were included in this analysis, a negative value in the final total does not indicate poorer water quality than existing or future baseline conditions. Second, because greater differences among alternative plans in the values of indicators result in larger relative deviations, greater differences in the final totals for alternative plans indicate greater differences in overall effects on water quality conditions. Conversely, similar final totals for two alternatives indicate that their overall effects on water quality conditions are not very different.

Comparison of Alternative Plans

Watershed totals and overall totals for relative deviations of water quality indicators from mean values are shown in Table 78. This analysis indicates that the greatest overall water quality benefit is provided by Alternative C2. This alternative is followed, in decreasing order of the benefit provided, by Alternative C1, Alternative B2, and Alternative B1. In most watersheds, the relative effects of the alternative plans follow this overall pattern.

There are four important exceptions to this generalization. First, the differences in total relative deviations between Alternative B1 and Alternative B2 in the Menomonee River, Milwaukee River, and Oak Creek watersheds are small, suggesting that there is little difference between the overall water quality resulting from these two alternatives in these watersheds. Second, there is no difference in the total relative deviations between Alternative C1 and C2 in the Kinnickinnic River watershed, suggesting that there is little difference in overall water quality resulting from these two alternatives in this watershed. Third, in the Kinnickinnic River watershed,

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[15]*Because the methodology for assessing relative water quality conditions among alternatives was based on combining relative deviations computed for given indicators that are characteristic of given pollutants, it was necessary that the sign of the relative deviation relate to differences in water quality in a consistent manner. In cases where a lower concentration indicated better water quality, the sign of the relative deviation of a better than average alternative would be computed to be negative. In contrast, in cases where a higher concentration indicated better water quality the sign of the relative deviation of a better than average alternative would be computed to be positive. Therefore, to facilitate combining relative deviations in a manner that would properly represent relative water quality conditions, the sign of the relative deviation was reversed for those indicators for which a lower concentration indicated better water quality. This enabled the relative deviations from different indicators to be combined into a single index for which a larger positive value indicated better relative water quality.*

[16]*This unweighting was necessary because different numbers of indicators were used to characterize different water quality parameters. For example, eight indicators were used to characterize fecal coliform bacteria. By contrast, total phosphorus was characterized by three indicators, Thus, to ensure that each water quality parameter had equal influence when the relative deviations were totaled, the sum of the relative deviations for the eight fecal coliform indicators was divided by eight and the sum of the relative deviations for total phosphorus was divided by three.*

Table 78 (revised)

SUMMED RELATIVE DEVIATIONS OF WATER QUALITY INDICATORS FROM THE AVERAGE VALUE FOR ALTERNATIVE PLANS B1, B2, C1, AND C2

Plan Alternative	Watershed						Total
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan[a]	
B1	-0.367	-0.666	-0.131	-0.738	-0.721	-1.377	-4.001
B2	-0.400	-0.664	-0.131	-0.738	-1.156	-0.027	-3.116
C1	0.384	0.418	-0.597	0.727	-0.173	0.437	1.195
C2	0.384	0.913	0.859	0.750	2.050	0.967	5.922

[a]*Lake Michigan assessment points include sites in the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan areas.*

Source: SEWRPC.

Alternative B1 provides slightly greater water quality benefits than Alternative B2. This difference from the overall result is driven by lower arithmetic and geometric mean concentrations of fecal coliform bacteria and slightly lower mean concentrations of total nitrogen and mean and median concentrations of total phosphorus for Alternative B1 at some assessment points along the mainstem of the Kinnickinnic River. Fourth, in the Milwaukee River watershed, Alternatives B1 and B2 provide greater water quality benefit than Alternative C1. These differences from the overall result are driven by Alternatives B1 and B2 resulting in lower mean concentrations of total phosphorus and total nitrogen and higher percent of compliance with the standard for total phosphorus than Alternative C1 at some assessment points.

The compliance with applicable regulatory or planning water quality standards and criteria for fecal coliform bacteria, dissolved oxygen, and total phosphorus expected under the four alternative plans are summarized in Appendix K (revised). In general, only small differences in compliance with water quality standards were noted among the alternative plans.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that violations of the applicable regulatory standards for fecal coliform bacteria may be expected to occur in the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek under each alternative plan. The frequency of these violations is expected to range from occasional to frequent, with chronic violations expected to occur at a few assessment points in upstream areas of the Milwaukee River. By contrast, substantial achievement of applicable standards for fecal coliform bacteria is expected under each alternative plan at most assessment points in the estuary, outer harbor, and nearshore Lake Michigan areas.[17] At most assessment points, the expected level of compliance with applicable standards for fecal coliform bacteria is slightly higher during the May to September swimming season than during the entire year. While differences in the expected levels of compliance among alternative plans are small, Alternative C2 provides the highest level of compliance with water quality standards for fecal coliform bacteria followed by Alternative C1, Alternative B2, and Alternative B1.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that each alternative would allow for substantial achievement of the applicable regulatory dissolved oxygen standards in the Kinnickinnic River, Menomonee River, Milwaukee River, Root River, estuary, outer harbor, and nearshore Lake Michigan areas. The analyses also indicate that each alternative would allow for substantial achievement of the dissolved oxygen standard for fish and aquatic life in the downstream reaches of Oak Creek. Violations of the dissolved oxygen standard for fish and aquatic life would be expected to occur occasionally to frequently in the upstream reaches of Oak Creek. The analyses indicated that there are few

[17]*In the outer harbor and nearshore Lake Michigan area, the full recreational use fecal coliform standards of a geometric mean concentration of 200 counts per 100 ml and a maximum single sample concentration of 400 counts per 100 ml were used to evaluate compliance.*

differences among alternatives in the expected level of compliance with applicable dissolved oxygen standards. At assessment points where differences are expected, these differences are small.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that violations of the recommended planning standard for total phosphorus may be expected to occur in the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers; Oak Creek; and the estuary under each alternative plan. The frequency of these violations is expected to range from occasional to frequent, with total phosphorus exceeding the recommended concentration the majority of the time at all assessment points in the Kinnickinnic River watershed and most in the Milwaukee River watershed, but generally not exceeding the planning standard the majority of the time in the other watersheds. While differences in the expected levels of compliance among alternative plans are small, Alternative C1 provides the highest level of compliance with the recommended planning water quality standard for total phosphorus, followed by Alternative C2, and then by Alternatives B2, and B1, which would generally be expected to achieve the same level of compliance.

Economic Analysis

To compare the costs and evaluate the financial feasibility of the alternative water quality management plans, an economic analysis was conducted. Table 76 sets forth the capital cost, average annual operation and maintenance cost, the 50-year present worth, and equivalent annual costs of each of the alternative plans.

The costs of these alternative plans must be viewed in terms of the water quality benefits they provide for the streams in the planning area. It must be recognized that all of the alternative plans do not provide equivalent water quality benefits, although all, to some degree, help to improve water quality. It must also be recognized that the water quality benefits of the regulatory-based alternatives—Alternatives B1 and B2—are more localized within the MMSD planning area than are the water quality-based alternatives, whose benefits extend to the entire planning area.

With respect to the three economic indicators presented in the table, Alternatives B1 and B2 have the lowest cost of all of the alternatives other than the baseline alternative, entailing a capital cost of about $1.999 billion, an annual operation and maintenance cost of about $91.3 million, and a 50-year equivalent annual cost of about $223.1 million. The cost of both these alternatives is estimated to be the same since the only difference between them is in the operation of the ISS. Of all the alternatives other than the baseline alternative, Alternative C1 has the highest overall cost, with a capital cost of about $2.564 billion, an annual operation and maintenance cost of about $116.5 million, and a 50-year equivalent annual cost of about $293.7 million. Alternative C2, which includes the highest level of nonpoint source runoff controls, has a capital cost of about $2.227 billion, an annual operation and maintenance cost of about $113.2 million, an equivalent annual cost of about $279.8 million.

Implementability

Development of the alternative water quality management plans was based on a broad set of criteria. Among these were the requirements that the measures identified within each alternative plan be technologically feasible and that they be capable of implementation within a reasonable time frame that is consistent with facilities planning periods for wastewater treatment facilities in the study area, including the MMSD 2020 Facilities Plan.

Of the alternative plans considered, Alternative A would be the easiest to implement since it consists mainly of actions that are either already committed to be carried out by the MMSD and the communities within its service area or are required to be carried out under State regulations. These include facilities and programs contained within the current MMSD budget, agreements between the MMSD member and contract communities and the State of Wisconsin regarding maintenance of current levels of I/I, and rules governing nonpoint source runoff as set forth in Chapter NR 151 of the *Wisconsin Administrative Code*.

The second easiest alternative to implement would be Alternative B1, which consists mainly of additional facilities that would be constructed by the MMSD. Under both Alternatives B1 and B2 it is assumed that the NR 151 rules regarding rural nonpoint source pollution controls would be fully implemented. That is unlikely to occur unless adequate public cost-share funds become available.

Alternative B2 would be harder to implement than Alternative B1 since it would require changes at the State and Federal level in terms of how SSOs are regulated. Also, under Alternative B2, the ISS would fill sooner and would not be available to provide hydraulic relief to local sanitary sewers when all separate sewer gates are closed. This could result in an increased frequency of basement backups in those portions of the system where the MIS water level exceeds the elevation of local sewer connections.

Alternatives C1 and C2 both have higher overall costs than Alternatives A, B1, and B2, although their water quality benefits extend to a larger area. Alternatives C1 and C2 include greater levels of rural nonpoint source runoff controls than do the other alternatives. Current State regulations regarding rural controls are tied to the availability of public cost-share dollars. Therefore, implementation of either of these two alternatives would require that sufficient funds be made available.

SUPPLEMENTARY ANALYSES OF WATER QUALITY MANAGEMENT MEASURES

Subsequent to the evaluation of the alternative water quality management plans, additional analyses were carried out to further test and refine certain aspects of those alternatives so as to help in selection of those measures to be included in the preliminary recommended plan. These analyses focused on changes in the operating procedures for the MMSD ISS and on both urban and rural nonpoint source loading sources and best management practices.

Changes to MMSD ISS Operating Procedure

Subsequent to the development and evaluation of the alternative water quality management plans, additional modeling simulations were made that addressed the MMSD operational procedures for the ISS, namely, the current practice of reserving storage capacity for inflow from the separate sewer service area. Alternative B2 included an assumption that no storage capacity would be reserved, thus allowing for an increase in SSOs while reducing the number and volume of CSOs. That alternative was designed to be compared with Alternative B1, which represented the MMSD operating practice of reserving ISS storage volume for separate sewage inflow,[18] and also provided conveyance, storage, and treatment enhancements to attain a five-year LOP for SSOs. In order to be consistent, Alternative B2 also included those system enhancements.

Under the additional evaluation, a comparison was made between the future baseline condition (Alternative A) and the future baseline condition with the same ISS operating procedure as was assumed under Alternative B2 (i.e., no ISS capacity reserved solely for separate sewer inflow). Thus, the new evaluation considered the water quality impact that would occur if there would be no additional system improvements other than those that are already committed, with simply a change in the operating procedure for the ISS.

The results of this investigation indicated that, with the revised operating procedure, fecal coliform bacteria levels as measured by the mean, geometric mean, and median may be expected to be higher at riverine locations in the Kinnickinnic and Milwaukee River watersheds, but slightly lower at riverine locations within the Menomonee River watershed. Within the Milwaukee Harbor estuary, fecal coliform levels would tend to be slightly lower with the revised operating procedure, although at some locations they are slightly higher. In terms of percentage of time that the applicable water quality standards would be met, no appreciable difference was found. It should be pointed out that the differences noted are well within the accuracy of the models being used, and thus both procedures could be considered to have the same effect on water quality conditions. However, in comparison to the future baseline condition representing current MMSD operating procedures, model results indicate that the revised operating option that would not distinguish between separate and combined sewer flows to the ISS would reduce the average annual number of tunnel-related CSOs and SSOs combined (from 3.5 to two), reduce the

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[18]*Current MMSD operating practice calls for the ISS volume reserved for separate sewer inflows to be adjusted as conditions dictate during the course of a storm event. The simulation model that represents the MMSD system requires that the volume reserved for separate sewer inflows be constant. As noted previously a volume of 177 million gallons was chosen to approximate MMSD operating conditions for the analysis of the screening alternatives and the alternative plans.*

average annual number of CSOs by two (from three to one), increase the average annual number of tunnel-related SSOs by 0.5 (from 0.5 to one), and would decrease the total annual average overflow volume by about 12 percent, from 930 million gallons to 720 million gallons.

One further consideration regarding this analysis is that the model simulations reflect the impact of all CSO reductions but they only reflect the impact of increased SSO loading from the MMSD conveyance system. If the ISS were operated to strictly adhere to a rule that reserved no volume for SSOs, during large storms, the ISS could fill rapidly and its volume would not be available to provide hydraulic relief to local sanitary sewers when all separate sewer gates are closed. This could result in an increased frequency of basement backups in those portions of the system where the MIS water level exceeds the elevation of local sewer connections. Also, under that scenario, additional loading may be expected due to an increase in the incidence of overflows from local community systems. However, those potential problems could be alleviated through an ISS operating procedure similar to that currently practiced by MMSD whereby the volume reserved for separate sewer inflow is adjusted during real time over the course of a storm in an effort to avoid, or reduce, overflow volumes to levels less than would be achieved with a constant volume reserved for separate sewer flows.[19] Thus, because it is desirable to minimize the number and volume of overflows, there is merit to MMSD pursuing efforts to refine and systematize its ISS operating strategy. This should be done in a manner that provides hydraulic relief to local sanitary sewers and does not result in an increased frequency of basement backups.

Depending on the impact of changes in operation of the ISS, a change in the way that the USEPA and the WDNR regulate SSOs may be required.

Sensitivity Analyses of Urban and Rural Best Management Practices

Subsequent to the evaluation of the alternative water quality management plans, additional small-scale sensitivity analyses were carried out to further test the effectiveness of certain nonpoint source control BMPs in improving instream water quality conditions with the goal of meeting the recommended water quality standards. These studies were carried out to further guide the selection of practices to be included in the preliminary recommended water quality management plan. Analyses that focused on urban runoff control measures were carried out for the Underwood Creek subwatershed of the Menomonee River watershed. Analyses that focused on rural runoff control measures were carried out for the West Branch of the Root River Canal subwatershed. Descriptions of these studies and their conclusions were set forth in a pair of MMSD technical memoranda.[20]

The results of the Underwood Creek study indicated that urban impervious surfaces are the predominant source of fecal coliform bacteria loads. The findings indicated that those areas would need to be targeted in order to achieve any significant reduction in overall loads. However, the findings also showed that significant reductions in such loads do not produce any meaningful reduction in the percentage of time that instream fecal coliform standards are exceeded in Underwood Creek. This is because the concentrations during wet weather events are orders of magnitude greater than allowed under the standards. Another finding of the study showed that longer term mean concentrations are dominated by subsurface sources such as illicit connections. Therefore, it would also be necessary to address these sources through a program of improved sewer system maintenance and detection and elimination of illicit connections between the sanitary and storm sewer systems.

The results of the West Branch of the Root River Canal study showed that, for rural areas, reductions in fecal coliform bacteria loads could best be achieved through manure management. Smaller impacts on bacteria loads and concentrations were realized when addressing subsurface sources such as failing septic systems. The rural

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[19]*The success of that procedure is dependent to a great degree on the accuracy of weather forecasts and the real-time availability of system operational data.*

[20]*MMSD Technical Memorandum,* Sensitivity Analysis of Urban BMPs–Underwood Creek (revised), *September 28, 2006, and MMSD Technical Memorandum,* Sensitivity Analysis of Rural BMPs–West Branch Root River Canal (revised), *September 13, 2006.*

subwatershed study also investigated the expansion of stream corridor buffers. It was found that expanding current buffer widths could reduce loads of total suspended solids, total phosphorus, and total nitrogen from agricultural lands by about 20 percent. Load reductions ranging from about 13 to 20 percent could also be achieved by converting agricultural land to either wetland or prairie vegetation.

PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT

Based upon the inventories, analyses, and alternative plan evaluations presented in this report, a preliminary recommended water quality management plan was developed for the greater Milwaukee watersheds. The selection of the preliminary plan was based upon careful consideration of the objectives, principles, and standards developed for this planning process and set forth in Chapter VII of this report. Objectives pertinent to selection of the preliminary recommended plan include those related to water quality management, land use development, outdoor recreation and open space, and water control facilities. In addition to considering the objectives, principles, and standards, selection of the components of the preliminary recommended plan included considerations of the technical feasibility, economic viability, water quality impact, potential public acceptance, and practicability of the alternative plans considered.

The selection of the preliminary recommended plan focused primarily on the degree to which the water use objectives and supporting water quality standards could be expected to be met and on the accompanying costs. Consideration was also given to the existing regulatory framework regarding wastewater discharges. Accordingly, the preliminary plan was developed including all components of the future baseline condition (Alternative A) along with elements from both the B alternatives (regulatory-based) and the C alternatives (water quality-based). Components of the plan are set forth in Table 79. The plan incorporates the actions identified in the MMSD 2020 facilities plan, as well as additional measures directed towards meeting the adopted plan objectives through reducing urban point and both urban and rural nonpoint source pollutant loadings.

The measures set forth in the MMSD 2020 Facilities Plan are aimed at meeting the current requirements of the MMSD discharge permit, the 2002 MMSD stipulation with the WDNR, and current CSO and SSO regulations, including providing a five-year recurrence interval level of protection for SSOs, based on long-term (64.5 years) simulation of SSOs under recommended facilities plan conditions. Largely because of the significant MMSD sewerage system and wastewater treatment system upgrades that have been implemented, such as construction of the ISS, along with system upgrades by other communities in the study area, water quality modeling results indicate that additional measures to control CSOs or to meet the regulatory requirements regarding discharges from SSOs would not be expected to achieve a significant improvement in overall water quality. Greater improvement in water quality would be expected through an aggressive application of measures that address nonpoint sources of pollution. Recognizing this, a second alternative plan recommendation was also considered for the regional water quality management plan. The objective of that alternative recommended plan is to target limited financial resources to those measures that would achieve the greatest improvement in water quality. In developing the alternative recommended plan, lower-cost MMSD wastewater treatment options that would maintain the five-year level of protection (LOP) called for under the MMSD facilities plan were considered as was the possibility of foregoing wastewater treatment plant capacity upgrades and providing for a lesser level of protection (LOP) from SSOs within the MMSD service area. Any cost savings realized through the elimination of system improvements aimed at achieving the five-year LOP recommended in the MMSD 2020 facilities plan would be applied to implement additional nonpoint source control measures that would achieve a greater improvement in water quality. A review of the MMSD 2020 Facilities Plan indicates that, under the reduced LOP option, the need for an additional 150 mgd of treatment capacity at the South Shore treatment plant might be eliminated. The cost saving from the elimination of capacity could be partially offset by the cost of additional system measures that would be required to maintain adequate capacity for individual community sewers. Depending on whether the alternative recommended plan calls for elimination of additional treatment, or lower-cost additional treatment, at the South Shore plant, the capital cost savings, which could be applied to more effective measures for improving water quality, could range up to about $160 million.

Table 79

PRINCIPAL FEATURES OF THE PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN

Description	Component
Assumes revised future year 2020 planned land use conditions	MMSD Committed Projects (2007 Capital Budget)
Includes components of the future baseline condition alternative	150 MGD additional treatment capacity at South Shore WWTP
Maintain current MMSD operating procedures to limit occurrence of CSOs and SSOs	100 MGD additional pumping capacity from ISS to Jones Island WWTP
Additional conveyance, storage, and treatment (CST) measures to provide a five-year level of protection (LOP) for SSOs	Upgrade MIS conveyance capacity at potential hydraulic restrictions as needed[a]
Assume communities outside of MMSD service area upgrade waste-water systems to accommodate new development as necessary	Maintain current levels of I/I for MMSD service area
Expanded level of nonpoint source pollutant control beyond that required for Chapter NR 151	MMSD Wet Weather Peak Flow Manage-ment Plan
	Other miscellaneous MMSD 2020 Facilities Plan Recommendations
	Illicit discharge elimination program
	Ongoing evaluation of need for future wastewater treatment plant upgrades through facilities planning process for systems located outside the MMSD
	Future sanitary sewer service/wastewater treatment recommendation for the City of South Milwaukee
	Consideration of possible future regional wastewater treatment facility for the City of Cedarburg and the Village of Grafton
	Investigate alternative corrosion control processes for water utilities
	Rural nonpoint source measures:
	1. Conservation tillage
	2. Manure management for all livestock operations (provide six months of storage, spread twice annually)
	3. Provide more stringent controls on barnyard runoff
	4. Management of milkhouse waste
	5. Fencing along 50 percent of pastures adjacent to waterways
	6. Expand buffers to 75 feet minimum for all cropland and pasture adjacent to streams
	7. Expand level of inspection, and, if necessary, replacement of private onsite waste treatment (septic) systems (POWTS)
	8. Fertilizer management education program
	9. Wetland/prairie restoration (10 percent of cropland and pasture, focusing on marginally productive land)
	Urban nonpoint source measures:
	1. Infiltration systems (NR 151)
	2. Stormwater treatment systems (NR 151)
	3. Wet detention basins (NR 151)

Table 79 (continued)

Description	Component
	Urban nonpoint source measures (continued) 4. Vacuum sweeping of roadways (NR 151) 5. Chloride reduction programs 6. Downspout disconnection with rain barrels (15 percent of homes in the combined sewer service area) 7. Downspout disconnection with rain gardens (15 percent of homes in the combined sewer service area) 8. Stormwater disinfection units 9. Waterfowl control program 10. Litter control programs 11. Pet litter management programs 12. Marina waste management (provide additional pump-out stations) 13. Skimmer boat (harbor and estuary)

[a]*MMSD is monitoring population levels in sewersheds tributary to potential hydraulic restrictions and will upgrade MIS conveyance capacity as warranted by the monitoring data.*

Source: SEWRPC.

For communities outside of the MMSD service area, the preliminary recommended plan assumes that they will continue to assess their wastewater conveyance and treatment systems so as to provide the capacity necessary to allow for future development as it occurs while adhering to the conditions of their operating permits. As shown in Table 80, it is estimated that the public wastewater treatment plants for the City of Cedarburg[21] and the Villages of Jackson and Newburg may meet or exceed their current hydraulic capacities under planned year 2020 conditions, and that the plants for the Villages of Grafton and Kewaskum may be nearing their existing capacities by 2020.[22] The plan also includes a recommendation for increased efforts by all communities to identify and eliminate cross-connections and other illicit discharges of wastewater to streams and storm sewers.

For industrial point sources, it is assumed that they will continue to be regulated under the Wisconsin Pollutant Discharge Elimination System and that they will continue to meet the effluent limits established under their permits.

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[21]*The City retained a consultant to study the hydraulic capacity of the existing wastewater treatment plant. That study indicated that the plant capacity may be considerably greater than its current rating. Before undertaking future facilities planning, the City would pursue officially rerating the plant to reflect the higher capacity.*

[22]*The final recommended plan, which is presented in Chapter X of this report, 1) includes consideration of wastewater treatment plant facilities planning that was recently completed for the Village of Kewaskum at the time that the regional water quality management plan update was being conducted, 2) addresses the issue of considering a new regional wastewater treatment plant at such future time that expansion of the existing treatment capacity is warranted for either the City of Cedarburg and the Village of Grafton, and 3) includes recommendations regarding whether the City of South Milwaukee wastewater treatment plant should be upgraded to meet anticipated year 2020 conditions, or whether the City sewerage system should be connected to the MMSD system.*

Table 80

SELECTED CHARACTERISTICS OF PUBLIC WASTEWATER TREATMENT PLANTS IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA OUTSIDE THE MMSD PLANNING AREA[a]

Facility	2000 Estimated Area Served (square miles)	2000 Estimated Population Served	2000 Unsewered Population[b]	Date of Latest Major Modification	Receiving Water	Design Average Hydraulic Loading (mgd)	Average Annual Hydraulic Loading (mgd)[c]	Planned 2020		Ratio of Estimated 2020 Average Annual Hydraulic Loading to Design Loading
								Estimated Population Served[d]	Estimated Average Annual Hydraulic Loading (mgd)	
City of Cedarburg	3.3	11,400	1,980	1988	Cedar Creek	2.75[e]	2.24[f]	14,700	2.88	1.05
City of West Bend	8.5	30,400	1,360	1980	Milwaukee River	9.00	3.42	39,100	4.51	0.50
Village of Campbellsport	1.1	1,900	- -	1989	Milwaukee River	0.47	0.22	2,100[g]	0.25	0.52
Village of Cascade	0.8	700	- -	1976	North Branch Milwaukee River	0.17	0.06	700[g]	0.06	0.38
Village of Fredonia	0.6	2,000	20	1983	Milwaukee River	0.60	0.24[f]	2,500	0.38	0.63
Village of Grafton	2.6	11,000	840	1983	Milwaukee River	2.15	1.27	14,400	1.69	0.79
Village of Jackson	1.6	5,000	480	1997	Cedar Creek	1.25	0.81	8,000[h]	1.29	1.04
Village of Kewaskum	1.0	3,300	140	1972	Milwaukee River	0.67[i]	0.51	5,200	0.63	0.94
Village of Newburg	0.4	1,200	300	1997	Milwaukee River	0.18	0.11	1,700	0.18	1.00
Village of Random Lake	1.7	1,600	- -	1979	Silver Creek	0.45	0.21	1,800[g]	0.24	0.52
Village of Saukville	1.4	4,100	520	2002	Milwaukee River	1.60	0.82	5,200	1.04	0.65
Village of Union Grove	0.8	5,300	110	2003	West Branch Root River Canal	2.00	0.72	5,900[j]	0.83	0.41
Town of Scott	0.4	200	- -	1985	Groundwater	0.03	0.02	200	0.02	0.67
Town of Yorkville	0.4	200	- -	1983	Tributary to Hoods Creek	0.15	0.07	400	0.11	0.72

[a]*The City of South Milwaukee wastewater treatment plant is assessed in more detail in Chapter X of this report.*

[b]*Existing year 2000 unsewered population within sewer service areas that is proposed to be sewered under plan conditions.*

[c]*For year 2003, unless indicated otherwise.*

[d]*Based upon interpolation between the year 2000 population and the 2035 recommended plan level as set forth in the regional land use plan for Southeastern Wisconsin, unless noted differently.*

[e]*In 2000, the City retained a consultant to study the hydraulic capacity of the existing wastewater treatment plant. That study indicated that the plant capacity may be considerably greater than its current rating. Before undertaking future facilities planning, the City would pursue officially rerating the plant to reflect the higher capacity.*

[f]*For year 2006.*

[g]*Based upon Wisconsin Department of Administration estimate for each civil division.*

[h]*This population differs appreciably from the 2020 population set forth in Chapter VIII because the population in Chapter VIII is based on the 2020 regional land use plan, which in this case, does not reflect the amount of growth projected under the 2035 land use plan.*

[i]*Based upon January 2007,* WTF Facility Plan–Village of Kewaskum, Washington County, Wisconsin*, Ruekert & Mielke, Inc.*

[j]*Includes the portion of the Village in the Des Plaines River watershed which is outside the study area.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

One additional point source issue identified under the regional water quality management plan update is that of elevated phosphorus loads from some industrial noncontact cooling water discharges. The industries involved do not normally add phosphorus to their cooling waters. It is believed that the high phosphorus concentrations are contained in the source water since some water utilities, such as the Cities of Cudahy, Milwaukee, New Berlin, and South Milwaukee, add orthophosphate or polyphosphate as a corrosion control to prevent heavy metals from leaching from transmission pipes into the treated water. Given the public health benefits involved and the reliability of the current technology, the Milwaukee Water Works has indicated that it would not consider changing its current practice. Recognizing the benefits involved, it is not recommended that the water utilities end their current practice. It is, however, recommended that water utilities in the study area give further consideration to changing to an alternative technology that does not result in increased phosphorus loading.

The preliminary recommended nonpoint source control measures are set forth in Table 79. In some instances the plan includes measures that go beyond what would be required to meet the performance standards of Chapter NR 151. For rural areas, these include manure and livestock management measures for all livestock operations in the study area. Manure management would include provision of adequate storage to contain six months worth of waste, with application being carried out prior to spring planting and after summer and fall harvest. This would alleviate the need for winter spreading of manure. Other rural nonpoint source measures include providing a minimum stream buffer of 75 feet along all current crop and pasture land; the conversion to either wetland or prairie, of a total of 10 percent of existing cropland and/or pasture, focusing on marginally productive land; and an increased level of inspections, and, if necessary, replacement, of private wastewater treatment systems.

Additional nonpoint source measures for urban areas include implementation of chloride reduction programs by communities in the study area, the targeted application of stormwater disinfection units at storm sewer outfalls, downspout disconnection coupled with rain barrels and rain gardens, and waterfowl and litter control programs for Lake Michigan beaches.

The water quality impact of the measures identified in the preliminary recommended plan will be evaluated through application of the water quality models developed under this planning program. In addition, input will be sought through public informational activities. Based on those model results and public input, adjustments to the plan may be expected in order to arrive at a final recommended water quality management plan. That plan and its costs and related water quality benefits are described in detail in Chapter X.

SUMMARY

This chapter presents alternative plans for water pollution abatement and includes an analysis of the extent to which the various alternative measures may be expected to achieve the agreed-upon water use objectives. Based on evaluation of the technical, economic, and environmental performance of the alternative plans considered, a recommendation is presented for an integrated, preliminary set of water quality management measures for incorporation into the regional water quality management update. The evaluation and refinement of that preliminary recommendation is set forth in Chapter X of this report.

The regional water quality management plan update was carried out in a cooperative manner with the ongoing MMSD 2020 facility planning program, with both projects being conducted as separate, but coordinated and cooperative, work efforts. Both the MMSD 2020 facility planning and the regional water quality management plan update utilized a watershed-based approach that includes evaluation of water quality impacts of receiving waters.

As part of ongoing program management and planning for the Milwaukee River and Root-Pike basins, the WDNR has prepared state-of-the-basin plans for both of those basins. In addition to incorporating the current regulatory surface water use classifications, the regional water quality management plan update has also considered incorporated potential higher use classifications that were identified in those state-of-the-basin plans.

Evaluations of water quality conditions within the greater Milwaukee watersheds were carried out for both existing and planned year 2020 land use conditions. The planned year 2020 condition served as the baseline condition for comparison of alternative water quality management plans and included the assumed implementation of committed MMSD projects as well as practices for the control of nonpoint source pollution and stormwater runoff as required under current State and local regulations.

Public and stakeholder input were considered in development of the alternative water quality management plans. The comparison of the alternative plans focused on the ability of the plans to meet the surface water use objectives and supporting water quality standards and criteria, as well as the associated costs of the alternatives. The economic analyses included estimation of total present worth of each alternative based on a project economic life of 50 years and an interest rate of 6 percent.

Prior to the development of the alternative water quality management plans, a systematic evaluation of the costs and effectiveness of varying water pollution control technologies was carried out through the development of a state-of-the-art report. A total of 169 water pollution abatement technologies were identified and screened into one of six categories. Where applicable, technologies were evaluated using the concept of production theory to identify those that produced maximum benefits while minimizing costs. In addition to the state-of-the-art report, a sensitivity study was carried out through which a set of five screening alternatives was developed and analyzed to address extreme “what-if” scenarios. Both the state-of-the-art report and the screening alternative analyses served as background data for development of the alternative water quality management plans.

In addition to the future year 2020 baseline condition, four alternative water quality management plans were evaluated. Two of the four alternatives took a regulatory-based approach that concentrated on the ability of the MMSD and the communities in the study area to meet current permit requirements regarding control of CSOs and/or SSOs, as well as all private and public entities in the planning area meeting standards for control of nonpoint source pollution as called for under Chapter NR 151 of the *Wisconsin Administrative Code*. These two regulatory-based alternatives differed in assumed operating procedures for the MMSD ISS for control of CSOs and SSOs, with one alternative plan assuming that a constant amount of the ISS storage would be held in reserve for inflow from the separate sewer service area, while the second alternative plan assumed that no ISS storage would be preserved. The remaining two alternative plans took a water quality-based approach and included varying levels of nonpoint source pollution control measures while assuming only committed MMSD facilities and operating procedures would be in place.

Evaluation of the alternative water quality management plans included economic considerations and water quality benefits, both in terms of pollutant load reductions and instream water quality conditions. The results indicate that, under the future year 2020 baseline condition, the level of pollutant loading may be expected to remain generally similar to existing conditions even with an anticipated increase in land development. This can be attributed to the implementation of committed facilities by the MMSD as well as implementation of nonpoint source pollution control measures under Chapter NR 151. Pollutant loads under the two regulatory-based alternatives are similar, with the alternative plan calling for zero ISS reserve capacity for separate sewer inflow resulting in a reduction in the occurrence and volume of CSOs and an increase in the occurrence and volume of SSOs. Of the two water quality-based alternatives, one provided similar loading results to the regulatory-based alternatives, while the second alternative calling for the highest level of nonpoint source control measures also produced the highest level of pollutant load reduction.

Instream water quality benefits of each of the alternative plans were evaluated using a series of metrics including mean and median concentrations and, where applicable, the percentage of time in compliance with the recommended water quality standard. Comparisons were made at representative locations throughout the planning area. In general, the differences in water quality conditions among alternatives are small, with the two water quality-based alternatives providing somewhat better improvement than the two regulatory-based alternatives. The water quality-based alternative calling for the highest level of nonpoint source pollutant controls showed the highest level of improvement. In terms of meeting the water quality standards, the results showed that the dissolved oxygen standard would be substantially achieved throughout the study area under all of the alternative plans with the exception of the upper reaches of the Oak Creek watershed. Continued violations of the applicable fecal coliform bacteria regulatory standard and phosphorus planning standard would be expected under all of the alternative plans in all five watersheds. Violation of the phosphorus standard would also be expected to continue in the harbor estuary.

Other than the future baseline condition, the two regulatory-based alternatives have the lowest cost, while the water quality-based alternative calling for the higher level of nonpoint source controls has the highest overall cost. That alternative also produced the highest level of water quality improvement.

Following consideration of the findings of the alternative plan evaluations, a preliminary recommended plan was formulated that included elements of both the regulatory-based and water quality-based alternatives. The preliminary recommended plan includes measures set forth in the MMSD 2020 Facilities Plan that are aimed at meeting current regulatory requirements, including achieving a five-year recurrence interval level of protection against wet weather-related SSOs. Recognizing the fact that the alternative plan analysis indicated that a greater level of water quality improvement could be achieved through control of nonpoint source pollutants, a secondary recommended plan was also formulated that would provide for a lower level of SSO control, with the associated cost savings in wastewater facilities being applied to additional nonpoint source control measures. The objective of that alternative recommended plan is to target limited financial resources to those measures that would achieve the greatest improvement in water quality. In developing the alternative recommended plan, lower-cost MMSD wastewater treatment options that would maintain the five-year level of protection (LOP) called for under the MMSD facilities plan were considered as was the possibility of foregoing wastewater treatment plant capacity upgrades and providing for a lesser level of protection (LOP) from SSOs within the MMSD service area.

For communities outside of the MMSD service area, the preliminary recommended plan assumes that wastewater conveyance and treatment system improvements will be made as needed to address additional development and to continue meeting the terms of their operating permits. Additional point source control measures include an increased effort to identify and eliminate illicit wastewater connections and a recommendation that water utilities in the study area investigate alternative corrosion control measures that do not increase the level of phosphorus in treated water.

The preliminary recommended plan includes nonpoint source pollution control measures that in some instances go beyond what would be needed to meet the performance standards of Chapter NR 151 of the *Wisconsin Administrative Code*. Additional rural nonpoint source measures include expanded manure and livestock management, expansion of stream buffers, and an expanded program of private wastewater treatment system inspections. Additional urban nonpoint measures include implementation of chloride reduction programs, the targeted application of stormwater disinfection units at storm sewer outfalls, downspout disconnection with rain barrels and rain gardens, and waterfowl and litter control programs along Lake Michigan beaches.

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Chapter X

RECOMMENDED WATER QUALITY MANAGEMENT PLAN

INTRODUCTION

The primary purpose of the update of the regional water quality management plan is to develop a sound and workable plan for the abatement of water pollution within the greater Milwaukee watersheds so as to meet the plan objectives which are described in Chapter VII of this report. This chapter sets forth a recommended plan for the management of surface water for the greater Milwaukee watersheds, incorporating measures to abate existing pollution problems and elements intended to prevent future pollution problems. The analysis and evaluation of the screening alternatives and alternative water quality plans led to the synthesis of a preliminary recommended plan as described in Chapter IX of this report. The recommended water quality management plan expands upon and refines that preliminary plan.

As noted in Chapter I of this report, the regional water quality management plan update (Section 208 plan update) was prepared as part of a coordinated planning effort that also involved preparation of the 2020 facilities plan (Section 201 plan)[1] for the Milwaukee Metropolitan Sewerage District (MMSD). Thus, the components of the recommended MMSD 2020 facilities plan are included in the recommended regional plan. Consideration was also given to modifications to the MMSD facilities plan which might eliminate certain point source pollution control components of that plan and substitute additional nonpoint source controls which would be more effective in improving water quality in the streams of the study area and Lake Michigan.

The recommended plan calls for the implementation of a comprehensive set of specific actions devised to ensure the enhancement and/or preservation of the surface water quality of the streams and lakes in the greater Milwaukee watersheds study area, including Lake Michigan, and to preserve the quality of the groundwater which provides the baseflow for those streams and lakes and also serves as a source of drinking water in the Southeastern Wisconsin Region. A primary consideration in the selection of the components of the recommended plan was the degree to which those measures, functioning together as a watershed-based system, would be expected to achieve the agreed-upon water use objectives in a cost-effective manner. The selection of the recommended plan followed an extensive review by the Technical Advisory Committee of the technical feasibility, economic viability, environmental impacts, potential public acceptance, and practicality of the various alternative water quality management plans considered. Those factors were also considered, with an emphasis on

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[1]*Public Law 92-500, as amended, (the Federal Clean Water Act) requires under Section 208, the preparation of area wide water quality management plans; and, to implement those plans, requires under Section 201 the preparation of sewerage system facilities plans.*

the technical aspects of the water quality models, by the Modeling Subcommittee. In addition, as described in Appendix A of this report, public input was solicited over the course of the planning period and that input was considered in formulating the screening alternatives, the alternative water quality management plans, and the recommended plan that was built from those alternatives.

The comprehensive recommended plan is comprised of the following major elements that are presented in this chapter:

- A land use plan element,

- Surface water quality plan elements, including point and nonpoint source pollution abatement subelements, and

- A groundwater management plan element

A detailed analysis of the estimated costs of plan implementation is presented as is an evaluation of the ability of the recommended plan to meet the adopted water resource management goals, objectives, and standards as set forth in Chapter VII and Appendix G of this report, with particular emphasis on the ability to meet the surface water use objectives and water quality standards. No water resource plan element can fully satisfy all desirable water resource objectives. The recommended comprehensive plan must, therefore, consist of a combination of individual plan elements, with each element contributing to the satisfaction of the plan objectives. The recommended plan elements are complementary in nature, and the recommended water quality management plan represents a synthesis of carefully coordinated individual plan elements which together are intended to achieve the adopted plan objectives to the degree practicable.

The water quality planning process is based on a watershed approach which integrates all potential sources of pollution to the streams and lakes of the greater Milwaukee watersheds and to Lake Michigan. Under that process, the nonpoint source pollution control subelement of the recommended plan is combined with the point source subelement and a groundwater/stream baseflow quality subelement to form an overall plan to improve surface water quality in the study area. As described in Chapter V of this report, “Water Resource Simulation Models and Analytic Methods,” an integrated computer simulation approach was applied to evaluate water quality conditions under alternative and recommended plan conditions.

The watershed approach, which has been used by SEWRPC for water resources planning since 1966, and which is now being applied elsewhere around the country, is based on three key concepts:

- Water quality planning and management should be based upon watersheds as the geographic area of consideration, that is, upon natural boundaries, and not upon man-made civil division boundaries

- Water quality planning and management should be based on sound science (strong scientific data and analytical techniques) and upon sound economic analyses to arrive at cost-effective solutions

- Water quality planning and management must provide for effective public participation and cooperative governmental partnerships that actively involve concerned individuals, agencies, and organizations that have a stake in the condition of their watersheds

Summary of Previous Regional Water Quality Planning Efforts

The areawide water quality management plan for southeastern Wisconsin which was completed by SEWRPC in 1979, adopted by the Wisconsin Department of Natural Resources (WDNR) Board, and approved by the U.S. Environmental Protection Agency (USEPA) is documented in SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000,* Volumes One through Three. That plan was designed, in part, to meet the Congressional mandate that the waters of the United States be made to the extent practicable “fishable and swimmable.” In accordance with the requirements of Section 208 of the Federal Clean

Water Act, the plan provides recommendations for the control of water pollution from such point sources as sewage treatment plants, points of separate and combined sewer overflow, and industrial waste outfalls and from such nonpoint sources as urban and rural stormwater runoff. The plan also provided the necessary framework for the preparation and adoption of the 1980 MMSD facilities plan.

Pursuant to the recommendation of the areawide plan that the water resources of the Milwaukee Harbor estuary be considered in more-detailed, site-specific studies, SEWRPC prepared an amendment to the regional water quality management plan which addressed water quality issues in the estuary. That plan, which was adopted in 1987, is documented in SEWRPC Planning Report No. 37, *A Water Resources Management Plan for the Milwaukee Harbor Estuary*, Volumes 1 and 2. The estuary plan set forth recommendations to abate water pollution from combined sewer overflows, including a determination of the level of protection to be provided by such abatement, and from other point and nonpoint sources of pollution in the tributary watersheds, including recommendations for instream measures, that might be needed to achieve established water use objectives.

In 1995, SEWRPC completed a report documenting the implementation status of the regional water quality management plan as amended over the approximately first 15 years since the initial adoption of the plan. This report, SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995, provides a comprehensive restatement of the regional water quality management plan as amended. The plan status report reflects implementation actions taken and plan amendments adopted since the initial plan was completed. The status report also documents, as available data permitted, the extent of progress which had been made toward meeting the water use objectives and supporting water quality standards set forth in the regional water quality management plan.

Since completion of the initial regional water quality management plan, SEWRPC and the WDNR have cooperatively conducted a continuing water quality management planning effort which has focused on sanitary sewer service area planning, groundwater inventories and analyses, and selected plan implementation activities.

In addition to providing clear and concise recommendations for the control of water pollution, the adopted areawide plan, including subsequent plan updates, provides the basis for the continued eligibility of local units of government for Federal and State grants and loans in partial support of sewerage system development and redevelopment, for the issuance of waste discharge permits by the WDNR, for the review and approval of public sanitary sewer extensions by that Department, and for the review and approval of private sanitary sewer extensions and large onsite sewage disposal systems and holding tanks by the Wisconsin Department of Commerce.

Although certain elements of the areawide plan have been updated since 1979, and although many of its key recommendations have been implemented, the plan has now been updated to provide a needed framework for the preparation of the 2020 MMSD facilities plan and to update recommendations intended to improve water quality conditions throughout the greater Milwaukee watersheds.

Relationship to the Recommended MMSD 2020 Facilities Plan

Point source pollution controls as established under the MMSD 2020 facilities plan are a component of the recommended regional water quality management plan. The MMSD must submit a facilities plan that meets regulatory requirements, particularly those related to control of combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs). With regard to SSOs, the water quality information set forth in Chapter IX of this report, "Development of Alternative Plans: Description and Evaluation," demonstrates that there would be no significant improvement in overall instream and in-Lake water quality resulting from implementation of additional measures (beyond those that are already in place or that are committed to be implemented) to control SSOs from the MMSD Metropolitan Interceptor System (MIS). This is the case largely because of the significant MMSD sewerage system and wastewater treatment system upgrades that have been implemented, such as construction of the ISS, and system improvements which are under construction or otherwise committed to, along with system upgrades by other communities in the study area. These improvements, which were driven by regulatory requirements for control of sanitary and combined sewer overflows, have substantially reduced the frequency and volume of overflows. While some overflows will remain, of far greater significance is stormwater runoff pollution from both urban and rural areas.

Approaches to Developing the Recommended Plan

Two approaches were considered in developing the recommended water quality management plan for the greater Milwaukee watersheds. The first approach stems from the necessity that the MMSD 2020 facilities plan meet regulatory requirements. That approach is termed the "Regulatory Watershed-Based Approach" (regulatory approach). The second approach has its genesis in the finding that because of significant and effective past or committed actions by the operators of wastewater systems, other point source dischargers throughout the study area, and measures implemented under WDNR regulatory programs, additional point source controls would result in no significant improvement in overall instream and in-Lake water quality. That approach, which is called the "Integrated Watershed-Based Approach," is predicated on the concepts that if certain, limited components of the MMSD recommended 2020 facilities plan were not implemented 1) there would be a reduction in costs to implement the MMSD facilities plan with no significant change in water quality and 2) the cost savings from elimination of the specific facilities plan components could be applied to nonpoint source pollution control measures that would be more effective in improving instream water quality.[2] The components of those two approaches are generally the same. The similarities and differences between the two approaches are described in this chapter. A single recommended plan was selected by the committee as set forth later in the chapter.

Considerations Related to Plan Implementation and Prioritization of Recommendations

This chapter presents a detailed description of the recommended water quality management plan. Issues related to plan implementation are addressed in Chapter XI of this report. That chapter:

- Prioritizes the plan recommendations,
- Recommends ways to fund implementation of the plan, and
- Identifies the entities responsible for implementing recommendations

LAND USE PLAN ELEMENT

The most fundamental and basic element of the regional water quality management plan update is the land use element. The future distribution of urban and rural land uses will largely determine the character, magnitude, and distribution of nonpoint sources of pollution and ultimately, the quality of surface waters in the greater Milwaukee watersheds. Consequently, the selection of a land use plan for the study area is the first and most basic step in synthesizing the water quality plan. The process for developing the planned land use data that form the land use element of the plan is described in Chapter VIII of this report. Detailed information on planned land use in the portion of the study area within the Southeastern Wisconsin Region is set forth in SEWRPC Planning Report No. 45, *A Regional Land Use Plan for Southeastern Wisconsin: 2020*, December 1997, and SEWRPC Planning Report No. 48, *A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006. Planned land use information for areas outside the Southeastern Wisconsin Region was obtained from available State, county, and local land use plans, land preservation plans, and related documents. Information from all of those planning efforts were used in developing the land use plan element for the water quality management plan. The land use plan element described in this report subsection is common to both the regulatory watershed-based approach and the integrated watershed-based approach.

[2]*Although a cost saving would accrue to the MMSD if certain components of the MMSD 2020 facilities plan were foregone, the additional funds that could be applied to more effective nonpoint source pollution control measures would not necessarily be provided by MMSD. Chapter XI, "Plan Implementation," provides information on funding sources and assigns responsibilities for implementing the various components of the plan.*

Population and Land Use in the Study Area

One of the major elements of the regional water quality management plan update is the incorporation of updated land use information, including both an inventory of existing (2000) development and the identification of planned year 2020 development. In addition, projections of buildout land use conditions were developed for municipalities within the MMSD planning area. A summary of existing development is presented in Chapter II, while a discussion of planned future development is set forth in Chapter VIII.

As described in Chapter VIII, 2020 and buildout population and land use estimates were initially developed by the SEWRPC staff and the communities served by the MMSD based on future land use information provided by those communities. Planned land use data from the SEWRPC 2020 Regional land use plan and available county and local land use information for the area outside the Southeastern Wisconsin Region were applied for communities in the study area that are not served by MMSD. Those initial year 2020 population and land development assessments were used for sizing the conveyance components of the MMSD Metropolitan Interceptor System under both the year 2020 MMSD facilities plan and the recommended regional water management plan update. When data from the SEWRPC 2035 regional land use plan became available, 2020 land use and population estimates for the MMSD communities were revised using a 2020 stage of those data and the revised data were used to develop the wastewater treatment components called for under the recommended MMSD 2020 facilities plan which is incorporated in the regional plan. Similarly refined population estimates were used for the 2020 condition evaluation of all of the public sewage treatment plants in the study area. Revised 2020 industrial and commercial land use estimates were also applied for the development of revised nonpoint source pollution loads used in modeling the instream and in-lake water quality conditions under revised future year 2020 and recommended water quality plan conditions.

Year 2020 planned land uses for the greater Milwaukee watersheds, based on the original 2020 land use data provided by the communities within the MMSD planning area and on the SEWRPC 2020 regional land use plan and available State, county, and local plans outside the MMSD area, are set forth on Maps 63 through 69 which provide data for the entire study area and for each watershed in that area. Original year 2020 land use data are provided by watershed in Table 81.

Environmentally Significant Lands

Environmental Corridors and Isolated Natural Resource Areas

One of the most important tasks undertaken by the Commission as part of its regional planning effort is the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources and which, therefore, should be preserved and protected in order to maintain the overall quality of the environment.[3] Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and the natural beauty of the Region: 1) lakes, rivers, and streams and the associated undeveloped shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and 7) rugged terrain and high-relief topography. While the foregoing seven elements constitute integral parts of the natural resource base, there are five additional elements which, although not a part of the natural resource base per se, are closely related to or centered on that base and therefore are important considerations in identifying and delineating areas with scenic, recreational, and educational value. These additional elements are: 1) existing outdoor recreation sites; 2) potential outdoor recreation and related open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and 5) natural and scientific areas.

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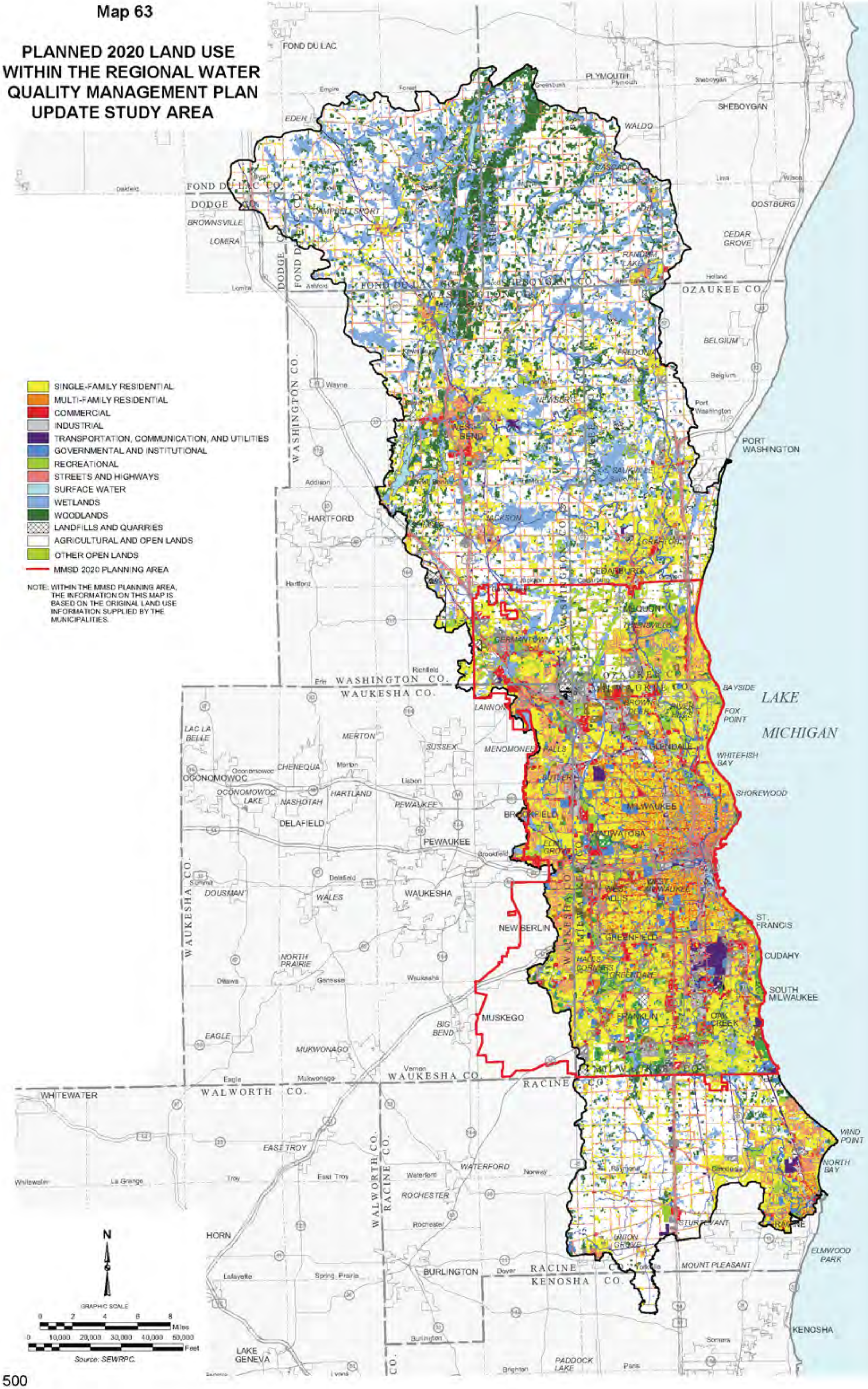
[3]*The process of delineating environmental corridors and isolated natural resource areas as areas encompassing concentrations of natural resource base features such as wetlands, woodlands, and wildlife habitat areas, along with the resulting configuration of environmental corridors and isolated natural resource areas, is described in Chapter II of SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006. Similar methodology was used to delineate environmental corridors and isolated natural resource areas in areas outside the Southeastern Wisconsin Region.*

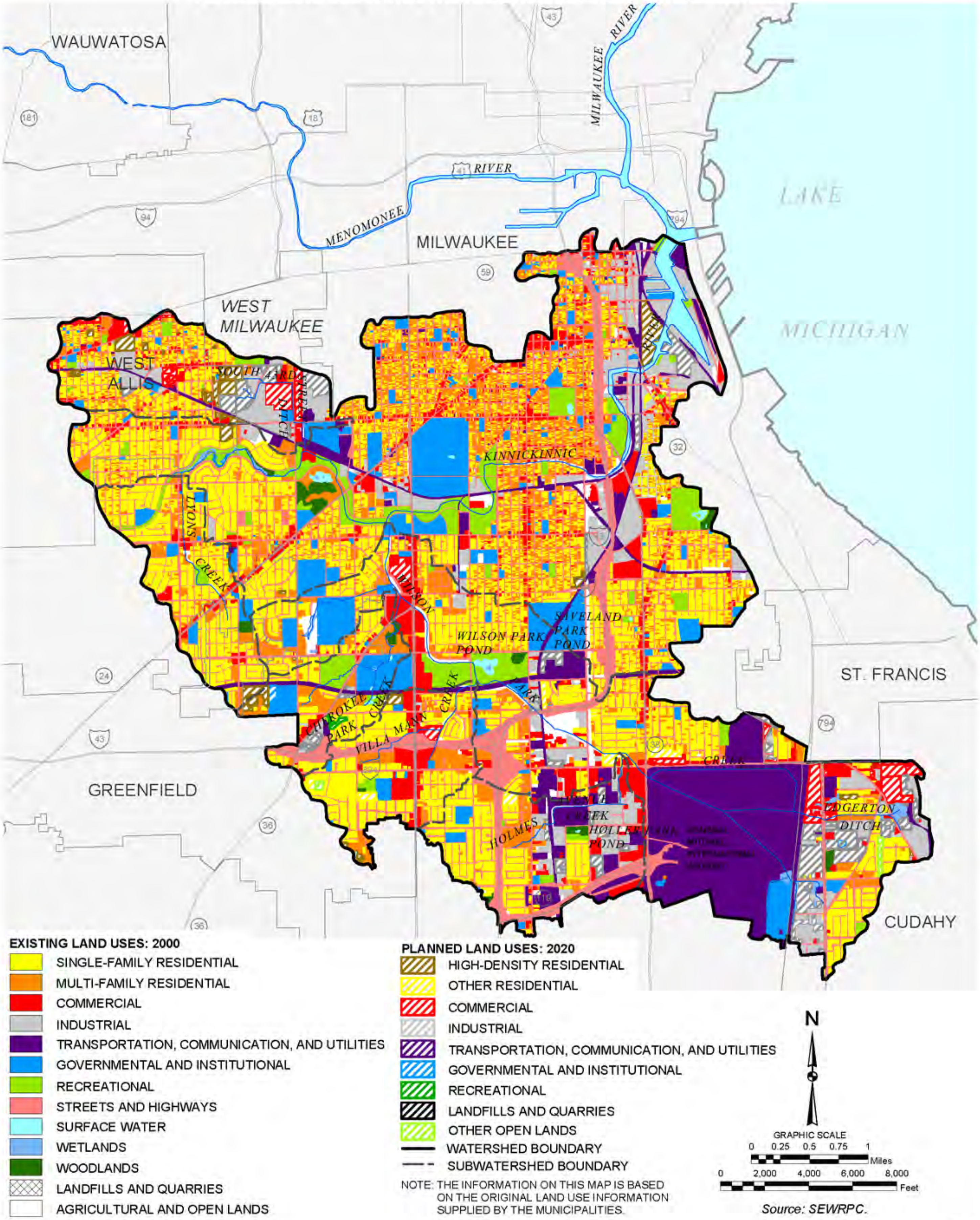
Map 63

PLANNED 2020 LAND USE WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



Map 64

PLANNED LAND USE WITHIN THE KINNICKINNIC RIVER WATERSHED: 2020

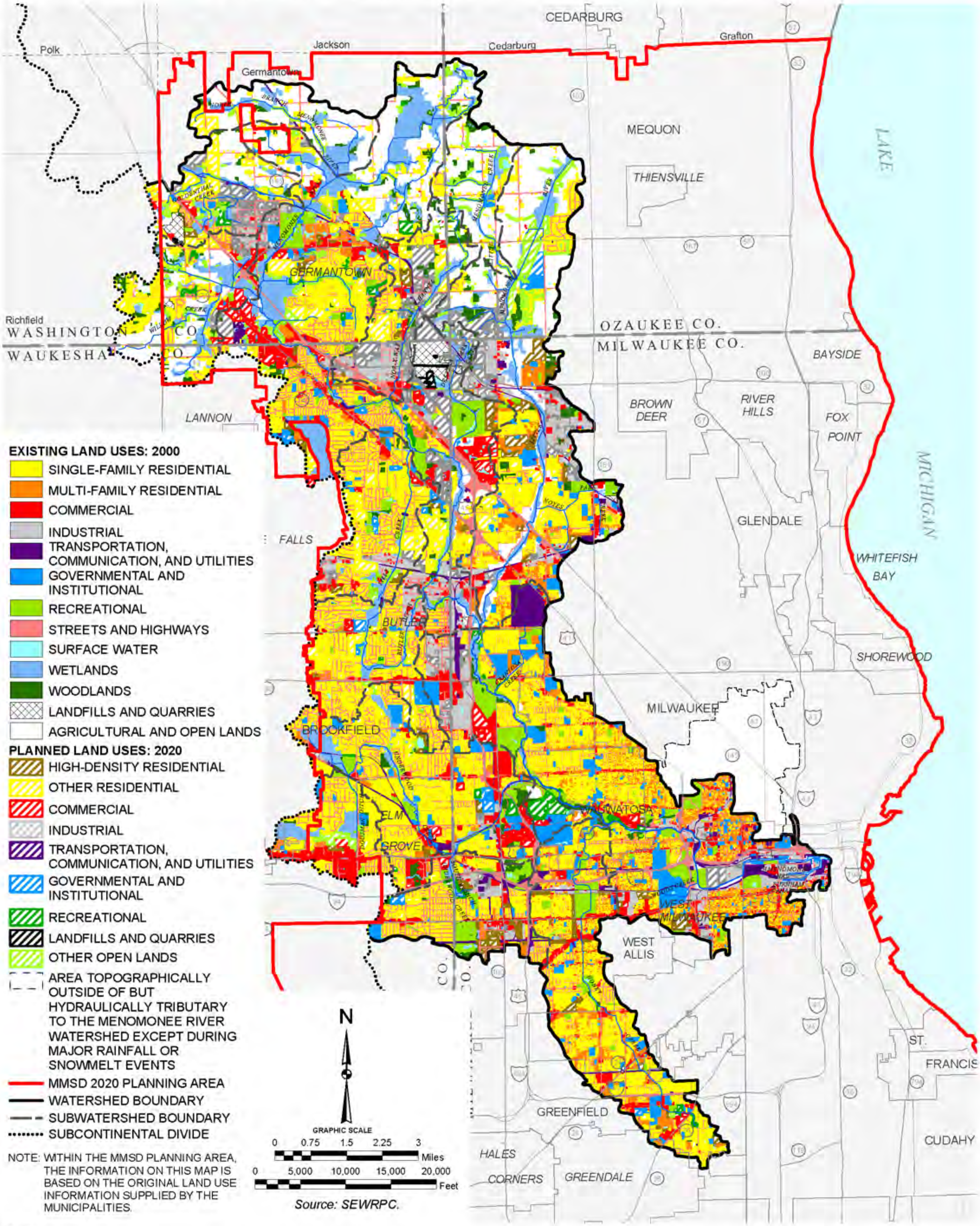


NOTE: THE INFORMATION ON THIS MAP IS BASED ON THE ORIGINAL LAND USE INFORMATION SUPPLIED BY THE MUNICIPALITIES.

Source: SEWRPC.

Map 65

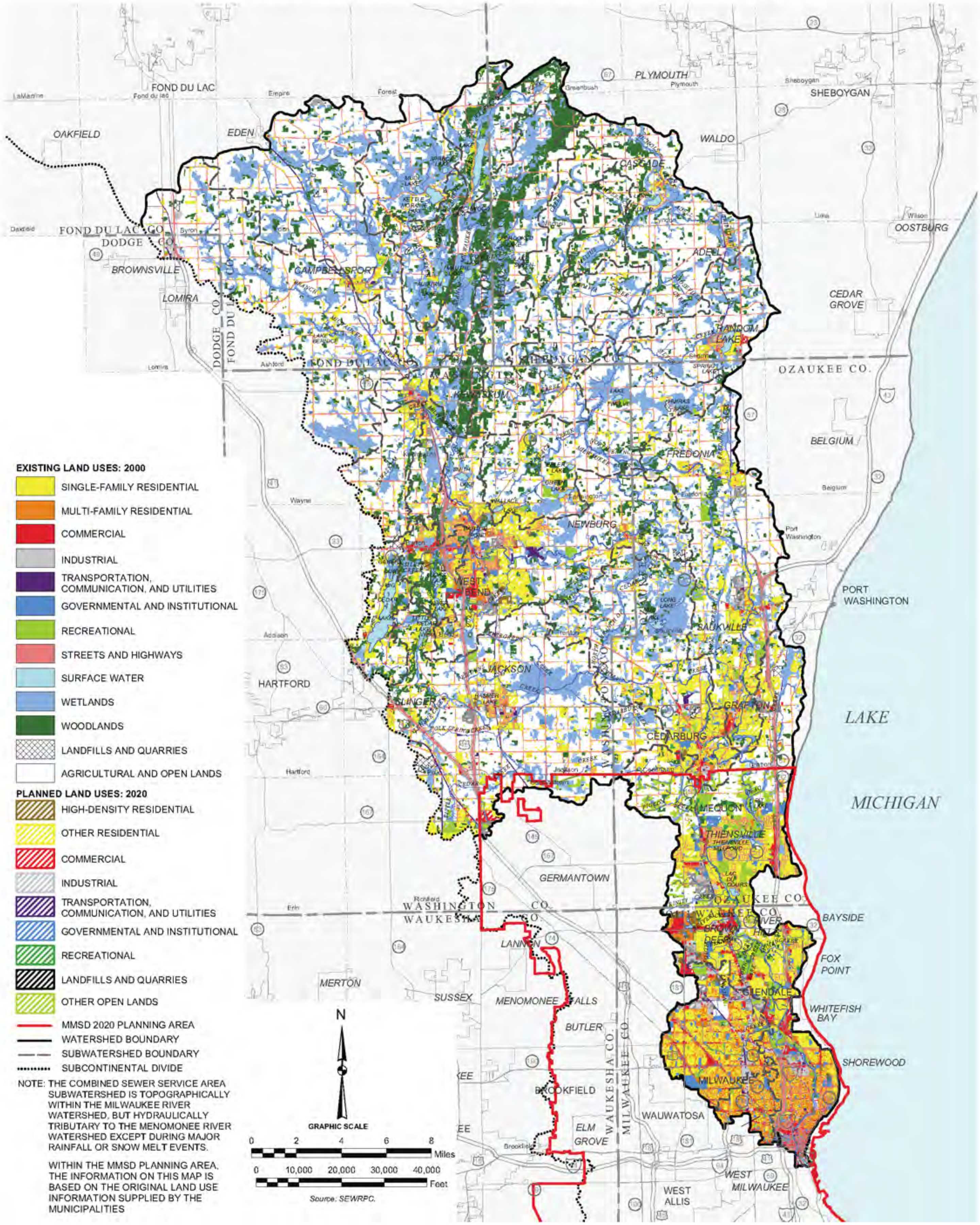
PLANNED LAND USE WITHIN THE MENOMONEE RIVER WATERSHED: 2020



Source: SEWRPC.

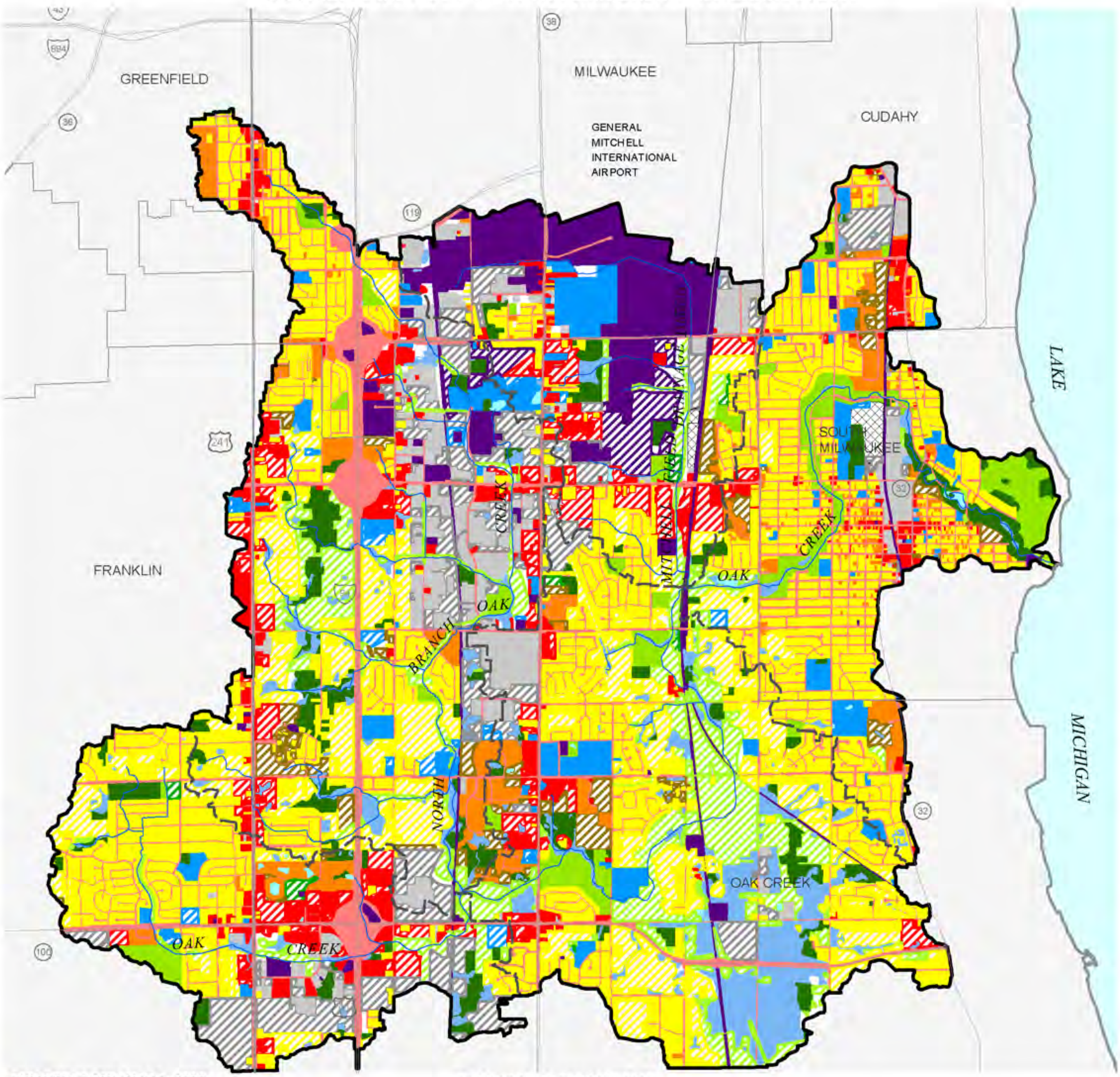
Map 66

PLANNED LAND USE WITHIN THE MILWAUKEE RIVER WATERSHED: 2020



Map 67

PLANNED LAND USE WITHIN THE OAK CREEK WATERSHED: 2020



EXISTING LAND USES: 2000

- SINGLE-FAMILY RESIDENTIAL
- MULTI-FAMILY RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATION, AND UTILITIES
- GOVERNMENTAL AND INSTITUTIONAL
- RECREATIONAL
- STREETS AND HIGHWAYS
- SURFACE WATER
- WETLANDS
- WOODLANDS
- LANDFILLS AND QUARRIES
- AGRICULTURAL AND OPEN LANDS

PLANNED LAND USES: 2020

- HIGH-DENSITY RESIDENTIAL
- OTHER RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- TRANSPORTATION, COMMUNICATION, AND UTILITIES
- GOVERNMENTAL AND INSTITUTIONAL
- RECREATIONAL
- LANDFILLS AND QUARRIES
- OTHER OPEN LANDS
- WATERSHED BOUNDARY
- SUBWATERSHED BOUNDARY

NOTE: THE INFORMATION ON THIS MAP IS BASED ON THE ORIGINAL LAND USE INFORMATION SUPPLIED BY THE MUNICIPALITIES.

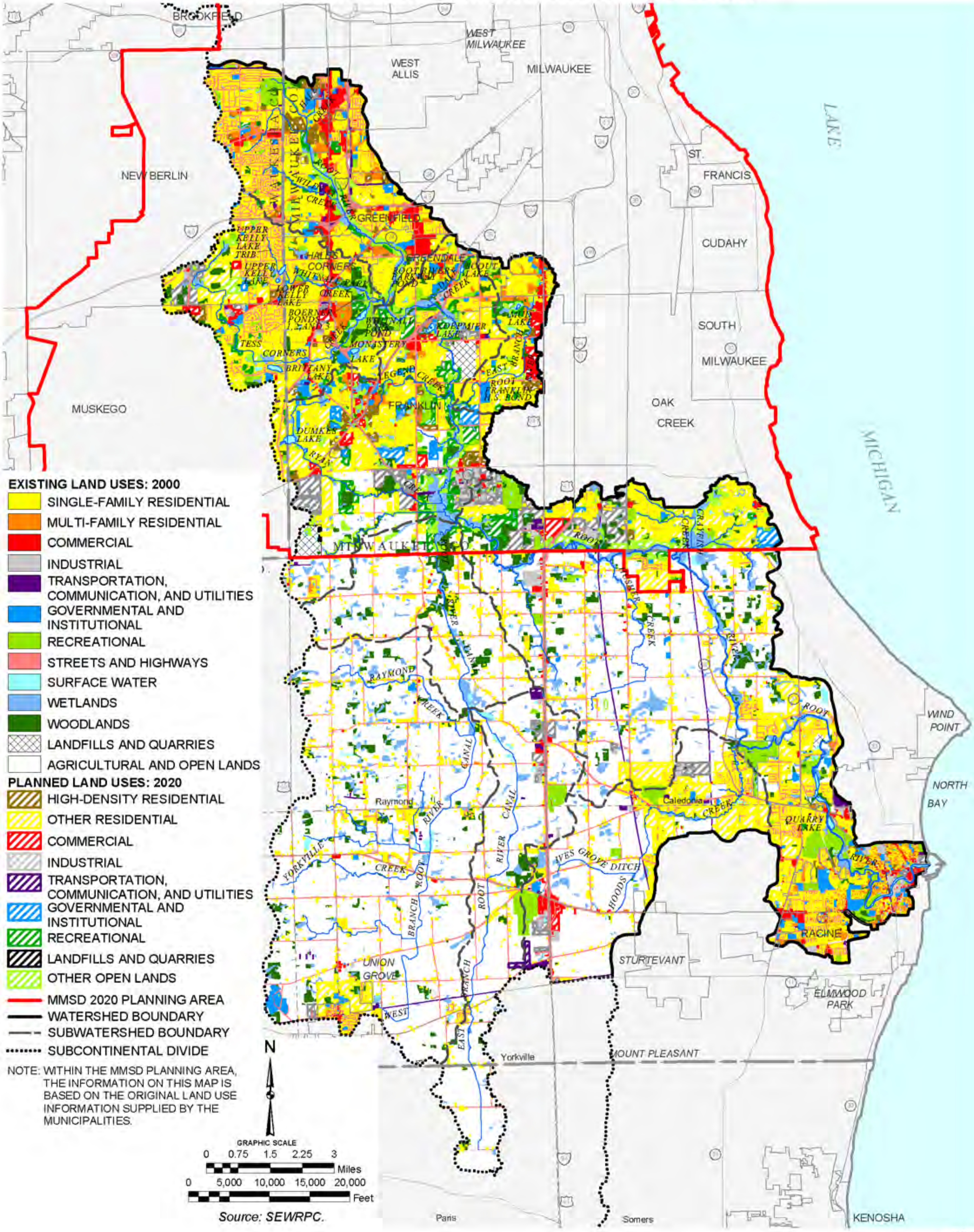
N

GRAPHIC SCALE
0 0.25 0.5 0.75 1 Miles
0 2,000 4,000 6,000 8,000 Feet

Source: SEWRPC.

Map 68

PLANNED LAND USE WITHIN THE ROOT RIVER WATERSHED: 2020



Source: SEWRPC.

Map 69

PLANNED LAND USE WITHIN THE AREA DIRECTLY TRIBUTARY TO LAKE MICHIGAN

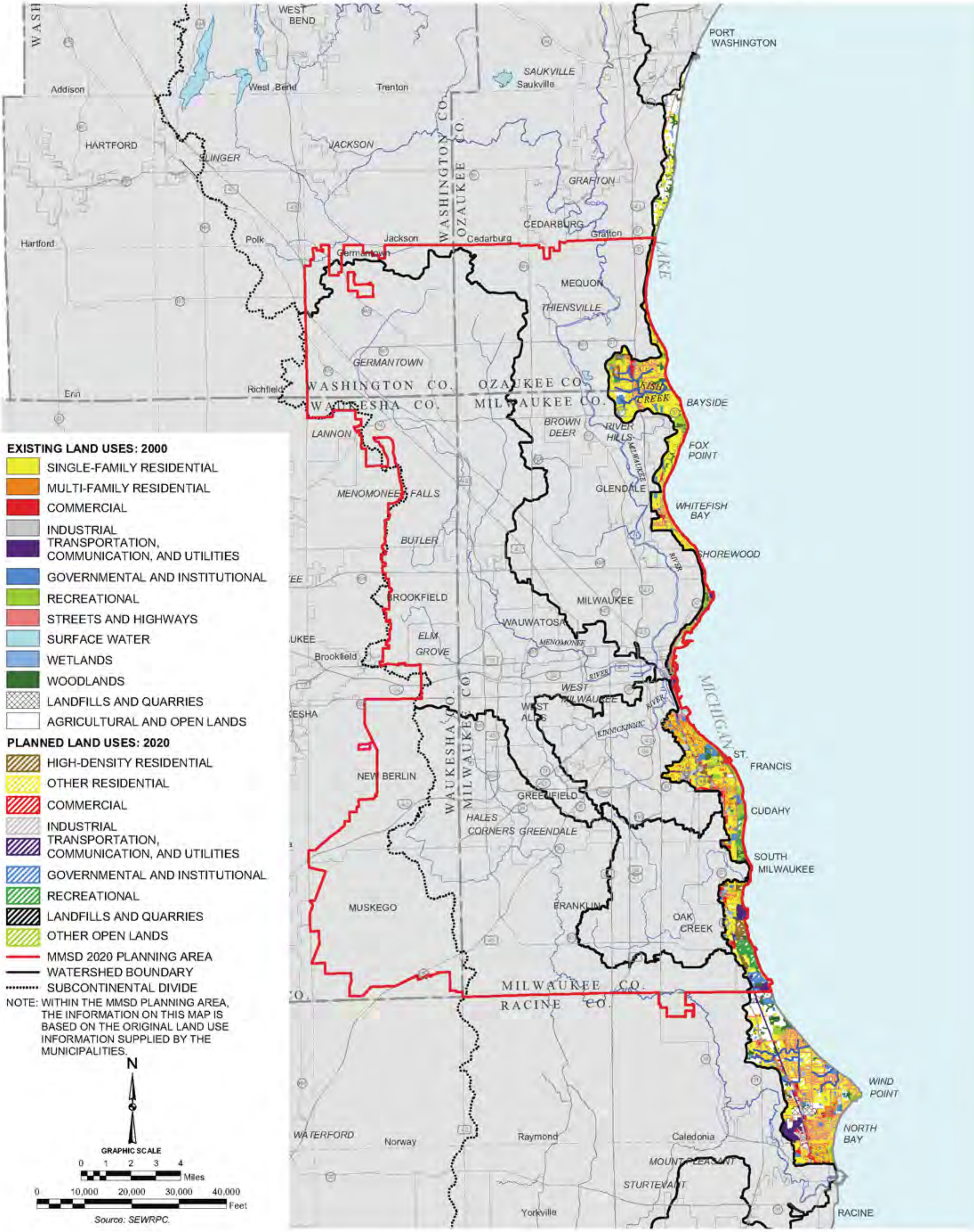


Table 81

PLANNED LAND USE IN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2020

	Watershed												Total	
	Lake Michigan Direct Drainage		Kinnickinnic River		Menomonee River		Milwaukee River		Oak Creek		Root River			
Category	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Urban														
Residential	10,728	41.4	5,634	35.7	30,376	35.0	56,568	12.6	6,260	34.7	29,615	23.4	139,181	19.3
Commercial	623	2.4	1,059	6.7	4,796	5.5	4,775	1.1	1,163	6.4	2,618	2.1	15,034	2.1
Industrial	608	2.3	1,343	8.5	6,716	7.7	5,874	1.3	1,777	9.9	3,353	2.7	19,671	2.7
Transportation, Communication, and Utilities[a]	4,887	18.9	5,284	33.5	16,499	19.0	31,594	7.0	4,375	24.3	13,147	10.4	75,786	10.5
Governmental and Institutional	1,098	4.3	1,189	7.5	3,853	4.4	4,743	1.1	746	4.1	2,578	2.0	14,207	2.0
Recreational	1,450	5.6	654	4.2	3,898	4.5	6,623	1.5	601	3.3	4,862	3.8	18,088	2.5
Subtotal	19,394	74.9	15,163	96.1	66,138	76.1	110,177	24.6	14,922	82.7	56,173	44.4	281,967	39.1
Rural														
Agricultural and Related[b]	4,284	16.5	314	2.0	10,866	12.5	221,445	49.4	1,372	7.6	56,946	45.0	295,227	40.9
Water	123	0.5	153	1.0	542	0.6	7,715	1.7	29	0.2	1,017	0.8	9,579	1.3
Wetlands	415	1.6	57	0.3	6,734	7.8	67,109	15.0	920	5.1	6,775	5.4	82,010	11.4
Woodlands	1,461	5.6	92	0.6	2,011	2.3	39,828	8.9	744	4.1	4,912	3.9	49,048	6.8
Landfill, Extractive, Unused, and Other Open Land	223	0.9	- -	0.0	602	0.7	1,727	0.4	54	0.3	649	0.5	3,255	0.5
Subtotal	6,506	25.1	616	3.9	20,755	23.9	337,824	75.4	3,119	17.3	70,299	55.6	439,119	60.9
Total	25,900	100.0	15,779	100.0	86,893	100.0	448,001	100.0	18,041	100.0	126,472	100.0	721,086	100.0

[a] *Off-street parking of more than 10 spaces is included with the associated land use.*

[b] *Full implementation of the plan recommendation to convert 10 percent of cropland and pasture to wetlands and prairies would result in the total land area in this category being reduced by about 29,500 acres, and a corresponding increase in the combined area of wetlands and other open land.*

Source: SEWRPC.

The delineation of these 12 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed “environmental corridors” by the Commission. Primary environmental corridors include a wide variety of the abovementioned important resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors generally connect with the primary environmental corridors and are at least 100 acres in size and one mile long. In addition, smaller concentrations of natural resource features that have been separated physically from the environmental corridors by intensive urban or agricultural land uses have also been identified. These areas, which are at least five acres in size, are referred to as isolated natural resource areas.

It is important to point out that, because of the many interlocking and interacting relationships between living organisms and their environment, the destruction or deterioration of any one element of the total environment may lead to a chain reaction of deterioration and destruction among the others. The drainage of wetlands, for example, may have far-reaching effects, since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting lake and stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides a basis for low flows in rivers and streams. Similarly, the destruction of woodland cover, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes may not in and of itself be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the greater Milwaukee watersheds thus becomes apparent.

Information on existing year 2000 primary and secondary environmental corridors and isolated natural resource areas is set forth in SEWRPC Technical Report No. 39 (TR No. 39), *Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds,* which is a companion report to this planning report.

Primary Environmental Corridors

The primary environmental corridors in the study area generally lie along major stream valleys and around major lakes, and contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all of the major bodies of surface water and related undeveloped floodlands and shorelands. Primary corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors, however, not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental and development problems as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewerage systems. As shown on Map 70, planned primary environmental corridors in the study area encompass about 115,000 acres, or about 16 percent of the study area.

Secondary Environmental Corridors

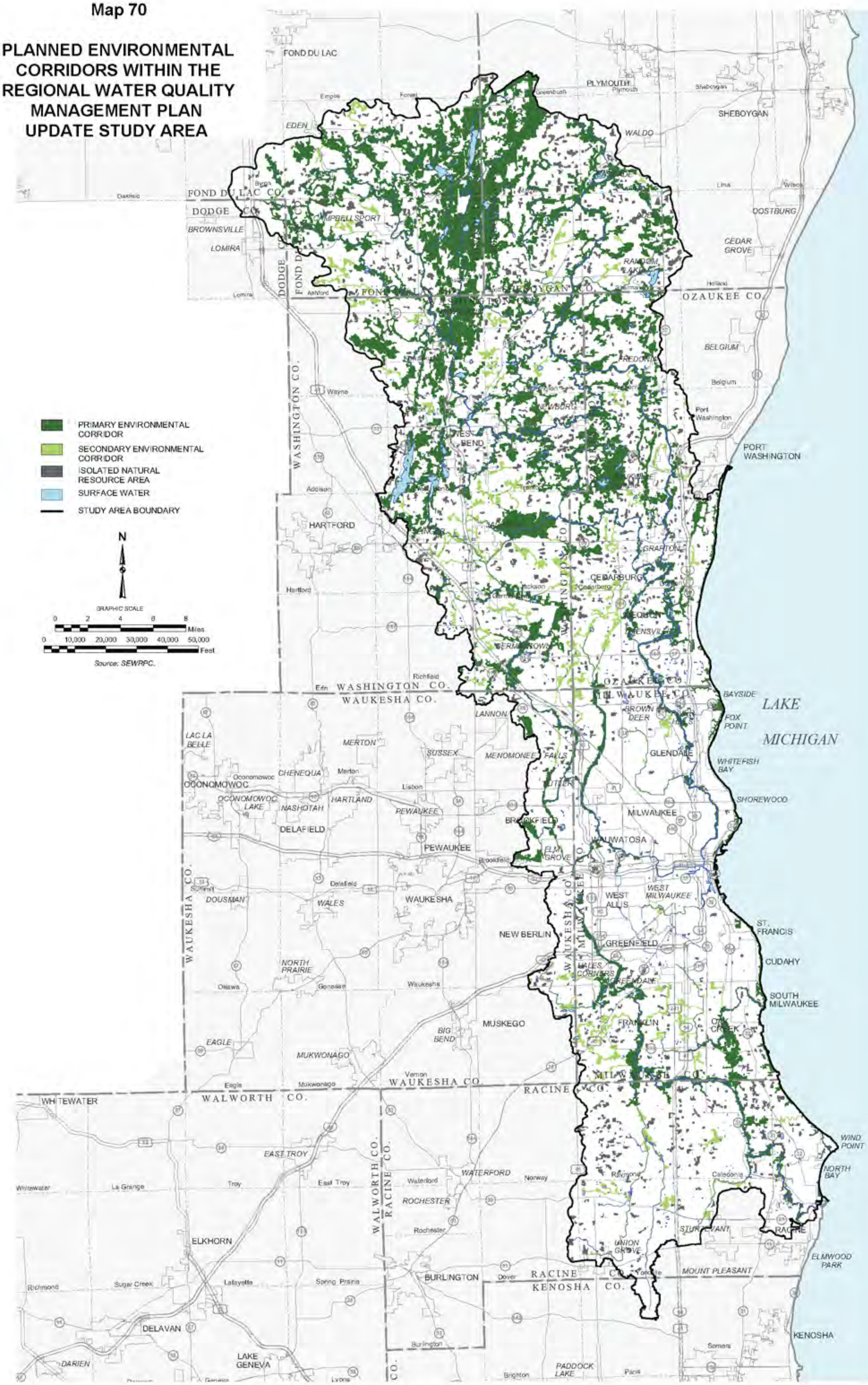
Secondary environmental corridors are located generally along intermittent streams or serve as links between segments of primary environmental corridors. Secondary environmental corridors contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive agricultural purposes or urban land uses, and facilitate surface water drainage, maintain “pockets” of natural resource features, and provide for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species. As shown on Map 70, planned secondary environmental corridors encompass about 16,600 acres, or about 2 percent of the study area.

Isolated Natural Resource Areas

In addition to the primary environmental corridors, other small concentrations of natural resource base elements exist within the study area. These concentrations are isolated from the environmental corridors by urban development or agricultural lands and, although separated from the environmental corridor network, have

Map 70

PLANNED ENVIRONMENTAL CORRIDORS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



important natural values. These isolated natural resource areas may provide the only available wildlife habitat in a localized area, provide good locations for local parks and nature study areas, and lend a desirable aesthetic character and diversity to the area. Important isolated natural resource features include a variety of isolated wetlands, woodlands, and wildlife habitat. These isolated natural resource features should also be protected and preserved in a natural state whenever possible. Such isolated areas five or more acres in size within the study area also are shown on Map 70. Planned isolated natural resource areas total about 17,200 acres, or about 2 percent of the study area.

Natural Areas and Critical Species Habitat Sites

A comprehensive inventory of natural areas—tracts of land or water that contain plant and animal communities believed to be representative of the pre-European-settlement landscape—and critical species habitat areas—other areas that support endangered, threatened, or rare plant or animal species—was completed for the Region as part of the regional natural areas and critical species habitat protection and management plan.[4] Detailed map and tabular information from that plan are included in SEWRPC TR No. 39, *Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*, which is a companion report to this water quality plan. In addition to those lands within the Southeastern Wisconsin Region, eight areas in the Milwaukee River watershed that are located outside of the Region in Fond du Lac and Sheboygan Counties, but that are in the water quality management plan study area, have been acquired by the State of Wisconsin and designated as State Natural Areas. The vast majority of the natural areas and critical species habitat sites in the study area are located within environmental corridors and isolated natural resource areas.

Recommendations Regarding Environmentally Significant Lands

Consistent with the objectives and standards adopted under this regional water quality management plan update, it is recommended that primary environmental corridors be preserved in essentially natural, open uses, forming an integrated system of open space lands in the study area. Under the plan, development within the primary environmental corridors would be limited to essential transportation and utility facilities, compatible outdoor recreation facilities, and rural-density residential development (a maximum of one dwelling unit per five acres) in upland corridor areas not encompassing steep slopes. The plan also encourages the preservation in a similar manner of secondary environmental corridors and isolated natural resource areas, and recommends that counties and communities consider the preservation of these areas in the preparation of county and local land use plans.

There are a number of important measures in effect that help to ensure the preservation of environmentally significant areas in the study area. The current protection status of primary environmental corridors in the study area is shown on Map 71. About 95 square miles, or 85 percent of the primary environmental corridors in the portion of the Southeastern Wisconsin Region within the study area were protected, or substantially protected, through one or more of the following means:[5]

- Public interest ownership, including publicly owned lands, privately held lands owned by conservancy organizations and other privately held lands that were in compatible outdoor recreational use, and surface water;

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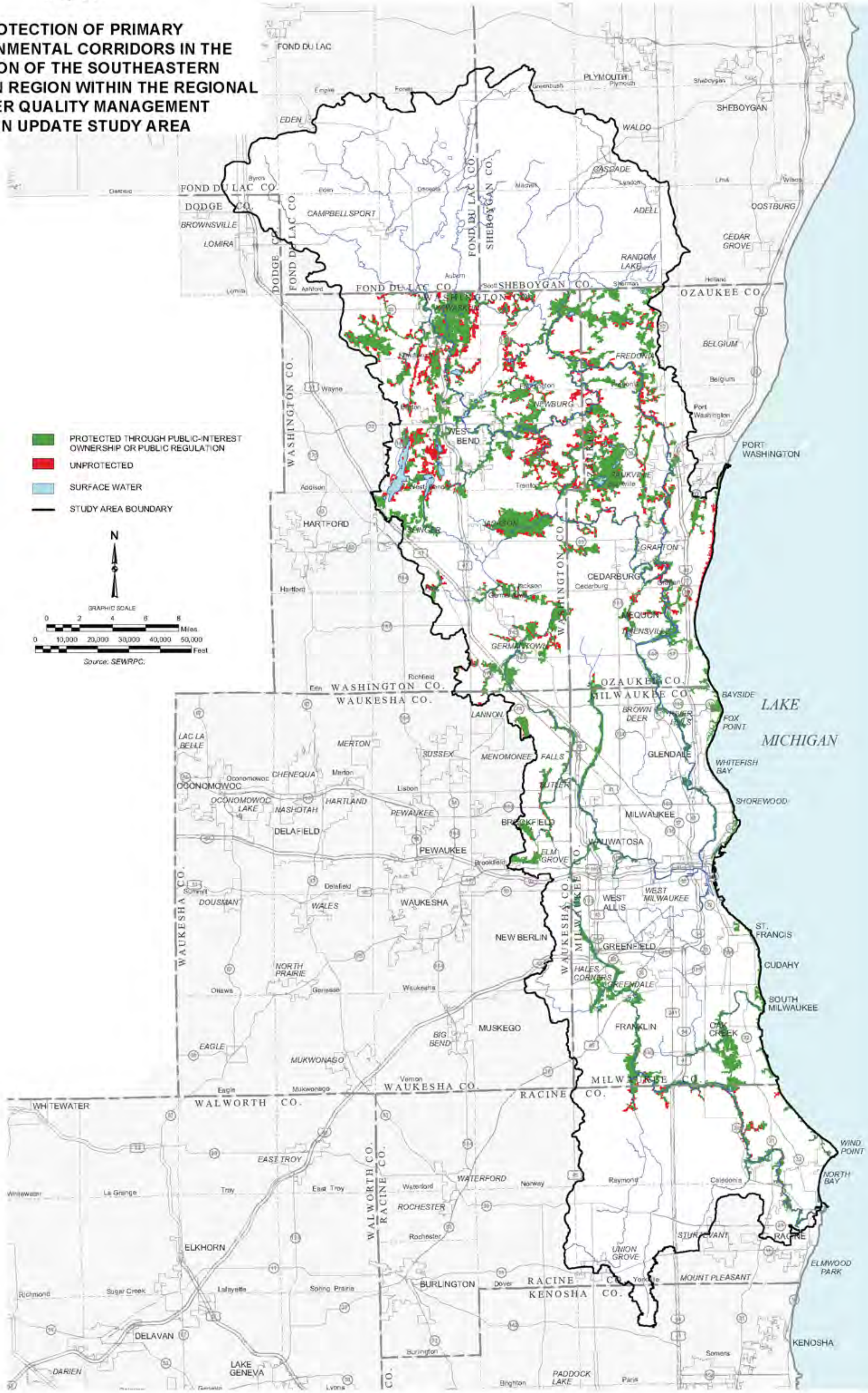
[4]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

[5]*Primary environmental corridor lands that were not protected from urban development encompassed just over 17 square miles, or about 15 percent of the remaining primary environmental corridors in the study area in 2000. These unprotected corridors consist largely of upland areas comprised of woodlands, significant wildlife habitat, and steeply sloped areas. Destruction of these areas may occur as a result of urban residential development projects supported by wastewater treatment systems and other urban encroachment not served by sanitary sewers. Adherence to the water quality management plan recommendation to provide centralized sanitary sewer and water supply services to the greatest degree possible will minimize the loss of such primary environmental corridor lands.*

Map 71

PROTECTION OF PRIMARY ENVIRONMENTAL CORRIDORS IN THE PORTION OF THE SOUTHEASTERN WISCONSIN REGION WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



- Joint State-local floodplain and shoreland-wetland zoning;

- State administrative rules governing sanitary sewer extensions within planned sanitary sewer service areas;[6] and

- Local land use regulations, including protection through local conservancy zoning and, in the case of Waukesha County, through its review of proposed land divisions.[7]

In the design of the recommended land use plan, other than for a limited number of exceptions, incremental urban and rural development was not allocated to primary or secondary environmental corridors or isolated natural resource areas. The exceptions pertain to local commitments to development that are identified in local sanitary sewer service area plans adopted as part of the regional water quality management plan. The delineation of environmental corridors on Map 71 reflects these relatively minor commitments to development. The delineated planned environmental corridors also include certain farmed floodplains and certain other lands which are expected to revert to more natural conditions over time, eventually becoming part of the adjacent environmental corridor—as envisioned in local sewer service area plans and county park and open space plans.[8]

Consistent with the regional land use plan, the regional water quality management plan update recommends the preservation of all of the identified natural areas and critical species habitat sites and, as called for under the regional natural areas and critical species habitat protection and management plan, it recommends acquisition of those sites not in existing public or public-interest ownership. The agencies and organizations that are recommended to acquire those sites are set forth in Chapter XI of this report, which presents the implementation component of the water quality management plan.

Highly Productive Agricultural Land

The regional water quality management plan update land use objectives and standards call for the preservation, to the extent practicable, of the most productive farmland, identified as farmland covered by agricultural capability Class I and Class II soils as classified by the U.S. Natural Resources Conservation Service. Thus, the recommended land use plan element was designed in a manner consistent with those objectives and standards. Under the recommended land use plan, the limited incremental rural-density residential development was allocated to rural areas not comprised of farmland with U.S. Natural Resources Conservation Service agricultural capability Class I and Class II soils. The plan thus seeks to accommodate incremental rural density residential development without adversely impacting highly productive farmland. Class I and II farmland within the study area is shown on Map 72.

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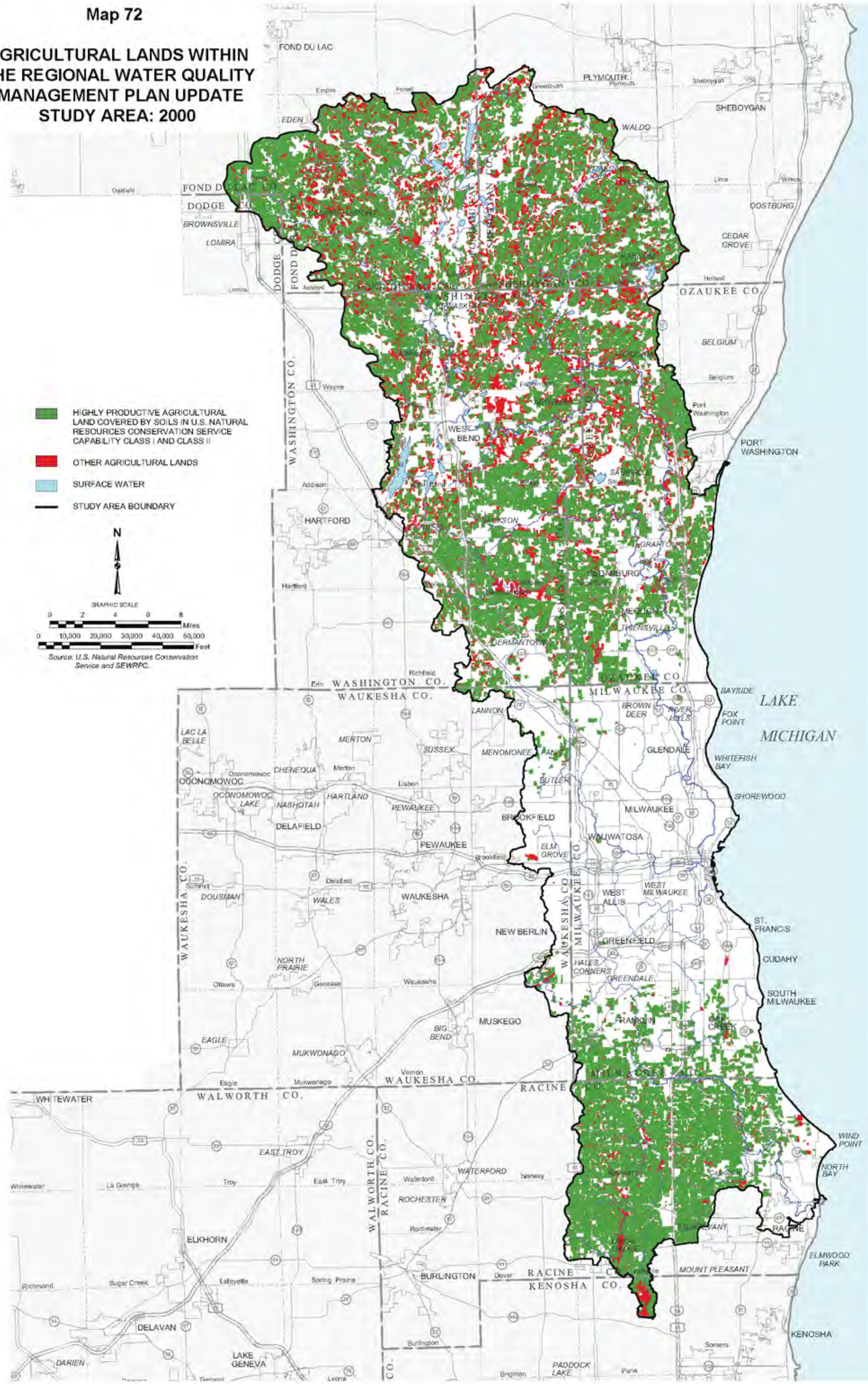
[6]*Such State administrative rules would not prevent destruction of environmental corridor lands as a result of urban development that occurs without sanitary sewer service.*

[7]*Waukesha County utilizes its land division approval-objection authority to help ensure the preservation of environmental corridors in accordance with the Waukesha County development plan. Waukesha County reviews all proposed subdivision plats and some, but not all, proposed certified survey maps in Waukesha County.*

[8]*In addition to farmed floodlands, the adopted objectives, principles, and standards for the regional water quality management plan update support carefully planned efforts to restore other farmland and open space to more natural conditions, resulting in the re-establishment of wetlands, woodlands, prairies, grasslands, and forest interiors. That principle is reflected in the nonpoint source pollution abatement recommendations set forth later in this chapter. The delineation of environmental corridors and isolated natural resources areas should be modified as appropriate in subsequent planning efforts to reflect the re-establishment of natural resource features resulting from such restoration efforts in other areas.*

Map 72

AGRICULTURAL LANDS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA: 2000



The plan does envision that some Class I and Class II farmland that is located in the vicinity of existing urban service areas will be converted to urban use as a result of planned expansion of those urban service areas. This is a matter of balancing objectives for the preservation of productive farmland with objectives of meeting urban land needs as warranted by increases in population, households, and employment and objectives for the orderly and efficient provision of urban facilities and services. The plan also anticipates the development of lands beyond planned urban service areas that have been committed to low-density and suburban-density residential development through subdivision plats and certified surveys. This may be expected to result in the additional loss of Class I and Class II farmland.

SURFACE WATER QUALITY PLAN ELEMENTS

This report section describes the recommended point and nonpoint source pollution control measures, instream water quality measures, and auxiliary measures for the greater Milwaukee watersheds, all of which are directed toward improving surface water quality conditions in the study area.

Point Source Pollution Abatement Plan Subelement

This subelement includes recommendations related to public wastewater treatment and associated sewer service areas, private wastewater treatment plants, and other point sources of pollution. The recommended point source pollution control measures described in this report subsection are components of the Regulatory Watershed-Based Approach. Recommendations related to the provision of additional treatment capacity at the MMSD South Shore wastewater treatment plant were changed for the Integrated Watershed-Based Approach as described below.

Public Wastewater Treatment Plants and Associated Sewer Service Areas

As noted previously, SEWRPC, the WDNR, and the local communities have conducted sewer service area planning studies to refine and update sanitary sewer service areas throughout the study area since the regional water quality management plan was adopted in 1979. Map 73 shows the planned sanitary sewer service areas within the study area and the MMSD planning area outside the study area. With the exception of most of the MMSD service area within Milwaukee County; the City of South Milwaukee service area; the Villages of Adell, Campbellsport, Cascade, Lomira, and Random Lake; the Town of Scott Sanitary District No. 1 service area; and the Town of Yorkville Sanitary District No. 1 service area, all sewer service areas within the greater Milwaukee watersheds have been refined.[9] It is recommended that the MMSD, South Milwaukee, Adell, Campbellsport, Cascade, Lomira, Random Lake, Scott, and Yorkville service areas be refined through a joint effort involving the municipalities; the appropriate regional, county, or local agencies; and the WDNR.

Public Wastewater Treatment Systems Outside of the Milwaukee Metropolitan Sewerage District Planning Area

It is recommended that communities in the study area, but outside of the MMSD planning area continue to assess their wastewater conveyance and treatment systems so as to provide the capacity necessary to allow for future development as it occurs while adhering to the conditions of their operating permits. The regional water quality management plan update evaluates facilities planning needs based on a criterion that facilities planning should be initiated when the average daily flow to a wastewater treatment plant reaches 80 percent of the plant design capacity. As shown in Table 80 in Chapter IX of this report, it is estimated that by the year 2020, assuming existing wastewater treatment plant design capacities:

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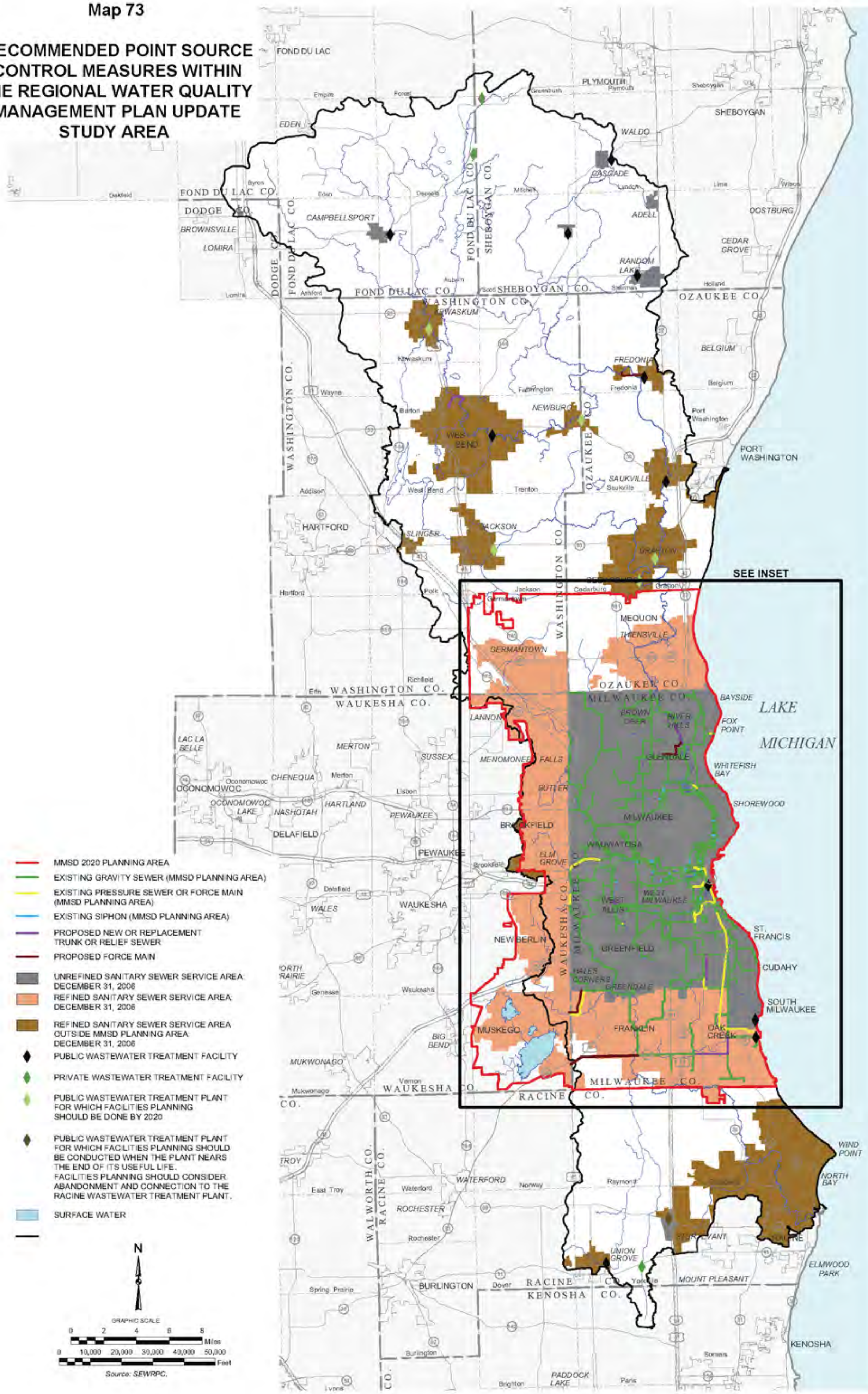
[9]*Refined sewer service areas have been delineated through the local sewer service area planning process. As part of this process, the community concerned, assisted by SEWRPC, determines a precise sewer service area boundary consistent with local land use plans and development objectives. Reports documenting the sewer service areas include detailed maps of environmentally significant areas within the sewer service area. Following adoption by the designated management agency for the sewage treatment plant, local sewer service area plans are considered for adoption by the Regional Planning Commission as a formal amendment to the regional water quality management plan. The Commission then forwards the plans to the WDNR for approval.*

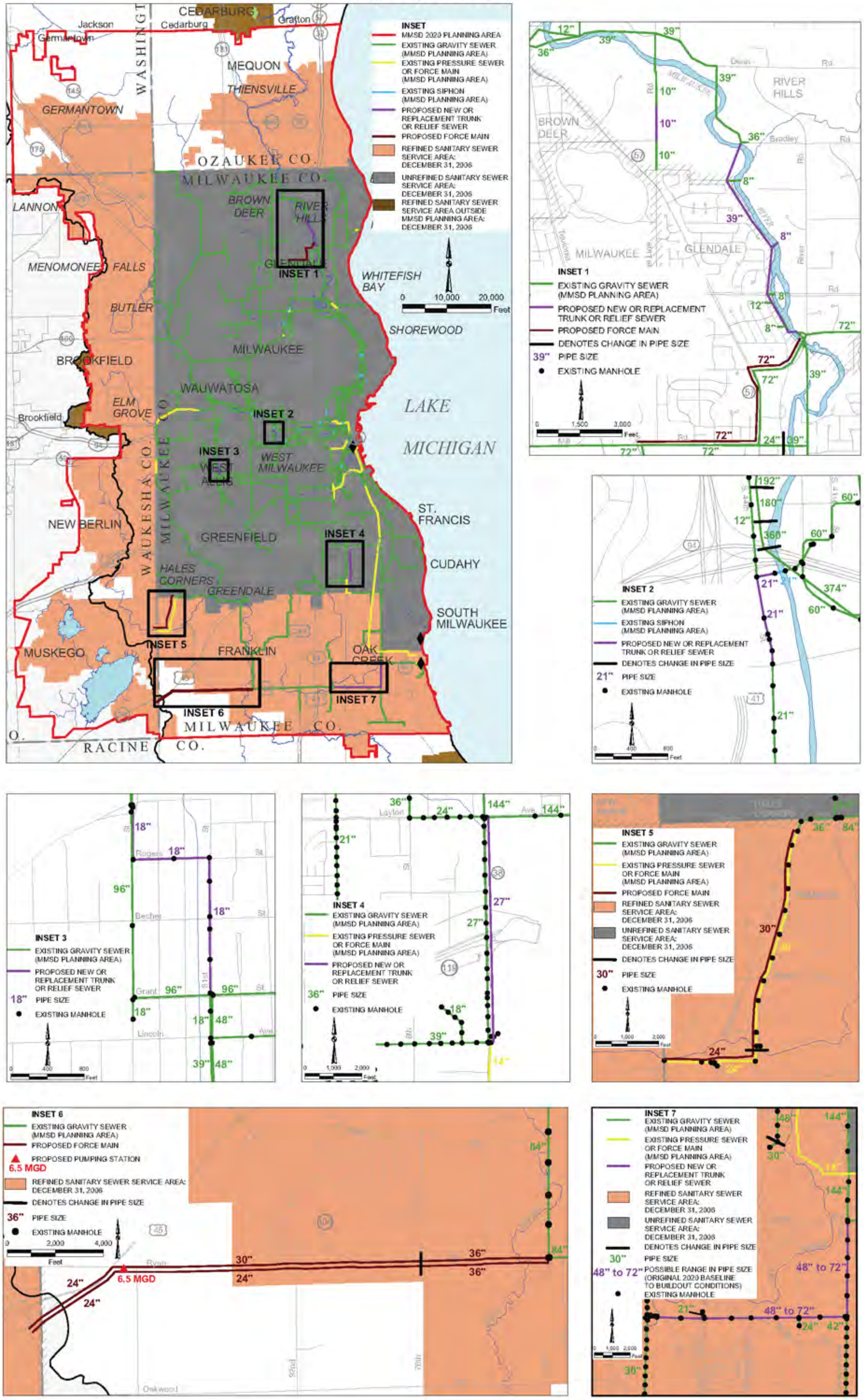
Unrefined sewer service areas are normally generalized in nature and are the product of systems level planning.

Map 73

RECOMMENDED POINT SOURCE CONTROL MEASURES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



Map 73 (continued)



- Sewage flows to the Village of Grafton plant would be nearing 80 percent of the plant design capacity,
- Sewage flows to the Village of Kewaskum and Village of Newburg plants would have exceeded the 80 percent threshold and would be approaching, or equaling, the plant design capacities, and
- Sewage flows to the City of Cedarburg and Village of Jackson plants would have exceeded plant design capacities.

The Village of Kewaskum has recently prepared a facilities plan for upgrades to its wastewater treatment system.[10] Depending on the rate of growth of population and the rate of expansion of commercial and industrial land, the Village may have to undertake additional facilities planning prior to 2020.

While average annual sewage flows to the wastewater treatment plants for the Villages of Newburg and Jackson have not yet reached the 80 percent threshold, because they are projected to exceed the threshold sometime between now and 2020, it is recommended that those municipalities monitor development and population levels in their sewer service areas and that they prepare facilities plans prior to 2020 in order to provide adequate treatment capacity to meet future needs.

Based on the information in Table 80 in Chapter IX of this report, it is estimated that facilities planning for the City of Cedarburg may be warranted prior to 2020[11] and facilities planning for the Village of Grafton may be warranted in about the year 2020. The City and the Village have given preliminary consideration to constructing a new regional wastewater treatment plant at such future time that expansion of the existing treatment capacity for those communities is warranted. It is recommended that, when facilities planning is first initiated for either of the municipalities, that the plan include cost-effectiveness analyses to evaluate upgrading the individual treatment plants versus construction of a new regional wastewater treatment plant to serve both communities.

A wastewater treatment facilities plan was recently prepared by the Village of Fredonia.[12] The plan was prepared to address plant hydraulic capacity and sludge storage issues. The plan report notes that monthly average wet weather flows have ranged from 80 to 90 percent of design capacity, maximum daily flows and peak hourly flows have approached the plant capacity, and the sludge storage tank is being loaded up to 90 percent of its capacity. The facilities plan does not call for the Fredonia plant to treat wastewater from the Waubeka area because that area has not yet been provided with a sanitary sewerage system and there are no imminent plans to do so. The regional water quality management plan update recommends eventual connection of the Waubeka area to the Fredonia wastewater treatment plant; however, in the absence of a sanitary sewerage system to serve Waubeka, it is considered to be consistent with the regional plan for Fredonia to exclude the Waubeka area from its planning area at this time.

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[10]*Ruekert & Mielke, Inc,* WTF Facility Plan-Village of Kewaskum Washington County, Wisconsin*, January 2007.*

[11]*In 2000, the City retained a consultant to study the hydraulic capacity of the existing wastewater treatment plant. That study indicated that the plant capacity may be considerably greater than 2.75 mgd. Before undertaking future facilities planning, the City would pursue officially rerating the plant to reflect the higher capacity.*

[12]*McMahon Associates,* Wastewater Treatment Facility Plan, prepared for the Village of Fredonia*, June 2007.*

The Village of Caledonia recently completed a study to determine the most cost-effective way to provide sanitary sewer service to portions of the Village that are anticipated to be developed by the year 2035.[13] The study also involved the City of Racine, Villages of Mt. Pleasant and Sturtevant, and the Towns of Raymond and Yorkville. Wastewater from the City of Racine and the Villages of Caledonia, Mt. Pleasant, and Sturtevant is currently treated at the plant operated by the Racine Water and Wastewater Utility. Wastewater flows from the Town of Yorkville sewer service area are treated at the plant operated by Town of Yorkville Sanitary District No. 1. Pursuant to the cost-effectiveness analysis, a sewer service area amendment was adopted that expands the boundaries of the sewer service area for the City of Racine and environs to include additional areas in the Villages of Caledonia and Mt. Pleasant. At some time following adoption of the sewer service area amendments for Racine and environs, it is recommended that detailed facilities planning be undertaken to establish what new conveyance, pumping, and storage facilities would be needed to provide service.

The Town of Yorkville Sanitary District No. 1 service area was not included in the refined Racine sewer service area; however, consistent with SEWRPC Community Assistance Planning Report No. 147 (2nd Edition), *Sanitary Sewer Service Area for the City of Racine and Environs*, which was adopted by the Regional Planning Commission on June 18, 2003, it is recommended that the entire Yorkville system be connected to the sewerage system tributary to the Racine wastewater treatment plant and that the Yorkville plant be abandoned when the Yorkville plant reaches the end of its useful life. The population and sewage flow information set forth in Table 80 in Chapter IX of this report, indicates that the Yorkville plant would still have adequate treatment capacity in 2020. Thus, unless the physical condition of the plant dictates the need for significant upgrades prior to 2020, in which case connection to the Racine system should be considered, abandonment of the Yorkville plant may not occur until after the year 2020.

Recommended Intercommunity Trunk Sewers

Map 73 shows a proposed new intercommunity trunk sewer, designated as the Northwest Interceptor by the City of West Bend, which is anticipated to be constructed in the City and the Town of Barton from 2011 through 2015. Map 73 also shows a recommended force main that would connect urban development in the Waubeka area with the Village of Fredonia sewerage system. That intercommunity trunk sewer was originally recommended in 1979 under the initial regional water quality management plan. The costs for these recommended trunk sewers are set forth in Table 82.

Implement Local Programs to Ensure Maintenance of Adequate Sewage Collection System Capacity

In order to ensure the maintenance of adequate sanitary sewage collection system capacity, it is recommended that the municipalities outside the MMSD service area implement locally-designed programs similar to the Capacity, Management, Operations, and Maintenance (CMOM) program that is currently being promoted by the U.S. Environmental Protection Agency as a means of evaluating and maintaining sewage collection systems.[14] The program objectives are to:

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[13]*This planning effort was conducted by Earth Tech, Inc., for the Village of Caledonia in cooperation with the Racine Water and Wastewater Utility, the Villages of Mt. Pleasant and Sturtevant, the Towns of Raymond and Yorkville, and SEWRPC. The study is documented in the report entitled* Village of Caledonia IH 94 Sewer Service Area Trunk Sewer Analysis, *February 2007. The study is a refinement and update of a portion of the plan set forth in the 1992 Alvord, Burdick & Howson report entitled* A Coordinated Sanitary Sewer and Water Supply System Plan for the Greater Racine Area.

[14]*As of December 2007, the WDNR was preparing draft revisions to Chapter NR 210, "Sewage Treatment Works," of the* Wisconsin Administrative Code *which would require WPDES permittees, including owners of satellite collection systems, to implement a CMOM program in order to prevent sanitary sewer overflows or bypasses.*

Table 82

COMPONENTS OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Land Use Plan Element[c]	Population and Land Use Subelement	- -	1. Develop water quality plan components on the basis of planned year 2020 population and land use estimates	- -	- -	- -
	Environmentally Significant Lands Subelement	Recommendations Regarding Environmentally Significant Lands	1. Maintain primary environmental corridors in essentially natural, open uses	- -	- -	- -
			2. Consider maintaining secondary environmental corridors and isolated natural resource areas in essentially natural, open uses	- -	- -	- -
			3. Preserve all identified natural areas and critical species habitat sites	- -	- -	- -
			4. Acquire identified natural areas and critical species habitat sites not in existing public or public-interest ownership	- -	- -	- -
	Highly Productive Agricultural Land Subelement	- -	1. Preserve to the extent practicable farmland covered by agricultural capacity Class I and Class II soils as classified by the U.S. Natural Resources Conservation Service	- -	- -	- -
			Subtotal	- -	- -	
Surface Water Quality Plan Element	Point Source Pollution Abatement Plan Subelement	Public Wastewater Treatment Plants and Associated Sewer Service Areas	1. Refine sanitary sewer service areas for the MMSD, City of South Milwaukee, Villages of Adell, Campbellsport, Cascade, Lomira, and Random Lake, and Town of Yorkville Sanitary District No. 1	- -	- -	- -
			2. Continue assessment of sewage conveyance and treatment systems for communities outside of the MMSD planning area	- -[d]	- -[d]	- -
			3. Implementation of the Village of Kewaskum WWTP Facilities Plan	$ 3,440	$ 97	- -
			4. Prepare facilities plans for the Villages of Jackson and Newburg	200	- -	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Point Source Pollution Abatement Plan Subelement (continued)	Public Wastewater Treatment Plants and Associated Sewer Service Areas (continued)	5. Prepare facilities plans for the City of Cedarburg and Village of Grafton, including consideration of merging operations into a single, regional treatment facility	$ 175	- -	- -
			6. Prepare facilities plan for City of Racine and environs upon completion of amendment to sewer service area	250	- -	- -
			7. Capacity, Management, Operations, and Maintenance (CMOM) programs for municipalities outside of the MMSD service area	1,425	- -	- -
			8. City of West Bend Northwest Interceptor	4,091	$ 3	- -
			9. Force main from Waubeka in the Town of Fredonia to the Village of Fredonia sewerage system	1,549	11	- -
			10. Ryan Creek interceptor sewer	51,386	70	- -
			11. Implementation of MMSD 2020 Facilities Plan as Recommended under the RWQMPU[e]	954,900[f]	900[g]	X
			12. Implementation of wastewater treatment plant upgrades for City of South Milwaukee	4,298	575[g]	- -
		Private Wastewater Treatment Facilities	1. Continue operation of the private treatment facilities at Long Lake Recreational Area, Kettle Moraine Correctional Institute, and Fonks Mobile Home Park	- -[h]	- -[h]	- -
		Regulation of Wastewater Treatment Facilities and Industrial Discharges	1. Continue regulation of discharges through the WPDES permitting program	- -	- -	- -
			2. Consider change in method of applying corrosion control in municipal water treatment systems to limit phosphorus loading	- -	- -	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Nonpoint Source Pollution Abatement Plan Subelement	Recommended Rural Nonpoint Source Pollution Control Measures	1. Reduce soil erosion from cropland	- -[i]	- -[i]	- -
			2. Provide six months of manure storage for livestock operations	$ 47,050	$ 3,072	X
			3. Prepare and/or implement nutrient management plans	1,526	1,308	- -
			4. As required by WPDES permit, all CAFOs to follow a nutrient management plan	- -[j]	- -[j]	- -
			5. Control barnyard runoff	2,280	- -	- -
			6. Expand riparian buffers	1,747	389	X
			7. Convert marginal cropland and pasture to wetlands and prairies	72,253	16,250	- -
			8. Restrict livestock access to streams	969	48	- -
			9. Manage milking center wastewater	3,799	83	X
			10. Expand oversight and maintenance of private onsite wastewater treatment systems (POWTS)	113,660	663	X
		Recommended Urban Nonpoint Source Pollution Control Measures	1. Implementation of the nonagricultural (urban) performance standards of Chapter NR 151	- -[k]	- -[k]	- -
			2. Programs to detect and eliminate illicit discharges and control pathogens that are harmful to human health	$ 19,524[l]	- -	X
			3. Chloride reduction programs	499	$ 1,496	- -
			4. Implement fertilizer management programs	160	- -	X
			5. Disconnect residential roof drains from sanitary and combined sewers and infiltrate roof runoff	22,171	350	X
			6. Manage pet litter	- -[m]	- -[m]	X
			7. Beach and riparian litter and debris control	- -	596	- -
			8. Marina waste management facilities	- -	- -	- -
			9. Research and implementation projects	- -[n]	- -[n]	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Instream Water Quality Measures Plan Subelement	Hydrologic and Hydraulic Management	1. Concrete channel renovation and rehabilitation	$ 175,200	- -	- -
			2. Renovation of the MMSD Kinnickinnic River flushing station	3,400	$ 600	- -
			3. Dam abandonment and restoration plans	1,800	- -	X
			4. Limit number of culverts, bridges, drop structures, and channelized stream segments and incorporate design measures to allow for passage of aquatic life	- -	- -	- -
			5. Remove abandoned bridges and culverts	- -[d]	- -[d]	- -
		Restoration and Remediation Programs	1. Manage contaminated sediment sites	- -[d]	- -[d]	- -
			2. Extend Milwaukee Harbor Estuary Area of Concern to include contaminated portions of Cedar Creek in Cedarburg and Little Menomonee River in Milwaukee	- -	- -	- -
			3. Continue implementation and support of the Milwaukee Estuary Remedial Action Plan	- -	- -	- -
			4. Continue navigational dredging in the inner and outer harbors	- -[h]	- -[h]	- -
			5. Increase the dredged material storage volume of the Jones Island Confined Disposal Facility	$ 3,500	$ 12	- -
		Fisheries Protection and Enhancement	1. To the extent practicable, protect remaining natural stream channels including small tributaries and shoreland wetlands	- -[d]	- -[d]	X
			2. Restore wetlands, woodlands, and grasslands adjacent to the stream channels and establish riparian buffers	- -[j]	- -[j]	X
			3. Restore, enhance, and rehabilitate stream channels to provide increased water quality and quantity of available fisheries habitat	- -[d]	- -[d]	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Instream Water Quality Measures Plan Subelement (continued)	Fisheries Protection and Enhancement (continued)	4. Monitor fish and macroinvertebrate populations	- -[j]	- -[j]	- -
			5. Consider more intensive fisheries manipulation measures where warranted	- -[d]	- -[d]	- -
	Inland Lakes Water Quality Measures Plan Subelement	- -	1. Lake management plans for 17 major lakes	$ 850	- -	- -
			2. Implement trophic state monitoring programs for 20 major lakes	- -	$ 120	- -
			3. Milwaukee County pond and lagoon management plan implementation	- -	- -	- -
	Auxiliary Water Quality Management Plan Subelement	Public Beaches	1. Continue current public health monitoring programs and expand to all public beaches in the study area	- -	$ 31	- -
			2. Evaluate beaches with high frequencies of closings for local sources of contamination and remediate	- -[d]	- -[d]	- -
			3. Continue and expand current beach grooming programs	- -	710	- -
		Waterfowl Control	1. Implement programs to discourage unacceptably high numbers of waterfowl from congregating near beaches and other water features	- -	$ 165	- -
		Coastal Zone Management	1. Continue implementation and refinement of the Lake Michigan Lakewide Management Plan	- -	- -	- -
			2. Maintain liaison and linkage between local, State, and Federal Great Lakes programs	- -	- -	- -
			3. Coordinate shipping and harbor management programs and activities with environmental management programs and activities	- -	- -	X
		Water Pollution Control	1. Continue collection programs for household hazardous wastes and expand such programs to communities that currently do not have them	- -	$ 374	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Auxiliary Water Quality Management Plan Subelement (continued)	Emerging Issues	1. Conduct assessments and evaluations of the significance for human health and aquatic and terrestrial wildlife of the presence of pharmaceuticals and personal care products in surface waters	- -[d]	- -[d]	- -
			2. Implement collection programs for expired and unused household pharmaceuticals	- -	$ 40	- -
			3. Continue and support programs to reduce the spread of exotic invasive species, including public education programs	- -	- -	X
		Water Quality Monitoring	1. Continue and possibly expand current MMSD, WDNR, and USGS water quality monitoring programs, including Phases II and III of the MMSD corridor study	- -	- -	- -
			2. Continue and possibly expand USGS stream gauging program	$ 145	$ 126	- -
			3. Establish long-term water quality monitoring programs for areas outside of MMSD service area	- -	156	- -
			4. Establish long-term fisheries and macroinvertebrate monitoring stations	- -	100	- -
			5. Establish long-term aquatic habitat monitoring stations	- -	59	- -
			6. Conduct aquatic plant surveys for areas where plant management measures are being implemented	- -[d]	- -[d]	- -
			7. Monitor exotic and invasive species	- -[d]	- -[d]	- -
			8. Continue citizen-based monitoring efforts	- -	- -	- -

Table 82 (continued)

Plan Element	Plan Subelement	Description	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost (thousands)[a]	Implementation of Component May Require New or Modified Regulations or Changes in Enforcement[b]
Surface Water Quality Plan Element (continued)	Auxiliary Water Quality Management Plan Subelement (continued)	Maintenance of the Regional Water MMSD 2020 Facilities Plan Modeling System	1. Continue maintenance of MMSD conveyance system modeling tools	- -	$ 15	- -
			2. Continue maintenance of watershed-wide riverine water quality models (LSPC) and Milwaukee Harbor estuary/nearshore Lake Michigan hydrodynamic (ECOMSED) and water quality (RCA) models	- -	15	- -
			Subtotal	$1,492,248	$28,435	
Groundwater Management Plan Element	Plan Recommendations Related to Groundwater	Groundwater Recharge Areas	1. Extend groundwater recharge area mapping to those portions of the study area located outside of the Southeastern Wisconsin Region	$ 25	- -	- -
			2. Follow recommendations of the regional water supply plan regarding maintenance of groundwater recharge areas	- -[o]	- -[o]	X
		Groundwater Sustainability	1. Utilize groundwater sustainability guidance results in evaluating the sustainability of proposed developments and in conduct of local land use planning	- -[d]	- -[d]	X
		Mapping Groundwater Contamination Potential	1. Extend mapping of groundwater contamination potential for shallow aquifers to those portions of the study area located outside of the Southeastern Wisconsin Region	$ 25	- -	- -
		Stormwater Management Measures Affecting Groundwater Quality	1. Design of stormwater management facilities that directly or indirectly involve infiltration to consider the potential impacts on groundwater quality	- -	- -	- -
		Groundwater Issues Related to Disposal of Emergency and Unregulated Contaminants	1. Reduce disposal of pharmaceuticals and personal care products in onsite waste disposal systems through expanding household waste collection programs	- -	- -	- -
		Water Conservation	1. Utility- or community-specific water conservation programs	- -	- -	X
			Subtotal	$ 50	- -	- -
			Total	$1,492,298	$28,435	- -

Table 82 Footnotes

[a] *Costs represent 2007 conditions. 2007 Engineering New-Record Construction Cost Index = 10,000. In general, where not qualified by another footnote, double dashes indicate that either it is not appropriate to assign a cost to a component, a cost is already incurred under another program or plan, or it is not possible to reasonably estimate the cost of a component because it is affected by future actions whose scope cannot be determined at this time.*

[b] *The mechanism for implementing components that may require new or modified regulations or changes in enforcement would be established at the Federal, State, or local government levels. Many of those components might also be implemented voluntarily.*

[c] *The costs associated with implementation of the components of the regional land use plan that are incorporated in this plan are determined by many different, variable factors, such as fluctuations in the real estate market and changing Federal and State programs, making realistic estimation of those costs highly speculative. Thus, the overall costs of implementing a regional land use plan element are traditionally not estimated.*

[d] *Case- or project-specific.*

[e] *A detailed breakdown of the MMSD 2020 Facilities Plan components and associated costs is presented in Tables 83 and 84. The costs presented here reflect only those shown in Table 83 which represent proposed new facilities, programs, operational improvements, and policies, including an estimated $400 million for management of sanitary sewer infiltration and inflow by the MMSD member and contract communities and Milwaukee County. The total capital cost presented under this item is $152 million less than the total in Table 83, and the total annual operation and maintenance cost is $1.7 million less than the amount in Table 83. Those differences reflect the regional water quality management plan update recommendation that the addition of physical-chemical treatment at the MMSD South Shore wastewater treatment plant not be implemented, pending 1) further development by MMSD of the variable volume reserved for sanitary sewer inflow operating strategy for the Inline Storage System, 2) the results of capacity analyses for the Jones Island and South Shore plants, 3) determination of actual population and land use changes, and 4) determination of the success of the wet weather peak flow management program undertaken by MMSD and the communities that it serves.*

[f] *This cost includes $46.8 million for installation of a 48-inch-diameter sewer for the Ryan Road MIS relief sewer to convey anticipated sewage flows under original 2020 baseline conditions. The cost could be up to $17.1 million more if a 72-inch-diameter relief sewer were required to convey anticipated flows under buildout conditions. The determination of which size sewer to install will be made at a future date when growth trends are reviewed.*

[g] *Incremental cost.*

[h] *No cost assigned to this component since no new measures are recommended that would affect current facilities or operating costs.*

[i] *No cost assigned to this component. Assumed nutrient management plan include measures to control soil loss.*

[j] *Costs are already included as part of other plan elements.*

[k] *No costs have been assigned to the regional water quality management plan update as these measures are already mandated by State code. Estimated costs of carrying out these measures within the study area are presented in Table 87.*

[l] *Cost only reflects program to detect locations of illicit discharges. Costs of elimination are case specific and therefore not included here.*

[m] *Programs assumed to be self-supporting through collection of fines.*

[n] *These projects are ongoing with committed costs and thus no additional cost is assigned to the regional water quality management plan update. The cost of these projects is presented in Table 87 for informational purposes.*

[o] *Certain groundwater management plan costs are assigned to the regional water supply plan and, thus, no costs are assigned under the regional water quality management plan update.*

Source: SEWRPC.

- Better manage, operate, and maintain collection systems;
- Investigate capacity constrained sections of the collection systems; and
- Proactively prevent SSOs.

Recommended 2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District
As noted in the introduction to this chapter, the regional water quality management plan update was prepared as part of a coordinated planning effort that also involved preparation of the 2020 facilities plan for the MMSD. A detailed description of the development of the recommended MMSD facilities plan is set forth in Chapters 9 and 10 of the facilities plan report.[15]

The following facilities, programs, operations, and policies that are recommended under the MMSD facilities plan are also incorporated as components under the regional water quality management plan update:

- Facilities recommended under the wet-weather control plan that is designed to meet MMSD's discharge permit requirements,
- MMSD programs and policies to maximize capture and treatment of sewage during wet weather,
- Improvement of existing MMSD facilities to ensure the continued provision of adequate sewage treatment,
- A biosolids plan,
- Watercourse projects directed toward improving instream water quality and reducing municipal infiltration and inflow (I/I) through reducing overland flooding in developed areas,
- Best management practice (BMP) demonstration projects intended to assess the effectiveness of specific BMPs in reducing nonpoint source pollution and improving water quality consistent with the urban nonpoint source pollution control recommendations of the regional water quality management plan,
- New MMSD programs and policies implemented to support other elements of the recommended plan,
- Existing MMSD programs and policies that are to be continued,
- Existing MMSD operations that are to be continued,
- MMSD committed projects, and
- Community-based components.

Further description of these plan components is provided in the following subsections. The 2020 facilities plan divided the individual plan components into three categories: those representing new facilities, programs, operations, and policies; those representing existing facilities, programs, operations, and policies necessary to support the goals of the facilities plan; and those representing recommendations for the 28 satellite communities served by the MMSD. Components and costs for these first two categories are set forth in Tables 83 and 84,

[15]*The MMSD facilities plan is documented in the report entitled* 2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District, *June 2007. Companion reports to the facilities plan include the MMSD Treatment Report, the MMSD Conveyance Report, and the State of the Art Report.*

Table 83

COMPONENTS OF THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT 2020 FACILITIES PLAN NEW FACILITIES, PROGRAMS, OPERATIONS, AND POLICIES TO BE IMPLEMENTED

Plan Element	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost[a] (thousands)
Wet Weather Control Plan: Facilities	1. Perform Capacity Analysis of South Shore WWTP	- -[b]	- -
	2. Increase ISS Pump Station Capacity to Jones Island WWTP to 180 MGD	$108,000	$900
	3. Increase South Shore WWTP Treatment Capacity with Physical-Chemical Treatment Methods	$97,000-$152,000[c]	$1,400-$1,700[c]
	4. Improvements to MMSD Flow Monitoring and Rain Gauge System	$25,000-$37,000	- -
	5. Add MIS Capacity as Necessary		
	– N. 91st Street	$ 5,900	- -
	– Milwaukee River	18,100	- -
	– Range Line Road	1,100	- -
	– River Hills	500	- -
	– Green Bay Avenue and W. Mill Road	16,000	- -
	– Menomonee River	1,300	- -
	– S. 81st Street	3,500	- -
	– S. Howell Avenue	8,300	- -
	– W. Ryan Road	46,800[d]	- -
	– Franklin-Muskego Force Main (Ryan Creek interceptor)	- -[e]	- -
	– Real Time Control Strategy Improvements	400	- -
	Total of MIS Capacity Projects	$0-$101,900[f]	- -
	Subtotal	$230,000-$398,900	$2,300-$2,600
Wet Weather Control Plan: Programs, Operational Improvements and Policies	1. Evaluate Need for Control System Refinements at S. 6th Street and W. Oklahoma Avenue Drop Structure	- -[g]	- -[g]
	Subtotal	- -	- -
Plan for Existing Milwaukee Metropolitan Sewerage District Facilities	1. Rehabilitate Dewatering and Drying at Jones Island WWTP	- -[h]	- -
	2. Additional Force Main	$0-$23,000[i]	- -
	3. Evaluation of Jones Island WWTP Aeration System	$0-$15,000[j]	- -[j]
	Subtotal	$0-$38,000	- -
Interim Biosolids Management Plan	1. Maintenance of Jones Island Dewatering and Drying Facility	$115,000	- -
	2. New Biosolids/Energy System	20,000	- -
	3. Interplant Solids Pumping and Pipeline Improvements	3,000	- -
	4. New Gravity Belt Thickeners for South Shore Waste Sludge Thickening	7,700	- -
	5. Three new two-meter gravity belt thickeners	2,225	- -
	6. South Shore Digester Rehabilitation	117,000	- -
	7. Maximize Operation of Primary Clarifiers	- -	- -
	8. Upgrade and Maintain South Shore Plate and Frame Presses	5,000	- -
	9. Overall Planning Report on Energy and Energy Management	300	- -
	10. Marketing Study for Lower Percent Nitrogen Milorganite®	- -	- -
	11. Evaluation of Milorganite® Nitrogen Balance	- -	- -
	Subtotal	$270,000[k]	- -

Table 83 (continued)

Plan Element	Component	Capital Cost (thousands)[a]	Annual Operation and Maintenance Cost[a] (thousands)
New Milwaukee Metropolitan Sewerage District Programs and Policies	1. Watershed Approach Implementation Tactics	- -	- -
	2. Policies to Support RWQMPU	- -	- -
	3. MMSD Chapter 13 Revisions	- -	- -
	4. Sewer Separation	- -	- -
	5. Educational Outreach Program	- -	- -
	Subtotal	- -	- -
Community-Based Components of the Recommended Plan[l]	1. I/I Management- Communities Hold I/I at 2020 FP Assumptions	$400,000	- -
	Subtotal	$400,000	- -
	Total	$900,000-$1,106,900	$2,300-$2,600

[a]*Costs reflect projected June 2007 dollars.* Engineering News Record *Construction Cost Index (CCI) = 10,000. In general, where not qualified by another footnote, double dashes indicate that either it is not appropriate to assign a cost to a component, a cost is already incurred under another program or plan, or a cost was not provided in the MMSD 2020 facilities plan.*

[b]*No capital cost was assigned in the 2020 Facilities Plan. A cost of $0.3 million was assigned to cover preliminary engineering.*

[c]*The 2020 Facilities Plan also included a cost estimate of $1.5 million to conduct a pilot project to determine the feasibility of this technology. The capital and annual operation and maintenance costs listed in this table are not included in Table 82, which sets forth the costs for the recommended regional water quality management plan update. That recommendation calls for possibly avoiding the addition of physical-chemical treatment at the MMSD South Shore wastewater treatment plant, pending 1) further development by MMSD of the variable volume reserved for sanitary sewer inflow operating strategy for the Inline Storage System, 2) the results of capacity analyses for the Jones Island and South Shore plants, 3) determination of actual population and land use changes, and 4) determination of the success of the wet weather peak flow management program undertaken by MMSD and the communities that it serves.*

[d]*This cost reflects installation of a 48-inch-diameter sewer for the Ryan Road MLS relief sewer to convey anticipated sewage flows under original 2020 baseline conditions. The cost could be up to $17.1 million more if a 72-inch-diameter relief sewer were required to convey anticipated flows under buildout conditions. The determination of which size sewer to install will be made at a future date when growth trends are reviewed.*

[e]*The Ryan Creek interceptor costs for the MMSD and affected communities are set forth in Table 82.*

[f]*The need for these upgrades will be evaluated over time based on flow monitoring and assessments of growth in population and land use. There would be no cost if it were found that none of the upgrades was required.*

[g]*Cost was not determined for this component under the facilities plan, but was expected to be minimal, and, therefore, could be included in ongoing annual budget.*

[h]*Cost of this component is included under the Interim Biosolids Management Plan element.*

[i]*The 2020 Facilities Plan also included a cost estimate of $0.3 million to cover preliminary engineering.*

[j]*A potential savings of $1.0 million per year in operation and maintenance costs could possibly be achieved if aeration system energy costs can be reduced.*

[k]*Rounded.*

[l]*The MMSD 2020 Facilities Plan also included costs for compliance with the urban performance standards in Chapter NR 151. These costs have not been assigned to the regional water quality management plan update, but are identified separately in Table 87.*

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

respectively. The satellite community component and cost has also been included in Table 83. Because the components included in Table 84 represent ongoing projects or ones identified in the facilities plan as having minimal or no cost, no costs are assigned under the recommended regional water quality management plan update.

Table 84

COMPONENTS OF THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT 2020 FACILITIES PLAN EXISTING FACILITIES, PROGRAMS, OPERATIONS, AND POLICIES TO BE CONTINUED

Plan Element	Component	Capital Cost[a] (thousands)	Annual Operation and Maintenance Cost[a] (thousands)
Wet Weather Control Plan: Facilities	6. Hydraulic Analysis of Jones Island WWTP	- -[b]	- -[b]
	Subtotal	- -	- -
Wet Weather Control Plan: Programs, Operational Improvements and Policies	2. Implement MMSD WWPFMP to Control I/I Growth	- -[c]	$600
	3. Implement MMSD CMOM Program	- -[c]	- -[c]
	4. Implement CMOM for Municipalities and Milwaukee County	- -[c]	- -[c]
	5. Implement MMSD SECAP	- -[c]	- -[c]
	6. Implement SECAP for Municipalities	- -[c]	- -[c]
	7. Implement Flow Monitoring for High-Priority Areas	- -[c]	- -[c]
	8. Continue Operation of Real Time Control (RTC)	- -[c]	- -[c]
	Subtotal	- -	$600
Plan for Existing Milwaukee Metropolitan Sewerage District Facilities	4. Rehabilitate the ISS Pump Station	$ 25,000	- -
	5. Ongoing Treatment Upgrades	143,000[d]	- -
	6. Ongoing Conveyance Upgrades	195,000[d]	- -
	7. Geotechnical/Structural Analysis of Wastewater Treatment Plants	- -[e]	- -
	8. Additional Treatment Recommendations	- -[c]	- -[c]
	9. Recommended Conveyance and Treatment Projects Included in MMSD 2007 Annual Budget	76.4	- -
	Subtotal	$ 439,200	- -
Watercourse Plan	12. Watercourse Flood Mitigation Plan	- -[f]	- -
	13. Greenseams Project Continue Implementation	$ 20,000	- -
	14. Ongoing Watercourse Upgrades	39,000	- -
	Subtotal	$ 59,000	- -
Existing Milwaukee Metropolitan Sewerage District Programs and Policies to Be Maintained	1. Long-Term Control Plan	- -	- -
	2. Maintain All Other Water Quality Programs	- -	- -
	Subtotal	- -	- -
Existing Milwaukee Metropolitan Sewerage District Operations to Be Continued	1. Jones Island WWTP Wet Weather Blending	- -	- -
	2. River Skimmer Boat Operation	- -	- -
	3. Watercourse Operations	- -	- -
	Subtotal	- -	- -
Milwaukee Metropolitan Sewerage District Committed Projects	1. Committed Conveyance and Treatment Projects	$ 528,000	- -
	2. Committed Watercourse Projects	- -[g]	- -[g]
	Subtotal	- -	- -
	Total	$1,026,200	$600

Table 84 Footnotes

[a]*Costs reflect projected June 2007 dollars.* Engineering News Record *Construction Cost Index (CCI) = 10,000. In general, where not qualified by another footnote, double dashes indicate that either it is not appropriate to assign a cost to a component, a cost is already incurred under another program or plan, or a cost was not provided in the MMSD 2020 facilities plan.*

[b]*No capital cost was assigned in the 2020 Facilities Plan. A cost of $0.3 million was assigned to cover preliminary engineering.*

[c]*Cost was not determined for this component under the facilities plan, but was expected to be minimal, and, therefore, could be included in ongoing annual budget.*

[d]*Reflects MMSD estimate of total capital cost for ongoing treatment and conveyance systems needs from 2008 through 2020 (MMSD Memo 12/28/06).*

[e]*Capital costs cannot be estimated until engineering work is completed. Facilities plan included a cost estimate of $0.8 million to cover the engineering study.*

[f]*MMSD 2020 Facilities Plan identified a total capital cost of $198 million. Since watercourse projects are primarily designed for flood control purposes with an ancillary stream rehabilitation aspect, the costs of such projects are not assigned to the regional water quality management plan.*

[g]*MMSD 2020 Facilities Plan identified a total capital cost of $141 million. Since watercourse projects are primarily designed for flood control purposes with an ancillary stream rehabilitation aspect, the costs of such projects are not assigned to the regional water quality management plan.*

Source: Milwaukee Metropolitan Sewerage District and SEWRPC.

WET WEATHER CONTROL PLAN

The wet weather control plan is designed to meet State and Federal regulatory requirements regarding sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). SSOs are releases to waters of the State of untreated wastewater from a sanitary sewer system. CSOs are releases to waters of the State of untreated stormwater and wastewater from a combined sanitary sewer system that receives both wastewater flow and stormwater runoff. Combined sewers are only located in portions of the City of Milwaukee and the Village of Shorewood.

As noted in Chapter IV, "Legal Structures Affecting the Regional Water Quality Management Plan Update," and Chapter IX, "Development of Alternative Plans: Description and Evaluation," of this planning report, sanitary sewer overflows are prohibited under the Clean Water Act (CWA) and under the WPDES discharge permits for MMSD facilities and the other wastewater treatment facilities in the study area; however, current Federal and State regulations acknowledge that it is not feasible to prevent SSOs at all times and under all circumstances. Therefore, those regulations allow regulators to include "exceptional circumstances" language in permits. While all SSOs are prohibited under current Federal and State rules, the WDNR may exercise enforcement discretion for certain SSO events such as 1) those that are unavoidable to prevent loss of life, personal injury, or severe property damage; 2) those for which there are no feasible alternatives; and 3) those associated with wet weather conditions where the bypass or overflow of excessive storm drainage or runoff results from a precipitation event having a probable frequency of once in five years or less. To meet regulatory requirements, the 2020 MMSD facilities plan proposes to provide a five-year level of control of SSOs.[16,17]

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[16]*For the MMSD facilities plan, the five-year level of protection was determined based on continuous simulation of 64.5 years of meteorological data. That methodology enables consideration of factors, such as soil moisture conditions prior to a storm, which can have a significant impact on both stormwater runoff and infiltration and inflow to sanitary sewers. The rainfall event recurrence interval approach does not consider those important factors. Thus, the approach to establishing the level of protection against sanitary sewer overflows as applied for the facilities plan is considered superior to an approach based on rainfall frequency.*

[17]*The estimated level of protection against SSOs from the MMSD system is about two years, thus, the proposed five-year level of protection represents a significant improvement.*

The MMSD WPDES permit contains requirements which cover CSO events. As noted in Chapter VI of this planning report, the permit lists two CSO performance standards: one related to CSO volume and the other related to the number of CSO events. The CSO objective can be satisfied by meeting either of these two performance standards. The volumetric standard requires that at least 85 percent of the combined sewage volume collected during wet weather be delivered to the Jones Island and South Shore wastewater treatment plants. The other performance standard allows no more than six CSO events in any year.

The volumetric capture performance standard is less restrictive than the event-based regulation due to the specific formulation of the terms of the performance standard. The standard based on the frequency of CSO events was selected by MMSD as a conservative basis for evaluating adequate control of CSOs. Because the standard limiting CSOs to no more than six events per year is already met by the existing facilities and operations, the CSO objective of the recommended MMSD facilities plan was established to be equal to the current levels of control.

The following MMSD projects are incorporated into the MMSD facilities plan to be constructed or further improved in order to maximize capture and treatment of sewage during wet weather. These recommended facilities would have the primary function of reducing overflows from either the separate sewer area or the combined sewer area.[18]

- ***Increase Capacity to Pump From the Inline Storage System (ISS) to the Jones Island Wastewater Treatment Plant***
  The provision of this additional pumping capacity will 1) enable more efficient use of the existing treatment capacity at the Jones Island plant by allowing larger wastewater volumes to be treated, 2) allow for quicker evacuation of the ISS; and 3) contribute to control SSOs to a five-year level of protection (LOP).

  The MMSD facilities plan recommends that the pumping capacity from the ISS to the Jones Island plant be increased from the existing capacity of 80 million gallons per day (mgd) to a capacity of 180 mgd.[19] The plan recommends that this effort begin with a preliminary engineering (PE) study of the ISS pumping station capacity considering both current and 2020 baseline recommended systems. The PE study can be used to determine how to maximize the current system, rehabilitate it, and best add additional capacity.[20]

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[18]*The Inline Storage System (ISS) is a dual-purpose facility since it provides both separate and combined sewer area protection. When operating the ISS, the volume reserved for sanitary sewer inflow (VRSSI) is an operational parameter that adjusts the balance between CSOs and the SSOs.*

[19]*Details regarding the need to increase the pumping capacity from the ISS to the Jones Island plant are set forth in Chapter 9 of the MMSD Treatment Report and Chapter 9 of the MMSD 2020 facilities plan.*

[20]*The MMSD acted on this recommendation in November 2006 by issuing a request for proposals that addresses the evaluation of the ISS pump station. The original purpose of the project was to maximize the pumping capacity from the ISS during wet weather events. The 2020 facilities planning process identified the need to increase the pumping capacity to achieve a five-year LOP under 2020 baseline population and land use conditions. Therefore, the project will also evaluate and include recommendations to upgrade the existing ISS pump station systems and ensure that the capacity is sufficient to provide a five-year LOP.*

- ***Increase South Shore Wastewater Treatment Plant Capacity***
  The MMSD facilities plan recommends that the treatment capacity of the South Shore plant be increased from the existing capacity of 300 mgd to 450 mgd in order to assist in meeting the five-year LOP.[21, 22]

  The analysis completed in the *State of the Art Report* (SOAR) revealed that the most cost-effective and acceptable method to increase treatment capacity at the South Shore plant is to add physical-chemical treatment (PCT) with ultraviolet (UV) disinfection for the PCT effluent. A long-term (two- to three-year) demonstration project is recommended at the South Shore plant in order to adequately address long-term operational issues, disinfection effectiveness, and community concerns. In addition to the demonstration project, an evaluation is necessary to determine if increasing the MIS flow rate to the plant will require control system refinements at the S. 6th Street and W. Oklahoma Avenue drop structure connection to the ISS.

- ***Add Metropolitan Interceptor System Sewer Capacity as Necessary***
  Additional conveyance capacity may be required at selected locations within the Metropolitan Interceptor System (MIS) due to anticipated future growth in population and/or land use changes through 2020. The MMSD facilities plan recommends that additional flow monitoring and assessment of growth be made in order to determine the future need for increasing the MIS capacity at these (or other) locations.[23] The locations of possible upgrades are shown on Map 73.[24]

The MMSD facilities plan recommends that the following MMSD operational and monitoring programs be implemented and hydraulic analyses be performed as part of the program to maximize capture and treatment of sewage during wet weather.

- ***Implement Improvements to Flow Monitoring and Rain Gauge System***
  It is recommended that MMSD make improvements to its flow monitoring system to assist in optimizing both flow measurements and the data received by the RTC system during wet weather events. The flow monitoring improvements may be made at connections to sewersheds, satellite municipalities, and/or the Metropolitan Interceptor System (MIS).

  In addition, improvements are recommended to the existing rain gauge system that collects information regarding the quantity and intensity of rainfall at various locations throughout the MMSD

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[21]*Details regarding the need to increase the treatment capacity at the South Shore plant are set forth in Chapter 9 of the MMSD Treatment Report.*

[22]*This is the only component of the MMSD 2020 facilities plan listed herein that was modified under the recommended regional water quality management plan update. The regional plan recommendations relative to the South Shore plant are set forth in the section of this chapter that is entitled "Recommended Regional Water Quality Management Plan."*

[23]*Details regarding MIS sewer capacities are set forth in Chapter 9 of the MMSD Conveyance Report.*

[24]*As noted in Chapter VIII of this report, buildout population and commercial and industrial land use estimates were applied to evaluate the adequacy of these potential Metropolitan Interceptor Sewers (MIS) upgrades. It was found that, except for the Ryan Road MIS relief sewer in the City of Oak Creek, all of the potential MIS projects as sized for revised 2020 baseline conditions would also have adequate capacity to convey the wastewater flows under buildout conditions. The additional studies that are recommended prior to constructing the potential MIS relief sewers would consider buildout conditions. Depending on the results of the studies and monitoring, the Ryan Road relief sewer size may ultimately fall between the 48-inch-diameter pipe required under revised 2020 land use conditions and the 72-inch-diameter pipe required under buildout conditions as currently defined.*

sewer service area. These recommendations are intended to improve management of infiltration and inflow to the sanitary sewer system and will enhance the performance of the RTC system.[25]

- ***Perform Capacity Analysis of South Shore Wastewater Treatment Plant***
  As noted above, the 2020 facilities plan identified the need to increase the treatment capacity of the South Shore wastewater treatment plant to achieve a five-year LOP for SSOs.[26] Although the current maximum design capacity of the plant is 250 mgd, based on actual historical flow data, the 2020 facilities plan uses 300 mgd as the maximum capacity. It is possible that the actual maximum capacity may be even greater than 300 mgd. The MMSD facilities plan recommends that a detailed capacity analysis for the South Shore plant be conducted in order to update the design capacity. If the capacity of the plant is found to actually be larger than 300 mgd, the need for additional capacity may be reduced, which would reduce the cost of the recommended new physical-chemical treatment system.

- ***Hydraulic Analysis of the Jones Island Wastewater Treatment Plant***
  The MMSD facilities plan recommends a hydraulic capacity analysis of the Jones Island plant. An existing MMSD project included in the 2007 Annual Budget (J01008, Upgrade Primary Clarifier Mechanisms) addresses upgrading the primary clarifiers to ensure full and adequate hydraulic capacity. The 2020 facilities plan recommends that the scope of that project be expanded to include investigation of all hydraulic issues in the preliminary/primary portion of the treatment system or that a new project be developed to investigate those issues.

The MMSD facilities plan recommends that the following MMSD programs and policies be implemented as part of the program to maximize capture and treatment of sewage during wet weather.

- ***Fully Implement the Milwaukee Metropolitan Sewerage District's Wet Weather Peak Flow Management Plan to Control the Growth of Infiltration and Inflow***
  In 2006, the MMSD Commission adopted a policy for MMSD to draft a Wet Weather Peak Flow Management Plan (WWPFMP) in cooperation with the technical advisory team (TAT), which is comprised of members from all communities served by the District. The WWPFMP is to be coordinated with MMSD's Capacity, Management, Operations, and Maintenance (CMOM) program.

  The MMSD facilities plan recommends that MMSD fully implement a WWPFMP to assist in controlling increases in I/I. The WWPFMP should develop a comprehensive and sustainable plan with the goals of:

  - Removing I/I from regional separate sanitary sewerage systems,
  - Managing peak wet weather flows in the combined sewerage system, and
  - Incorporating wet weather peak flow source control measures.

  The WWPFMP should establish peak wet weather flow standards for each municipality served by MMSD and incorporate activities that will serve to keep I/I from growing beyond current levels. The water quality modeling of recommended plan conditions assumed that infiltration and inflow from areas of existing development in the MMSD planning area will not increase under planned year 2020 conditions. At a minimum, it is recommended that the wet weather flow standards be designed to

[25]*Details regarding proposed improvements to the flow monitoring system are set forth in the MMSD Conveyance Report.*

[26]*See Chapter 9 of the MMSD 2020 facilities plan.*

achieve that level of control. Implementation of the WWPFMP will likely require revisions to Chapter 3, "Infiltration and Inflow," of the MMSD Rules.

- ***Implement MMSD's Capacity, Management, Operations, and Maintenance Program***
  The Capacity, Management, Operations, and Maintenance (CMOM) program is a regulatory program initiated by the USEPA that provides a framework for municipalities to identify and incorporate widely accepted wastewater industry practices in order to accomplish the following:

  - ♦ Better manage, operate, and maintain collection systems
  - ♦ Investigate capacity constrained areas of the collection system
  - ♦ Respond to SSO events

  As required by the WDNR in the 2002 Stipulation,[27] MMSD currently is in the process of developing and implementing a CMOM program to assist MMSD and the 28 municipalities it serves to improve sewer service and maintenance by controlling degradation of the sewer systems and curtailing I/I. The MMSD has completed its CMOM Strategic Plan and is now in the process of implementing the program. The MMSD's CMOM program elements include the following:

  - ♦ Management Plan
  - ♦ Overflow Response Plan
  - ♦ System Evaluation and Capacity Assurance Plan (SECAP)
  - ♦ Compliance Communication Plan and Program Audit

  The MMSD facilities plan recommends that MMSD proceed with implementation of its CMOM program, including the System, Evaluation, and Capacity Assurance Plan (SECAP) components of that program.

- ***Implement Capacity, Management, Operations, and Maintenance Programs for Member and Contract Municipalities and for Milwaukee County***
  As required by the WDNR in the 2002 Stipulation, MMSD must pass new rules that require all municipalities served by MMSD to implement CMOM programs. Thus, the MMSD facilities plan recommends that MMSD lead and support the implementation of CMOM programs for Milwaukee County and the 28 municipalities that MMSD serves. The MMSD has already begun to work with those municipalities to develop such programs.

- ***Implement System Evaluation and Capacity Assurance Plans for MMSD Municipalities***
  The MMSD facilities plan recommends that, as a part of its comprehensive CMOM program, MMSD lead and support the implementation of SECAPs for the 28 municipalities it serves.

- ***Implement Flow Monitoring for High-Priority Areas***
  The MMSD has already begun implementation of enhanced flow monitoring for high-priority areas or areas where high levels of I/I are expected. Thirty portable area/velocity flow meters were installed in October 2006 to monitor flows from 53 sewersheds that appeared to have high levels of I/I during wet weather conditions. These meters were installed in an effort to ascertain the accuracy of the flow

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[27]*A court-ordered stipulation signed with the State of Wisconsin in 2002 requires that the MMSD 2020 facilities plan be adopted by MMSD's Commission and submitted by MMSD to the WDNR by June 30, 2007.*

assignments to the high-priority areas. Full implementation of this flow monitoring program is recommended to assist in controlling I/I.

- ***Continue Operation of Real-Time Control System***
  Monitoring and control of the MMSD sewer system employs a complex network of monitors, sensors and computerized weather reporting systems, collectively referred to as the Real-Time Control (RTC) system. The MMSD facilities plan recommends that the operation of the RTC system be continued and enhanced in order to use all wet weather event data and to further improve both the analysis of operating data and the prediction algorithm which is used to optimize the operation of MMSD's systems (e.g., storage and wastewater treatment plant capacities) during wet weather events.[28]

The MMSD facilities plan recommends that the following MMSD rehabilitation projects, routine facility upgrades, and engineering studies and evaluations be implemented in order to continue to provide adequate sewage treatment for the MMSD service area.

- ***Rehabilitate Dewatering and Drying Systems at the Jones Island Wastewater Treatment Plant***
  The facilities plan recommends that a preliminary engineering study be conducted to confirm the requirements for rehabilitating various components of the dewatering and drying systems at the Jones Island plant.[29]

- ***Complete Preliminary Engineering Study for Additional Force Main***
  The facilities plan recommends that a preliminary engineering study be performed to determine the utility and system benefits of adding a 48-inch-diameter force main from the ISS pump station to diversion chamber DC0103 at S. 6th Street and W. Oklahoma Avenue. This study would likely be a part of a larger study of the Jones Island plant to evaluate the feasibility of taking the plant out of service for short-term maintenance.[30]

- ***Evaluation of Jones Island Wastewater Treatment Plant Aeration System***
  The facilities plan recommends that a study be conducted of the Jones Island plant aeration system and associated power needs and costs. The loss of "wet" industries over the past 10 to 20 years, and especially the recent loss of LeSaffre Yeast, has greatly reduced the BOD load to Jones Island. The Jones Island plant currently has four 2,000 horsepower blowers with a firm capacity of 6,000 horsepower, if one blower were not available. That capacity is adequate to handle wet weather flows, and it should be maintained. However, under lower flow conditions, MMSD can currently only reduce blower operation to combinations of the 2,000 horsepower units. Providing several smaller blowers to replace one 2,000 horsepower unit, along with new diffusers, while retaining the overall total combined blower capacity, could allow greater flexibility and efficiency of operation, reduce energy consumption, and achieve an operational cost saving. Thus, the recommended study would consider the best means to achieve such flexibility and efficiency, while maintaining the overall blower capacity.[31]

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[28]*Details regarding proposed improvements to the real-time control system are set forth in Chapter 10 of the MMSD Conveyance Report.*

[29]*Further details on the rehabilitation of drying and dewatering systems can be found in Chapter 9 of the MMSD 2020 Treatment Report.*

[30]*Details regarding this additional force main are set forth in Chapter 8 of the MMSD Conveyance Report.*

[31]*Details regarding this recommended study of the Jones Island plant aeration system are set forth in Chapter 10 of the MMSD Treatment Report.*

- ***Ongoing Treatment and Conveyance Upgrades***
  The facilities plan recommends that MMSD continue to fund routine, ongoing treatment and conveyance upgrades that are necessary to provide adequate sewage treatment.

- ***Geotechnical/Structural Analysis of Wastewater Treatment Plants***
  The facilities plan recommends that complete geotechnical and structural analyses be performed on both MMSD wastewater treatment plants. Parts of the Jones Island plant will be nearly 100 years old by 2020 and a full analysis of the condition of the facilities has not been completed in over 20 years. Such a study should identify areas that may need repair or replacement in order to prevent any unanticipated expenditure due to structural/geotechnical failures.[32]

BIOSOLIDS PLAN

The MMSD currently recycles the biosolids that are a normal byproduct of the wastewater treatment process. The biosolids from the Jones Island wastewater treatment plant are converted to and sold as Milorganite®, a popular natural organic fertilizer. The biosolids at the South Shore plant are processed into Agri-Life®, a natural organic product that is applied to the soil at farms to provide nutrients for the crops. Any remaining biosolids not used for the production of Milorganite® or Agri-Life® are made into filter cake. Milorganite® production, and corresponding sales and revenue, are expected to decrease in the coming years due to the decrease in flows from wet industries with high organic loads. Therefore, the MMSD 2020 facilities plan included an analysis of the long-term trends in Milorganite® production and a future plan for biosolids. A detailed description of the alternatives evaluation and the selection of the recommended plan is provided in Chapter 9 of the MMSD Treatment Report.

The recommended MMSD facilities plan calls for continuing existing biosolids operations during the period from 2007 through 2008, or beyond if necessary for the preparation of additional analyses needed to assess biosolids options. The facilities plan recommends that the following analyses be conducted during the assessment period:

- An evaluation of the Milorganite® nitrogen balance using data from 2006 and beyond on the wasteloads from the Jones Island and South Shore plants,

- A study to address marketing Milorganite® with a nitrogen content less than the currently guaranteed 6 percent,[33]

- An overall assessment report on energy, energy management, and power supply/power generation (energy costs are a significant percentage of the costs to process biosolids).

Following completion of the preceding recommended analyses, the MMSD facilities plan recommends developing a final biosolids plan through modification and reevaluation of the following alternatives:

- Glass furnace technology,

- Sell Milorganite® with less than 6 percent nitrogen,

- Sell Milorganite® with 6 percent nitrogen and land apply the rest,

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[32] *Details regarding the recommended geotechnical and structural analyses are set forth in Chapter 10 of the MMSD Treatment Report.*

[33] *The recent loss of the wasteload from LeSaffre Yeast has resulted in decreases in the nitrogen content of Milorganite®.*

- Combination of Milorganite® and glass furnace technology, and

- Combination of Milorganite® and landfill.

The MMSD facilities plan also recommends specific facilities and operational improvements needed to continue the current biosolids program during the interim evaluation. Those improvements are described in Chapters 9 and 10 of the MMSD Treatment Report, as revised in Chapter 12 of the MMSD Facilities Plan Report.

WATERCOURSE-RELATED PLAN ELEMENTS

During the 1980s and 1990s, SEWRPC assisted MMSD in both policy planning and system planning for watercourses within the District's jurisdiction. This effort provided guidance for decision-making during flood management planning for flood problem areas.[34] In 1998, MMSD established a Watercourse Policy Advisory Group and approved a policy on flood management activities, funding responsibilities, and project prioritization. The District then developed updated watercourse management plans in the late 1990s for each watershed within Milwaukee County. In 2002, MMSD adopted the Chapter 13 *Surface Water and Storm Water Rules* which required stormwater runoff management for selected new development and redevelopment applied throughout the District service area. At that time the District also began to carry out a conservation and greenway connection plan (Greenseams project) which provided for the purchase of properties for the purpose of detaining or retaining stormwater. The watercourse management plans identify existing and possible future flooding problems, and they recommend structural and nonstructural measures to abate those problems. Many of those measures have been, or are being, implemented by MMSD. Implementation of the conservation plan and of the Chapter 13 rule complements the recommended flood reduction measures and will help to reduce the risk of future flooding.

The MMSD facilities plan recommends that MMSD 1) implement the flood mitigation projects that have been identified under its watercourse system planning program, 2) implement projects to remove concrete linings from stream channels and to rehabilitate those channels where such removal can be accomplished without creating flood or erosion hazards, 3) continue implementation of the conservation and greenway connection plan to acquire land for flood management and water quality protection, and 4) renovate the Kinnickinnic River flushing station. The implementation of the watercourse-related plan will improve water quality and instream and riparian habitat, reduce municipal I/I, and enhance flood mitigation. Because the watercourse-related programs are existing, ongoing programs that can be coordinated with the regional water quality management plan update, but are not dependent on implementation of the water quality plan, no costs are assigned under the recommended plan.

- ***Watercourse Management Plan***
  The proposed MMSD flood mitigation projects are intended to protect structures from flooding during events with recurrence intervals up to, and including, 100 years (a flood with a 1 percent probability of occurring in any given year). Such projects will also help to reduce inflow to sanitary sewers during wet weather, thereby reducing the likelihood of SSOs and sanitary sewer backups into basements.

  Specific projects which are currently in various stages of planning and design include:

  - Milwaukee River mainstem flood management project to provide flood control primarily in the Cities of Glendale and Milwaukee

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[34]*See SEWRPC Community Assistance Planning Report No. 130,* A Stormwater Drainage and Flood Control Policy Plan for the Milwaukee Metropolitan Sewerage District, *March 1986; SEWRPC Memorandum Report No. 28,* Streams and Watercourses for Which the Milwaukee Metropolitan Sewerage District Has Assumed Jurisdiction for Drainage and Flood Control Purposes, *August 1987; and SEWRPC Community Assistance Planning Report No. 152,* A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District, *December 1990.*

- Indian Creek flood management project to primarily provide flood control benefits in the Village of Fox Point

- Lower Wauwatosa flood control, stream restoration, and floodproofing project along the Menomonee River mainstem

- Milwaukee County Grounds detention basin to provide flood control for portions of Underwood Creek and the Menomonee River mainstem in the Cities of Milwaukee and Wauwatosa[35]

- Western Milwaukee flood management project along the mainstem of the Menomonee River

These projects include various combinations of the following measures:

- Nonstructural measures, including structure floodproofing, land acquisition, or structure purchase and removal

- Levee/floodwall construction

- Floodplain lowering

- Offline and online detention

- Conveyance enhancements (including bridge and culvert additions or bed and bank modifications)

- Watercourse channel repair or replacement

- ***Concrete Channel Renovation and Rehabilitation***
Recommendations regarding concrete channel renovation and rehabilitation are set forth under the instream water quality management plan subelement.

- ***Conservation and Greenway Connection Plans***
Recommendations regarding the Conservation and Greenway Connection Plans are set forth under the nonpoint source pollution abatement plan subelement.

- ***Renovation of the Kinnickinnic River Flushing Station***
Recommendations regarding the Kinnickinnic River flushing system are set forth under the instream water quality management plan subelement.

NEW MILWAUKEE METROPOLITAN SEWERAGE DISTRICT SEWER SEPARATION POLICY

The MMSD facilities plan recommends that MMSD develop a policy supporting the long-term implementation of selective cost-effective sewer separation in the combined sewer service area (CSSA). This policy, which would define necessary conditions that warrant separation, would not be a plan to fully separate sewers in the CSSA. Instead, it would be a policy for “opportunistic” separation that guides decision making when opportunities arise to separate selected portions of the CSSA because of other development activities. The policy would also identify the best management practices needed to treat the runoff that would no longer be captured and treated at a wastewater treatment plant as it is under current combined sewer conditions.

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[35]*Because of the diversion of higher flow from Underwood Creek into the Milwaukee County Grounds detention basin, peak flood flows and flood stages would be reduced along the reach of Underwood Creek downstream of the diversion at USH 45. This would provide flood control benefits at several properties on Fisher Parkway along Underwood Creek near its confluence with the Menomonee River.*

OTHER EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT PROGRAMS AND POLICIES TO BE CONTINUED

The MMSD facilities plan recommends that the following existing MMSD programs and policies be continued.

- ***Long-Term Control Plan to Address Combined Sewer Overflows***
  The MMSD is required by WDNR to prepare and implement a written Long-Term Control Plan (LTCP) to address controlling CSOs. The plan, which is documented in the MMSD report entitled *Combined Sewer Overflows - Long-Term Control Plan,* contains the following elements:

  - Characterization, monitoring, and modeling of the combined sewer system
  - Public participation
  - Consideration of sensitive areas
  - Cost/performance considerations
  - Operational plan
  - Maximizing treatment at the treatment plants
  - Implementation schedule
  - Post construction compliance monitoring program
  - Evaluation of alternatives to meet Clean Water Act (CWA) requirements using either the "presumptive approach" or the "demonstrative approach"[36]

  As noted previously, MMSD currently meets the requirements of the "presumptive approach", and will continue to meet those requirements under year 2020 baseline land use and population projections.

  It is recommended that the LTCP be expanded to include identification of high-priority areas related to CSO issues, that the plan include recommendations to address those areas, and that the LTCP recommendations be implemented.

- ***Stormwater Reduction Program***
  The MMSD facilities plan recommends that MMSD continue its Stormwater Reduction Program which targets home and business owners, conducting demonstration projects and encouraging the use of techniques, such as green roofs, rain barrels, and rain gardens. Such measures reduce the amount, and improve the quality, of stormwater runoff.

- ***Stormwater Disconnection Program***
  In order to reduce the volume of clear water in the combined sewer system, leading to a reduction in combined sewer overflows, and to reduce the volume of water that requires treatment, the MMSD facilities plan recommends that MMSD continue its Stormwater Disconnection Program. That program involves disconnecting and rerouting storm sewers that are currently connected to the combined sewer system.

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[36]*The "presumptive approach" relies on the premise that an overflow abatement program that meets certain listed criteria, such as a limit of no more than four overflow events per year on average, will be adequate to meet the requirements of the Clean Water Act. The "demonstrative approach" relies on the demonstration that an overflow abatement program, though not meeting the listed criteria for the "presumptive approach," is adequate to meet water quality-based requirements of the Clean Water Act.*

- ***Industrial Waste Pretreatment Program***
  The MMSD Industrial Waste Pretreatment Program (IWPP), which is required by Federal and State law, is designed to monitor and regulate certain industries that discharge to the MMSD system. The program has substantially reduced the amount of contaminants entering streams and Lake Michigan through monitoring and enforcement of pretreatment limits that apply to regulated industrial dischargers. The program also includes management of mercury from dental amalgam generated in dental offices and a Pollution Prevention Initiative that encourages industries to reduce pollution at the source rather than treating it at the "end of the pipe." Examples of pollutant source reduction activities include switching to less hazardous raw materials and recycling residual streams. The MMSD facilities plan recommends that the MMSD Industrial Waste Pretreatment Program be continued.

OTHER EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT OPERATIONS TO BE CONTINUED

The MMSD facilities plan recommends that the following existing MMSD operations be continued. Because these are ongoing operations, no costs are assigned under the recommended water quality management plan.

- ***Jones Island Wastewater Treatment Plant Wet Weather Blending***
  Blending is the practice of diverting wastewater flows around secondary treatment during peak wet weather events, in an effort to avoid significant damage to biological treatment units and loss of treatment capability. The diverted flows are then normally recombined with flows from the fully utilized secondary treatment units for further treatment, including disinfection, prior to discharge. The MMSD is allowed to blend up to 60 million gallons in a 24-hour period at the Jones Island plant during extreme wet weather events as outlined in MMSD's current WPDES permit.[37] The water quality modeling conducted to characterize instream water quality conditions under recommended plan conditions includes up to 60 million gallons of blending at Jones Island in a 24-hour period during wet weather conditions. The MMSD facilities plan recommends that the MMSD maximize sewage treatment during extreme wet weather events by continuing the current blending practices in compliance with its WPDES permit.

- ***Skimmer Boat Operation***
  The MMSD facilities plan recommends that MMSD continue to fund operation of the skimmer boat that collects floatable debris and trash from the water surface in the estuary portion of the Kinnickinnic, Menomonee, and Milwaukee Rivers, according to its current schedule of operation during the spring, summer, and fall, and after every CSO event that occurs during that time.

- ***Watercourse Operations***
  As noted previously, the MMSD has statutory authority over planning, design, construction, maintenance, and operation activities related to watercourses under its jurisdiction.[38] The MMSD facilities plan recommends that MMSD continue to exercise its watercourse jurisdictional responsibilities in the following areas:

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[37]*The approval process for wet weather blending at wastewater treatment plants serving combined sewer systems, such as the Jones Island plant, is outlined in the April 19, 1994, U.S. Environmental Protection Agency (USEPA)* Combined Sewer Overflow Policy*, Volume 59, Federal Register, pages 18693-18694). As noted in Chapter VI of this report, entitled "Legal Structures Affecting the Regional Water Quality Management Plan Update," on December 19, 2005, the USEPA issued a draft policy regarding blending at publicly owned wastewater treatment plants serving separate sanitary sewer systems. That policy does not apply to the Jones Island plant, which serves a combined sewer system.*

[38]*A list of the stream reaches over which MMSD has jurisdiction is provided in the appendix to MMSD's Chapter 13 Surface Water and Storm Water Rules.*

- Jurisdictional stream inspections
- Culvert inspections
- Flow-impeding debris removal
- Debris removal from natural or concrete channels on MMSD property
- Vegetative maintenance on MMSD property
- Repairs to structural controls such as channel linings, flow devices, and habitat devices
- Repairs to mechanical and electrical controls
- Repairs to concrete and natural channels

Because these are ongoing operations, no costs are assigned under the recommended water quality management plan.

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT COMMITTED PROJECTS

The MMSD facilities plan recommends that MMSD complete all committed projects that are either identified in the 2002 Stipulation with WDNR, but have not yet been completed, or that are under construction.[39]

MANAGEMENT OF INFILTRATION AND INFLOW FOR MMSD SATELLITE COMMUNITIES

The MMSD facilities plan and the regional water quality management plan update both assume that the 28 satellite communities served by the MMSD will implement measures to ensure that infiltration and inflow do not grow beyond existing levels.

Cost-Effectiveness Analysis of Wastewater Treatment Options for the City of South Milwaukee

The City of South Milwaukee is the only community in Milwaukee County that maintains its own wastewater treatment facility and does not belong to the Milwaukee Metropolitan Sewerage District. The regional water quality management plan update included an analysis to determine if it would be more cost effective for the City to continue to maintain its own treatment facility or to abandon it and connect to the MMSD system.

The South Milwaukee wastewater treatment plant (WWTP) is designed to handle an average flow rate of six mgd, with a designed peak capacity of 25 mgd. Effluent from the plant is discharged to Lake Michigan. As a result of several effluent violations, the City agreed in June 2004 to a court-ordered stipulation that requires a number of improvements and upgrades to be implemented by 2014. Those improvements and upgrades include increasing the raw sewage pump capacity to meet a design peak flow of 30 mgd with the largest unit out of service, installing two new secondary clarifiers, and replacing the ultraviolet disinfection system.

Approach to Upgrading the Existing City of South Milwaukee Wastewater Treatment Plant

In May 2006 a site study for the facility was completed that developed a plan for implementation of the court-ordered upgrades. That study also identified other potential needs based on a 20-year planning period.[40] Included in the report were cost estimates for the recommended upgrades and improvements. The total estimated capital

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[39]*The list of these projects is presented in Chapter 8 of the MMSD 2020 facilities plan.*

[40]*Applied Technologies,* Wastewater Treatment Facility Site Study, City of South Milwaukee, *May 2006.*

cost of the recommended measures is $4.30 million dollars.[41] Current annual operation and maintenance costs for the facility are estimated at $1.60 million. As set forth in Table 85, assuming a 50-year economic life and an annual interest rate of 6 percent, the estimated equivalent annual cost of continuing to operate the facility, including implementing the required upgrades, would be $1.93 million. In addition to the measures recommended to be implemented, the site study also noted that the potential exists for future effluent limitations on ammonia that may require nitrification. Since the current aeration basins are not adequate to achieve nitrification, the study presented several nitrification options. No costs were assigned to these options in the report as they would not be needed to meet the current operating permit requirements.[42]

Alternatives Calling for Connection to the MMSD South Shore Wastewater Treatment Plant
An alternative to maintaining its own treatment facility would be for the City to abandon its facility and connect to the MMSD sewerage system. Under that scenario, sewage from the City would be conveyed to the MMSD South Shore WWTP by a new force main to be constructed along 5th Avenue. The South Shore plant would have sufficient capacity to handle the additional flow from South Milwaukee during most conditions. However, assuming that peak flows from the South Milwaukee system coincide with peak flows to the South Shore plant from the MMSD system, an expansion of the wet-weather peak capacity would be required to treat flow from the South Milwaukee sewerage system.

That expansion could be made in accordance with the high rate treatment options already under consideration for the MMSD 2020 facilities plan. The two options being considered for providing additional treatment at the South Shore plant for flows from the existing MMSD service area are physical-chemical treatment (PCT) using ballasted flocculation and PCT using chemical flocculation. In addition, the existing two primary clarifiers, four activated sludge units, and two secondary clarifiers at the South Milwaukee plant could provide 2.85 million gallons of storage that could be used to reduce the peak flow from South Milwaukee to the South Shore plant from 30 mgd to 17 mgd. With that reduced peak flow, the costs of pumping and conveyance to South Shore, and of additional treatment, would be reduced. If no storage were utilized at the South Milwaukee WWTP, the design peak hourly flow at the South Shore WWTP would equal the peak flow of 450 mgd as recommended under MMSD 2020 facilities plan plus 30 mgd from South Milwaukee, for a total of 480 mgd. If storage were utilized at the South Milwaukee WWTP, the design peak hourly flow at the South Shore WWTP would equal the peak flow of 450 mgd plus 17 mgd from South Milwaukee, for a total of 467 mgd.

Analysis and Evaluation of Alternative Plans
The following alternatives were initially analyzed:

- Alternative No. 1—Upgrade the existing South Milwaukee WWTP according to the 2006 site study,

- Alternative No. 2—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with ballasted flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant,

[41]*The actual total capital cost as presented in the facility site study report is $3.7 million. That cost included a 15 percent allowance for engineering and administrative costs. In order to maintain a consistent basis for comparison to the cost estimate for connection to the MMSD system and for consistency with the cost estimating procedure applied for the MMSD 2020 facilities plan, the capital cost was adjusted to reflect a 35 percent allowance for engineering and administrative costs.*

[42]*In an April 5, 2007, electronic mail message, the WDNR provided comments on the 2006 site study. A WDNR requirement that the ultraviolet disinfection system be expanded to provide capacity to treat the peak hourly design flow of 30 mgd could affect the estimated project cost as set forth in the site study and listed in Table 85.*

Table 85

COST COMPARISON FOR SOUTH MILWAUKEE WASTEWATER TREATMENT ALTERNATIVES 50-YEAR COST ANALYSIS

Alternative Number	Description	Capital Cost ($)	Annual Operation and Maintenance Cost ($)	Present Worth Total Cost ($)	Equivalent Annual Cost ($)	Difference in Equivalent Annual Cost Relative to Alternative No. 1 (percent)
1	Upgrade the existing South Milwaukee WWTP	4,298,000	1,600,000	30,381,000	1,928,000	- -
2	Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with ballasted flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant	39,289,000	459,000	55,120,000	3,497,000	81
3	Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant	29,289,000	395,000	41,621,000	2,641,000	37
4	Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with ballasted flocculation at South Shore and utilizing existing storage at the South Milwaukee plant	25,866,000	314,000	36,126,000	2,292,000	19
5	Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and utilizing existing storage at the South Milwaukee plant	19,866,000	278,000	28,148,000	1,786,000	-7

NOTES: Capital and O&M costs obtained from HNTB Corporation.

Ten-, 20- and 40-year replacement costs and 50-year salvage values estimated by SEWRPC.

Capital costs reflect a 25 percent allowance for contingencies and a 35 percent allowance for engineering and administration costs, consistent with MMSD 2020 Facilities Plan.

Present worth and equivalent annual cost estimates based on 50-year economic life and 6 percent interest rate.

Source: HNTB and SEWRPC.

- Alternative No. 3—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant,

- Alternative No. 4—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with ballasted flocculation at South Shore and utilizing existing storage at the South Milwaukee plant, and

- Alternative No. 5—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and utilizing existing storage at the South Milwaukee plant.

As set forth in Table 85, the capital costs of Alternatives 2, 3, 4, and 5, calling for connection to the South Shore plant, would be expected to range from $19.87 million to $39.29 million and the estimated annual operation and maintenance cost would range from $0.28 million to $0.46 million. In comparison, the estimated capital cost of Alternative No. 1, which calls for upgrading the South Milwaukee WWTP, is $4.30 million and the estimated annual operation and maintenance cost is $1.60 million. Assuming a 50-year economic life and an annual interest rate of 6 percent, the estimated equivalent annual cost of the alternative of upgrading the South Milwaukee

WWTP would be $1.93 million and the estimated annual average costs of the four alternatives calling for connection to the MMSD system would range from $1.79 million to $3.50 million. The only alternative for connection to the MMSD system that has a lower equivalent annual cost than Alternative No. 1 is Alternative No. 5, which calls for the South Milwaukee WWTP to be connected to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and utilizing existing storage at the South Milwaukee plant. The equivalent annual cost of that alternative plan is $1.79 million, which is 7 percent less than the equivalent annual cost of Alternative No. 1.[43] The other alternative plans each have equivalent annual costs that are at least 19 percent greater than Alternative No. 1. As described in a later section of this report, based on cost considerations, the regional water quality management plan update does not recommend implementation of PCT with ballasted flocculation at the MMSD South Shore plant. The analysis of the cost to treat additional flow to South Shore from the South Milwaukee sewerage system also supports that conclusion. Thus, Alternative Nos. 2 and 4, which call for ballasted flocculation, were eliminated from further consideration.[44]

Based on the cost evaluation presented above and in Table 85, Alternative No. 1—Upgrade the Existing South Milwaukee WWTP and Alternative No. 5—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP Using PCT with Chemical Flocculation at South Shore and Utilizing Existing Storage at the South Milwaukee WWTP are considered to be essentially equal in cost. Alternative No. 5 assumes that peak flows from the South Milwaukee sewerage system and from the MMSD system tributary to the South Shore plant would coincide.

Because of the considerably smaller size of the South Milwaukee sewerage system relative to the system tributary to the South Shore plant, flow records from each plant were evaluated to determine if the peak from South Milwaukee would occur in advance of the peak to the South Shore plant. If the two flow hydrographs were sufficiently separated in time, the addition of flow from the South Milwaukee system might be treated at the South Shore plant without exceeding the estimated existing plant capacity.[45] In that case, additional capacity at the South Shore WWTP would not be required to treat the flow from South Milwaukee.

Daily flows at both the South Milwaukee and South Shore wastewater treatment plants during May 2004 were compared using data from discharge monitoring reports submitted to the WDNR. Those data, as set forth in Table 86, show that from May 22 through May 24, 2004, the total daily average flow determined through addition of the corresponding South Milwaukee and South Shore peak flows exceeded the South Shore capacity of 300 mgd. Thus, the addition of flow from South Milwaukee would have added to the peak at South Shore and, in

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[43]*Given the accuracy of cost estimates, for a cost effectiveness analysis such as this, equivalent annual costs are generally considered to be equal if they are within 10 percent.*

[44]*Detailed cost-effectiveness analyses based on both a 20-year economic period and a 50-year period are set forth in Appendix L. The conclusions regarding relative costs of the alternatives are the same based on either the 20- or 50-year analysis period.*

[45]*This comparison is made using the existing condition peak flow to the South Shore plant because the level of treatment of the South Milwaukee wastewater under an alternative calling for connection to the South Shore plant should be comparable to the existing level of treatment, including primary and secondary treatment and disinfection. Under one of the possible recommended approaches for the South Shore plant as described in the Recommended Regional Water Quality Management Plan section of this chapter, blending would be recommended at South Shore during large wet weather events that exceed the existing plant capacity. To ensure that wastewater from South Milwaukee will not bypass secondary treatment, a necessary constraint on the hydrograph timing analysis is that the South Shore plant must be able to provide full primary and secondary treatment and disinfection for flows from the South Milwaukee sewerage system.*

Table 86

ANALYSIS OF DAILY WASTEWATER FLOWS AT THE SOUTH MILWAUKEE AND MMSD SOUTH SHORE WASTEWATER TREATMENT PLANTS: MAY 2004

Date	South Shore Wastewater Treatment Plant Flow (MGD)[a]	South Milwaukee Wastewater Treatment Plant Flow (MGD)[b]	Total
05/10/2004	145	4.546	150
05/11/2004	259	4.309	263
05/12/2004	206	4.154	210
05/13/2004	256	6.847	263
05/14/2004	289	13.642	303
05/15/2004	281	8.737	290
05/16/2004	268	6.439	274
05/17/2004	217	5.998	223
05/18/2004	260	7.613	268
05/19/2004	255	6.094	261
05/20/2004	229	5.932	235
05/21/2004	263	6.895	270
05/22/2004	301	10.829	312
05/23/2004	307	14.409	321
05/24/2004	301	8.785	310
05/25/2004	292	7.197	299
05/26/2004	247	6.268	253
05/27/2004	215	5.943	221
05/28/2004	191	5.411	196
05/29/2004	178	5.589	184

[a]*South Shore Wastewater Treatment Plant data from May 2004 Discharge Monitoring Report, submitted by United Water Services on behalf of MMSD.*

[b]*South Milwaukee Wastewater Treatment Plant data from WDNR, based on Discharge Monitoring Report data submitted by South Milwaukee.*

Source: City of South Milwaukee, United Water Services, and Wisconsin Department of Natural Resources.

this case, would have caused the South Shore treatment capacity to be exceeded.[46] Therefore, it can be concluded that additional capacity at the South Shore WWTP would be required to treat the flow from South Milwaukee, and the assumption of concurrent peaks is valid.

Conclusions

As described later in this chapter, the regional water quality management plan update does not recommend providing additional treatment capacity at the South Shore WWTP in the near future. It does, however recommend that additional studies be conducted to evaluate the capacity that can actually be attained at South Shore under existing conditions and that a demonstration project be conducted to evaluate the feasibility of expanding the South Shore plant capacity through physical-chemical treatment with chemical flocculation. If in the future it was determined that 1) the treatment capacity at South Shore would have to be increased to meet anticipated flows from the communities that are currently served by MMSD and 2) implementation of physical-chemical treatment with chemical flocculation was feasible at the South Shore plant, then, considered in isolation, connection of the South Milwaukee plant (utilizing existing tanks for storage) to the MMSD system would be

[46]*Because peak, or near-peak, flows were sustained at South Shore and peak, or elevated, flows occurred at South Milwaukee over the course of three days, it is not necessary to consider peak flows at a shorter time increment than one day in order to establish that, under certain circumstances, the peak flow at the South Milwaukee plant could coincide with the peak at the South Shore plant from the existing tributary area.*

equally cost-effective as the option of upgrading the South Milwaukee wastewater treatment plant to meet the requirements of the court-ordered stipulation.

However, because the analysis of the May 2004 wastewater flows as described above establishes that the additional flow from South Milwaukee cannot be adequately treated at the MMSD South Shore WWTP without an increase in treatment capacity at South Shore, connection of the South Milwaukee system to the South Shore plant would not be feasible in the near term. The preliminary draft MMSD 2020 facilities plan implementation plan sets forth a schedule for adaptive implementation of the plan that calls for performing the South Shore capacity analysis in 2008, but deferring the PCT demonstration project until the period from 2013 through 2016, enabling population data from the 2010 Federal census to be accounted for in planning future implementation actions. The adaptive implementation schedule is predicated on the assumptions that MMSD will be able to meet regulations through continued refinement of its real time control strategy for the inline storage system and that population will grow more slowly than projected under the 2020 facilities plan. The preliminary draft plan also includes a full implementation schedule that calls for performing the South Shore capacity analysis in 2008, and completing the PCT demonstration project by the end of 2011. The draft MMSD implementation plan indicates that the actual implementation timeline is likely to fall between the adaptive and full implementation schedules. Thus, completion of the South Shore PCT demonstration project might be expected between 2011 and 2016. Because the 2004 court-ordered stipulation requires the City of South Milwaukee to implement actions from 2004 through 2014, with major plant modifications to commence in 2007, it is unlikely that the City would know the results of the MMSD South Shore PCT demonstration project soon enough to consider those results in its program to comply with the court order.

Thus, it is recommended that:

- The City of South Milwaukee continue its program of wastewater treatment plant upgrades established under the court stipulation.

- The City of South Milwaukee discuss with the WDNR the likelihood of an ammonia limit being required under the next permit which is to be issued in 2011. Should it appear likely that such a limit will be imposed, the City should conduct detailed facilities planning to evaluate all reasonable alternatives.

Private Wastewater Treatment Facilities

As described in SEWRPC TR No. 39, which is a companion report to this technical report, there are no private wastewater treatment plants currently in operation within the Kinnickinnic and Menomonee River watersheds, the Oak Creek watershed, and the Lake Michigan direct drainage area. There are two private plants in the Milwaukee River watershed—one serving the Long Lake Recreational Area in the Town of Osceola in Fond du Lac County and one serving the Kettle Moraine Correctional Institution in the Town of Greenbush in Sheboygan County.[47] There is one private plant serving an isolated enclave of urban land use in Fonks Mobile Home Park in the Town of Yorkville in Racine County in the Root River watershed. These facilities are located beyond the current limits of planned public sanitary sewer service areas and are recommended to be retained. The need for upgrading these plants and the level of treatment should be formulated on a case-by-case basis as part of the WPDES permitting process.

Regulation of Wastewater Treatment Facilities and Industrial Discharges

The WPDES program requires a State permit for the discharge of any pollutant into the waters of the State, including the groundwaters. More specifically, permits are required for discharges from municipal wastewater treatment plants and associated collection systems, private wastewater treatment facilities, and industrial establishments. The permits may specify abatement requirements and provide a schedule of compliance, setting

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[47]*The Kettle Moraine Correctional Institution plant discharges to groundwater of the Watercress Creek subbasin within the East Branch Milwaukee River subwatershed.*

forth dates by which specific elements of the permit must be responded to. It is recommended that these sources of wastewater continue to be regulated and their effluent concentrations be controlled to acceptable levels on a case-by-case basis through the operation of the WPDES.

Industrial Noncontact Cooling Water Discharges

An additional point source issue identified under the regional water quality management plan update is that of phosphorus loads from some industrial noncontact cooling water discharges. The industries involved do not normally add phosphorus to their cooling waters. It is believed that the phosphorus is contained in the source water since some water utilities, such as the Cities of Cudahy, Milwaukee, New Berlin, and South Milwaukee, add orthophosphate or polyphosphate as a corrosion control agent to prevent certain metals from leaching from distribution systems and building plumbing materials into the treated water. Given the public health benefits involved and the reliability of the current technology, the Milwaukee Water Works has indicated that it would not consider changing its current practice. Recognizing the benefits involved, it is not recommended that the water utilities end their current practice. It is, however, recommended that water utilities in the study area give further consideration to changing to an alternative technology that does not result in increased phosphorus loading if such a technology is both effective in controlling corrosion in pipes and cost-effective for the utility to implement.

Nonpoint Source Pollution Abatement Plan Subelement

The recommended nonpoint source pollution control measures described in this report subsection are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach as described in the introduction to this chapter.

As noted previously, the nonpoint source pollution control subelement of the recommended regional water quality management plan update addresses both rural and urban nonpoint sources of water pollution. The recommended plan facilities and measures in those two categories are described below.

Recommended Rural Nonpoint Source Pollution Control Measures

The recommended best management practices to control rural nonpoint source pollution were developed by the SEWRPC staff and the consultant team staff[48] under the guidance of both the SEWRPC Technical Advisory Committee for the plan and the SEWRPC Modeling Subcommittee comprised of technical and modeling experts and with input from the County Land Conservationists from throughout the study area and the WDNR. Input was also solicited from the joint MMSD/SEWRPC Citizens Advisory Council and the SEWRPC Watershed Officials Forum that was established to provide information regarding the regional water quality management plan update to local elected officials and to solicit comments on various aspects of the plan from those officials.

The most effective rural nonpoint source control measures were selected based on modeling results from the screening alternatives and alternative plans, and a rural pollution control sensitivity analysis, all of which are described in Chapter IX. In addition, information developed in the state-of-the-art report on pollution control strategies[49] was utilized. The recommended rural nonpoint source control measures are generally consistent with the objectives of the Land and Water Resource Management Plans for the counties in the study area[50] and should be considered in future updates to those plans.

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[48]*Technical staff from HNTB and Tetra Tech.*

[49]*HNTB, State-of-the-Art of Water Pollution Control, in progress.*

[50]*Dodge County Land Conservation Department,* Dodge County Land and Water Resources Management Plan, *October 1999; Fond du Lac County Land Conservation Department,* Fond du Lac County Land and Water Resource Management Plan: 2008-2012*, June 26, 2007; SEWRPC Community Assistance Planning Report, No. 255, 2nd Edition,* A Land and Water Resource Management Plan for Kenosha County: 2008-2012*, October 2007; Ozaukee County Planning Resources Land Management Department,* Ozaukee County Land and Water Resource *(Footnote Continued on Next Page)*

The recommended rural nonpoint source control measures and their associated costs are set forth in Table 82. In some instances, based on the modeled water quality results for 1) the screening alternatives, 2) the alternative water quality plans, and 3) the rural nonpoint source sensitivity analyses, all of which are described in Chapter IX, the plan includes measures that go beyond what would be necessary to meet the requirements of Chapter NR 151, "Runoff Management," and Chapter ATCP 50, "Soil and Water Resource Management Program," of the *Wisconsin Administrative Code*.[51,52] Descriptions of each of those recommended measures, including the recommended level of implementation and/or the anticipated level of reduction in nonpoint source pollution loads, are set forth below.[53]

Reduction in Soil Erosion from Cropland

Based on information provided by County Land Conservationists throughout the study area, it is estimated that about three-quarters of the cropland in the study area is eroding at a rate less than or equal to the tolerable soil loss, T.[54] Also, based on that input, it was determined that it would be reasonable for cropland in the study area to attain soil erosion rates less than or equal to T by 2020. Certain critical areas that were previously identified under the WDNR priority watershed planning program would be targeted to attain soil loss rates below T. Thus, the recommended plan calls for practices to reduce soil loss from cropland to be expanded to attain erosion rates less than or equal to T by 2020. This could be accomplished through a combination of practices, including, but not limited to, expanded conservation tillage, grassed waterways, and riparian buffers. The applicable measures should be determined by the development of farm management plans which are consistent with the county land and water resources plans. The benefits of expansion of these practices in reducing sediment and nutrients delivered to the streams of the study area were explicitly represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N.

Manure and Nutrient Management

Based on input from County Land Conservationists and the Technical Advisory Committee for this water quality plan and on the identified need to control fecal coliform bacteria from both urban and rural sources, it was decided

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(Footnote Continued from Previous Page)

Management Plan, *January 2006; SEWRPC Community Assistance Planning Report, No. 259, 2nd Edition,* A Land and Water Resource Management Plan for Racine County: 2008-2012, *October 2007; Washington County Planning and Parks Department Land and Water Conservation Division,* Land and Water Resources Management Plan, Washington County, Wisconsin, *December 2005; Waukesha County Department of Parks and Land Use,* Waukesha County Land and Water Resource Management Plan: 2006-2010, *March 2006; and Sheboygan County Land and Water Conservation Department,* Sheboygan County Land and Water Resources Management Plan, *October 2004.*

[51]*Increased control of agricultural nonpoint source pollution beyond that achieved through meeting the performance standards of NR 151 may require changes in ATCP Section 50.14 to enable counties to establish requirements that are more stringent than those in Chapter NR 151.*

[52]*The WDNR is in the process of developing memoranda of understanding with county land and water conservation divisions to establish procedures for implementing the agricultural nonpoint performance standards and prohibitions under NR 151.*

[53]*The most significant rural nonpoint source pollution controls were explicitly represented in the water quality modeling analyses that were developed as described in Chapter V of this report and that were used to evaluate changes in water quality conditions in the streams of the study area, the Milwaukee Harbor estuary, and the Lake Michigan nearshore area.*

[54]*"T-value" is the tolerable soil loss rate—the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely, as determined by the U.S. Natural Resource Conservation Service. "Excessive" cropland erosion refers to erosion in excess of the tolerable rate, or T-value.*

to recommend that all livestock operations in the study area with 35 combined animal units or greater as defined in Chapter NR 243, "Animal Feeding Operations," of the *Wisconsin Administrative Code* provide six months of manure storage, enabling manure to be spread on fields twice annually during periods when the ground would not be frozen prior to spring planting and after summer and fall harvest.[55] Based on a review of the technical literature, it was found that storing the manure for that period of time could reduce fecal coliform bacteria and *E. coli.* concentrations by about 90 percent.[56] It is also recommended that manure and any supplemental nutrients be applied to cropland in accordance with a nutrient management plan consistent with the requirements of Sections ATCP 50.04, 50.48, and 50.50 and Section NR 151.07 of the *Wisconsin Administrative Code*. Finally, it is recommended that nutrient management requirements for concentrated animal feeding operations (CAFOs) in the study area be based on the WPDES permit conditions for those operations.[57] The benefits of more stringent manure management in reducing fecal coliform delivered to the streams of the study area by about 90 percent were explicitly represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N.

Barnyard Runoff

Chapters NR 151 and ATCP 50 have certain provisions that relate to control of barnyard runoff, including those related to manure storage facilities, manure management, and clean water diversions.[58] However, as noted in Chapter VI, of this report, "Legal Structures Affecting the Regional Water Quality Management Plan Update," because existing operations are excluded from the requirements if cost-share funding is not available and because of the limited amount of such funding that is available annually, many livestock operations are not compelled to comply with Administrative Code provisions related to barnyard runoff. In order to attain a greater level of control of barnyard runoff, it is recommended that consideration be given to increasing levels of cost-share funding to enable a higher level of implementation of the best management practices needed to meet the NR 151 performance standards.[59] Because of the relatively scattered nature of smaller-scale livestock operations and the lack of data on the locations of those operations, the benefits of expansion of these practices in reducing bacteria,

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[55]*Section NR 243.05 sets forth two methods for calculating animal units: one method based on "combined animal units" and one based on "individual animal units." In determining the number of animals for which the manure storage recommendation of the regional water quality management plan applies, it is recommended that the method be applied that yields the lowest number of animals for a given category. For example, based on that approach, 35 animal units are equivalent to 25 milking cows; 35 steers; 87 55-pound pigs; and 1,050 to 4,375 chickens, depending on the type and whether the manure is liquid or nonliquid.*

[56]*S.R. Crane and J.A. Moore, "Modeling Enteric Bacterial Die-off: A Review,"* Water Air, & Soil Pollution, *Volume 27, Numbers 3-4, February 1986. Virginia Tech University Department of Biological Systems Engineering,* Fecal Coliform TMDL for Naked Creek in Augusta and Rockingham Counties, Virginia, *prepared for Virginia Department of Environmental Quality and Virginia Department of Conservation and Recreation, April 2002. Tetra Tech, Inc.,* Manure Management, *EPA Regional Priority AFO Science Question Synthesis Document, Workshop Review Draft, prepared for USEPA Office of Science Policy and Office of Research and Development, December 2004. Donald W. Meals and David C. Braun, "Demonstration of Methods to Reduce* E. coli *Runoff from Dairy Manure Application Sites,"* Journal of Environmental Quality, *35:1088-1100, 2006. S.V. Ravva, C.Z. Sarreal, B. Duffy, and L.H. Stanker, "Survival of* Eschericia coli *O157:H7 in Wastewater from Dairy Lagoons,* Journal of Applied Microbiology, *Volume 1010, Issue 4, October 2006.*

[57]*Chapter NR 243, "Animal Feeding Operations," of the* Wisconsin Administrative Code *sets forth nutrient management requirements for CAFOs.*

[58]*Additional information on the Chapter NR 151 agricultural performance standards for the control of nonpoint source pollution, including the manure management prohibitions set forth in Section NR 151.08, are presented in Chapter VI, of this report, "Legal Structures Affecting the Regional Water Quality Management Plan Update."*

[59]*The mechanism for increasing the level of cost-share funding and maximizing cost-share funding by pooling funds from Federal, State, and local sources is addressed in Chapter XI of this report, "Plan Implementation."*

pathogens, and nutrients delivered to the streams of the study area were not explicitly represented in the water quality modeling analyses.

Riparian Buffers

Chapters V through IX of SEWRPC Technical Report No. 39, the companion to this planning report, include maps and figures characterizing existing riparian buffer widths along streams in the study area. Such buffers serve important water quality-related functions, including removal of nonpoint source pollutants from both surface water and groundwater, reduction of instream water temperatures through shading of the stream channel, and maintenance of streambank stability, among others. In addition, riparian buffers provide habitat for a variety of aquatic and terrestrial wildlife and are an essential component of environmental corridors. The riparian corridor forms the nexus between the surface water and groundwater systems, including areas of groundwater discharge that coincide with the ability of streams to sustain economically important coldwater species and with groundwater recharge areas.

Fond du Lac, Ozaukee, Sheboygan, and Washington Counties currently have programs for the establishment of riparian buffers. Fond du Lac, Ozaukee, and Sheboygan Counties are aggressively promoting the creation of such buffers through the U.S. Department of Agriculture (USDA) Conservation Reserve Enhancement Program (CREP).[60] Washington County has adopted a minimum 75-foot setback for all development in unincorporated areas adjacent to lakes and streams as part of its lake and stream classification program and related zoning[61,62] The establishment and maintenance of riparian buffers are important mitigation measures recognized by this program and also by the statewide turf management standards recently adopted by the Wisconsin Standards Oversight Council.[63]

Based on review of the literature related to the effectiveness of riparian buffers in controlling nonpoint source pollution, it was decided that a minimum 75-foot riparian buffer width along each side of streams flowing through current crop and pasture land would be optimal for the control of nonpoint source pollution. In support of the generally recommended 75-foot buffer width, Appendix O sets forth the results of a literature review and analysis by SEWRPC staff regarding buffer width and effectiveness in controlling nonpoint source pollution and providing biological protection. Stream reaches for which the establishment or expansion of riparian buffers are to be considered are indicated on Maps 74 through 76. The benefits of expansion of riparian buffers in reducing total suspended solids, total nitrogen, and total phosphorus loads delivered to the streams of the study area were explicitly represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N.[64]

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[60]*Additional information on the USDA CREP program is provided in Chapter XI of this report, "Plan Implementation."*

[61]*SEWRPC Memorandum Report No. 139,* Surface Water Resources of Washington County Wisconsin, Lake and Stream Classification Project: 2000, *September 2001.*

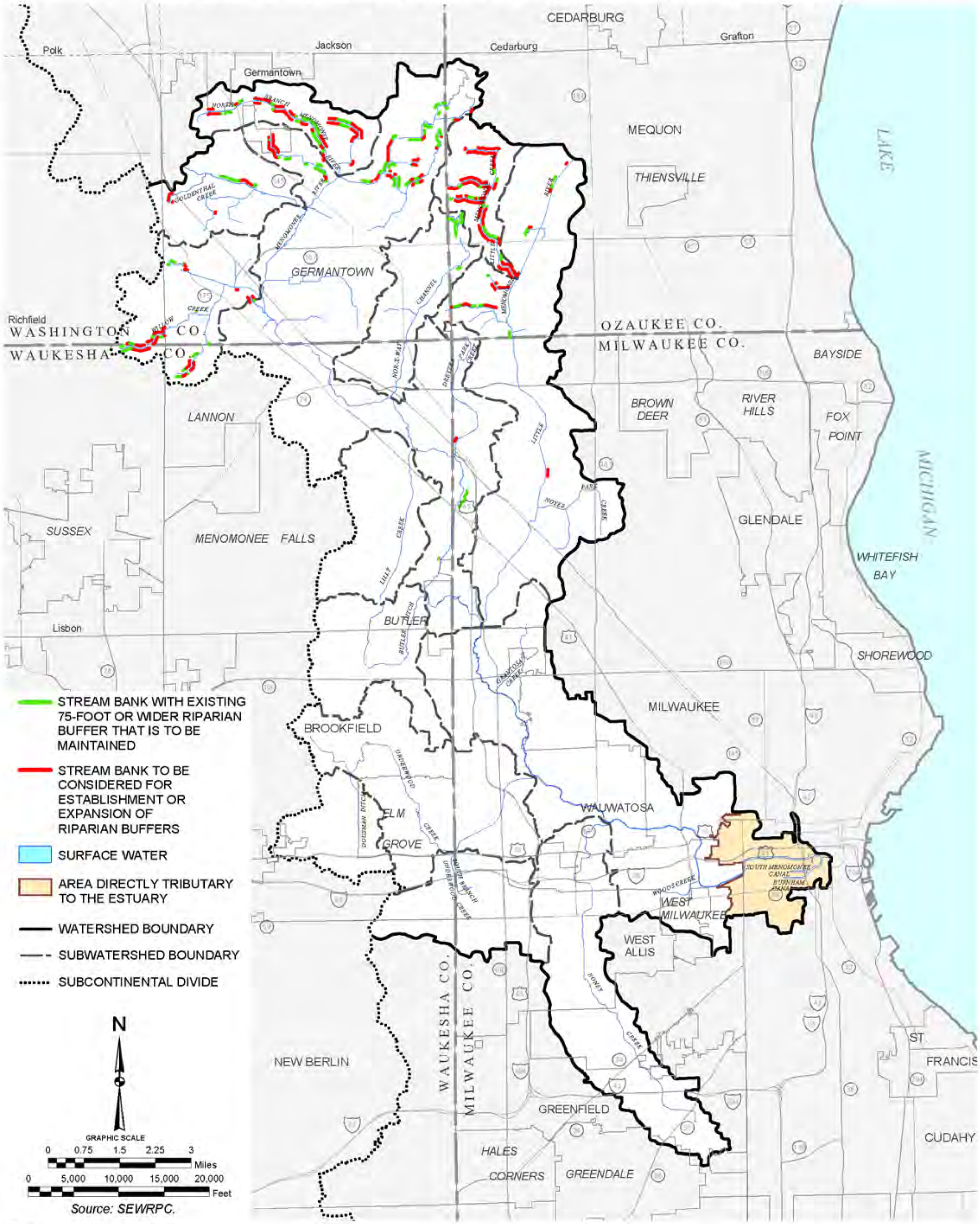
[62]*See Chapter 23 of the Washington County Code of Ordinances.*

[63]*Wisconsin Department of Natural Resources Technical Standard 1100,* Interim Turf Nutrient Management Standards, May 2006. *Standard can be accessed at http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm.*

[64]*Based on review of the Rhode Island Sea Grant paper entitled* "Vegetated Buffers in the Coastal Zone: A Summary Review," *July 1994 and on* "Wetland and Stream Buffer Size Requirements–A Review," *by A.J. Castelle, A.W. Johnson, and C. Conolly, Journal of Environmental Quality in 1994, which summarized the results of numerous published studies related to the pollutant removal effectiveness of riparian buffers, it was assumed that 75-foot-wide riparian buffers would be 75 percent effective in removing total suspended solids, total phosphorus, and total nitrogen from the land area which such a buffer could be expected to effectively treat. That land area was determined based on a ratio of land area to buffer area of 20. That ratio is a conservative reduction of the 50:1 to 70:1 ratio used by the NRCS in its conservation practice standard for buffer strip design. The reduction was applied to represent "natural" buffers such as are recommended under this plan as opposed to the "engineered" buffers for which the NRCS standard is applicable.*

Map 74

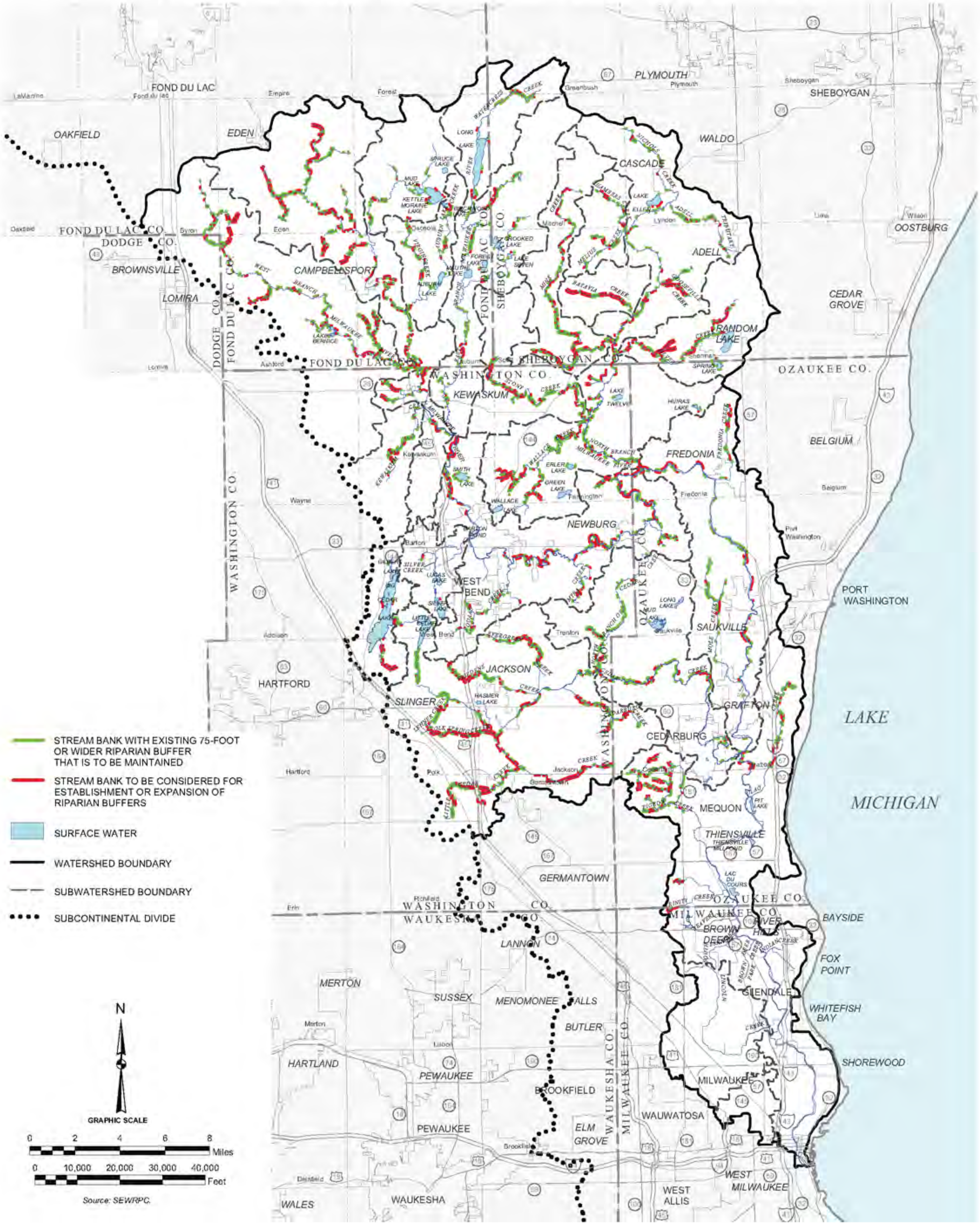
MENOMONEE RIVER WATERSHED: STREAM REACHES FOR WHICH ESTABLISHMENT OR EXPANSION OF RIPARIAN BUFFERS ARE TO BE CONSIDERED



Source: SEWRPC.

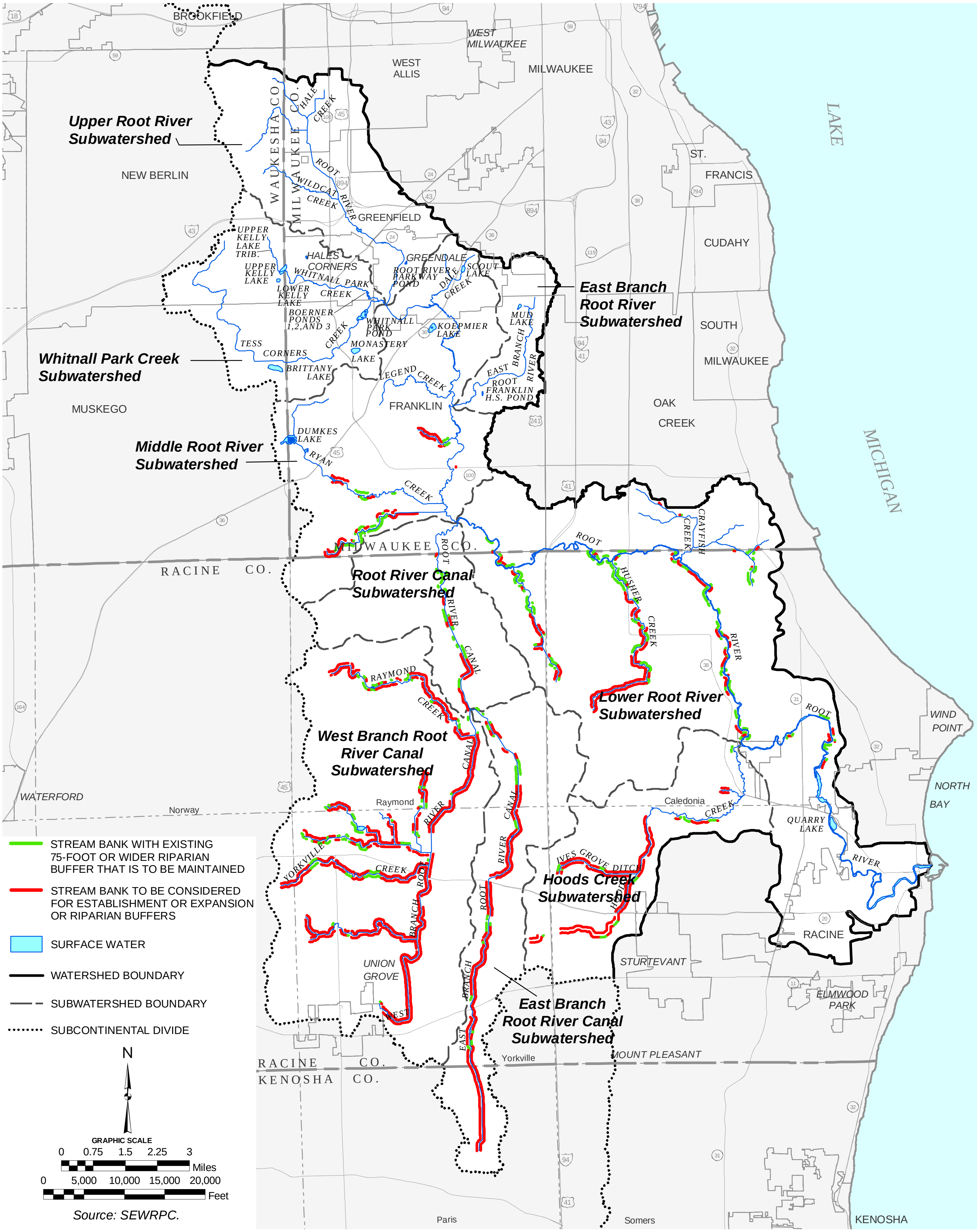
Map 75

MILWAUKEE RIVER WATERSHED: STREAM REACHES FOR WHICH ESTABLISHMENT OR EXPANSION OF RIPARIAN BUFFERS ARE TO BE CONSIDERED



Map 76

ROOT RIVER WATERSHED: STREAM REACHES FOR WHICH ESTABLISHMENT OR EXPANSION OF RIPARIAN BUFFERS ARE TO BE CONSIDERED



Source: SEWRPC.

It is recommended that:

- In general, where existing riparian buffers adjacent to crop and pasture lands are less than 75 feet in width they be expanded to a minimum of 75 feet,

- The procedures for targeting buffers to locations where they would be most effective as developed under the Wisconsin Buffer Initiative[65] be considered in the implementation of the riparian buffer recommendation made herein,[66]

- Opportunities to expand riparian buffers beyond the recommended 75-foot width be pursued along high-quality stream systems including those designated as outstanding or exceptional resource waters of the State, trout streams, or other waterways that support and sustain the life cycles of economically important species such as salmon, walleye, and northern pike, and

- The number of stream crossings be limited and configured to minimize the fragmentation of streambank habitat.

Recommendations regarding the MMSD Conservation and Greenway Connection Plans are set forth in the following subsection.

Conversion of Cropland and Pasture to Wetlands and Prairies
Consistent with the land use planning principle and standard set forth in Appendix G of this report which encourage efforts to restore farmland and other open space land to more natural conditions, such as wetlands, prairies, grasslands, and forest, it is recommended that a total of 10 percent of existing farmland and pasture be converted to either wetland or prairie conditions, focusing that effort on marginally productive land. Ten percent of the existing farmland and pasture represents an area of about 47.5 square miles. As shown on Map 72, agricultural lands other than those highly productive lands designated as Class I and Class II lands by the U.S. Natural Resources Conservation Service cover an area of about 143.8 square miles. Those lands, as identified on Map 77, should be given first consideration when identifying more marginally productive lands to be converted to wetlands or prairies. The benefits of expansion of this practice in reducing fecal coliform bacteria, total suspended solids, total nitrogen, and total phosphorus loads delivered to the streams of the study area were explicitly represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N. This measure also has some auxiliary benefit in maintaining and, to a limited degree, reducing peak stormwater runoff rates.

MMSD CONSERVATION AND GREENWAY CONNECTION PLANS
The MMSD conservation and greenway connection plans program (Greenseams) provides for the purchase, from willing sellers, of natural wetlands to retain stormwater with the intention of reducing the risk of flooding, protecting riparian land from development, and providing increased public access. The MMSD facilities plan recommends that these programs continue and be integrated with the regional water quality management plan update recommendations regarding environmental corridors and conversion of cropland and pasture to wetland and prairie conditions.

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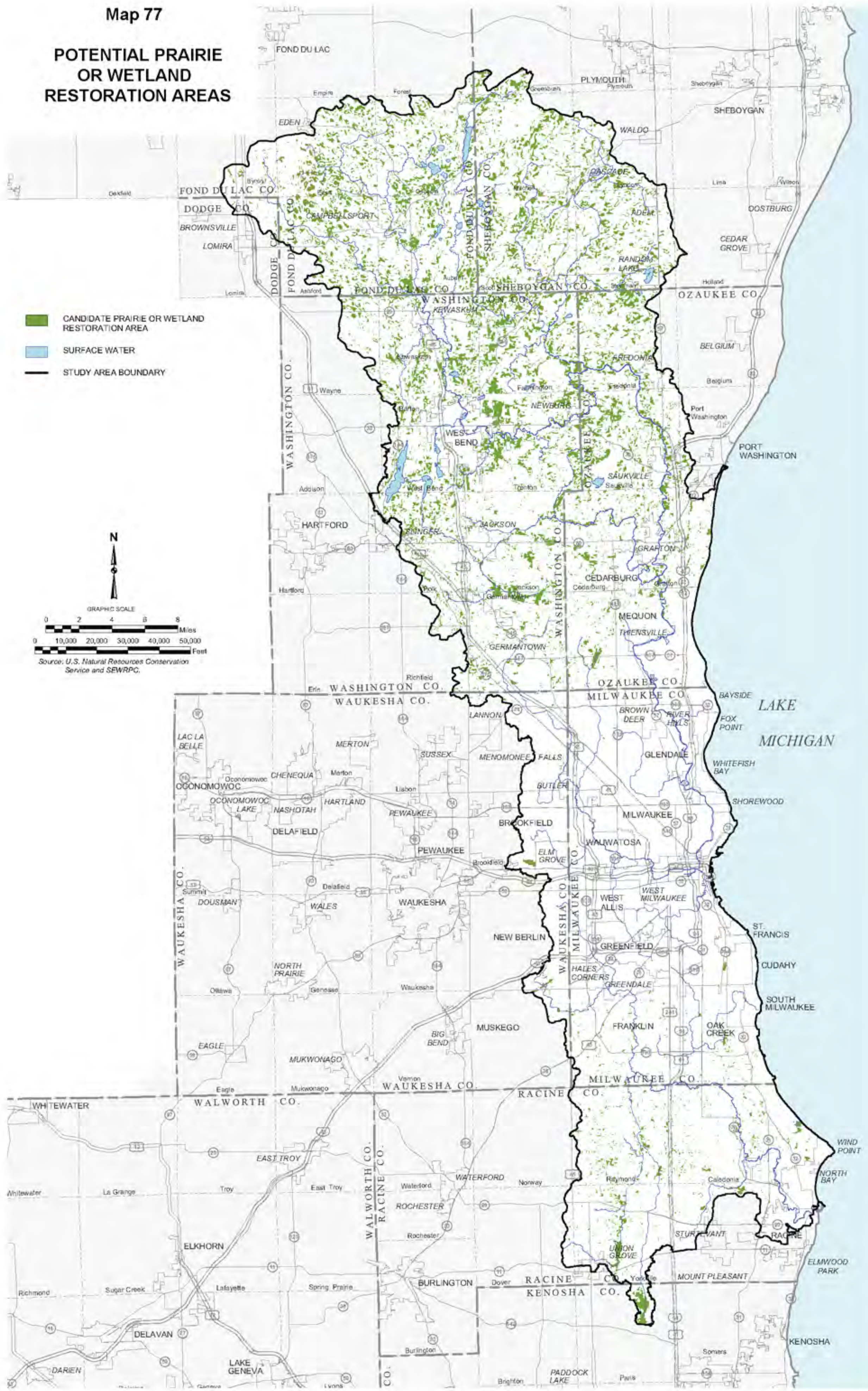
[65]*College of Agricultural & Life Sciences, University of Wisconsin-Madison,* The Wisconsin Buffer Initiative, *December 2005.*

[66]*As of December 2007, Chapter NR 151 of the* Wisconsin Administrative Code *did not include any requirements for riparian buffers adjacent to agricultural lands. The WDNR reopened those rules in 2007 to consider several possible revisions, including the addition of standards for riparian buffers on agricultural lands.*

Map 77

POTENTIAL PRAIRIE OR WETLAND RESTORATION AREAS



Source: U.S. Natural Resources Conservation Service and SEWRPC.

Restricting Livestock Access to Streams
It is recommended that livestock access to streams be restricted through fencing or other means.[67] Because of the relatively scattered nature of smaller-scale livestock operations and the lack of data on existing livestock access to streams, the benefits of additional restrictions on stream access in reducing bacteria, pathogens, and nutrients delivered to the streams of the study area were not explicitly represented in the water quality modeling analyses.

Management of Milking Center Wastewater
Milking center wastewater from dairy farms is the effluent produced by cleaning milking equipment, storage tanks, and pipelines to such tanks. That wastewater can contain relatively large quantities of total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, chlorines (from sanitizers and detergents), oil, and grease. If improperly disposed of on the land surface, this wastewater can have a detrimental effect on receiving stream water quality. It is recommended that measures be taken to ensure proper handling and treatment of milking center wastewater. The water quality benefits of improved handling of milking center wastewater were not explicitly represented in the water quality modeling analyses for the recommended plan.

Expanded Oversight and Maintenance of Private Onsite Wastewater Treatment Systems (POWTS)
The Technical Advisory Committee guiding the regional water quality management planning process identified improved oversight and maintenance of POWTS as a priority that should be addressed to improve groundwater and surface water quality.[68] The rural nonpoint source sensitivity analysis described in Chapter IX indicated that such a program could be an effective component of the overall water quality plan. Therefore, it is recommended that, at a minimum, county-enforced inspection and maintenance programs be implemented for all new or replacement POWTS constructed after the date on which the counties adopted private sewage system programs. It is also recommended that voluntary county programs be instituted to inventory and inspect POWTS that were constructed prior to the dates on which the counties adopted private sewage system programs.[69,70] The implementation of such a program was represented in the water quality modeling analyses as a 10 percent reduction in fecal coliform and nutrient loads from POWTS. The benefits of those reductions are reflected in the water quality results set forth in Appendices M and N.

Another concern identified by the Committee was illegal land dumping of septage, consisting of sewage pumped from holding tanks and private onsite wastewater treatment systems (POWTS). It was noted by the Committee that the programs dealing with septage disposal are understaffed and underfunded, and it was suggested that the State should increase oversight of septage disposal and enforcement of violations. Disposal of septage is regulated

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[67]*As noted in Chapter VI of this report, Section NR 151.08 of Chapter NR 151 of the* Wisconsin Administrative Code *includes a prohibition on "unlimited access by livestock to waters of the state in a location where high concentrations of animals prevent the maintenance of adequate sod or self-sustaining vegetative cover.*

[68]*The level of oversight of POWTS varies throughout the study area. Ozaukee County inspects all POWTS every three years and the systems are generally pumped out following those inspections. In other counties, the oversight is not as stringent. Chapters VI through X of SEWRPC Technical Report No. 39 provide descriptions of the level of oversight of POWTS in the Menomonee, Milwaukee, and Root River watersheds, the Oak Creek watershed, and the Lake Michigan direct drainage area.*

[69]*See Chapter XI of this report for information regarding possible administrative frameworks for management of POWTS and for funding inventory, inspection, and maintenance programs, including the possible establishment of Town Utility Districts.*

[70]*There is some disagreement over whether or not counties should assume responsibility for retroactive inventory and enforced maintenance of all POWTS. The Wisconsin County Code Administrators (WCCA)-Southeast District is opposed to the idea of making counties responsible for a mandated maintenance program for POWTS constructed prior to the county adoption of a private sewage system program (typically around 1980) due to the added expense and burden to run the program in the absence of any current Federal or State cost-share funding.*

under Chapter NR 113 of the *Wisconsin Administrative Code.* Section 281.48 (5m) of the *Wisconsin Statutes* states that a county may regulate the disposal of septage, subject to the approval of the WDNR. It is recommended that the WDNR and the counties in the study area work together to strengthen oversight and enforcement of regulations for disposal of septage and to increase funding to adequately staff and implement such programs.

Recommended Urban Nonpoint Source Pollution Abatement Measures

The recommended best management practices to abate urban nonpoint source pollution were developed by the SEWRPC staff and the consultant team modeling staff[71] under the guidance of both the SEWRPC Technical Advisory Committee for the plan and the SEWRPC Modeling Subcommittee comprised of technical and modeling experts and in conjunction with the WDNR. Input was also solicited from the MMSD Technical Advisory Team, consisting of representatives of each of the 28 municipalities served by MMSD; the joint MMSD/SEWRPC Citizens Advisory Council; and the SEWRPC Watershed Officials Forum that was established to provide information regarding the regional water quality management plan update to local elected officials and to solicit comment on various aspects of the plan from those officials.

The most effective urban nonpoint source control measures were selected based on modeling results from the screening alternatives, alternative plans, and urban pollution control sensitivity analysis, all of which are described in Chapter IX.

The recommended measures and their associated costs are set forth in Table 82. In some instances the plan includes measures that go beyond what would be required to meet the performance standards of Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*. Descriptions of each of those recommended measures, including the recommended level of implementation and/or the anticipated level of reduction in nonpoint source pollution loads, are set forth below.[72]

Implementation of the Nonagricultural (urban) Performance Standards of Chapter NR 151

It is recommended that urban nonpoint source pollution controls be implemented that are consistent with the standards of Chapter NR 151. As noted in Chapters V through X in SEWRPC Technical Report No. 39, almost all of the municipalities in the study area are, or will be, required to meet NR 151 standards to the maximum extent practicable under the conditions of their WPDES municipal stormwater discharge permits issued pursuant to Chapter NR 216 of the *Wisconsin Administrative Code.* By implementing controls to meet the standards of NR 151, municipalities will address the following:

- Control of construction site erosion;
- Control of stormwater pollution from areas of existing and planned urban development, redevelopment, and infill; and
- Infiltration of stormwater runoff from areas of new development.

Details of the NR 151 standards are provided in Chapter VI of this report, "Legal Structures Affecting the Regional Water Quality Management Plan Update." Urban best management practices that would be installed under this recommendation to control nonpoint source pollution from existing or new development could include 1) runoff infiltration/evapotranspiration and/or pollutant filtration devices such as grassed swales, infiltration basins, bioretention facilities, rain gardens, green roofs, and porous pavement; 2) stormwater treatment facilities,

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[71]*Technical staff from HNTB and Tetra Tech.*

[72]*As was the case for recommended rural controls, the most significant urban nonpoint source pollution controls were explicitly represented in the water quality modeling analyses that were developed as described in Chapter V of this report and that were used to evaluate changes in water quality conditions in the streams of the study area, the Milwaukee Harbor estuary, and the Lake Michigan nearshore area.*

such as wet detention basins, constructed wetlands, sedimentation/flotation devices; and 3) maintenance practices such as vacuum sweeping of roads and parking lots.

The benefits of full implementation of the urban standards set forth under Chapter NR 151 in reducing fecal coliform bacteria, total suspended solids, total nitrogen, total phosphorus, and heavy metals loads delivered to the streams of the study area and in reducing runoff volumes through infiltration practices were explicitly represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N.

Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems and to Control Urban-Sourced Pathogens that are Harmful to Human Health

The results of the analyses made by applying the calibrated water quality model as described in Chapters V and IX of this report indicated that urban impervious surfaces were significant contributors of fecal coliform bacteria to the streams of the study area. They also indicated that urban subsurface flows could be significant sources of fecal coliform bacteria. Some of these subsurface flows could be entering storm sewers through “illicit” connections from the sanitary sewer system such as infiltration from leaking sanitary sewers or cross connections between sanitary and storm sewers. Data for the MMSD service area as set forth in a 2005 bacteria fate and transport study[73] show that human-specific *Bacteroides* were detected in discharges from 11 of 17 stormwater outfalls sampled under the study. A recent MMSD study of bacteria at storm sewer outfalls in the Honey Creek subwatershed of the Menomonee River watershed indicated high fecal coliform counts from human sources even during dry-weather periods.[74] In addition, high bacterial concentrations have been observed at certain locations in streams in the study area during dry weather base flow conditions.

Fecal coliform bacteria were selected as one of the pollutants to be modeled under the water quality planning effort 1) because, from a regulatory perspective, they are used as an indicator of human sewage contamination, as evidenced by the adoption of fecal coliform water quality standards for streams under Chapter NR 102 of the *Wisconsin Administrative Code*, and 2) as a result of the adoption of the fecal coliform standard, a large amount of measured data on instream fecal coliform counts is available throughout the study area. In Lake Michigan, the USEPA has promulgated criteria for Wisconsin that call for application of an *Escherichia coli* (*E. coli*) standard. (*E. coli* constitute a major component of fecal coliform bacteria.)

While mainly intended as an indicator of human sewage contamination, fecal coliform bacteria and *E. coli* also serve as indicators of the possible presence of a broader range of possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes. Pathogens associated with human sewage include viruses, bacteria, such as *Salmonella enteritidis, Salmonella typhi, Vibrio cholera, and Shigella dysenteries,* and protozoa such as C*ryptosporidium* and Giardia intestinalis. Pathogens associated with domestic and/or wild animals and livestock include *Salmonella enteritidis*, C*ryptosporidium* and Giardia intestinalis.

Comparison of fecal coliform concentrations under existing conditions, planned year 2020 conditions, and planned year 2020 conditions with implementation of the recommended plan are the only readily available means of evaluating the degree to which implementation of the recommended plan improves water quality conditions and achieves regulatory water quality standards. However, because the presence of fecal coliform bacteria is not sufficient indication of a significant threat to human health, which would actually result from the presence of pathogens that are generally not directly measured, the recommended plan calls for a coordinated program to reduce pathogens in surface waters through better identification of the sources of fecal coliform bacteria and

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[73]*University of Wisconsin-Milwaukee Great Lakes WATER Institute,* Bacteria Source, Transport and Fate Study-Phase 1, *Volume 3, prepared for the Milwaukee Metropolitan Sewerage District, 2005.*

[74]*Milwaukee Metropolitan Sewerage District,* Honey Creek Bacteria Investigation Survey, *Technical Services—Engineering & Planning Department and Water Quality Research Department, July-August 2006.*

elimination or control of those sources that would potentially be most harmful to human health. While the program to control pathogens is intended to focus on pathogens from human sources, which would be expected to more likely be harmful to human health, pathogens from domestic and/or wild animals and livestock could also pose threats to human health. (Control of bacteria and other pathogens from livestock are addressed elsewhere in this report.)

Although human-sourced pathogens in stormwater management systems might be found in stormwater runoff, it is more likely that they enter storm sewers through "illicit" connections from the sanitary sewer system such as infiltration from leaking sanitary sewers or cross connections between sanitary and storm sewers. Thus, the main component of the recommended program to control pathogens from the urban environment is detection and elimination of illicit discharges from the sanitary sewerage system to the stormwater management system. In cases where a human bacteria source is detected, but illicit connections cannot be identified, or where there are high bacteria counts, but no human bacteria source is detected (indicating the bacteria are contained in stormwater runoff), it is recommended that consideration be given to pursuing innovative means of identifying and controlling possible pathogen sources in stormwater runoff.[75]

The WPDES stormwater discharge permits issued pursuant to Chapter NR 216 of the *Wisconsin Administrative Code* call for each permitted municipality to implement a program for detection and elimination of illicit discharges to the municipal separate storm sewer system. Such programs typically involve enforcement of an illicit discharge and connection ordinance prohibiting the discharge, spill, or dumping of nonstormwater substances into waters of the State or the municipal storm sewer system; annual dry weather field screening at major outfalls,[76] including field analysis of any dry weather flows from those outfalls; and immediate investigation of portions of the municipal storm sewer system that have a reasonable potential for containing illicit discharges based on field screening results or other information.[77]

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[75]*Because most more-traditional urban best management practices are not designed to control bacteria and other pathogens, it is necessary to consider alternative approaches to reduce bacteria and pathogen concentrations in the streams and lakes of the study area. The urban nonpoint source sensitivity analysis described in Chapter IX indicated that installation of stormwater end-of-pipe treatment, such as disinfection units, could be an effective component of the overall water quality plan; however, when the effects of disinfection units on reducing fecal coliform on a watershedwide basis were evaluated based on water quality model analyses, it was found that neither significant improvements in instream water quality nor improvements in compliance with the fecal coliform bacteria water quality standards would be expected if a large-scale disinfection unit program were implemented. The Technical Advisory Committee expressed strong opposition to recommending the installation of such "end-of-pipe" treatment facilities. That opposition was primarily based on relatively high capital and operation and maintenance costs; concerns related to the effectiveness of the units in treating turbid stormwater runoff, which can reduce the effectiveness of ultraviolet disinfection; and overall concerns about the feasibility of effectively operating and maintaining such units. Thus, after further investigation, and in consideration of the factors listed above, installation of disinfection units is not recommended.*

[76]*Section NR 216.002(16) defines a "major outfall" as "a municipal separate storm sewer system outfall that meets one of the following criteria:*

(a) A single pipe with an inside diameter of 36 inches or more, or from an equivalent conveyance (cross-sectional area of 1,018 inch^2) which is associated with a drainage area of more than 50 acres.

(b) A municipal separate storm sewer system that receives storm water runoff from lands zoned for industrial activity that is associated with a drainage area of more than 2 acres or from other lands with more than 2 acres of industrial activity…"

[77]*Under the requirements of the WPDES permits, field analysis is generally done for pH, total chlorine, total copper, total phenols, and detergents or surfactants.*

Based on review of recommended plan water quality model results for the streams of the study area and Lake Michigan, it was decided to recommend enhanced urban illicit discharge control and/or innovative methods to identify and control possible pathogen sources in stormwater runoff from all urban areas in the study area. To address the threats to human health and degradation of water quality resulting from human-specific pathogens and viruses entering stormwater systems, it is recommended that each municipality in the study area implement a program consisting of:[78]

- Enhanced storm sewer outfall monitoring to test for fecal coliform bacteria in dry- and wet-weather discharges,

- Molecular tests for presence or absence of human-specific strains of *Bacteroides*, an indicator of human fecal contamination, at outfalls where high fecal coliform counts are found in the initial dry-weather screenings,

- Additional dry-weather screening upstream of outfalls where human-specific strains of *Bacteroides* are found to be present, with the goal of isolating the source of the illicit discharge, and

- Elimination of illicit discharges that were detected through the program described in the preceding three steps.

It is anticipated that the program outlined above would also identify cases where illicit connections are not the primary source of bacteria, indicating that stormwater runoff is the main source. To adequately assess the appropriate way to deal with such bacteria sources (and the potentially associated pathogens), it is recommended that human health and ecological risk assessments be conducted to address pathogens in stormwater runoff. Such risk assessments generally include the following:

- "Hazard identification, in which the human health (or ecological) effects of the particular hazard are described;

- Exposure assessment, which determines the relevant pathways and nature of the exposed population along with quantitative estimates on the levels of exposure;

- Dose-response assessment, which characterizes the relationship between administered dose and incidence of health effects (or ecological degradation); and

- Risk characterization, which integrates the information from the previous steps in order to estimate the magnitude of risks and to evaluate variability and uncertainty."[79]

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[78]*Guidance on conducting an illicit discharge detection and elimination program can be found in the manual entitled* Illicit Discharge Detection and Elimination – A Guidance Manual for Program Development and Technical Assessments, *by Edward Brown and Deb Caraco of the Center for Watershed Protection and Robert Pitt of the University of Alabama, October 2004. The manual can be accessed at www.cwp.org/idde_verify.htm.*

[79]*National Research Council (NRC),* Science and Judgment in Risk Assessment, *National Academy Press, 1994, and U.S. Environmental Protection Agency,* Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A), Interim Final, *December 1989, both cited in GeoSyntec Consultants*, Interim Phase I Dry Weather Risk Assessment of Human Health Impacts of Disinfection Vs. No Disinfection of the Chicago Area Waterways System (CWS), *prepared for the Metropolitan Water Reclamation District of Greater Chicago,* November 2006.

Depending on the findings of the risk assessments, consideration should be given to pursuing innovative means of identifying and controlling possible pathogen sources in stormwater runoff.[80]

The benefits of coordinated programs to detect and eliminate illicit discharges to storm sewer systems and to control urban-source pathogens that are harmful to human health were represented in the water quality modeling analyses relative to their potential reduction in instream and in-Lake fecal coliform bacteria counts and are reflected in the water quality results set forth in Appendices M and N.[81]

Chloride Reduction Programs
Water quality monitoring data set forth in SEWRPC TR No. 39 indicated that chloride concentrations in the streams of the study area are increasing over time. The chloride is likely from multiple sources, including 1) sodium chloride and calcium chloride applied for ice and snow control on local and collector streets, county trunk highways, State trunk highways, United States highways, interstate highways, and public and private parking lots and 2) discharges from water softener systems to either private onsite wastewater treatment systems (POWTS) which discharge to groundwater which ultimately discharges to streams and lakes as baseflow, or which discharge to public wastewater treatment plants which discharge to surface waters.

While observed instream chloride concentrations are generally still less than the planning standard of 1,000 milligrams per liter (mg/l) that was adopted under the original regional water quality management plan, they occasionally approach that concentration except in the Milwaukee River watershed where concentrations are generally less than 200 mg/l.[82] Observed instream concentrations more frequently exceed the 250 mg/l secondary drinking water standard.[83] Instream concentrations generally do not exceed the chronic toxicity criterion of 395 mg/l or the acute toxicity criterion of 757 mg/l as set forth in Chapter NR 105, "Surface Water Quality Criteria and Secondary Values for Toxic Substances," of the *Wisconsin Administrative Code*. Chloride concentrations are generally below 200 mg/l in the outer harbor and the nearshore Lake Michigan area. In the lakes of the Milwaukee River watershed for which data are available, chloride concentrations are generally less than 50 mg/l, although concentrations appear to be increasing over time. Overall, the increasing trends in concentrations are a cause for concern.

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[80]*It is not expected that municipalities would conduct individual risk assessments. It is envisioned that such assessments would be done at a watershed scale. Possible mechanisms for administering and funding such assessments are described in Chapter XI of this report.*

[81]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[82]*The one exception to this, among the streams for which data are available, is Lincoln Creek, where chloride concentrations approaching 700 mg/l have been observed.*

[83]*In Section 809.60 of Chapter NR 809, "Safe Drinking Water," of the* Wisconsin Administrative Code, *establishes a secondary standard for chloride of 250 mg/l and notes that, while that concentration is not considered hazardous to health, it may be objectionable to an appreciable number of persons.*

Thus, it is recommended that the municipalities and counties in the study area continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose.[84] It is also recommended that municipalities consider alternatives to current ice and snow control programs, such as applying a sand/salt mix to local roads with enhanced street sweeping in the spring of the year to remove accumulated sand.[85] It is recommended that education programs be implemented to provide information about 1) alternative ice and snow control measures in public and private parking lots and 2) optimal application rates in such areas.

Chlorides used in water softeners can increase instream chloride concentrations and they can also pose problems with elevated concentrations at wastewater treatment plants. It is recommended that education programs be implemented to provide information about alternative water softening media and the use of more-efficient water softeners which are regenerated based upon the amount of water used and the quality of the water. Other alternative measures for communities to consider include calibration of deicer application equipment, prewetting of solid deicers, and use of alternative ice and snow control materials.

Fertilizer Management

Review of the water quality modeling analysis results set forth in Appendix N indicates that in many cases, significant reductions in year 2020 instream phosphorus concentrations relative to existing year 2000 conditions may be achieved through programs to meet the nonpoint source pollution control standards of Chapter NR 151 of the *Wisconsin Administrative Code* along with the construction of committed MMSD projects.[86] However, as represented in the recommended plan model results, large additional reductions in instream phosphorus concentrations and significant increases in compliance with the phosphorus water quality planning standard would not be anticipated from implementation of measures intended to achieve an additional 10 percent reduction in loads delivered to streams.

Because the washoff of fertilizer into inland lakes is a significant factor contributing to lake eutrophication, it is recommended that the use of low- or no-phosphorus fertilizers be encouraged in areas tributary to inland lakes and ponds and that consideration be given to adopting low- or no-phosphorus fertilizer ordinances in those areas.[87] Also, because of the general benefit in reducing phosphorus inputs to streams and to Lake Michigan, it is also recommended that information and education programs required under municipal WPDES stormwater discharge permits promote voluntary practices that optimize urban fertilizer application consistent with the requirements of WDNR Technical Standard No 1100, "Interim Turf Nutrient Management."[88] One key provision of those standards calls for no application of fertilizer within 20 feet of a waterbody.

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[84]*Under the conditions of its WPDES stormwater discharge permit, Milwaukee County is considering conducting a study to quantify and monitor concentrations of chlorides entering streams in stormwater runoff from arterial streets and highways.*

[85]*The City of Brookfield has adopted such a program which can serve as a model for other municipalities.*

[86]*Through comparison of the "Existing" and "2020 Future (baseline)" conditions.*

[87]*It is appropriate for no-phosphorus ordinances to allow the use of compost-based fertilizers with relatively low phosphorus concentrations, such as Milorganite®.*

[88]*Sections NR 151.13 and 151.14 of Chapter NR 151 of the* Wisconsin Administrative Code *set forth fertilizer performance standards for municipal and nonmunicipal properties with over five acres of pervious surface where fertilizer is applied. Those standards call for fertilizer application to be done "in accordance with site-specific nutrient application schedules based on appropriate soil tests." Those standards are required to be followed in municipalities with WPDES stormwater discharge permits.*

Residential Roof Drain Disconnection from Sanitary and Combined Sewers and Infiltration of Roof Runoff

In an effort to reduce clearwater flows in the separate and combined sewer systems in the study area, it is recommended that programs be implemented to achieve a practical level of disconnection of the residential roof drains that are currently connected to sanitary and combined sewers. It is also recommended that roof drains that are not directly connected to sanitary or combined sewers, but which discharge to impervious areas, be redirected to pervious areas where feasible. The number and location of the roof drains which are to be disconnected should be determined with technical advice and guidance from municipalities and residents to consider impacts on private and public sewer infiltration and inflow, residence foundation and basement structural considerations, and icing conditions. It is recommended that consideration be given to directing those roof drains which are to be disconnected to rain barrels and/or rain gardens, with the runoff from those roofs ultimately being infiltrated. The benefits of infiltration of roof runoff were represented in the water quality modeling analyses and are reflected in the water quality results set forth in Appendices M and N.

Beach and Riparian Litter and Debris Control Programs

It is recommended that existing litter and debris control programs along Lake Michigan beaches, inland lake beaches, and along the urban streams of the study area be continued and that opportunities to expand such efforts be explored. Existing programs are conducted by several environmental organizations in cooperation with numerous citizen volunteers and volunteer organizations. The environmental organizations involved in such programs include Keep Greater Milwaukee Beautiful, Inc., and its corporate sponsors who stage annual river cleanup programs in Milwaukee, Ozaukee, Washington, and Waukesha Counties, and the Friends of Milwaukee's Rivers, who also organize periodic river cleanups. An estimated cost for the recommended programs, assuming an expanded level of effort beyond the current programs, is set forth in Table 82.

Pet Litter Management

The transport into streams and lakes of bacteria and other contaminants found in pet waste is accelerated in an urban environment with significant areas of impervious surface and engineered stormwater drainage systems. Many municipalities in the study area have pet litter control ordinances and control of pet litter can be readily incorporated in the ordinances of municipalities that will be developing or updating stormwater management ordinances under the conditions of their WPDES stormwater discharge permits. It is recommended that all municipalities in the study area have pet litter control ordinance requirements and that those requirements be enforced. The effects of implementing pet litter management programs were not explicitly represented in the water quality modeling analyses.

Marina Waste Management Facilities

To avoid the direct discharge of sewage from holding tanks in recreational boats to the waters of Lake Michigan it is recommended that the Milwaukee County McKinley Marina, the Milwaukee Yacht Club, and the South Shore Yacht Club in the City of Milwaukee, and the Racine Reef Point Marina and other boating facility operators continue to maintain pump-out stations for disposal of those wastes through the public sanitary sewerage system and upgrade or expand those stations as necessary.

Research and Implementation Projects

The MMSD currently promotes and funds bacteria and pathogen research related to Lake Michigan beaches and characterization of discharges from storm sewer outfalls and it is currently developing and implementing stormwater best management practices (BMP) projects that demonstrate the benefits of BMPs on managing the volume, rate, and quality of stormwater runoff. The goal of these studies is to understand the origins and fate of disease-causing pathogens so that cost-effective, scientifically based measures can be developed to best address bacterial contamination in streams and in Lake Michigan, with the ultimate goal of better protecting public health and reducing the number of beach closings.

It is recommended that MMSD and others continue to support targeted research on bacteria and pathogens and research and implementation of stormwater BMP techniques and programs. Because the monitoring of indicator organisms such as fecal coliform bacteria and *E. coli* constitute an indirect method of screening for the presence of pathogens, it is recommended that research to develop and apply more direct methods of identifying sources of pathogens important to human health also be supported. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, between 2006 and 2010 sampling will be conducted at three locations to determine the concentrations of five pathogenic human enteric viruses. In addition, as a part of Phase III, USGS and MMSD will conduct sampling for the protozoan parasites *Cryptosporidium* and *Giardia* in order to define relative loadings of these pathogens from different land uses and source areas. It is recommended that these projects be supported.

Instream Water Quality Measures Plan Subelement

The instream water quality management measures described in this report subsection are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Hydrologic and Hydraulic Management

Concrete Channel Renovation and Rehabilitation

Approximately 22 miles of concrete channelized waterways under MMSD jurisdiction that were constructed by MMSD from the 1960s through the 1980s are in need of repair or replacement. These channels were lined with concrete to improve conveyance of the natural waterways and reduce the risk of flooding of riparian structures and property. In many areas, the channel liners are failing, particularly near storm sewer outfalls and bridge crossings. The MMSD facilities plan recommends implementing projects to remove concrete linings from stream channels under MMSD jurisdiction and to rehabilitate those channels where such removal can be accomplished without creating flood or erosion hazards.

MILWAUKEE COUNTY STREAM ASSESSMENT

The stability and fluvial geomorphic character of streams in the Kinnickinnic River, Menomonee River, Milwaukee River, and Oak Creek watersheds within Milwaukee County were assessed by the County in 2004.[89] Appendix E of that study report sets forth and prioritizes projects for concrete lining removal, channel rehabilitation, and fish passage improvement. It is recommended under the regional water quality management plan that the projects called for under the Milwaukee County stream assessment study be implemented over time in a manner consistent with the need to provide flood protection and consistent with the stream rehabilitation recommendations of the regional plan update.

Renovation of the MMSD Kinnickinnic River Flushing Station

The Kinnickinnic River flushing station was constructed in the early 1900s to improve water quality in the lower reach of the Kinnickinnic River. The system pumps water from Lake Michigan into the River. The intake structure is located at East Russell Avenue and South Lincoln Memorial Drive and the outlet structure is located on the River just downstream of South Chase Avenue. The tunnel that conveys the Lake water to the River is about two miles long.

The MMSD assumed ownership of the Kinnickinnic River flushing station in 1980. Portions of the River have experienced problems with low dissolved oxygen, thus, MMSD operates the flushing station when dissolved oxygen concentrations in the River are less than 3.0 mg/l. A comparison of actual flushing tunnel flow data and observed downstream dissolved oxygen data verifies the usefulness of flushing tunnel operation in increasing dissolved oxygen levels in the Kinnickinnic River.

In 2002, a preliminary engineering study reviewed options for renovating the intake and the outlet structures of the flushing system.[90] The intake structure was noted as being severely deteriorated and a public safety hazard. The outlet structure was filled with silt and debris that could not be readily removed because of difficult access. The accumulated silt and debris were thought to be significantly reducing the capacity of the pump station and,

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[89] *Inter-Fluve, Inc.,* Milwaukee County Stream Assessment, *prepared for Milwaukee County, September 24, 2004.*

[90] *Donohue & Associates, Inc., MMSD Project F04-KK River Flushing System Improvements MMSD Conveyance Facilities (Contract No. S06005D01), August 30, 2002.*

thus, the ability of the system to improve the water quality of the River. The tunnel and the pump station were not evaluated under the 2002 study.

It is recommended that an engineering study be conducted to evaluate the condition of the tunnel and the pump station and that, depending on the findings of that study, consideration be given to renovating the flushing tunnel intake and outlet and the tunnel and pump station, if necessary and economically justifiable. Prior to implementing any major modifications to the flushing station, it is recommended that MMSD reevaluate dissolved oxygen levels in the estuary in light of possible future sediment removal projects that could improve dissolved oxygen conditions.

Dams

Dams are a common form of direct human control on river, stream, and lake processes throughout the greater Milwaukee watersheds study area. The majority of the lakes within the study area are maintained or augmented by dams, which provide both economic and recreational values to these waterways. Although the majority of the dams in the study area are low head structures, they significantly affect the physical, chemical, and biological communities of the streams and lakes of the study area. While most of the dams were constructed for specific economic purposes such as providing hydropower for grist mills or saw mills, these purposes have long since ceased. The waterbodies created or maintained by many of the dams now serve as focal points for residential communities and recreation. In addition, some dams may provide limited flood control benefits.

It is important to recognize that dams are man-made structures constructed of materials subject to erosion, corrosion, weathering, and deterioration. These structures deteriorate over time. If ongoing maintenance and repair measures are not conducted, a dam can fail, causing property damage downstream and possible loss of life. It is recommended that dam owners perform ongoing maintenance and repair of their dams. This is particularly important for high-hazard dams.[91]

Many of the structures in the study area may be reaching the end of their designed life. The World Commission on Dams, in reviewing the issue of dam life spans, has recommended the development of abandonment and restoration plans as part of the design process for any constructed lakes. This dam abandonment process should include consideration of the fact that dams are accreting systems and typically retain considerable amounts of sediment and associated contaminants during their lifetime. Commonly, the sediment within the former lake basin is ignored when the dam is abandoned, resulting in significant downstream transport and deposition and the potential downstream transport of contaminants. Historically, abandonment has been conducted based upon the philosophy of the stream within the former lakebed “finding its own level”. This has resulted in significant head cutting and downstream transport of sediment from within former lakebeds. In the greater Milwaukee watersheds study area a number of priority pollutants are known to occur in the sediments retained by dams. Therefore, the stabilization and management of the former lakebed should be a key element of the abandonment of dams in the system and the re-creation of the stream channel and floodplain. Failure to plan for abandonment can result in long-term disturbance to stream ecosystems both upstream and downstream of a former dam site. These disturbances have included inundation by sediments of downstream habitat sites as well as chronic instability of streambed and streambanks within the area of the former impoundment, making these areas prime candidates for colonization of exotic invasive species such as purple loosestrife and reed canary grass. Therefore, it is recommended that abandonment and associated riverine area restoration plans be prepared as part of the design of new, or reconstructed, dams and prior to abandonment of existing dams. In addition, any dam removals should also specifically include provisions to protect upstream reaches from erosion and downstream reaches from sedimentation by prohibiting excessive sediment transport from the impoundment during and after dam removal.

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[91]*Chapter VI of this report provides information on the WDNR authority to regulate construction of dams affecting navigable bodies of water. That authority is granted under Chapter 31 of the* Wisconsin Statutes. *Chapter NR 333 of the* Wisconsin Administrative Code *sets forth the extensive State requirements related to dam design and construction and includes a requirement that dams have operation, inspection, and maintenance plans.*

Historically, consideration of dam abandonment and removal has usually come about because of a failure incident or as the result of a WDNR inspection which found significant defects that require major repairs to correct. Economic, social, and environmental factors all play a significant role in decisions to remove dams.

The three major reasons for dam removals in Wisconsin are:

- Removal of an unsafe structure under Section 31.19 of the *Wisconsin Statutes*.
- Removal of "abandoned" dams under Section 31.187 when either no owner is found or the owner or owners are not able to fund repairs.
- Removal of dams that have a significant environmental impact.

The process for construction, operation, and abandonment—or life stages—of constructed waterbodies, including dams, weirs, and detention basins, should involve consultation and participation by a range of stakeholders including riparian residents as well as governmental agencies. Throughout their lifetimes, specific dams can serve a variety of purposes that frequently evolve as communities change. For example, as noted above many dams were originally constructed for hydropower purposes, evolved through a role as receptacles for stormwater runoff, and currently serve to maintain constructed waterbodies that act as recreational focal points. This frequently results in conflicts if these changing attributes are not recognized and the multiple viewpoints not respected. Therefore, it is recommended that the various stages in the life of constructed waterbodies develop through a public process with due recognition of the attitudes and concerns of this wide range of stakeholders.

Culverts, Bridges, Drop Structures, and Channelized Stream Segments
Culverts, bridges, drop structures, and channelized stream segments, especially concrete lined segments, fragment and limit connectivity within stream habitat and ecosystems.[92] It is recommended that, to the extent practicable, these stream crossings and management strategies be limited. Where such crossings are required it is recommended that they be designed not only to pass water, but also allow the passage of aquatic organisms thus ensuring the connectedness of the ecosystem both upstream and downstream. Low flow conditions are especially critical to the survival of high-quality stream ecosystems and require specific structural accommodation in design. Recommended design standards and criteria are included in Appendix P.

When opportunities arise, such as at the time of reconstruction of roadways and highways, it is recommended that "ecosystem-friendly" design standards be considered for implementation. These include the removal of concrete streambed and/or streambank lining where such removal can be accomplished without creating a risk of flooding or streambank and streambed erosion, remeandering of the stream channel, reconnection of the stream to its floodplain, and reestablishment of riparian habitat. In addition, the removal of barriers to fish passage such as culverts and drop structures is recommended. For example, culverts originally intended for access to agricultural lands may be retained at the time of conversion to other land uses although the culverts no longer serve a practical purpose. The number of crossings in a given stream system is directly proportional to the level of degradation of that system. It is recommended that, to the extent practicable, opportunities be considered for the removal of existing hydraulic structures, or for their replacement with "ecosystem-friendly" structures based on the design standards and criteria set forth in Appendix P.

Restoration, Remediation, and Dredging Programs
Restoration and remediation programs include a variety of activities focusing on the remediation of historically contaminated sites and the restoration of instream habitat, including restoration of riverine fisheries. Such programs include activities related to remediation of legacy sediment contamination, decommissioning of

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[92]*Brian M. Weigel, Edward E. Emmons, Jana S. Stewart, and Roger Bannerman,* "Buffer Width and Continuity for Preserving Stream Health in Agricultural Landscapes", *Research/Management Findings, Issue Fifty-six, December 2005.*

hydraulic structures, restoration of channelized streamcourses, and reconnection of streams and associated floodplains. Ideally, these actions collectively, and individually, should contribute to the enhancement and rehabilitation of the riverine fishery in the study area.

The presence of contaminated sediments continues to be of concern in the study area. Contaminated sediments can have the following effects on water quality:

- They have been demonstrated to be toxic to benthic-dwelling organisms. Many sediment contaminants bioaccumulate in organism tissue and can be biomagnified as they are carried through the food web.

- They can compromise human health both through direct exposure such as swimming and wading and consumption of contaminated fish and shellfish.

- Beneficial uses of waterbodies can be compromised by the presence of contaminated sediment, leading, for example, to fish consumption advisories for waterbodies and reductions in sportfish populations.

- Deposits of contaminated sediment can serve as a source of contaminants to the water, contributing to downstream transport of contaminants.

As described and characterized in Chapter VII, “Surface Water Quality Conditions and Sources of Pollution in the Milwaukee River Watershed,” of SEWRPC TR No. 39, sites containing deposits of contaminated sediment have been identified in a five-mile segment of Cedar Creek in Cedarburg, Zeunert Pond in Cedarburg, Thiensville Millpond, Estabrook Impoundment, and the Milwaukee Harbor Estuary Area of Concern.

Milwaukee Estuary Remedial Action Plan

The process of developing the Remedial Action Plan (RAP) for the Milwaukee Estuary Area of Concern (AOC) has been ongoing since 1988. The WDNR is the lead agency for development of the plan, and they have been advised by a Technical Advisory Committee, a Citizen’s Advisory Committee, and a Citizen’s Education and Participation Subcommittee. The RAP process has focused on issues related to remediation of contaminated sediments, eutrophication, nonpoint source pollution, beach water quality, fish and wildlife populations, and habitat.

The Milwaukee Estuary AOC includes the Milwaukee River downstream from the site of the former North Avenue dam, the Menomonee River downstream from S. 35th Street, the Kinnickinnic River downstream from S. Chase Avenue, the inner and outer harbors, and the nearshore waters of Lake Michigan bounded by a line extending north from Sheridan Park to the intake from the City of Milwaukee’s Linnwood water treatment plant. Eleven beneficial use impairments have been identified in the Milwaukee Estuary AOC including restrictions on fish and wildlife consumption, degradation of fish and wildlife populations, fish tumors or other deformities, bird or animal deformities or reproductive problems, degradation of benthos, restrictions on dredging activities, eutrophication or undesirable algae, beach closings, degradation of aesthetics, degradation of phytoplankton and zooplankton populations, and loss of fish and wildlife habitat.[93] While these impairments are the result of many causes, many are related, at least in part, to the presence of toxic substances in water, sediment, and the tissue of organisms.

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[93]*Wisconsin Department of Natural Resources,* Milwaukee Estuary Remedial Action Plan Progress through January 1994, *1995.*

A joint WDNR/USEPA effort is currently underway to examine and assess the identified beneficial use impairments for the Milwaukee Estuary AOC, to eliminate those that no longer apply, and to develop restoration criteria to address the remaining beneficial use impairments, with the ultimate goal of delisting the AOC.[94]

Management of Contaminated Sediment Sites

Management of contaminated sediment sites is recommended. As of 2006, remediation projects were ongoing for two sites: the Moss-American Superfund site along the Little Menomonee River and the Kinnickinnic River Environmental Restoration Project located in the Kinnickinnic River between S. Kinnickinnic Avenue and W. Becher Street. Management programs for remediation of contaminated sediment at Cedar Creek, Zeunert Pond, Thiensville Millpond, and Estabrook Impoundment should be reviewed and implemented. Ideally, remediation efforts should be coordinated from upstream to downstream to minimize downstream transport of contaminants; however, this concern alone should not serve as a barrier should an opportunity arise to remediate a downstream site. In support of this, it is recommended that consideration be given to extending the Milwaukee Estuary AOC to include:

- The Little Menomonee River from W. Brown Deer Road (STH 100) to its confluence with the Menomonee River (Moss-American Superfund site),
- The Menomonee River from its confluence with the Little Menomonee River to N. 35th Street,
- Cedar Creek from Bridge Street to its confluence with the Milwaukee River,
- The Milwaukee River from its confluence with Cedar Creek to the site of the former North Avenue dam (includes the Estabrook Park dam and the associated impoundment), and
- Lincoln Creek.

The recommended stream reaches to be added to the AOC are shown on Map 78.

Monitoring of Toxic Substances

Continued monitoring of toxic substances will be important in prioritizing remediation efforts for toxic substances. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, there will be a study examining urban stream toxicity. Samples of surface water, sediment, and sediment pore water collected from 14 urban streams and one reference stream in the MMSD planning area will be examined for the presence and concentrations of toxic substances. In addition, as part of Phase III of the MMSD Corridor Study, studies using semi-permeable membrane devices will be conducted in order to measure the potential level of toxicity from hydrophobic organic compounds. It is recommended that these studies be continued and supported.

Dredging and Dredged Materials Disposal

A dredging and dredged material disposal plan was developed under the SEWRPC Milwaukee Harbor estuary study.[95] The regional water quality management plan update revises the recommendations from that study, taking into account the current status of navigational dredging programs and the implementation status of remedial action plans in the Milwaukee Estuary AOC, which is one of 43 sites in the Great Lakes area targeted for priority attention under the U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) due to impairment of beneficial use of the area's ability to support aquatic life.

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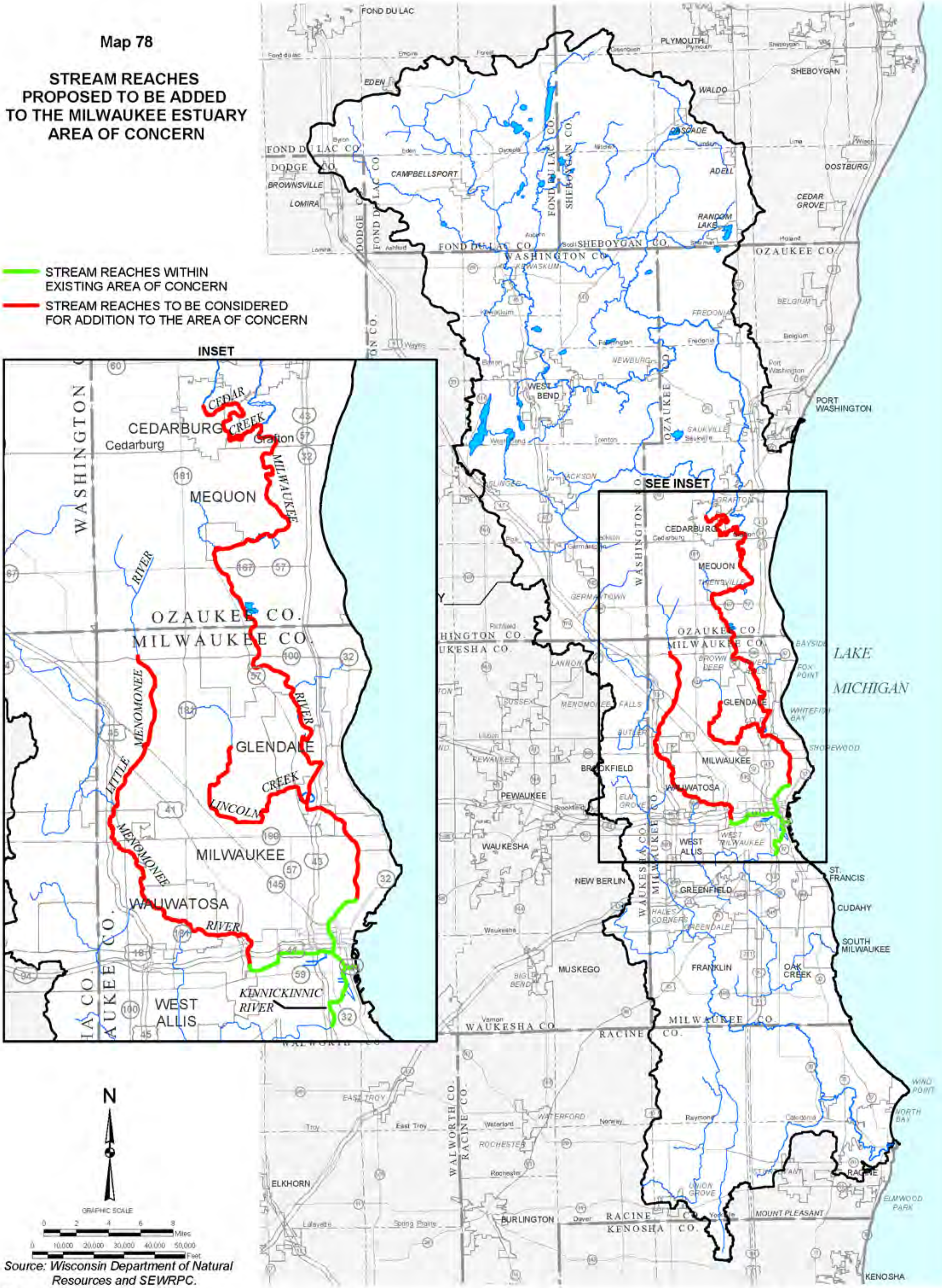
[94]*Short, Elliot and Hendrickson and Environmental Consulting & Technology, Inc.,* Restoration Criteria for the Milwaukee Harbor Estuary Area of Concern, *submitted to the Wisconsin Department of Natural Resources, in progress.*

[95]*SEWRPC Planning Report No. 37,* A Water Resources Management Plan for the Milwaukee Harbor Estuary, *Volume Two,* Alternative and Recommended Plans, *December 1987.*

Map 78

STREAM REACHES PROPOSED TO BE ADDED TO THE MILWAUKEE ESTUARY AREA OF CONCERN



Source: Wisconsin Department of Natural Resources and SEWRPC.

The need for dredging in the Milwaukee Harbor estuary is determined primarily by the need to maintain commercial navigation. That need may, however, also be determined by the need for the construction of new or updated port facilities; port safety; the need to provide for water quality improvement by reducing the impacts of polluted sediment on the water column and on the flora and fauna of the area; and the need to improve aquatic habitat. Each of these potential needs was carefully considered in the SEWRPC Milwaukee Harbor estuary study, and was reevaluated under the regional water quality management plan update.

CURRENT NAVIGATIONAL DREDGING ACTIVITIES IN THE LAKE MICHIGAN INNER AND OUTER HARBOR AREAS

Dredging and the disposal of the dredged materials is presently carried out within the Milwaukee Harbor estuary for maintenance of adequate water depths for commercial navigation. Dredged materials are disposed of at the Jones Island Confined Disposal Facility (CDF) constructed by the U.S. Army Corps of Engineers (USCOE) in 1975 along the shoreline of the southern portion of the outer harbor (see Map 79). As shown on Map 79, the current USCOE dredging program is focused on the outer harbor where a 28-foot depth below the established low water datum is authorized and maintained; the main gap from the outer harbor into Lake Michigan where a 30-foot depth is authorized and maintained; a short reach of the Milwaukee River downstream of E. Buffalo Street where a 21-foot depth is authorized and maintained; the Menomonee River from N. 20th Street extended to its confluence with the Milwaukee River where an 18-foot depth is currently maintained, although a 21-foot depth is authorized; the South Menomonee Canal where an approximately 16-foot depth is maintained, although a 21-foot depth is authorized; and the Kinnickinnic River from S. Kinnickinnic Avenue to the Union Pacific Railroad swing bridge, where a 21-foot depth is authorized and maintained and from the swing bridge to the confluence with the Milwaukee River where a 27-foot depth is authorized and maintained. The reach of the Milwaukee River estuary upstream of E. Buffalo St. that was historically dredged has now been Federally deauthorized and is no longer dredged. The reach of the Menomonee River from N. 25th Street downstream to N. 20th Street extended and the Burnham Canal, where 21-foot dredging depths are authorized, are part of the USCOE “backlog” and they have not been regularly maintained in recent years.

The Port of Milwaukee dredges within the municipal mooring basin along the Kinnickinnic River (27-foot-depth) and in the ship slips in the outer harbor, while the slips in the inner harbor are maintained by private concerns.

DREDGING NEEDS

Dredging for Navigation

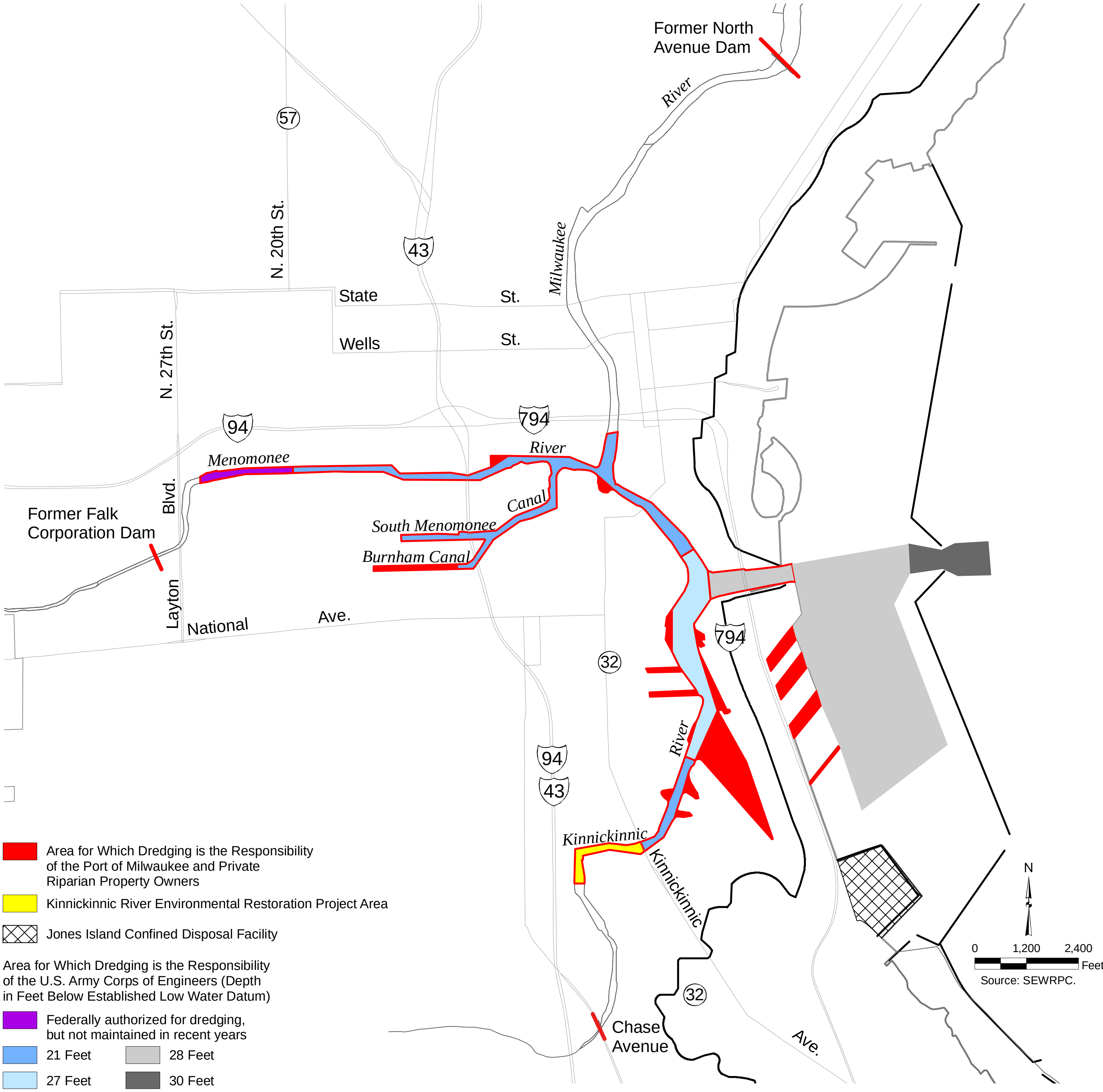
Materials deposited by sedimentation in the inner harbor and outer harbor, if not removed by dredging, become a hindrance to commercial navigation and related activities in the Port of Milwaukee. Commercial vessels cannot operate at full capacity—or in extreme cases, at all—if shallower waters that are the result of sediment accumulation in the channels, mooring basin, and outer harbor must be negotiated. In order to accommodate the draft of large lake- and sea-going commercial vessels, the channels of the St. Lawrence Seaway are intended to be uniformly constructed and maintained at 27 feet below established low water datum.[96] Since the viability of the Port of Milwaukee and industries along portions of the estuary depend, in part, upon the economical operation of such lake- and seagoing vessels, the Milwaukee Harbor estuary should be maintained at similar depths. The extent of the dredging recommended for navigation maintenance is shown on Map 79, which also shows the depths to be maintained by dredging. With the exception of the Menomonee River upstream of N. 20th Street extended, where navigational dredging is not considered to be necessary, the recommended dredging depths are consistent with the Federally authorized depths.

No substantial additional dredging is presently envisioned in the Milwaukee Harbor estuary. Should projects develop requiring such work, additional dredged materials will be generated. However, such quantities would likely be limited and would have a minimal effect on the recommended dredging methods and dredged material disposal facilities.

[96] *Lake level fluctuations may intermittently complicate port access and management of vessels.*

Map 79

RECOMMENDED DREDGING ELEMENT OF THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE



Dredging for Water Quality Improvement

Dredging for water quality improvement was not specifically recommended under the Milwaukee Harbor estuary study; however, the toxic substances management plan element did recommend that a second level, detailed study of the problems associated with toxic substances in the bottom sediments of the Milwaukee Harbor estuary be conducted. Since the Harbor estuary study was published, the need for dredging in the Kinnickinnic River in the reach from W. Becher Street downstream to S. Kinnickinnic Avenue has been identified under the RAP process for the Milwaukee Estuary AOC.[97] The Kinnickinnic River Environmental Restoration Project, which is scheduled for implementation during 2008 and 2009, calls for 1) dredging up to 170,000 cubic yards of sediments contaminated with polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), which will remove about 90 percent of the PCB mass in the project area, and 2) creating an 80-foot-wide, 20 to 24-foot-deep navigational channel.[98] It is proposed to place the dredged material in the CDF, which would essentially exhaust the existing capacity of the CDF.[99]

It is recommended that the Kinnickinnic River Environmental Restoration Project be implemented and that implementation of the Milwaukee Estuary Remedial Action Plan be continued and supported.

Dredging to Improve Aquatic Habitat

Another consideration regarding dredging is the need to improve aquatic habitat within the estuary. Detailed inventories of the existing habitat were conducted as part of the 1987 SEWRPC Milwaukee Harbor estuary study, and the findings documented in Chapter VI of Volume One of that report. Review of the conditions documented in the Harbor estuary study supplemented by information collected under the regional water quality management plan update effort, indicates that no widespread dredging should be undertaken to improve aquatic habitat. This conclusion was reached because the inventories found that there are adequate localized areas within the inner harbor that provide suitable feeding, cover, and spawning habitats for warmwater fish and aquatic life, even though habitat conditions for a desirable fishery throughout most of the inner harbor are generally poor. For example, in the reach of the Milwaukee River from the North Avenue dam to N. Humboldt Avenue, there are numerous scoured areas with a substrate of rocks, sand, and hard clay. In addition, WDNR has implemented several restoration projects to enhance gamefish spawning habitat and nursery areas such as located just downstream of the site of the former North Avenue dam walleye spawning shoal.[100] Inventory data indicate that many warmwater fish species, including walleye, smallmouth and largemouth bass, northern pike, bullhead, catfish, suckers, carp, and sunfish, currently spawn in this reach. Similarly, there are localized shallow areas in the upper ends of the Menomonee and Kinnickinnic River estuaries, as well as in the upper ends of the Burnham and South Menomonee Canals, that support rooted aquatic vegetation that is used for spawning by northern pike, yellow perch, carp, and sunfish. Many of the fish that spawn in the inner harbor migrate in from Lake Michigan during spring and summer. As a result of pollution abatement actions including the MMSD Water Pollution

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[97]*Altech Environmental Services, Inc.,* Final Report – Sediment Sampling from the Kinnickinnic River, Milwaukee, Wisconsin, *prepared for U.S. Army Corps of Engineers Detroit District, March 2003.*

[98]*Barr Engineering,* Concept Design Documentation Report Kinnickinnic River, Wisconsin Milwaukee Estuary Area of Concern Sediment Removal, *prepared for U.S. Army Corps of Engineers Detroit District and Wisconsin Department of Natural Resources, April 2004.*

[99]*The U.S. Army Corps of Engineers and the Great Lakes National Program Office of the USEPA have conducted research at the Jones Island CDF to determine the feasibility of bioremediating dredged material contaminated with PAHs and PCBs. If contaminated dredged material can be cost-effectively cleaned to satisfy the requirements for beneficial use, it could allow the service life of the CDF to be extended by treating, removing, and beneficially using dredged material. Currently, this technology does not appear to be sufficiently developed to affect CDF capacity over the period of this plan update.*

[100]*Wisconsin Department of Natural Resources,* Milwaukee River Estuary Habitat Restoration Project Fact Sheet, *2006.*

Abatement Program with its construction of the Inline Storage System, inputs of organic material and other pollutants into the estuary through combined sewer overflows and other sources of pollution have been reduced. These reductions coupled with decomposition and flushing of organic materials have resulted in riverbeds with cleaner sediments containing less organic matter. Thus, existing localized areas providing habitat have been improved for the maintenance of a limited, yet diverse, population of warmwater fish within the inner harbor.

Within the outer harbor, the existing bottom sediments, although in some locations classified as heavily polluted, are known to be conducive to the successful propagation of diverse populations of warmwater fish and aquatic life. The Milwaukee Harbor estuary study concluded that further site-specific analyses could indicate that it would be desirable to dredge or otherwise modify selected small areas within the estuary in order to improve habitat for aquatic life. However, it is recommended that such limited dredging be considered only if site-specific evaluation or findings support such a need.

Conclusion Regarding Dredging Needs

In view of the above, it is recommended that dredging be limited primarily to the areas and depths noted on Map 79.

DREDGED MATERIAL DISPOSAL

The USCOE Detroit District recently completed a dredged material management plan for the Milwaukee Harbor.[101] That study addresses future dredged material disposal needs from continued navigational dredging and from the USEPA/WDNR Kinnickinnic River Environmental Restoration Project. The study estimates that disposal of the approximately 176,000 cubic yards of dredged material from the Kinnickinnic River Project would use up the remaining capacity in the Jones Island CDF by about 2011. The dredged material management plan is designed to provide an additional 510,000 cubic yards of capacity, which is expected to meet dredged material disposal needs for 20 years beyond 2011. The alternatives considered under the USCOE dredged material management plan include:

- Alternative No. 1–Construct the Milwaukee Harbor (Jones Island) Dredged Material Disposal Facility (DMDF) on top of the existing Jones Island CDF. Capital cost = $3.5 million.

- Alternative No. 2–Construct a DMDF adjacent to the existing Jones Island CDF (A version of this alternative was recommended under the 1987 SEWRPC Milwaukee Harbor estuary study.) Capital cost = $12.3 million.

- Alternative No. 3–Open Water placement of dredged material. Capital cost = $8.3 million.

- Alternative No. 4–Beach Nourishment. Dredged material is fine-grained with low, but detectable levels of PCBs, PAHs, and metals. Fine-grained nature of sediment makes it unsuitable for beach nourishment, and sediment would not meet State of Wisconsin standards for beneficial use of solid waste because of pollutant concentrations.

- Alternative No. 5–No Action.

Based on cost, water quality considerations, and permitting considerations, the USCOE dredged material management plan recommends that Alternative No. 1 be implemented. That alternative plan calls for constructing a raised perimeter dike offset from the existing CDF dikes. The top of the perimeter dike would be about eight feet above the existing dikes. Under the recommended plan, it would be possible to mound the spoil pile within the facility to an elevation about five feet above the raised perimeter dike. Consistent with the recommendation of the 2007 USCOE Detroit District study, under this regional water quality management plan update it is

[101]*U.S. Army Corps of Engineers Detroit District,* Phase II Report – Draft Dredged Material Management Plan Study and Environmental Assessment – Milwaukee Harbor, Wisconsin, *November 2007.*

recommended that the Jones Island CDF be expanded by constructing a dredged material disposal facility on top of the existing CDF.

Fisheries Protection and Enhancement

The maintenance and rehabilitation of the warmwater and coldwater sport fishery, key natural resources in the study area, are important components of this water quality management plan. Based upon an analysis and review of historic and recent fisheries surveys, fishery conditions in the greater Milwaukee watersheds study area range from very-poor to relatively excellent. The streams and lakes of the study area are generally capable of supporting a quality warmwater sportfish community, with capabilities of supporting coldwater sportfish communities in some areas (see Chapters III through IX in SEWRPC TR No. 39).

The watershed ecosystem is a continuum including the stream, the wildlife, all the other natural resources, and most importantly, the local citizens who reside there. In order to sustain the ecology of the watershed, action should not solely focus on the fishery. Other key natural resource features located throughout the greater Milwaukee watershed study area will need to be maintained and/or enhanced if the study area is to sustain a viable fishery. As recommended elsewhere in this report, to preserve and enhance the interconnection between the watershed's ecosystems, actions should focus on the restoration and management of declining habitats found not only within the stream, but also within the watershed as a whole.

There are a number of issues that affect the quality of the fisheries resource that should be addressed to ensure the continued maintenance and future productivity of the fishery. These issues are related to existing and forecast changes in land use and the associated effects of those changes on stream hydrology, water quality, aquatic habitat quality, and streambank stability. This subsection sets forth the recommended fisheries management plan, which was developed to complement and to be consistent with the other plan recommendations regarding land use, point and nonpoint source pollution control, runoff management, and environmental monitoring.

Specifically, these recommendations follow actions recommended by WDNR for habitat improvement of stream systems.[102] These include the following: 1) enhancement of streambank stability, 2) limitation of instream sediment deposition, 3) implementation of techniques to moderate the effects of channelization, and 4) restoration of instream and riparian habitat.[103] Implementation of these actions will improve water quality, including water clarity and temperature regime, and improve the quality/quantity of food resources and habitat for fish and other aquatic species.

The following recommendations were formulated as an outgrowth of the assessment of fish and aquatic life resources set forth in Chapters V through IX of SEWRPC TR No. 39, the companion to this planning report. These recommendations are made to supplement or reinforce related recommendations set forth above to control point and nonpoint sources of pollution, to establish riparian buffers, and to restore and rehabilitate stream channels where feasible. Implementation of the recommendations would help to protect and reestablish a high-quality native warmwater and/or coldwater fishery where appropriate.

1. To the extent practicable, protect remaining natural stream channels, including small tributaries and shoreland wetlands that provide habitat for the continued survival, growth, and reproduction of a sustainable fishery throughout the study area.

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[102]*Wisconsin Department of Natural Resources,* A Review of Fisheries Habitat Improvement Projects in Warmwater Streams, with Recommendations for Wisconsin, *Technical Bulletin No. 169, 1990.*

[103]Ibid.

2. Restore wetlands, woodlands, and grasslands adjacent to the stream channel and establish minimum buffers 75 feet in width to reduce pollutant loads entering the stream and protect water quality.[104]

3. Restore, enhance, and/or rehabilitate stream channels to provide increased quality and quantity of available fisheries habitat—through improvement of water quality, shelter/cover, food production, and spawning opportunities—using management measures that include, but are not limited to:[105]

   - Minimize the number of stream crossings and other obstructions to limit fragmentation of stream reaches.

   - Stabilize stream banks to reduce erosion.

   - Limit instream sedimentation and selectively remove excessive silt accumulations.

   - Reestablish instream vegetation and bank cover to provide fish with shelter from predators, food, spawning areas, and protection from floods.

   - Realign channelized reaches of streams and remove concrete lining to provide heterogeneity in depth (e.g., alternating riffle and pool habitat), velocity or flow regime, and bottom substrate composition.

   - As opportunities arise when roadways crossing streams are replaced or reconstructed, remove or retrofit obstructions such as culverts, dams, and drop structures that limit the maintenance of healthy fish and macroinvertebrate populations.

4. Monitor fish and macroinvertebrate populations in order to evaluate the effectiveness of the water quality management program.[106]

5. Consider more intensive fisheries manipulation measures—in terms of removal of exotic carp species and/or stocking of gamefish or other native species—where warranted based upon specific goals and objectives established for each project site, reach, or subwatershed, based on detailed local level planning, throughout the study area.

It is recommended that the locations for carrying out the recommended stream restoration measures be developed with the guidance and direct involvement of the WDNR, based upon site-specific field evaluations.

Inland Lake Water Quality Measures Plan Subelement
The inland lake water quality management measures described in Appendix Q are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Auxiliary Water Quality Management Plan Subelement
The auxiliary water quality management measures described in this report subsection are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

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[104]*See the subsections of the nonpoint source pollution abatement plan subelement that are entitled "Riparian Buffers" and "Conversion of Cropland and Pasture to Wetlands and Prairies."*

[105]*See the "Watercourse-Related Plan Elements" subsection of the point source pollution abatement plan subelement.*

[106]*See the "Water Quality Monitoring" subsection of the auxiliary water quality management plan subelement.*

Public Beaches

There is continuing public concern about water quality at public beaches along Lake Michigan and inland waterbodies. While water quality has improved at some public beaches, others continue to be closed or subject to water quality advisories because of high counts of bacteria. Based upon an extensive bacteriological fate and transport study by MMSD, local beach-specific sources were found to be major contributors of bacterial contamination to public beaches despite the close proximity to the Milwaukee Harbor Estuary and its associated pollutant loads. Because of this, the recommended water quality management plan includes recommendations for addressing water quality at public beaches. It is recommended that current public health monitoring programs at public beaches along Lake Michigan and inland waterbodies be maintained, and where possible, expanded to include public beaches that are not currently monitored. Monitoring agencies should continue to disseminate information regarding water quality at public beaches, including water quality advisories, both through postings at the beaches and through broadcast and internet media. In 2004, the Wisconsin Beach Monitoring Program developed advisory signs to inform the public about water quality conditions based on testing for *E. coli*. These signs were used on monitored beaches during the 2006 beach season. A green informational sign is posted when *E. coli* counts are below the 235 count per 100 ml standard for issuing advisories. This sign also gives a general warning, indicating that natural bodies of water will always hold some risk. In addition, local health departments have the option of posting a blue sign indicating good water quality with the green sign. A yellow “caution sign” is posted when the standard for issuing advisories is exceeded and a red “closed” sign is posted when concentrations of *E. coli* exceed 1,000 cells per 100 ml.

It is recommended that:

- Beaches with high frequencies of closings and water quality advisories due to high bacteria counts be evaluated for local sources of contamination, and that appropriate remedies be designed and implemented based on the findings of these evaluations.

- Sanitary surveys to identify sources of pollution be performed at beaches with high bacteria counts and that those surveys apply USEPA standards.[107]

- Current programs of beach grooming be continued and expanded to beaches currently not groomed. The grooming methods used should be chosen to minimize persistence of water quality indicator organisms, such as *E. coli*, in beach sand.

A better understanding of the scope and sources of bacterial contamination to Lake Michigan beaches is necessary in order to design appropriate source controls and to track the performance of those controls. As noted in a previous subsection, it is recommended that research to determine the public health impacts of bacterial contamination and appropriate measures to mitigate contamination to area watercourses be supported.

Waterfowl Control

Waterfowl, especially gulls, can be a significant source of fecal coliform bacteria to the waters of the study area. This is especially true at Lake Michigan beaches. Some programs are in place to discourage waterfowl from concentrating in certain locations, including 1) informational signs in Milwaukee County parks asking that park users not feed geese and noting the detrimental effects of concentrated flocks of geese, 2) programs to limit hatching of geese through treating unhatched eggs, and 3) landscaping which reduces the attractiveness of areas to waterfowl use. Gulls are a protected species, so measures directed towards their control are somewhat limited.

It is recommended that programs be implemented to discourage unacceptably high numbers of waterfowl from congregating near beaches and other water features. These measures could include expanded use of informational

[107]*Twenty coastal beaches in Wisconsin with high bacteria counts, including McKinley and South Shore beaches in Milwaukee County, were selected for sanitary surveys paid for through grants from the Great Lakes Protection fund.*

signs regarding the negative aspects of feeding waterfowl, ordinances prohibiting the feeding of waterfowl, covering trash receptacles at beaches and water features, vegetative buffers along shorelines that discourage geese from congregating, and other, innovative measures such as trained dogs. The effects of implementing programs to control waterfowl were not explicitly represented in the water quality modeling analyses.

Coastal Zone Management

The coastal areas along Lake Michigan represent a valuable resource and important legacy to Southeastern Wisconsin, making protection of these areas an important element in protecting the integrity of the nearshore areas of the Lake. Because of this, the recommended water quality management plan includes recommendations relating to coastal zone management. To coordinate management efforts for Lake Michigan among the many units of government, institutions, and organizations involved in management of the Lake, the U.S. Environmental Protection Agency has developed a Lakewide Management Plan. That plan contains recommendations regarding a number of issues, including ballast water control, control of combined and separate sanitary sewer overflows, development of agricultural pollution prevention strategies, remediation of legacy contaminated sediment sites, protection of drinking source water, protection of wildlife habitat, stewardship actions, implementation of Great Lakes Areas of Concern Remedial Action Plans, fisheries management, and filling of gaps in data on the Lake. The plan calls for biennial updates for review and revision of goals, strategies, and recommendations.[108] It is recommended that the Lake Michigan Lakewide Management Plan continue to be implemented and refined. To this end, it is also recommended that liaison and linkages be maintained with local, State, and Federal Great Lakes programs. It is recommended that the WDNR perform this role through their Office of the Great Lakes. In addition, shipping and harbor management programs and activities should be coordinated with environmental management programs and activities. Examples of activities to be coordinated include dredging and sediment remediation programs, ballast water management programs,[109] and toxic contaminant management strategies. The WDNR could play an important role in this coordination. It is envisioned that the Wisconsin Coastal Zone Management Program and the University of Wisconsin Sea Grant Program will continue to provide necessary funds and research-oriented resources to State and local governments.

Water Pollution Control

Household Hazardous Waste Collection

Improper disposal of household hazardous wastes can introduce pollutants into the environment, leading to contamination of surface waters and groundwater. Within its service area, the MMSD conducts a household hazardous waste collection program. In addition, most counties and several municipalities within the greater Milwaukee watersheds conduct household hazardous waste collection programs. The MMSD facilities plan recommends that MMSD continue its household hazardous waste collection program at the three permanent sites located in the Cities of Franklin and Milwaukee and the Village of Menomonee Falls and that MMSD continue providing waste collection at temporary collection sites between April and October each year. It is recommended that collection programs for household hazardous wastes be continued and supported. In addition, it is recommended that those communities not served by such programs consider developing and instituting them.

Emerging Issues

Recommendations are made regarding the following emerging issues.

Pharmaceuticals and Personal Care Products

Contaminants of emerging concern include pharmaceuticals and personal care products. Recent research shows that these contaminants are entering lakes, rivers, and streams and may be producing adverse effects on fish and other aquatic organisms. These compounds can enter surface waters in a number of ways. These include disposal

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[108]*The initial plan and subsequent updates are available for download from the USEPA at http://www.epa.gov/glnpo/michigan.html.*

[109]*As of the date of this report, the State of Wisconsin was investigating the feasibility of implementing a centralized ballast water treatment system for the Port of Milwaukee.*

of medicines or products through flushing down the toilet; disposal of medicines or products by pouring down the drain; and excretion of medications by humans, pets, or farm animals. The extent of the threat posed to human health and to the integrity of surface waters by the presence of these compounds is not currently known. Several factors account for this lack of knowledge. These categories represent a large number of chemical compounds. The concentrations of most of these compounds in surface waters have not been examined. The biological and toxicological effects of many of these compounds have not been characterized, especially at environmentally relevant concentrations. Few data are available on the fate of these compounds in the environment. Studies examining the presence of these compounds in the environment or the toxicological properties of these compounds have generally not examined their metabolites and transformation products, which may be biologically active.

It is recommended that assessments and evaluations be made of the significance for human health and for aquatic and terrestrial wildlife of the presence of pharmaceuticals and personal care products in surface waters. Ongoing research regarding the presence, effects, and fates of these compounds in the environment should continue to be monitored. As a part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, nine stream sites and three harbor sites will be sampled quarterly for two years for the presence of pharmaceuticals and personal care products in the water column, bed sediment, sediment pore water, and biota. It is recommended that this project be supported.

Given the uncertainty regarding the threat posed by these substances, it would be protective of human health and the integrity of surface waters to reduce inputs of these materials into the environment. Because of this, it is recommended that periodic collections of expired and unused medications be conducted. The WDNR has issued guidance on regulatory aspects of collecting unwanted household pharmaceuticals.[110] The MMSD facilities plan recommends that MMSD continue to support the periodic collection of pharmaceuticals as part of its Household Hazardous Waste Collection program. Because some of these compounds are considered controlled substances and are strictly regulated by the U.S. Drug Enforcement Administration, such collections will require the participation of local law enforcement departments. In addition, Wisconsin allows some unused cancer and chronic disease drugs and supplies to be donated to participating pharmacies or medical facilities for use by other patients. Rules governing this are set forth in Chapter HFS 148 of the *Wisconsin Administrative Code*. Consideration could also be given to establishing collection centers for pharmaceuticals at law enforcement offices. It is important to note that under current Wisconsin hazardous waste rules, unless the collected household pharmaceuticals are screened to exclude those that are also considered hazardous waste under the Federal Resource Conservation and Recovery Act, law enforcement offices participating in this sort of collection would be regulated as permanent household hazardous waste collection facilities. The inability or reluctance of law enforcement agencies to comply with hazardous waste requirements might discourage participation in this sort of collection option.[111]

Exotic Invasive Species

The introduction and spread of exotic invasive species continues to be a problem in the greater Milwaukee watersheds and Lake Michigan. The presence of exotic species in a habitat can produce alterations in physical and biological characteristics of the habitat. Since the early 19th century, at least 145 exotic species have become established in the Great Lakes. Discharge of ballast water by ships is a significant source of exotic invasive

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[110]*Wisconsin Department of Natural Resources,* Collecting Unwanted Household Pharmaceuticals: Regulatory Guidance for Organizers of Household Pharmaceutical Collection Events, *Pub. WA-1025-2006, August 9, 2006.*

[111]*Effective June 27, 2006, the WDNR developed an enforcement discretion memorandum, effective for one year, that conditionally exempted from the State's hazardous waste and solid waste rules household pharmaceutical waste collected by law enforcement officials or collected at household pharmaceutical waste collection facilities or events. This enforcement discretion memorandum was extended for an additional two-year period (to June 27, 2009), during which time the WDNR was to evaluate both the impacts of the policy and the possibility of revising the Department solid and hazardous waste rules.*

species to the Great Lakes. In addition, exotic invasive species such as common carp, Eurasian water milfoil, and zebra mussels have become established in some lakes and streams in the greater Milwaukee watersheds. Typically, populations of exotic invasive species can grow rapidly, due to both the high reproductive capacities of these organisms and the absence of predators, parasites, pathogens, and competitors in their new habitat. Once established in a waterbody, these species can rarely be eliminated. In addition, many of these species are capable of readily dispersing to other waterbodies. In many cases, this dispersal is aided by direct or indirect human intervention.

A number of programs have been developed to educate the public about exotic invasive species and to reduce the spread of exotic invasive species to inland waters, including the Watercraft Inspection Program and the Clean Boats, Clean Waters Program, both sponsored by the WDNR; aquatic invasive species educational materials, workshops, and outreach programs, all sponsored by the University of Wisconsin-Sea Grant Institute, University of Wisconsin-Extension, and the Wisconsin Association of Lakes. It is recommended that programs to reduce the spread of exotic invasive species be continued and supported. It is also recommended that programs to educate the public about exotic invasive species be continued and supported.

Water Temperature and Thermal Discharges

Water temperature is a critical variable affecting the suitability of a waterbody as habitat for aquatic organisms. Because the solubility of oxygen in water and the metabolic demands of aquatic organisms are strongly affected by temperature, excessively high water temperatures can act to exclude species of organisms from habitats which they might otherwise use. This is especially important for species that are intolerant of low dissolved oxygen concentrations. Because of these relationships, thermal discharges can act to alter the suitability of a waterbody as habitat. It is recommended that the WDNR develop a policy regarding water temperatures and thermal discharges into waterbodies.

Global Climate Change

Recent projections from global climate models suggest that patterns and frequency of precipitation in the Great Lakes area may change over the course of the next century. Should such changes occur, it is possible that they will cause alterations in stream hydrology and potentially affect sewerage systems and the capacities needed for wastewater treatment. It is recommended that future updates of this plan consider precipitation patterns and frequency and streamflow data and compare those data to the historical record.

Water Quality Monitoring

The land use, surface water quality, and auxiliary elements of the recommended plan contain proposed actions, which when taken together, should enhance and/or help preserve the surface water quality of the streams and lakes in the greater Milwaukee watersheds study area. It is also important that steps be taken to ensure the existence of a sound program of water quality monitoring to determine the extent to which water use objectives and their supporting standards and criteria are met over time, to measure temporal and spatial trends in the quality of surface waters, to provide data to evaluate the effectiveness of water pollution control measures, and to detect new and emerging water quality problems. It is important that such a monitoring program integrate and coordinate the use of scarce monitoring resources of multiple agencies and groups, generate monitoring data that are scientifically defensible and relevant to the decision-making process, and manage and report water quality data in ways that are meaningful and understandable to decision makers and other affected parties. Toward these ends, the recommended water quality management plan includes recommendations for water quality monitoring.

Evaluation of Existing Water Quality Monitoring and Data Collection Programs

Considerable effort is currently being expended on monitoring in some portions of the greater Milwaukee watersheds study area. The MMSD has conducted a long-term monitoring program in the areas that it serves since 1979. The MMSD currently monitors water quality at approximately 100 sampling stations within its planning area. These include stations located along five major streams and rivers and seven tributaries, as well as stations located in the Milwaukee outer harbor and nearshore Lake Michigan areas. The extensive database obtained by this long-term sampling program and by the MMSD/USGS Corridor Study has been invaluable for conducting the water quality analyses and watercourse modeling on which this recommended plan is based. Similarly, the data that would be obtained by continued monitoring at the stations in this network is vital both for evaluating the effectiveness of this plan and for designing future refinements of this plan.

The U.S. Geological Survey (USGS) monitors stream flow at several gages in the greater Milwaukee watersheds study area. The USGS also conducts water quality monitoring at several sampling sites.

The WDNR currently conducts water quality sampling and samples fish and macroinvertebrate populations at sites within the study area as a part of its statewide baseline monitoring and at specifically targeted sites. In addition, the WDNR monitors water quality at two sites within the study area as part of its "long term trend for ambient water quality monitoring program."

Additional surface water quality monitoring has been conducted by a number of organizations including local units of government, lake and stream groups, and colleges and universities, though much of this monitoring has been conducted on a short-term basis.

Despite this considerable effort, no recent data are available to assess the quality of surface waters in much of the greater Milwaukee watersheds study area. There are several dimensions to this lack of data.

First, the availability of water quality data varies greatly with geography throughout the study area. In particular, considerably fewer data exist for those portions of the study area that are outside the area served by the MMSD than for those portions of the area served by the MMSD. This is especially true for data collected at sites with longer periods of record. In part, this difference in coverage reflects the major commitment that the MMSD has made to water quality monitoring in the areas that it serves. Outside of the areas served by the MMSD, there are large data gaps that need to be filled.

Second, the availability of water quality data varies between river system mainstems and tributaries. Fairly large data sets from multiple sampling stations are available along the mainstems of the Menomonee and Kinnickinnic Rivers and Oak Creek and from large portions of the mainstems the Milwaukee and Root Rivers. Far fewer data are available from tributary streams. In the inventories contained in Chapters V through X of SEWRPC TR No. 39, 119 tributary steams were identified in the Kinnickinnic River, Menomonee River, Milwaukee River, Oak Creek, and Root River watersheds and in the Lake Michigan direct drainage area for assessing compliance with water quality standards and criteria related to five water quality parameters[112] during the baseline period.[113] Observed data were available to assess compliance with standards or criteria for all five parameters for only eight tributary streams. This represents less than 7 percent of the tributaries identified. Data were available for assessing compliance with standards or criteria for at least one of these parameters for another 20 tributary streams, representing less than 17 percent of the tributaries identified. It is important to note that these numbers reflect the tributaries for which any data were available. For many tributaries, these assessments were based upon small numbers of samples. For about half the tributaries assessed, the assessment of compliance was based on 15 or fewer samples. In some cases, the assessments were based on five or fewer samples.[114]

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[112]*The water quality parameters used in these assessments were dissolved oxygen concentration, temperature, ammonia concentration, total phosphorus concentration, and concentration of fecal coliform bacteria.*

[113]*The baseline was initially set as 1998-2001. During the course of the study, more recent data were incorporated into analyses as they became available. Thus, the baseline period used for these assessments in the Menomonee River, Kinnickinnic River, and Oak Creek watersheds was 1998-2001. Because more recent data were available when the analyses were conducted, the baseline period used for these assessments in the Milwaukee River and Root River watersheds and the Lake Michigan direct drainage area was 1998-2004.*

[114]*The water quality models described in Chapter V of this report were applied to assess anticipated future water quality conditions for screening alternative, alternative plan, and recommended plan conditions. Through application of the models, assessment of water quality conditions was possible at many more locations than those*
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Third, there are distinct differences among water quality parameters in the amount of data collected. This is illustrated by the differences in the number of samples examined for the parameters used to assess compliance with water quality standards and criteria in the set of tributary streams described above. For each parameter (dissolved oxygen, temperature, ammonia, and total phosphorus), data collected during the baseline period were available from 24 tributaries. For fecal coliform bacteria, data collected during the baseline period were available from 10 tributaries. In some cases, the lack of data for some water quality parameters complicates the interpretation of data on other water quality parameters. For example, the toxicity of several metals to fish and other aquatic organisms is dependent upon the hardness of the water. Without data on hardness, it cannot be determined whether concentrations of these metals in water pose a threat to aquatic organisms or comply with water quality criteria. Similar relationships exist between the toxicity of ammonia to fish and other aquatic organisms and temperature and pH. Some of the variation in which parameters are sampled is related to the fact that many of the samples were collected as a part of short-term sampling conducted in support of projects related to specific issues with the suite of water quality parameters examined having been determined by the needs and objectives of the projects. It needs to be recognized that, in many cases, data from samples collected from a waterbody under these circumstances will be the only data available for the waterbody during a given time period and are likely to be used for purposes beyond those that motivated their collection. Given this, it is desirable that any sampling conducted include as large a suite of water quality parameters as is practicable and affordable. At the least, those water quality parameters that can be assessed at relatively low cost and effort should always be examined in any sampling. Examples of these parameters include those that can be examined through the use of electronic meters such as dissolved oxygen, pH, specific conductance, and temperature as well as those that can be examined through the use of relatively inexpensive equipment, such as Secchi depth and streamflow. It should be noted that this unevenness in sampling of different parameters is not a significant problem in the areas served by the MMSD, because the MMSD collects data on a consistent set of water quality parameters in its long-term monitoring program.

Recommendations Regarding Monitoring and Data Collection

It is recommended that the surface water quality monitoring programs currently being conducted by the WDNR, the USGS, and the MMSD be supported and continued. In addition, the USGS stream gauging program should be maintained as a minimum and expanded when possible (see below). It is also recommended that these agencies and other agencies conducting monitoring review and evaluate their monitoring programs in order to refine their monitoring strategies to address some of the data gaps identified above. Examples of possible refinements include moving some sampling stations from sites along the mainstems of rivers with multiple sampling stations to sites along tributary streams that are not currently being monitored and reducing the frequency of sampling at some sampling stations in order to redirect some monitoring effort to streams not being monitored. However, any changes must consider the tremendous value of the existing long-term monitoring stations before changes are made. Phase III of MMSD's corridor study database will provide recommendations on the entire sampling and monitoring protocol, which should identify gaps or other necessary changes or modifications. Changes in sampling may not require changing stations or the addition of new sites, but a greater emphasis on sampling wet versus dry weather related events for more effective stormwater and facility modeling assessment. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, there will be continuous streamflow gauging along Honey Creek, Lincoln Creek, the Little Menomonee River, the Root River, and the Milwaukee River at Jones Island through 2010. It is recommended that this sampling be continued and supported.

Similarly, on those streams where data are being collected from multiple sampling stations in support of short-term projects, it may be desirable to continue sampling at some stations to provide long-term data. Candidate streams for monitoring within the areas served by MMSD include Mitchell Field Drainage Ditch, Wilson Park Creek, and the Little Menomonee River. Outside the area served by MMSD, there are numerous streams that are

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at which actual water quality data were collected. However, observed water quality data were essential to the calibration of the models, and expansion of the observed water quality database for the study area would enable future refinement of the water quality models through additional calibration.

candidates for monitoring. It is recognized that any such refinements must be made within the context of the objectives of the particular monitoring programs. Any changes should be predicated on the availability of resources, both financial and human, with priority given to maintaining long-term trend stations prior to the addition of new monitoring sites.

As noted above, fewer water quality data exist for those portions of the study area that are outside the area served by the MMSD than for those portions of the area served by the MMSD. To remedy this deficiency, it is recommended that long-term water quality monitoring programs be extended to areas outside of the MMSD service area. At a minimum, water quality and quantity stream gauging monitoring programs should be continued at the USGS sampling stations established or reinstated for this update of the regional water quality management plan. It is important to note that these station locations are positioned at the downstream end of subwatersheds in order to integrate the land use information, water quality, and water quantity to assist in application of modeling techniques.

Some refinements should be made in the choice of which water quality parameters are sampled. It is important to recognize that the numerical values of some water quality criteria are dependent on the values of other parameters. Without information on the value of these other parameters, compliance with the criteria cannot be determined. Because of this, it is recommended that data be collected on temperature and pH whenever ammonia is sampled. Similarly, it is recommended that samples assessed for concentrations of cadmium, chromium, copper, lead, nickel, or zinc also be examined for hardness. In addition, it is recommended that those water quality parameters that can be assessed at relatively low cost and effort always be examined in any sampling. Examples of these parameters include those that can be examined through the use of electronic meters such as dissolved oxygen, pH, specific conductance, and temperature as well as those that can be examined through the use of relatively inexpensive equipment, such as Secchi depth and streamflow.

Refinements should be made in the collection of fish and macroinvertebrate community data. Assessments of the state of fish and macroinvertebrate communities provide information on the biotic integrity of streams and lakes that can be useful because these communities represent the results of the combined effects of numerous environmental variables, including water quality parameters. Such assessments would also be valuable in evaluating the degree of success of implementation of the recommended water quality management plan. In the greater Milwaukee watersheds study area, the use of these assessments to examine and document temporal trends has been hampered by the lack of sites at which repeated sampling has been conducted. It is recommended that long-term fisheries monitoring stations be established and maintained and that fisheries surveys be conducted periodically at these stations to assess species composition and toxicant loads. It is also recommended that long-term macroinvertebrate monitoring stations be established and maintained and that sampling be conducted periodically at these stations to assess species composition of invertebrates. Ideally such sampling should be conducted with recognition of the seasonality and periodicity of organism life cycles. For example, macroinvertebrates should be sampled in the spring or fall, while fish should be sampled in spring, summer, and fall. This ensures the presence of identifiable life stages and good representation of species diversity. With respect to fish assessments this strategy would allow quantification of overwintering survival, reproductive success, available summer habitat, and adult breeding population numbers.

Currently the lack of the long-term data stations makes the interpretation of the biological data difficult and focus of effort in lesser developed areas has resulted in a paucity of data on the more urban reaches of the river systems. For example, a review of the availability of data in the Root River system reveals a lack of recent information in contrast to portions of the Milwaukee River system that have been extensively sampled during the same period. In addition, despite the availability of more than 100 years of fisheries data throughout the study area, it is nearly impossible to statistically determine changes in the biological community during this period. Thus it is recommended that a more rational sampling strategy be adopted. In this regard it is recommended that at a minimum fish community and, where possible, macroinvertebrate assessments be conducted at the long-term water quality monitoring sites at least every two years. These sites include those established by MMSD, USGS, and WDNR within the study area. This would allow the analysis of the biological community in relation to prevailing water quality conditions over time. Inclusion of the additional sites established as part of this regional water quality management plan update planning program in the Upper Milwaukee and Lower Root River watersheds is especially recommended.

Refinements should also be made in the collection of habitat data. Assessments of the state of habitat provide information on the biotic integrity of streams and lakes that can be useful because this bears on the ability of these environments to support healthy biological communities. In the study area, the use of habitat assessments to examine and document temporal trends in habitat condition has been hampered by the lack of sites at which repeated sampling has been conducted. It is recommended that long-term habitat monitoring stations be established and maintained and that surveys be conducted periodically at these stations to assess habitat quality and streambed and streambank stability. In addition, aquatic plant habitat assessments within lakes should be supported and better integrated with fishery survey assessments. Where aquatic plant management measures are being implemented, aquatic plant surveys should be conducted and updated every three to five years, consistent with the requirements for aquatic plant harvesting operations as set forth in Chapter NR 109 of the *Wisconsin Administrative Code*. While applications of aquatic herbicides are not covered in Chapter NR 109, this recommendation would be consistent with parallel provisions of Chapter NR 107 and the refinement of aquatic plant management plans involving use of herbicides is recommended.

The introduction and spread of exotic and invasive species continues to be a problem in Lake Michigan and the greater Milwaukee watersheds. The presence of exotic species in a habitat can produce alterations in physical and biological characteristics of the habitat. As noted previously, since the early 19th century, at least 145 exotic species have become established in the Great Lakes, and some, such as zebra mussels, have dispersed into inland lakes and streams. Because of this, it is recommended that the occurrence and spread of exotic and invasive species be monitored and documented. This monitoring should include monitoring of exotic disease agents capable of infecting fish and other aquatic organisms, such as the virus causing viral hemorrhagic septicemia, and organisms that vector these disease agents.

Given that it is desirable to be able to consolidate data from various monitoring programs to facilitate evaluation of temporal and spatial variation and trends in water quality, it is recommended that agencies and organizations conducting monitoring adopt common quality assurance and quality control procedures. In addition, it is recommended that, to the extent possible, sampling protocols and analysis protocols be standardized across monitoring programs, including both agency programs and citizen-based programs. In order to facilitate the coordination of sampling and the dissemination of water quality data, it is also recommended that current data management systems be maintained and upgraded. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, USGS intends to continue to maintain and enhance the MMSD Corridor Study Database through 2010. It is recommended that this action be supported.

Citizen-based water quality monitoring programs can obtain data on waterbodies that may otherwise go unmonitored. In addition, citizen-based monitoring can act to increase awareness and understanding of local water quality issues and can spur local decisions and action to protect water quality. Several citizen-based programs are active within the greater Milwaukee watersheds. These programs include the WDNR's Wisconsin Citizen Lake Monitoring Network,[115] the UW-Extension's Water Action Volunteers Program, and Riveredge Nature Center's Testing the Waters Program. In many cases the data gathered by the Wisconsin Citizen Lake Monitoring Network form the most comprehensive data set available for the assessment of lake trophic status and changes in trophic status. In addition, in 2006, the Friends of Milwaukee's Rivers began a program in which they recruited and trained volunteer monitors. Data collected by Level I volunteers in their program are submitted to the Water Action Volunteers Program's database. Data collected by Level II volunteers have been submitted for incorporation into publicly accessible WDNR databases. It is recommended that citizen-based monitoring efforts be continued and supported. The methods and protocols used by these programs should be reviewed and upgraded to promote integration of the data they generate with data from agency-based programs. Given the large number of lakes and streams for which no recent monitoring data exist, there is tremendous potential for citizen-based

[115]*Until recently, this was called the Lake Self-Help Program.*

monitoring programs to make a substantial contribution toward filling data gaps. Realizing this potential will require that these programs give high-priority to the monitoring of currently unmonitored waterbodies. It is recommended that, as these programs develop new sampling sites, they target streams and lakes not currently being monitored.

Appendix Q, which sets forth recommendations regarding inland lake management, includes a recommendation that long-term trend lake monitoring programs be established or continued.

As this plan is implemented, it will be important for implementing agencies to have access to monitoring data, in order to fine-tune implementation and to evaluate the effectiveness of water pollution control measures. It is further recommended that the findings of monitoring programs be set forth in reports prepared on an annual basis by the agencies and groups responsible for the data collection. In addition, it is recommended that the monitoring data be made available to agencies involved in plan implementation in a form that is readily usable and can be integrated with data from other monitoring programs.

Maintenance of the Regional Water Quality Management Plan Update/MMSD 2020 Facilities Plan Modeling System

It is recommended that the water quality models developed under the regional water quality management plan update and the MMSD 2020 facilities planning program be maintained and updated at least every 10 years.

Models of the MMSD System

The MMSD facilities plan recommends that MMSD continue to maintain the conveyance system modeling tools and use them for subsequent analysis. The modeling tools developed as a part of the 2020 facilities plans are a series of programs that simulate the flows in the sewersheds, the routing of these flows through the conveyance system (MIS and ISS), and the overall water balance. The simulated results are used to address a wide range of analytical questions ranging from the detailed system response at specific locations in the MIS, to the overall response of the entire system over a long period of time. The modeling tools, as described in Chapter V of this report are:

- Hydrological Simulation Program - FORTRAN (HSPF) (simulates the continuous hydrologic response due to rainfall, snowmelt, and gradual changes in soil moisture conditions)
- Flow Forecasting System (FFS) (simulates the sewershed flows based on calibration to flow meter data)
- Streamlined-MOUSE model (simulates the detailed hydraulic routing in the MIS)
- MACRO model (simulates the overall system response during a long period of time)

Ongoing maintenance of the modeling system will ensure that these models are suitable for subsequent modeling tasks. This will be particularly helpful when modeling results are desired for wet weather events occurring after June 2004 (which is the end of the record used for the 2020 FP analysis). Ongoing maintenance will also be necessary to accommodate refinements to the sewersheds, including calibration refinements that will develop as more flow meter data become available. Furthermore, ongoing maintenance will be necessary to reflect actual or proposed changes in the collection systems or changes in the operating strategies. Because of the interactions between the modeling tools, it is recommended that the modeling system be maintained as a group to insure that the tools remain compatible.

Watershedwide Models Developed for the Regional Water Quality Management Plan Update

It is recommended that the watershedwide riverine water quality model (LSPC), and the hydrodynamic (ECOMSED) and water quality (RCA) models of the Milwaukee Harbor estuary and the nearshore Lake Michigan area be maintained by SEWRPC and updated or refined under future regional-scale water quality management planning efforts in the study area. It is also recommended that MMSD and SEWRPC coordinate maintenance of the watershedwide and MMSD models so that the ability is maintained to transfer data from the MMSD system models to the watershed models. Maintenance of the watershed models may also be useful in future adaptive planning efforts to refine the regional water quality management plan and the MMSD 2020 facilities plan.

GROUNDWATER MANAGEMENT PLAN ELEMENT

As noted in Chapter III of this report, "Existing and Historical Surface Water and Groundwater Conditions," and in Chapter XI, "Groundwater Quality Conditions and Sources of Pollution in the Study Area," of SEWRPC Technical Report No. 39, this regional water quality management plan update was conducted concurrently with the regional water supply study documented in SEWRPC Planning Report No. 52, *A Regional Water Supply Plan for Southeastern Wisconsin*. In general, the recommendations of the regional water supply plan related to protection of groundwater quality are adopted by reference in the plan described herein.

Water Supply Sources in the Study Area

Map 80 distinguishes those municipal water supply systems within the regional water quality management plan update study area which currently utilize Lake Michigan as a source of supply and those systems which utilize groundwater as a source of supply. All of the study area private water supply systems utilize groundwater as a source of supply.

Within the study area, the area served by public water utilities in 2000 encompassed about 256 square miles, or about 23 percent of the total study area. An estimated 1,155,683 persons, or about 90 percent of the population of the study area, were served by public water utilities in 2000. In addition, urban areas not served by public water supplies constitute about 61 square miles, or about 5 percent of the study area. These areas are served by individual wells or by privately or cooperatively owned water systems operating in the study area. These water supply systems typically serve residential subdivisions, apartment or condominium developments, mobile home parks, and institutions.

The entire study area is located within the Great Lakes-St. Lawrence drainage basin. Thus, the use of Lake Michigan as a source of water supply is not a limitation from regulatory and policy considerations. However, given the distance from Lake Michigan and the availability of groundwater resources, much of the study area is expected to continue to rely upon groundwater as a source of supply.

The greatest use of water within the counties located within, or partially within, the study area is for electric power generation, comprising about 87 percent of the usage. Most of the water used for electric power generation is returned to Lake Michigan following use. About 77 and 96 percent of the public water supplies and total water supplies, respectively, within the counties involved, are obtained from Lake Michigan and 23 and 4 percent of the public water supplies and total water supplies, respectively, are obtained from groundwater. Thus, while Lake Michigan is the primary water source in the study area, groundwater sources are a significant component. The preceding sections of this report focus on issues related to surface water quality, including water quality in the nearshore Lake Michigan area. This section of the report, and the following plan recommendations, focus on groundwater quality and quantity.

Plan Recommendations Related to Groundwater

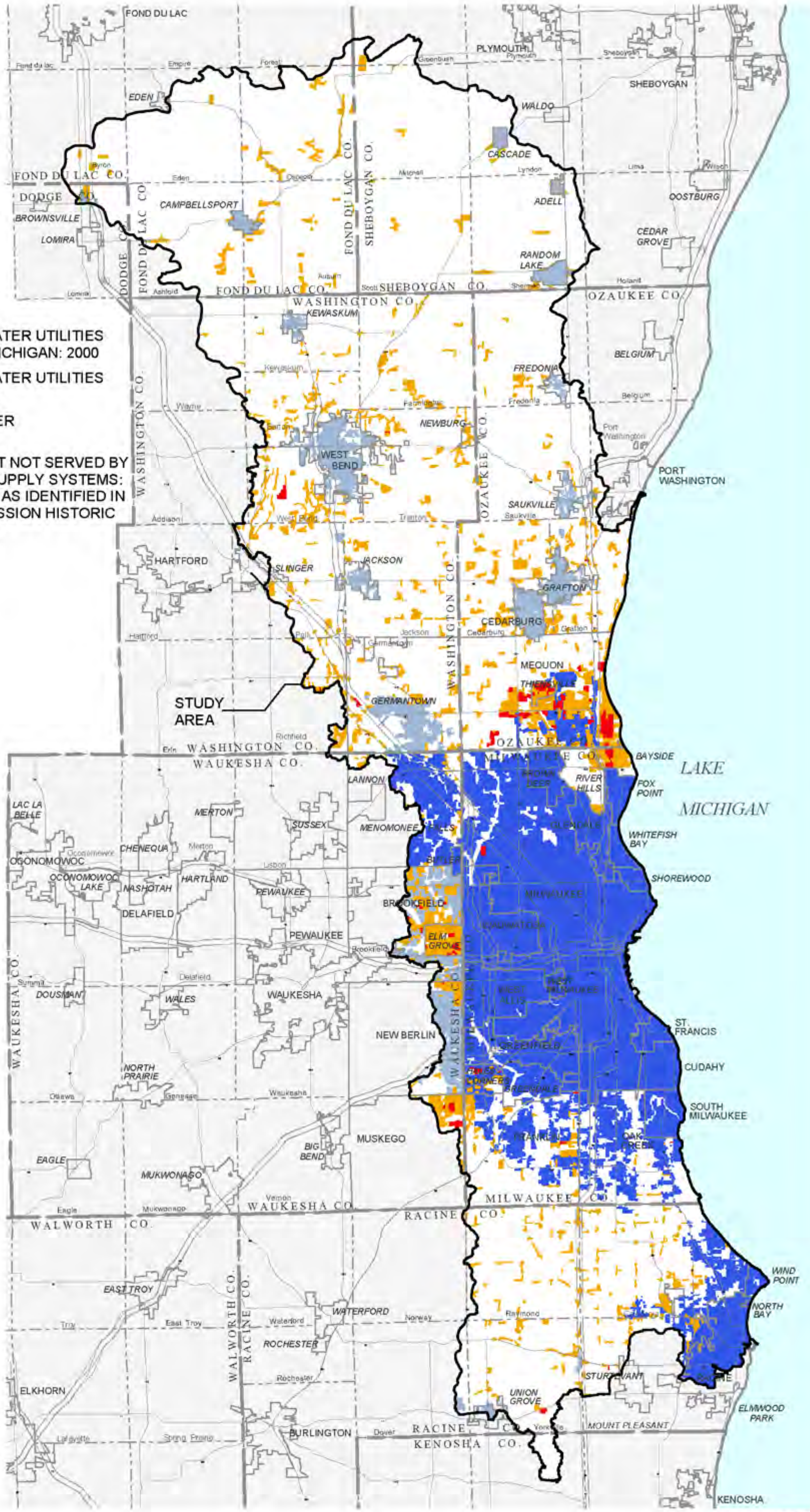
Specific recommendations related to groundwater recharge areas, groundwater sustainability, mapping of groundwater contamination potential, stormwater management measures affecting groundwater quality, issues related to the effects of emergency and unregulated contaminants on groundwater quality, and water conservation are set forth below.

Groundwater Recharge Areas

The most important groundwater recharge areas in that portion of the study area within the Region were identified and mapped under the SEWRPC regional water supply plan. That analysis was based on a deterministic water-balance model developed by the Wisconsin Geologic and Natural History Survey. Such recharge areas should be

Map 80

AREAS SERVED BY MUNICIPAL AND PRIVATE WATER UTILITIES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA



AREAS SERVED BY MUNICIPAL WATER UTILITIES PROVIDING WATER FROM LAKE MICHIGAN: 2000

AREAS SERVED BY MUNICIPAL WATER UTILITIES PROVIDING GROUNDWATER: 2000

AREAS SERVED BY PRIVATE WATER UTILITIES: 2000

EXTENT OF URBAN DEVELOPMENT NOT SERVED BY MUNICIPAL OR PRIVATE WATER SUPPLY SYSTEMS: INCLUDES URBAN DEVELOPMENT AS IDENTIFIED IN THE REGIONAL PLANNING COMMISSION HISTORIC URBAN GROWTH RING ANALYSIS

NOTE: PORTIONS OF THE CITY OF MEQUON SYSTEM WERE CONVERTED TO A MUNICIPAL SYSTEM OVER THE PERIOD 1998 THROUGH 2002.

Source: SEWRPC.

considered for preservation or for the use of development and stormwater management practices which are directed toward maintaining the natural hydrology as one measure to maintain the quality and quantity of groundwater in the shallow aquifer.

Because of the interchange of flow between the shallow aquifer and the streams and lakes of the study area, maintaining the quality and quantity of groundwater in the shallow aquifer has a direct bearing on the quality of surface water resources. Maintenance of cold or cool baseflow from the shallow aquifer to streams or lakes helps to maintain desirable water temperatures in streams and lakes. Maintenance of high-quality baseflow is a significant factor in establishing good water quality over much of each year when streamflow is dominated by baseflow. Finally, the maintenance of an adequate volume of baseflow is essential to providing adequate instream habitat, to maintaining the hydroperiod of wetlands, and to maintaining lake levels.

It is recommended that the groundwater recharge area mapping be extended to those portions of the regional water quality management plan update study area outside of the Southeastern Wisconsin Region (i.e., those portions of Dodge, Fond du Lac, and Sheboygan Counties in the Milwaukee River watershed) and that consideration be given to following the recommendations of the regional water supply plan regarding maintenance of groundwater recharge areas in the entire regional water quality management plan update study area.

Groundwater Sustainability

Under the regional water supply planning process, groundwater sustainability analyses were made for six selected demonstration areas, each selected to represent a range of hydrogeologic conditions. The analyses addressed different combinations of individual or shared common wells and private onsite wastewater treatment systems returning 90 percent of the water used to the groundwater system or public sanitary sewer systems which would remove the wastewater from the groundwatershed concerned. The areas were analyzed to provide guidance on the number of individual household wells or comparable number of shared common wells which could be sustained without significant impacts on the shallow groundwater aquifer system with the intent that the analysis results could be applied to the evaluation of similar developments throughout the Region. It is recommended that the groundwater sustainability guidance results be considered by municipalities in the regional water quality management plan update study area in evaluating the sustainability of proposed developments and in conducting local land use planning.

Mapping Groundwater Contamination Potential

As shown on Map 42 in Chapter IV of this report, the groundwater contamination potential of shallow aquifers in the Southeastern Wisconsin Region was mapped under the SEWRPC regional groundwater program. That mapping does not extend to that portion of the regional water quality management plan update study area in Dodge, Fond du Lac, and Sheboygan Counties. It is recommended that the groundwater contamination potential of the shallow aquifers in those counties be mapped.

Stormwater Management Measures Affecting Groundwater Quality

It is recommended that the design of stormwater management facilities that directly or indirectly involve infiltration of stormwater consider the potential impacts on groundwater quality. Those effects should be a consideration in the design of infiltration facilities such as infiltration trenches, infiltration basins, bioretention facilities, rain gardens, and grassed swales and in the design of stormwater detention basins. The WDNR has developed post-construction stormwater management technical standards for site evaluation for stormwater infiltration, infiltration basins, bioretention facilities, and wet detention basins.[116] Those standards include provisions intended to protect groundwater quality, and it is recommended that the standards be applied in the design of stormwater management facilities.

Chlorides that are applied for snow and ice control on roads are conservative constituents that are often dissolved in stormwater runoff. Stormwater infiltration practices do not treat and remove chlorides dissolved in runoff.

[116]*The technical standards can be found at http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm*

Thus, special safeguards must be applied to avoid adverse effects of chlorides on groundwater quality. The State technical standards recognize the inability of infiltration devices to remove chlorides from stormwater runoff and they suggest reducing, or eliminating the application of chlorides in the area tributary to an infiltration device. The recommendation in the nonpoint source pollution section of this chapter regarding implementing programs to reduce the use of road salt would have a positive effect on groundwater quality as well as surface water quality.

Groundwater Quality Issues Related to Disposal of Emergency and Unregulated Contaminants

The disposal of contaminants, such as pharmaceuticals, personal care products, and endocrine disruptor pharmaceutical products in onsite waste disposal systems or other systems which discharge to the groundwater system (e.g., septic systems, mound systems) can degrade the quality of the receiving groundwater. The water quality management plan subelement subsection of this report includes a recommendation regarding maintaining and expanding collection programs to properly dispose of household products. Implementation of that recommendation would serve to help protect groundwater quality as well as surface water quality.

Water Conservation

Detailed information on regional water conservation issues is set forth in Chapter VII, "Water Conservation," of SEWRPC Technical Report No. 43, *State-of-the-Art of Water Supply Practices*, which is a companion report to SEWRPC Planning Report No. 52. For the purposes of the regional water supply planning effort, a water conservation program is defined as a combination of practices, procedures, policies, and technologies used to reduce the amount of water usage or to improve or maintain water system efficiency. Public interest in, and demand for, water conservation programs are motivated by several factors, including: perceived limitation of water supplies, high costs and difficulties in developing new supplies, and public interest in, and support for, natural resource conservation and environmental protection.[117]

Water supply planning is a task in which water supply utilities must consider meeting the needs of the communities served in a cost-effective fashion. Water supply planning also requires the consideration of the need to protect and sustain the water resources of the Region. Ideally, utilities should consider a full range of supply and conservation strategies in order to assure that both valid system performance and environmental objectives are met.[118] Conservation programs should be developed on a utility-specific basis to find the best means available for meeting the water supply needs, while maintaining the sustainability of the source, or sources, of supply.

Consistent with the regional water supply plan, this water quality management plan update recommends that utility- or community-specific water conservation programs be developed and implemented based upon a number of factors, including the composition of the community water users, the operational characteristics of the utility, the level of efficiency already being achieved, the water supply infrastructure in place, that needed to meet future demands, and the sustainability of the water supply. Another factor which should be considered is the need to develop water conservation programs which are consistent with current and anticipated future rules, regulations, and policies. For example, consideration should be given to consistency with the proposed Great Lakes Charter Annex and the Wisconsin Groundwater Quantity Act and the related activities of the State of Wisconsin Groundwater Advisory Committee.[119] Any water conservation program developed should be flexible and

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[117]*American Water Works Association (AWWA),* Water Conservation Programs-A Planning Manual*, 2006 (11).*

[118]*Great Lakes Commission,* Selected Guidelines of Water Conservation Measures Applicable to the Great Lakes-St. Lawrence Region*, 2002, Available at http://www.glc.org, viewed 08/16/06.*

[119]*The State of Wisconsin Groundwater Advisory Committee was created by 2003 Wisconsin Act 310 to make recommendations to the State Legislature regarding future groundwater management needs in Wisconsin. In this regard, two reports are being prepared and provided to the environmental and natural resources standing committees of the Legislature. In December 2006, the first of these reports was completed. The report provides recommendations on how to manage areas of the State with existing groundwater problems. The second report,*

(Footnote Continued on Next Page)

adaptable to the requirements of such rules, regulations, and policies. In addition, the design and implementation of conservation plans will vary significantly due to the large combinations of measures and programs that each utility or community may utilize. Similar considerations apply to self-supplied water users.

INTEGRATED WATERSHED-BASED APPROACH

As noted previously in this chapter, two approaches were considered in developing the recommended water quality management plan for the greater Milwaukee watersheds. The first approach stems from the concept that the MMSD 2020 facilities plan must meet regulatory requirements. That approach is termed the "Regulatory Watershed-Based Approach" (regulatory approach). The second approach has its genesis in the finding that, because of significant and effective past or committed actions by the operators of wastewater systems and other point source dischargers throughout the study area and measures implemented under WDNR regulatory programs, additional point source controls would result in no significant improvement on an annual basis in overall instream and in-Lake water quality. That alternative approach, which is called the "Integrated Watershed-Based Approach," is presented in this section of the chapter. That approach is predicated on the concepts that if certain, limited components of the MMSD recommended 2020 facilities plan were not implemented 1) there could be a reduction in costs to implement the MMSD facilities plan with no significant change in water quality on an annual basis and 2) in the context of the overall plan costs, and independent of the source of funds for implementation, the foregone cost of eliminating the specific facilities plan components could be applied to nonpoint source pollution control measures that would be more effective in improving instream water quality.

With the exception of the MMSD 2020 facilities plan recommendations regarding increasing the capacity of the South Shore wastewater treatment plant as previously described in the subsection on that facilities plan, all of the preceding recommendations set forth in this chapter are common to both the regulatory and integrated watershed-based approaches.

Options for Providing Additional Capacity at the South Shore Wastewater Treatment Plant
As noted previously in this chapter, the MMSD facilities plan recommends that the treatment capacity of the South Shore plant be increased from the existing capacity of 300 mgd to 450 mgd in order to assist in meeting the recommended five-year level of protection (LOP) for separate sanitary sewer overflows. Although the current maximum design capacity of the plant is 250 mgd, based on actual historical flow data, the 2020 facilities plan uses 300 mgd as the maximum capacity. It is possible that the actual maximum capacity may be even greater than 300 mgd. The MMSD facilities plan recommends that a detailed capacity analysis for the South Shore plant be conducted in order to update the design capacity, and that recommendation is included in the regional water quality management plan update as well. If the capacity of the plant is found to actually be larger than 300 mgd, the need for additional capacity may be reduced, which would reduce the cost of each option for providing additional capacity.

Under the regional water quality management plan update, the following three options were considered for providing an additional 150 mgd in treatment capacity to increase the overall capacity to 450 mgd at the South Shore plant.[120,121]

(Footnote Continued from Previous Page)
which was issued in December 2007, reports on how well the current groundwater law is working to protect the groundwater resources.

[120]*Additional treatment capacity at South Shore is cost-effective because the existing treatment capacity is less than the conveyance capacity of the Metropolitan Interceptor System (MIS) leading to the plant. By increasing the treatment capacity of South Shore to match the conveyance capacity of the MIS, overflows can be reduced at a relatively low cost.*

[121]*Consistent with all economic analyses performed under this planning effort, the present worth and equivalent annual cost analyses are based on a five-year analysis period and a 6 percent interest rate.*

- Implement physical-chemical treatment with ballasted flocculation at an estimated capital cost of $152 million and an estimated annual operation and maintenance cost of $1.7 million. The present worth cost of implementing this option is $218 million and the equivalent annual cost is $13.8 million.

- Implement physical-chemical treatment with chemical flocculation at an estimated capital cost of $97 million and an estimated annual operation and maintenance cost of $1.4 million. The present worth cost of implementing this option is $144 million and the equivalent annual cost is $9.1 million. As indicated previously in this chapter, the MMSD facilities plan recommends a long-term demonstration project of physical-chemical treatment at the South Shore plant, potentially leading to implementation of such treatment as a means of increasing the treatment capacity of that plant. Because of the potential substantial cost saving if physical-chemical treatment with chemical flocculation were implemented rather than physical-chemical treatment with ballasted flocculation, that demonstration project will evaluate physical-chemical treatment with chemical flocculation.

- During peak wet weather events when inflow to the South Shore plant exceeds its capacity, operate the plant to provide preliminary, primary, and secondary treatment and disinfection for 300 mgd in wastewater flows and divert up to an additional 150 mgd in flows that are beyond the plant capacity around secondary treatment, to avoid significant damage to biological treatment units and loss of treatment capability. The diverted flow would be treated with ultraviolet disinfection and then recombined with chlorine disinfected flow from the secondary treatment units prior to discharge. That procedure is referred to as "blending" and is classified as a "controlled diversion" in Section NR 110.03(9) of Chapter NR 110, "Sewerage Systems," of the *Wisconsin Administrative Code*. The discharge must meet permit limits if blending is employed.

  The total capital cost to implement this approach would be about $92 million and the estimated annual operation and maintenance cost is $0.72 million The present worth cost of implementing this option is $122 million and the equivalent annual cost is $7.7 million.

Each of the options described above requires 1) additional influent screening and grit removal, 2) ultraviolet disinfection, and 3) additional effluent pumping and an outfall expansion.

Each of the three options, when combined with the other components of the recommended MMSD 2020 facilities plan, would achieve the same five-year LOP against sanitary sewer overflows and each would maintain the same level of protection against basement backups. Also, each of the options would include ultraviolet disinfection for either the effluent from the physical-chemical treatment process or for the flow diverted around secondary treatment prior to recombination with disinfected flow from the secondary treatment units. Ultraviolet disinfection of the effluent from either physical-chemical treatment or of the diverted flow would provide a level of control of fecal coliform bacteria that would meet existing permit limits.

Recommendation of the MMSD 2020 Facilities Plan

The MMSD facilities plan does not recommend blending at the South Shore wastewater treatment plant (SSWWTP) because it is not allowed in the current WPDES permit and, therefore, a permit modification would be required if it were to be implemented. However, the facilities plan notes that when the permit is renewed in 2008, the issue of blending could be considered. In Section 9.6.8 of the MMSD facilities plan it is stated that:

> "Blending at SSWWTP should also be evaluated as a measure to prevent the potential of surcharging of local sewer systems, which can cause basement backups when the need arises to close the SSO gates to the ISS. In situations when the ISS is nearly full, blending at SSWWTP should be explored as an alternative strategy to closing the SSO gates to the tunnel, which would keep the SSO gates to the ISS open to prevent potential basement backups. This issue should be explored in terms of the re-issuance of the MMSD WPDES permit as another strategy that will reduce the potential of

surcharging of local sewer systems and resulting basement backups. This operational measure could also reduce SSOs."

Implementation of the blending approach described in the preceding paragraph, or of any of the three options for increasing the treatment capacity of the South Shore plant, could be employed to enable the SSO gates to the tunnel to remain open and prevent possible basement backups that might occur under current operating procedures during wet weather events.

Water Quality Effects of the Options for Providing Additional Capacity at the South Shore Wastewater Treatment Plant

Implementation of each of the two physical-chemical treatment options described above would enable the MMSD to meet the effluent limits for total suspended solids, biochemical oxygen demand, and fecal coliform bacteria as established under its WPDES permit. Based on available data, implementation of the blending option would also enable the MMSD to meet the permit effluent limits. As noted previously, the provision of ultraviolet disinfection for either the effluent from the physical-chemical treatment process or for the diverted flow prior to recombination with chlorine disinfected flow from the secondary treatment units would provide a level of control of fecal coliform bacteria that would meet existing permit limits. Ultraviolet disinfection is generally considered to result in an enhanced level of pathogen control relative to chlorination.

If some form of physical-chemical treatment were implemented, effluent pollutant concentrations during the relatively infrequent wet weather occasions when such treatment would be utilized would generally be somewhat lower than with blending; however, the permit effluent limits that are intended to meet water quality standards for Lake Michigan would still be met with blending and no significant difference in overall water quality would be expected on an annual basis.

Regulatory Issues Related to Blending

In December of 2005, the USEPA proposed a draft policy regarding peak wet weather discharges from publicly owned treatment works (POTWs) serving separate sanitary sewer systems.[122] This policy was based upon an October 2005 guidance document developed jointly by the Natural Resources Defense Council and the National Association of Clean Water Agencies (NACWA).[123] The proposed USEPA policy spells out the limited circumstances under which blending can occur at POTWs serving separate sanitary sewer systems and requires detailed agency notification each time blending occurs.

The State of Wisconsin has convened a work group to revise Chapter NR 110, "Sewerage Systems," and Chapter NR 210, "Sewage Treatment Works," of the *Wisconsin Administrative Code*. That process is intended to deal with several issues, including, but not limited to, producing Code revisions that 1) address controlled diversions in a manner consistent with the draft USEPA policy on peak wet weather discharges and 2) also address sanitary sewer overflows.

Regarding the draft USEPA policy, Section 9.6.5 of the MMSD 2020 facilities plan states that the policy "is intended to address POTWs that serve only separate sanitary sewers (not combined sewers) and therefore would not directly apply to MMSD facilities because the MMSD system is integrated, i.e., conveys and treats separate and combined sewer flows." Because combined sewer flow can be diverted to the South Shore wastewater treatment plant, the facilities plan assumes the approach that the USEPA draft policy would not directly apply to

[122]*U.S. Environmental Protection Agency (USEPA),* National Pollutant Discharge Elimination System (NPDES) Permit Requirements for Peak Wet Weather Discharges from Publicly Owned Treatment Works Treatment Plants Serving Separate Sanitary Sewer Collection Systems, *Federal Register, Volume 70, No. 245, pages 76013-76018, December 22, 2005.*

[123]*Natural Resources Defense Council and National Association of Clean Water Agencies,* Guidance on Peak Wet Weather Flow Diversions, October 27, 2005.

South Shore. A definitive determination regarding the applicability of the draft USEPA policy to the South Shore plant, if the policy were to be finalized, would have to be made by WDNR in the context of review of a WPDES permit application. Thus, no evaluation of whether blending at the South Shore plant is permissible under the USEPA draft policy is provided here. However, a summary of the draft USEPA policy is presented in the following subsection.

Summary of December 2005 Draft USEPA Policy Regarding Peak Wet Weather Discharges from POTWs Serving Separate Sanitary Sewer Systems

As set forth in Volume 70, No. 245 of the Federal Register,[124] the draft USEPA policy "strongly discourages reliance on peak wet weather flow diversions around secondary treatment units as a long-term wet weather management approach at a POTW treatment plant serving separate sanitary sewer conveyance systems." The policy also states that USEPA "anticipates that, over time, the need to undertake peak wet weather flow diversions…can be eliminated from most systems…."

The approval of blending under the draft USEPA policy hinges on whether there are feasible alternatives to peak wet weather flow diversions and it cites several measures that should be implemented prior to consideration of blending. These include:

- "Ensuring full utilization of available secondary treatment capacity,
- Reducing infiltration and inflow (I/I),
- Maximizing the use of the collection system for storage,
- Providing off-line storage, and
- Providing sufficient secondary treatment capacity." [125]

Under the draft policy, blending would not be approved if feasible alternatives existed, and the policy states that "on permit renewal, the presumption by the NPDES authority would be against the utility's continued use of diversions to manage peak wet weather flow." [126] It should be noted that the reference here is to "continued use of diversions." As indicated previously, blending is not allowed at the South Shore plant under the current permit. Thus, instituting blending would raise an issue that is not directly addressed by the draft policy, but could present an additional obstacle to blending at South Shore.

The policy also states that when blending "cannot be feasibly avoided, additional technologies (e.g., providing supplemental biological or physical/chemical treatment) and approaches should be used to maximize treatment of diverted flows where feasible."[127]

Finally, the policy requires that all treatment plant discharges meet effluent limits consistent with meeting water quality standards.

Under the draft policy, when a POTW seeks approval for blending under peak wet weather flow conditions, it must prepare a utility analysis that includes evaluation of:

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[124]Federal Register, *Volume 70, No. 245,* op. cit., *page 76015.*

[125]Ibid., *page 76015.*

[126]Ibid., *page 76016.*

[127]Ibid.

- Existing onsite and collection system storage,
- Treatment technologies to provide additional peak wet weather capacity, including costs,
- The degree to which the ability to reduce infiltration and inflow is being maximized throughout the entire collection system,
- Peak flow reductions from implementation of capacity, management, operations, and maintenance (CMOM) programs, and
- The ability to fund the peak wet weather flow improvements.

In addition, the utility analysis must address effluent quality improvements that would be anticipated if the components of the utility analysis were implemented.

Comments on Blending at the South Shore Plant Relative to the Requirements of the Draft USEPA Policy
If it were determined by the WDNR that the draft USEPA policy regarding peak wet weather discharges from POTWs serving separate sanitary sewer systems would apply to the South Shore wastewater treatment plant, the following key conditions of the utility analysis and the draft policy requirements would appear to be satisfied:

- Blending as proposed at the South Shore plant would meet existing permit effluent limits that are intended to meet water quality standards,
- The 2020 facilities plan demonstrates that existing onsite and collection system storage is being utilized,
- Based on existing policies and programs and on the recommendations of the facilities plan, aggressive control of infiltration and inflow is being pursued,
- Peak flow reductions would be achieved from the recommended CMOM programs, and
- The peak wet weather flow improvements required to be evaluated under the utility analysis are called for under the 2020 facilities plans. Thus, it is anticipated that the MMSD and the communities it serves will provide funding for their implementation in future years.

The following possible obstacles to approval of blending would exist:

- Treatment technologies to provide additional peak wet weather capacity could be implemented, although at an additional cost, as identified under the facilities plan, and
- Blending is not allowed at the South Shore plant under the current permit. The draft policy is oriented toward addressing requests to continue, rather than initiate, blending.

Evaluation of Possibility of Blending at South Shore Plant
Considering the foregoing, it does not appear that blending at the South Shore plant would obviously be ruled out under the draft USEPA policy regarding blending at plants receiving sanitary sewer flows (if the policy is finalized and determined to apply to the South Shore plant), and/or under the USEPA policy allowing blending at treatment plants receiving combined sewer flows.[128] While there are considerations for and against allowing blending within the current, and evolving, Federal and State regulatory climate, there are several reasons why

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[128]*U.S. Environmental Protection Agency (USEPA),* Combined Sewer Overflow Policy, *Federal Register, Volume 59, pages 18693-18694, April 19, 1994.*

blending may be possible and even desirable, and should be considered at the South Shore treatment plant. These include:

- There would be no discernible improvement in the water quality of Lake Michigan on an annual basis as the result of providing additional physical-chemical treatment, as opposed to instituting blending under infrequent, wet weather conditions, which have been estimated to occur on average four times per year for about 24 hours each time.

- As noted previously, with blending at South Shore or with either of the physical-chemical treatment options considered, the SSO gates to the tunnel could remain open and prevent possible basement backups that might occur under current operating procedures during wet weather events.

- It is not clear that the South Shore plant would be required to be evaluated under the draft USEPA policy since the ability exists, and is used, to divert combined sewer flows to the South Shore plant.

- If the plant were required to be evaluated under the draft policy, several of the efforts required to be demonstrated in the utility analysis are being implemented by MMSD and its member communities, including reducing peak flows through infiltration and inflow measures and CMOM.

The amount of blending required would be further evaluated when the recommended South Shore capacity study is completed.

MMSD SYSTEM OPERATION OPPORTUNITIES

The MMSD inline storage system (ISS), or the "deep tunnel," is an integrated, dual use facility designed to store both combined and separate sanitary sewer system flows. Due to the nature of the system (combined sewer flow can fill the tunnel completely during a wet weather event leaving no volume available for separate sewer flow) the ISS has traditionally been operated to reserve a portion of its total volume (currently 405 million gallons and planned to be 432 million gallons) for separate sanitary sewer flows. The modeling conducted for the regional water quality management plan update and the recommended MMSD facilities plan is based on a constant volume reserved for separate sewer inflow (VRSSI). However, it is possible to maximize the effectiveness of the ISS and more fully utilize the capacity of the ISS by varying the volume for individual events, and MMSD currently operates the ISS using a variable VRSSI.

The MACRO screening tool (described in Chapter V of this report) was applied for the 64.5-year simulation period to assess the impact of several essentially no-cost (beyond that of committed projects) ISS operational strategies on MMSD ISS-related SSO and CSO frequency and volume.[129] Section 9.6.8 of the MMSD 2020 facilities plan sets forth a detailed description of the following four operational strategies that were analyzed for the inline storage system (ISS):

- VRSSI = 0 (No volume reserved for separate sanitary sewer area (SSSA)) flows,

- VRSSI = 432 million gallons (Full ISS volume used to store flow from SSSA),

[129]*An ISS-related overflow is one that is caused when the ISS fills and closes. A conveyance-related SSO occurs due to capacity restrictions in the metropolitan interceptor system (MIS). Possible MIS hydraulic capacity limitations under revised 2020 baseline population and land use conditions were identified during the planning process and the regional water quality management plan update and the 2020 facilities plan include a recommendation that additional flow monitoring and assessment of growth be made in order to determine the future need for increasing the MIS capacity.*

- VRSSI = Constant value between zero and full ISS volume,[130] and
- Variable VRSSI (0 to 432 million gallons).

The simulations were completed assuming revised 2020 baseline population and land use conditions, MMSD committed facilities, and the following operational assumptions:

- A Jones Island wastewater treatment plant (JIWWTP) sustained peak daily capacity of 300 mgd,
- A JIWWTP peak daily blending capacity of 60 mgd,
- A South Shore wastewater treatment plant (SSWWTP) sustained peak daily capacity of 300 mgd,
- An ISS peak pumping rate to JIWWTP of 80 mgd,
- An ISS peak pumping rate to SSWWTP of 40 mgd,
- An ISS volume of 432 million gallons, and
- Continuation of the current MMSD operating strategy for the Northwest Side Relief Sewer (which is a remote storage facility of 89 million gallons).

Because those operating assumptions reflect current capabilities, implementation of any of the four operational strategies considered could be accomplished at no significant additional cost. Each of the strategies is briefly described in the following subsections.[131]

No Volume Reserved for Separate Sewer Inflow

Variations of this strategy were described in Chapter IX of this report. That analysis included evaluations of effects on instream and in-Lake water quality. Under this approach, operation of the ISS would not differentiate between separate or combined sewer flows and the ISS would be allowed to fill with whatever flow reached it first. It was found that, relative to current operating conditions, this operating strategy would result in:

- A slight reduction in the total annual overflow (sum of both SSO and CSO) volume,
- A decrease in the frequency of all overflows (sum of both SSOs and CSOs),
- An increase in the frequency of ISS-related SSOs, and
- A decrease in the frequency of CSOs.

Within the parameters established for the ISS operation analysis as set forth previously, this operating approach would achieve a one-year level of protection against SSOs, an average annual SSO volume of 280 million gallons, an average of one CSO per year, and an average annual CSO volume of 440 million gallons.

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[130]*A VRSSI equal to 177 million gallons was used for the analyses, although the final recommended facilities plan used 197 million gallons.*

[131]*The analysis of operational strategies for the ISS was conducted on the basis of volumes of CSOs and SSOs. Loads of pollutants delivered to waterbodies in the study area during SSO and/or CSO events were estimated by applying average pollutant concentrations characteristic of SSOs or CSOs to the overflow volumes. In that way, total pollutant loads were adequately estimated. The variation in load over time during a given overflow event was not represented.*

This operational strategy would result in essentially the same instream and in-Lake water quality as compared to the constant VRSSI case as discussed below (VRSSI = 177 million gallons). But, this option would violate the current State and Federal law with regard to SSOs and would also violate the conditions of the current MMSD discharge permit because of the increased frequency of SSOs. The ISS would fill and all gates would be closed more frequently under this operating condition. In those situations the ISS would not be available to provide hydraulic relief to local sanitary sewers, possibly creating an unacceptable risk of increased frequency of basement backups in portions of the system. On the basis of the foregoing, the SEWRPC regional water quality management plan update and the MMSD 2020 facilities plan both eliminated this operational strategy from further consideration.

Volume Reserved for Separate Sewer Inflow Equals Full ISS Volume of 432 Million Gallons
Within the established parameters for the ISS operation analysis, this operating approach would achieve a seven-year level of protection against SSOs, an average annual SSO volume of 20 million gallons, an average of 27 CSOs per year, and an average annual CSO volume of 3,120 million gallons.

Under this operational strategy the annual number of CSO events could increase dramatically and the CSO volume would also increase substantially. This strategy would violate MMSD's discharge permit conditions and would result in an unacceptably high level of CSOs. Thus, it was eliminated from further consideration.

Constant Volume Reserved for Separate Sewer Inflow
This strategy, which was applied assuming a constant VRSSI=177 million gallons for wet weather events, does not reflect actual MMSD operating policy, which is to vary the VRSSI from event to event; however, its application does enable prediction of the long-term average ability of the MMSD system to contain SSOs and CSOs.[132]

Within the parameters established for the ISS operation analysis, this operating approach would achieve a two-year level of protection against SSOs, an average annual SSO volume of 110 million gallons, an average of three CSOs per year, and an average annual CSO volume of 820 million gallons.

Variable Volume Reserved for Separate Sewer Inflow
The goal of this approach is to optimize the use of the ISS storage by varying the VRSSI depending on the anticipated need for separate sewage storage during an event.

Under its Real Time Control Project, the MMSD has begun implementation of a new prediction algorithm designed to improve the ability to predict the required VRSSI. This new algorithm has not yet been fully verified because of a lack of significant wet weather events over the past two years, but it has been applied for those storms that have occurred since it was put into operation. Current operating practice is described as "active tunnel management," under which a default VRSSI of about 250 million gallons is assumed and then refined based on observed data up until the time that the combined sewer gates are closed.

The simulation models used to develop the 2020 facilities plan cannot represent the variable VRSSI strategy which relies on continuous operator judgment. However, it was possible to apply the models to provide some perspective on the upper limit of system performance using this strategy (i.e., the greatest level of protection against SSOs that could be achieved if system operators had perfect knowledge of the required VRSSI). That analysis is described in more detail in section 9.6.8 of the MMSD facilities plan.

Within the parameters established for the ISS operation analysis, if this operating approach could be fully realized, it would achieve a seven-year level of protection against SSOs, an average annual SSO volume of 20

[132]*The conveyance system model cannot represent MMSD's variable VRSSI approach, so the constant VRSSI approach was generally applied to model the long-term average effects of ISS operation under both the SEWRPC regional plan and the MMSD facilities plan.*

million gallons, an average of two CSOs per year, and an average annual CSO volume of 720 million gallons. The attainment of these levels of control would require that operators perfectly predict meteorological conditions and the I/I response to these conditions. That level of operation prediction cannot currently be reliably attained; however, the MMSD staff continues to work with the new algorithm and to apply information observed during wet weather events to refine the process of effectively predicting the necessary VRSSI.

Over the long-term, the variable VRSSI operating approach would be expected to achieve an SSO LOP between the two-year LOP against SSOs for the constant VRSSI approach and the seven-year LOP “perfect” variable VRSSI strategy. Operational experience over a wide range of hydrologic conditions and over an extended period of time is required to further demonstrate the accuracy with which the VRSSI can be predicted.

Conclusion
The variable VRSSI operating strategy based on continued refinement and improvement of the prediction algorithm developed under the MMSD Real Time Control Project holds some promise for achieving more effective operation of the ISS. If the variable operating strategy were successfully implemented over the long-term, it could be one component of an overall scenario under which additional capacity upgrades at the South Shore plant could be minimized or avoided. The current regulatory bifurcation with regard to CSO and SSO makes the MMSD’s operation of its system very complex and difficult. Over time, other measures should be considered in the operation rather than simply what type of overflow has to be considered. Water quality protection and improvement should continue to be the overriding concern.

The MMSD 2020 facilities plan recommendation to upgrade the pumping capacity from the ISS to the Jones Island plant could enhance the effectiveness of the ISS and improve the chances for successful long-term implementation of a variable VRSSI operating strategy. That additional pumping capacity is also recommended for the following reasons:

- It would provide needed capacity when the existing pumps are rehabilitated in the future,
- Sound engineering practice as defined in Section NR 110.14 of the *Wisconsin Administrative Code* calls for sewage pump stations to have adequate capacity with one pump out of service,[133] and
- The additional capacity would more quickly empty the Northwest Side Relief Sewer, which can only be emptied through the ISS.

RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN

If MMSD can successfully implement a variable VRSSI operating strategy based on continued refinement and improvement of the prediction algorithm developed under the MMSD Real Time Control Project, it could be one component of an overall scenario under which additional capacity upgrades at the South Shore plant could be minimized or avoided. Thus, it is recommended that MMSD continue efforts to refine and improve the ISS operating strategy and that upgrades at the South Shore plant be deferred, and possibly eliminated, pending:

- The results of recommended studies of system capacities.
- Determination of the actual population and land use changes within the planning area in comparison to estimates and predictions made for the regional water quality management plan update and the 2020 facilities plan.

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[133] *The requirement for the ISS pump station to have adequate capacity with one pump out of service was waived in a November 2, 1982 letter from the WDNR to the MMSD.*

- Determination of the success of the wet weather peak flow management planning effort. An additional factor of safety would be provided if that effort went beyond the goal of “holding the line” on infiltration and inflow (I/I) and actually reduced I/I.

- Completion of an improved analysis of the level of protection which can be achieved by the variable VRSSI operating strategy and the upgraded pumping from the ISS to the Jones Island plant. This analysis would be based upon actual operational experience over an expanded period of record.

In the event that it is ultimately determined that capacity upgrades are required at the South Shore plant, the following considerations apply. The estimated capital, annual operation and maintenance, and equivalent annual costs of blending at the South Shore plant are $5 million, $0.7 million, and $1.4 million, respectively, less than the corresponding costs of physical-chemical treatment with chemical flocculation.[134] Those cost differences are not so large that they would necessarily favor selection of blending over physical-chemical treatment with chemical flocculation when additional pertinent considerations are factored into the comparison. A primary consideration in that comparison is uncertainty over the regulatory acceptability of long-term blending at South Shore. Although the evaluation of regulatory issues as presented above concludes that blending at the South Shore plant would not obviously be ruled out under the draft USEPA policy regarding blending at plants receiving sanitary sewer flows and/or under the USEPA policy allowing blending at treatment plants receiving combined sewer flows, the final decision would be made by the WDNR. Given the evolving Federal and State regulatory climate on the issue of blending, it is not clear that a decision favorable to blending would be issued. In addition, if blending were implemented and the cost differential between blending and the treatment option that is next closest in cost (physical-chemical treatment with chemical flocculation) were to be applied to implement additional nonpoint source controls, it is not likely that the overall water quality benefits of the relatively small additional expenditure would be significant. Thus, because of regulatory uncertainties and the anticipated insignificant water quality benefits to be obtained through implementation of additional nonpoint source pollution controls commensurate with the relatively small cost differential, blending at the South Shore plant is not recommended as a long-term solution to satisfying the identified need to provide additional treatment capacity. That recommendation assumes that physical-chemical treatment with chemical flocculation is found to be an effective option at the South Shore plant.

If the long-term demonstration project recommended in the MMSD 2020 facilities plan concludes that physical-chemical treatment with chemical flocculation is not feasible, blending could become a more viable alternative to the remaining option of physical-chemical treatment with ballasted flocculation. Although the regulatory uncertainty regarding blending would remain, avoiding the large incremental cost between implementing physical-chemical treatment with ballasted flocculation and blending would present an opportunity to apply that level of funds to the achievement of discernible water quality improvements through control of nonpoint source pollution at a level beyond that of the base nonpoint source control component of the recommended regional water quality management plan.[135]

In light of the foregoing, the integrated watershed-based water quality management plan calls for the following:[136]

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[134]*The estimated capital, annual operation and maintenance, and equivalent annual costs of blending are 5, 50, and 15 percent less, respectively, than the corresponding costs of physical-chemical treatment with chemical flocculation.*

[135]*In the context of overall plan costs, a greater water quality benefit would be realized through providing expanded, targeted control of pathogens in illicit discharges to stormwater systems and, possibly, in stormwater itself and/or in rural runoff than by allocating funds to physical-chemical treatment.*

[136]*The first and fifth items in the bulleted list primarily distinguish the integrated watershed-based approach from the regulatory watershed-based approach.*

- All of the components of the land use, point and nonpoint source water pollution control, and groundwater management plan elements described as being part of the regulatory approach and listed in Table 82, except for physical-chemical treatment with chemical flocculation at the South Shore plant. The need for such treatment should be evaluated at a later date, following determination of 1) the degree to which MMSD can successfully implement a variable VRSSI operating strategy, 2) actual system capacities at the Jones Island and South Shore plants, 3) actual population and land use changes within the planning area, and 4) the success of the wet weather peak flow management planning effort. If it were found that additional treatment capacity was not needed, a capital cost saving of from $97 million to $152 million could be realized through not adding physical-chemical treatment.

- Continued efforts by MMSD to successfully implement a variable VRSSI operating strategy based on refinement and improvement of the prediction algorithm developed under the MMSD Real Time Control Project and with upgraded pumping capacity from the ISS. As indicated previously, the MMSD system is an integrated system and the current regulatory bifurcation with regard to CSOs and SSOs makes MMSD's operation of its system very complex and difficult. The regulatory requirement that a distinction be drawn between SSOs and CSOs from the MMSD system creates a situation under which the capacity of the ISS may be underutilized despite MMSD's best efforts to apply a variable VRSSI operating strategy to avoid overflows. Therefore, it is recommended that MMSD and its customer communities work with the WDNR and USEPA to obtain formal regulatory recognition of the integrated nature of the MMSD system, perhaps extending to elimination of the present distinction between ISS-related SSOs and CSOs.

- Consideration of additional study of blending at the South Shore plant, perhaps as part of the recommended capacity study and/or the long-term demonstration project. This recommendation is consistent with the previously-stated facilities plan recommendation calling for evaluation of blending as a means to prevent possible basement backups under certain conditions.

- Possible implementation of physical-chemical treatment to increase the treatment capacity of the South Shore plant if it were ultimately found that additional capacity was needed at South Shore and favorable results were obtained from the recommended long-term demonstration project of physical-chemical treatment with chemical flocculation. As indicated previously, this element may not be needed if favorable results are obtained from further analyses of the variable VRSSI operating strategy and the capacity of the South Shore plant.

- Possible implementation of blending at the South Shore plant if it were ultimately found that additional capacity was needed and the recommended long-term demonstration project of physical-chemical treatment with chemical flocculation results in a conclusion that such a treatment option is not feasible. The estimated capital, annual operation and maintenance, and equivalent annual costs of blending are $60 million, $1.0 million, and $6.1 million, respectively, less than the corresponding costs of the other remaining option, which is physical-chemical treatment with ballasted flocculation. In this case, it is recommended that additional funds be spent on achieving water quality improvements through control of nonpoint source pollution at a level beyond that of the base nonpoint source pollution control component of the regional plan, rather than on physical-chemical treatment with ballasted flocculation.[137] Once again, this element may not be needed depending

[137]*As noted previously in this chapter, although a cost savings would accrue to the MMSD if certain components of the MMSD 2020 facilities plan were foregone, the additional funds that could be applied to more effective nonpoint source pollution control measures would not necessarily be provided by MMSD. Chapter XI, "Plan Implementation," provides information on funding sources and assigns responsibilities for implementing the various components of the plan.*

on the results of analyses of the variable VRSSI operating strategy and the capacity of the South Shore plant.

- Revision of the USEPA draft policy regarding blending to specifically establish that it is acceptable to evaluate the water quality impacts of blending as part of a watershed-based approach to water quality management and to use that evaluation as a factor to be considered in determining if blending is to be allowed.

COST ANALYSIS

In order to assist public officials in evaluating the recommended regional water quality management plan update for the greater Milwaukee watersheds, estimates were prepared of capital costs and attendant annual operation and maintenance costs. The overall recommended plan costs are summarized in Table 82. Table 83 sets forth costs for new facilities, programs, operations, and policies to be implemented by MMSD under the recommended 2020 facilities plan. A summary of those costs is also included in Table 82.[138]

The capital cost of implementing the recommended plan for the greater Milwaukee watersheds is estimated at $1.492 billion and annual operation and maintenance costs are estimated to be $28.4 million. With the exception of an estimated $50,000 for additional studies recommended under the groundwater management plan element, that entire capital cost is for surface water quality measures.

As set forth in Table 87, an additional $1.228 billion is for 1) existing programs that are to continue, 2) plan elements that have been committed under other planning efforts, and 3) programs that are to be implemented to meet regulatory requirements. The estimated annual operation and maintenance costs for those programs is $33.0 million. These costs were not assigned to the recommended regional water quality management plan update.

The capital costs for the continuing-program, previously-committed, or regulatory measures include:

- About $197 million for implementation of the nonagricultural (urban) performance standards of Chapter NR 151 of the *Wisconsin Administrative Code*, as mandated under the Wisconsin Pollutant Discharge Elimination System municipal stormwater discharge permits issued pursuant to Chapter NR 216 of the *Administrative Code*,

- About $1.026 billion for existing and committed MMSD facilities, programs, operations, and policies (see Table 84),

- About $1.0 million for skimmer boat operation in the Milwaukee Harbor estuary, and

- About $3.6 million for research and implementation projects related to urban nonpoint source pollution control measures.

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[138]*The total capital cost for the MMSD component of the recommended regional water quality management plan update is $152 million less than the total in Table 83, and the total annual operation and maintenance cost is $1.7 million less than the amount in Table 83. Those differences reflect the regional water quality management plan update recommendation that the addition of physical-chemical treatment at the MMSD South Shore wastewater treatment plant not be implemented, pending 1) further development by MMSD of the variable volume reserved for sanitary sewer inflow operating strategy for the Inline Storage System, 2) the results of capacity analyses for the Jones Island and South Shore plants, 3) determination of actual population and land use changes, and 4) determination of the success of the wet weather peak flow management program undertaken by MMSD and the communities that it serves.*

Table 87

COSTS ASSOCIATED WITH EXISTING OR COMMITTED PROGRAMS AND REGULATORY MANDATES[a]

Description	Component	Capital Cost[b] (thousands)	Annual Operation and Maintenance Cost[b] (thousands)
Implementation of the nonagricultural (urban) performance standards of Chapter NR 151	9. Infiltration Systems[c]	$ 7,910	$ 387
	10. Stormwater Treatment Systems[c]	97,087	27,862
	11. Wet Detention Basins[c]	67,346	3,367
	12. Vacuum Sweeping of Roadways[c]	24,634	591
	Subtotal	$ 196,976	$32,208
MMSD 2020 Facilities Plan	10. Existing MMSD Facilities, Programs, Operations, and Policies to be Continued[d]	$1,026,200	$ 600
	Subtotal	$1,026,200	$ 600
River Skimmer Boat Operation	- -	1,000	$ 150
	Subtotal	$ 1,000	$ 150
Urban Nonpoint Source Pollution Control Measures	3. Research and Implementation Projects	$ 3,625	- -[e]
	Subtotal	$ 3,625	- -[e]
	Total	$1,227,801	$32,958

[a]*These costs have not been assigned to the regional water quality management plan update.*

[b]*Costs reflect projected June 2007 dollars. Engineering News Record Construction Cost Index (CCI) = 10,000.*

[c]*Typical best management practice. Other practices may be applied to meet the performance standards.*

[d]*A detailed breakdown of this component is provided in Table 84.*

[e]*No annual operation and maintenance cost for this component.*

Source: Milwaukee Metropolitan Sewerage District, HNTB, and SEWRPC.

Cost assignments to public and private sector entities are set forth in Table 100 in Chapter XI of this report. Detailed cost apportionment among municipalities, State and Federal agencies, and special units of government are set forth in Appendix R.

ABILITY OF THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN TO MEET ADOPTED OBJECTIVES AND STANDARDS

Water resources management-related objectives and supporting standards were formulated early in the regional water quality management planning process. The objectives and standards set forth in Chapter VII and Appendix G of this report include those adopted under related regional and/or subregional water quality management, land use, outdoor recreation and open space, and stormwater and floodland management planning programs, supplemented with objectives and standards developed specifically for the regional water quality management plan update. The main broad category of objectives and standards adopted specifically for this planning effort relates to educational and informational programming.

An evaluation of the plan was made on the basis of its ability to meet the objectives and standards. The broad categories for which objectives and standards were adopted include:

- Land use development,
- Water quality management,

- Outdoor recreation and open space preservation,
- Water control facility development,
- Plan structure and monitoring, and
- Educational and informational programming.

The adopted objectives and supporting standards provided the basis for preparation, testing, and evaluation of alternative water quality management plans, and the components of the recommended plan synthesized from the alternatives were selected to best meet the objectives and standards. Thus, review of the standards as set forth in detail in Appendix G, indicates that the recommended plan generally either meets the standards or could meet the standards, depending on how the plan is implemented and on the results of local planning efforts and studies.

Achievement of Water Use Objectives and Supporting Water Quality Standards/Criteria

Of particular interest is the degree to which the recommended plan achieves the water use objectives and supporting water quality standards as set forth in detail in Table 70 of this report and Chapter IV of the companion SEWRPC Technical Report No. 39[139] and as shown graphically on Maps N-1 through N-6 in Appendix N of this report. The applicable water quality standards and criteria supporting the designated water use objectives are summarized in Table 88.[140] Initial analyses were made to compare the water quality conditions modeled for the recommended plan with the existing regulatory standards as set forth in Chapter IV of Technical Report No. 39. Water quality summary statistics comparing existing year 2000, revised future 2020 conditions, revised future 2020 conditions with a five-year level of protection against sanitary sewer overflows of the MMSD system and tributary systems, recommended plan conditions, and "extreme measures" conditions are provided in Appendix N. The assessment point locations are shown on Maps N-1 through N-6. Figures 57 through 68 provide summaries of the degree to which the recommended plan achieves regulatory or planning water quality standards for various pollutants. Tables N-1 through N-6 also set forth evaluations of compliance with standards, and provide an indication of potential relative changes in concentrations for pollutants for which there are no standards.

Based on the assessment of the degree of attainment of regulatory and planning water quality standards, certain assessment points characteristic of stream reaches in the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds were identified as meeting the current regulatory or planning standards more than 85 percent of the time. If those stream reaches were identified in Table 70 in Chapter VII of this report as reaches to be considered for possible "auxiliary uses" with more-stringent water quality standards, additional analyses were performed to determine the percent compliance with standards for the "auxiliary use." Examples of this situation include a variance water that was assigned an "auxiliary use" of fish and aquatic life or limited forage fish, or a fish and aquatic life stream that was assigned a coldwater "auxiliary use." The evaluations of those situations are presented later in this report section.

Conditions for Which Detailed Water Quality Analyses and Summary Statistics Were Developed

As set forth in Tables N-1 through N-6, water quality statistics for streams in each watershed and the nearshore area of Lake Michigan were developed from water quality model analyses representing the following conditions:

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[139]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

[140]*In the Milwaukee outer harbor and nearshore Lake Michigan area, compliance with standards was evaluated through comparison of modeled water quality results with the standards for the fish and aquatic life water use objective with full recreational use.*

Table 88

APPLICABLE WATER USE OBJECTIVES AND WATER QUALITY STANDARDS (CRITERIA) AND GUIDELINES FOR LAKES AND STREAMS WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

Water Quality Parameter	Combinations of Water Use Objectives Adopted for Planning Purposes[a]						Source
	Coldwater Community	Warmwater Sportfish and Forage Fish Communities	Limited Forage Fish Community (variance category)	Limited Aquatic Life (variance category)	Special Variance Category A[b]	Special Variance Category B[c]	
Recreational Use	Full	Full	Full	Full	Limited	Limited	- -
Maximum Temperature (°F)[d]	Background	89.0	89.0	- -	89.0[e]	89.0	NR 102.04 (4)[f]
Dissolved Oxygen (mg/l)[d]	6.0 minimum 7.0 minimum during spawning	5.0 minimum	3.0 minimum	1.0 minimum	2.0 minimum	2.0 minimum	NR 102.04 (4) NR 104.02 (3)
pH Range (S.U.)	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0[e]	6.0-9.0[e]	NR 102.04 (4)[g] NR 104.02 (3)
Fecal Coliform (MFFCC)[h]							NR 102.04 (5) NR 104.06 (2)
Mean	200	200	200	200	1,000	1,000	- -
Maximum	400	400	400	400	2,000	- -	- -
Ammonia Nitrogen (mg/l)	- -[i]	- -[i]	- -[i]	- -[i]	- -[i]	- -[i]	NR 105 Tables 2c and 4b
Total Phosphorus (mg/l)							Regional water quality management plan[j]
Maximum for Streams	0.1	0.1	0.1	0.1	0.1[e]	0.1[e]	
Maximum for Lakes during Spring Turnover	0.02	0.02	0.02	0.02	- -	- -	
Chloride (mg/l)	1,000 maximum	1,000 maximum	1,000 maximum	1,000 maximum	1,000 maximum[e]	1,000 maximum[e]	Regional water quality management plan

[a]*NR 102.04(1) All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water, floating or submerged debris, oil, scum, or other material, and material producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[b]*As set forth in Chapter NR 104.06(2)(a) of the* Wisconsin Administrative Code.

[c]*As set forth in Chapter NR 104.06(2)(b) of the* Wisconsin Administrative Code.

[d]*Dissolved oxygen and temperature standards apply to continuous streams and the upper layers of stratified lakes and to unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inland lakes. However, trends in the period of anaerobic conditions in the hypolimnion of deep inland lakes should be considered important to the maintenance of their natural water quality.*

[e]*Not specifically addressed within the* Wisconsin Administrative Code*. For planning purposes only, these values are considered to apply.*

[f]*NR 102.04(4) There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the natural temperature shall not exceed 5°F for streams. There shall be no significant artificial increases in temperature where natural trout reproduction is to be maintained.*

[g]*The pH shall be within the stated range with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[h]*NR 102.04(5)(a) The membrane filter fecal coliform count may not exceed 200 per 100 ml as a geometric mean based on not less than five samples per month, nor exceed 400 per 100 ml in more than 10 percent of all samples during any month.*

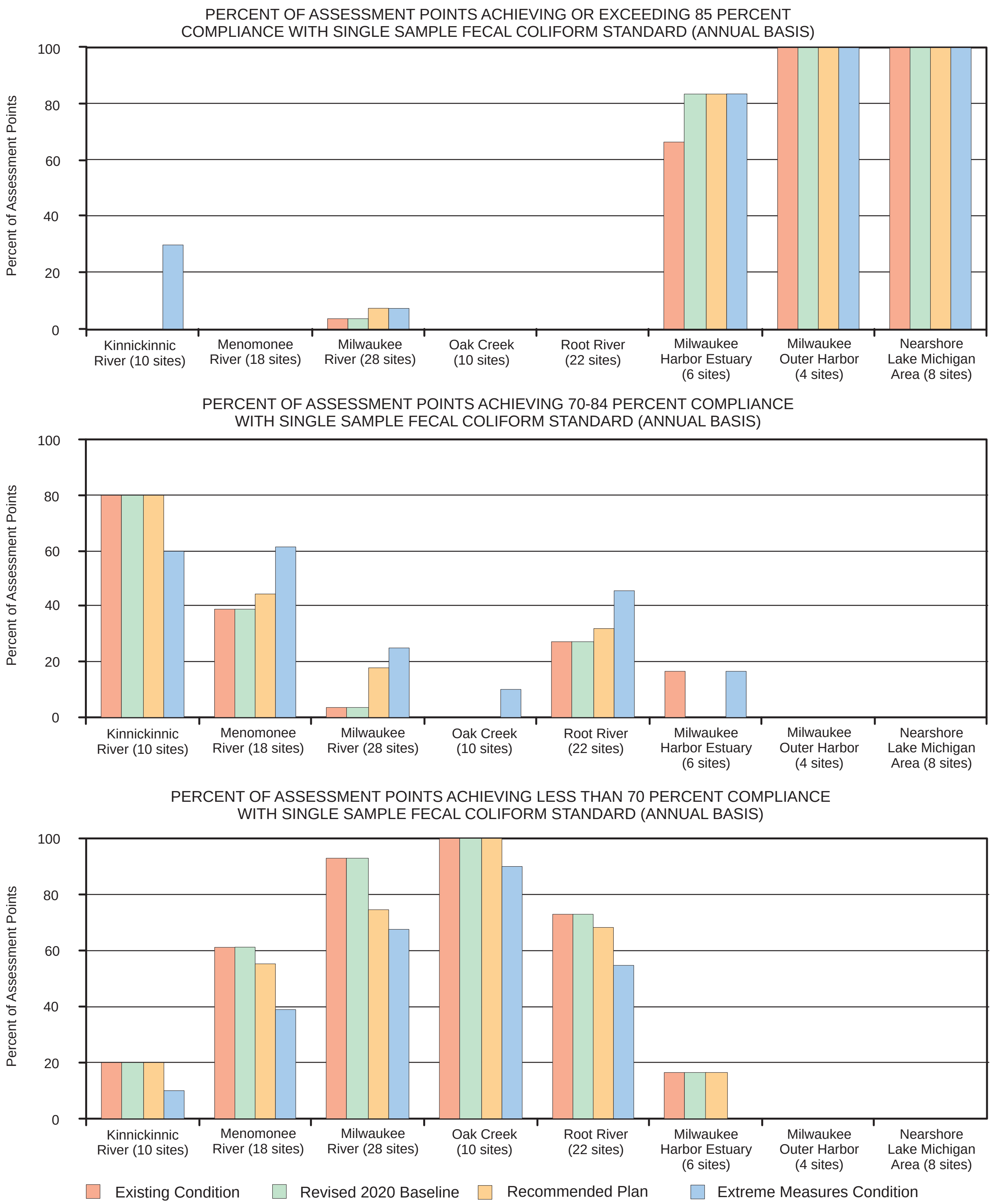
[i]*J.E. McKee and M.W. Wolf,* Water Quality Criteria, 2nd edition, *California State Water Quality Control Board, Sacramento, California, 1963. The standards for ammonia nitrogen are set forth in Chapter IV of SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*.*

[j]*U.S. Environmental Protection Agency,* Quality Criteria for Water, *EPA-440/9-76-023, 1976.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 57

ACHIEVEMENT OF THE SINGLE SAMPLE FECAL COLIFORM BACTERIA STANDARD ASSESSED ON AN ANNUAL BASIS

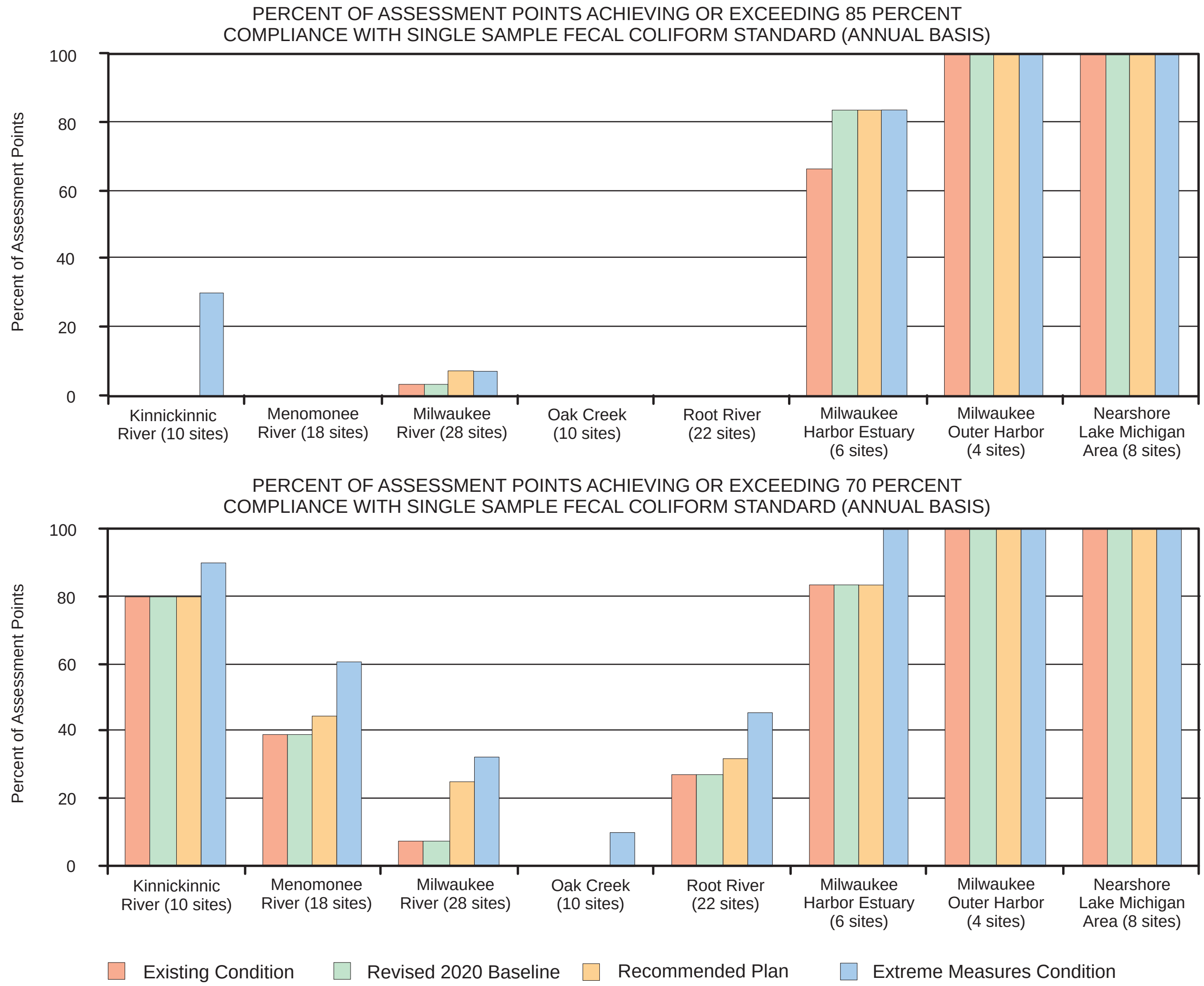


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

Figure 58

ACHIEVEMENT OF THE SINGLE SAMPLE FECAL COLIFORM BACTERIA STANDARD ASSESSED ON AN ANNUAL BASIS



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

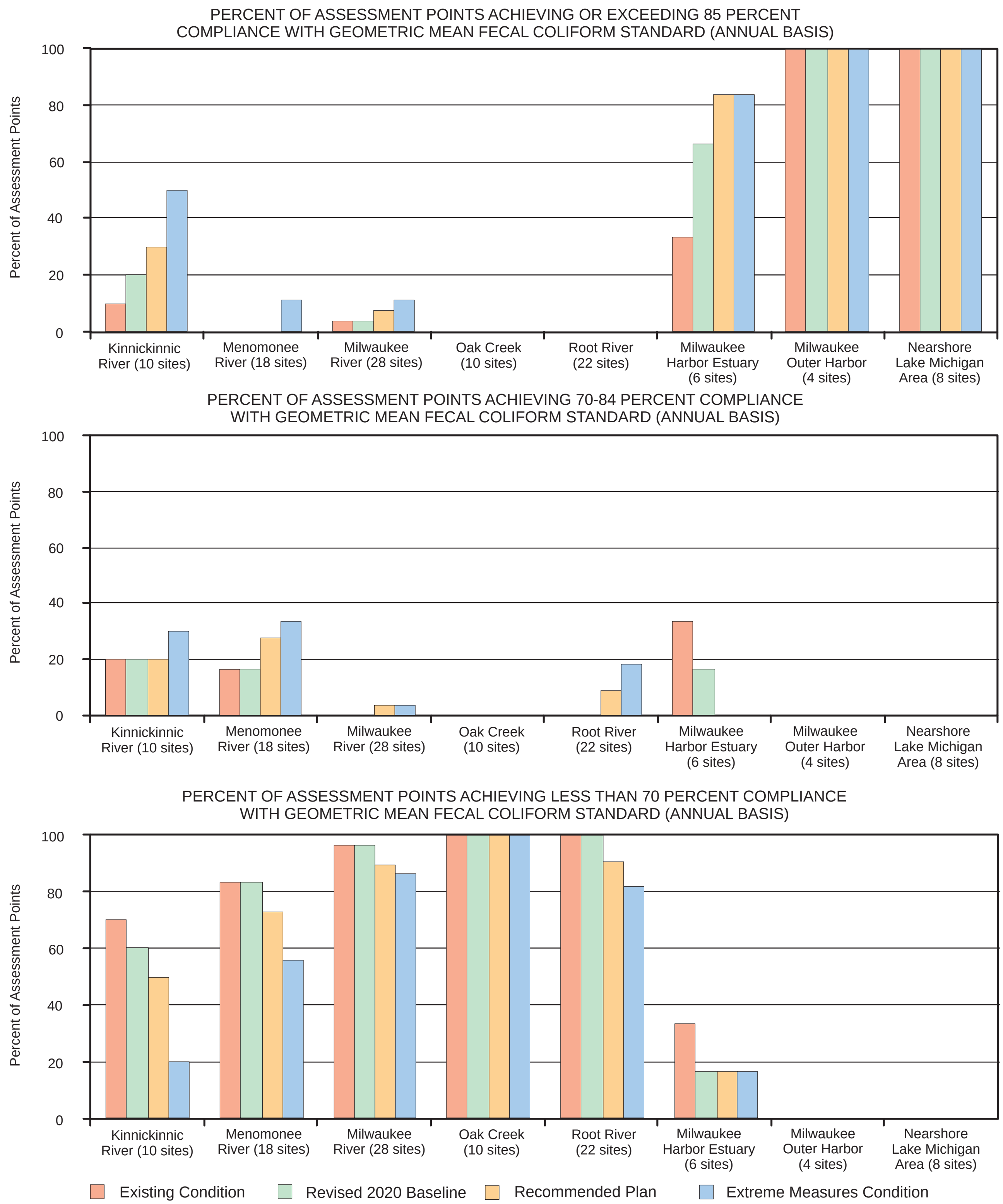
Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

- Existing year 2000,
- Revised 2020 baseline,[141]

[141] *As described in Chapter VIII of this report and in the recommended land use plan element subsection of this chapter, planned land use data from the SEWRPC 2020 regional land use plan and available county and local land use information for the area outside the Southeastern Wisconsin Region were applied for communities in the study area that are not served by MMSD. All MMSD metropolitan interceptor system sanitary sewers were evaluated and sized using the original community projections of year 2020 population and land use. When data from the SEWRPC 2035 regional land use plan became available, those 2020 land use and population estimates based on community projections of development in the MMSD planning area were revised using a 2020 stage of the SEWRPC 2035 data. The revised 2020 data in the MMSD planning area, along with the 2020 land use plan information for areas outside the MMSD planning area, were used to develop both refined land surface runoff for the "revised 2020 baseline" condition and hydraulic and pollutant loads to the MMSD Jones Island and South Shore wastewater treatment plants.*

Figure 59

ACHIEVEMENT OF THE GEOMETRIC MEAN FECAL COLIFORM BACTERIA STANDARD ASSESSED ON AN ANNUAL BASIS

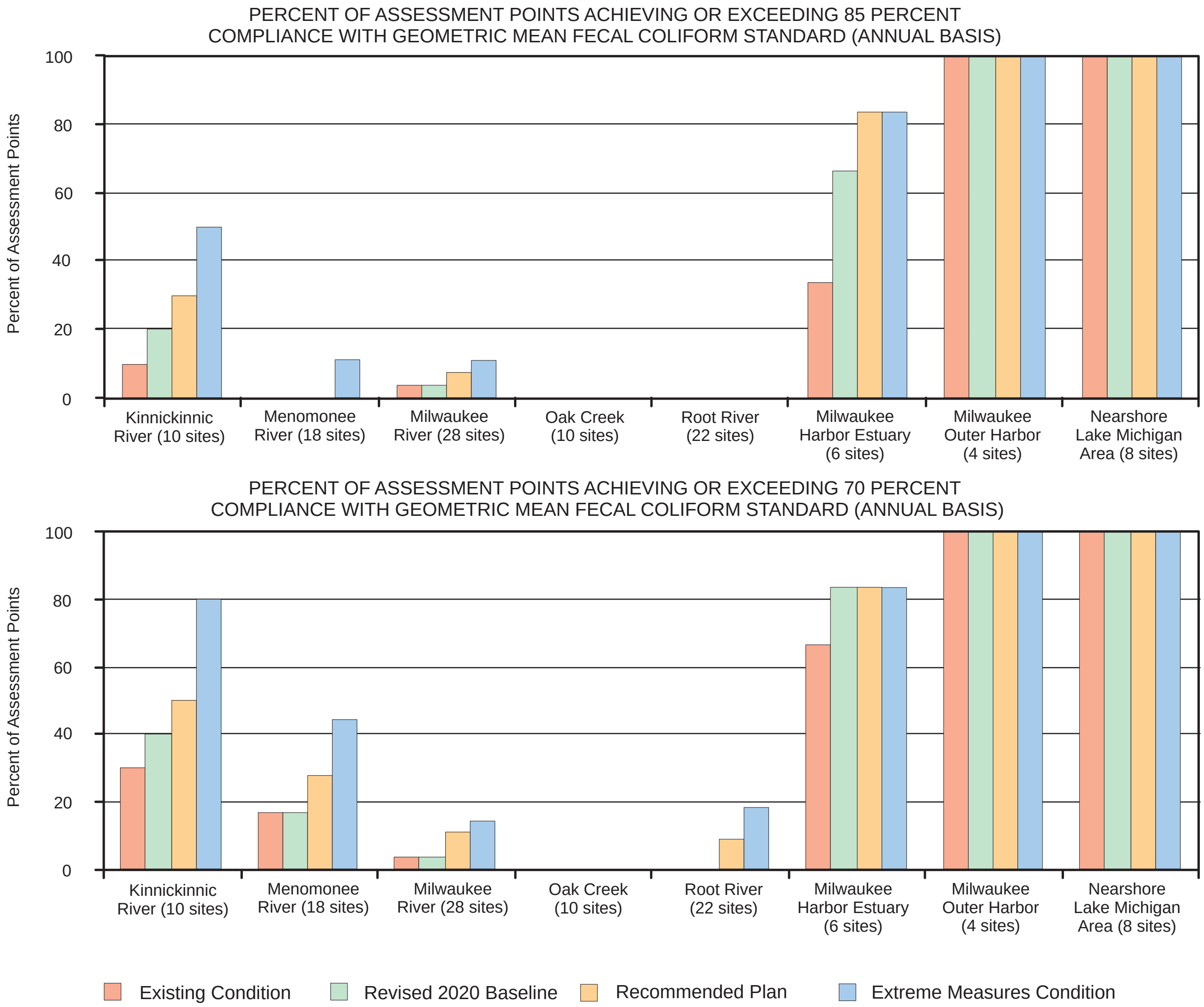


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

Figure 60

ACHIEVEMENT OF THE GEOMETRIC MEAN FECAL COLIFORM BACTERIA STANDARD ASSESSED ON AN ANNUAL BASIS



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

- Revised 2020 baseline with five-year level of protection against sanitary sewer overflows,
- Recommended plan, and
- "Extreme measures."

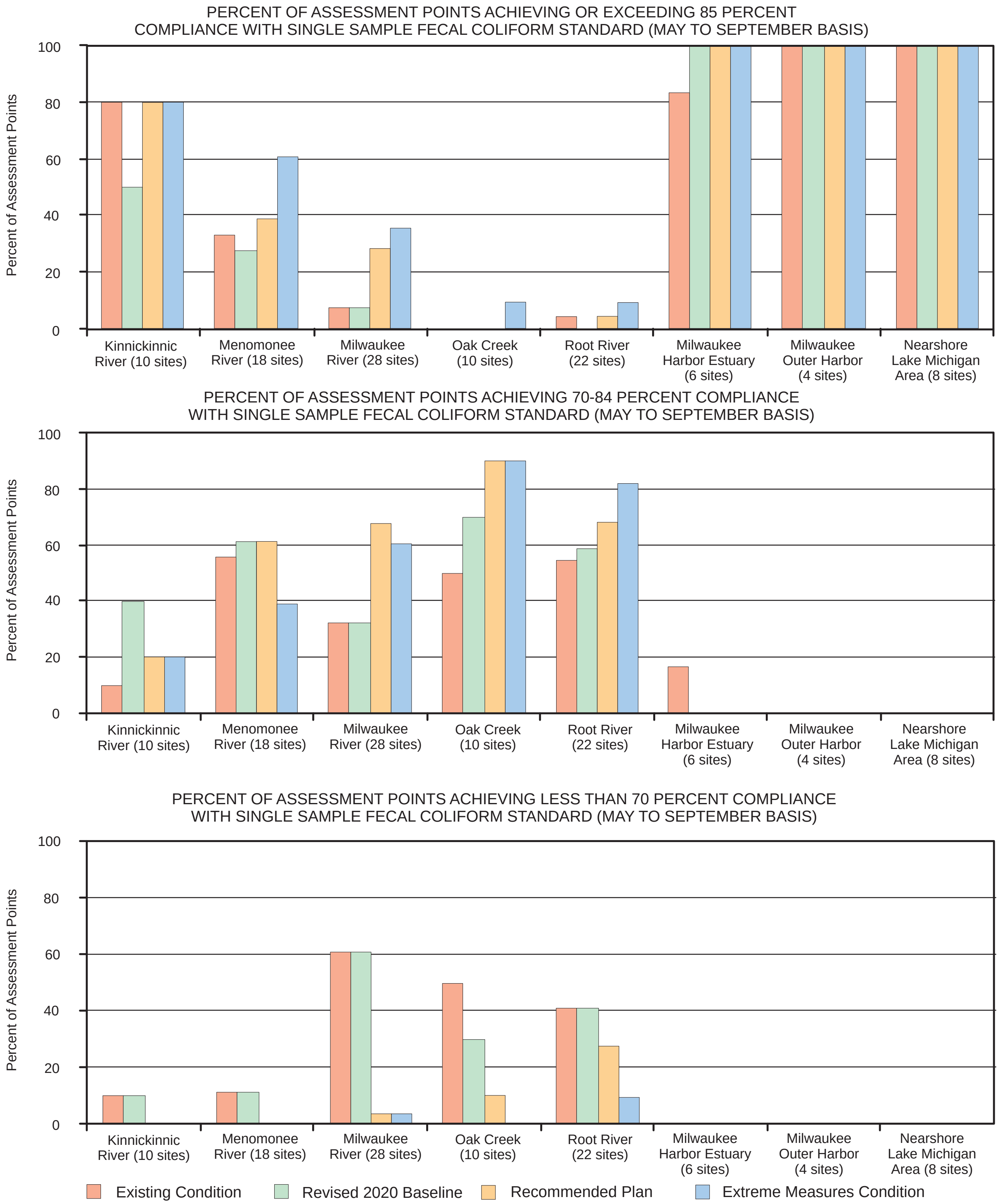
Through comparison of water quality modeling analyses among these conditions, it is possible to estimate relative changes in water quality and to obtain a sense of the effectiveness of the recommended plan in improving water quality conditions.

Water quality statistics were computed for:

- Fecal coliform bacteria on an annual basis,

Figure 61

ACHIEVEMENT OF THE SINGLE SAMPLE FECAL COLIFORM BACTERIA STANDARD ASSESSED ON A MAY TO SEPTEMBER BASIS

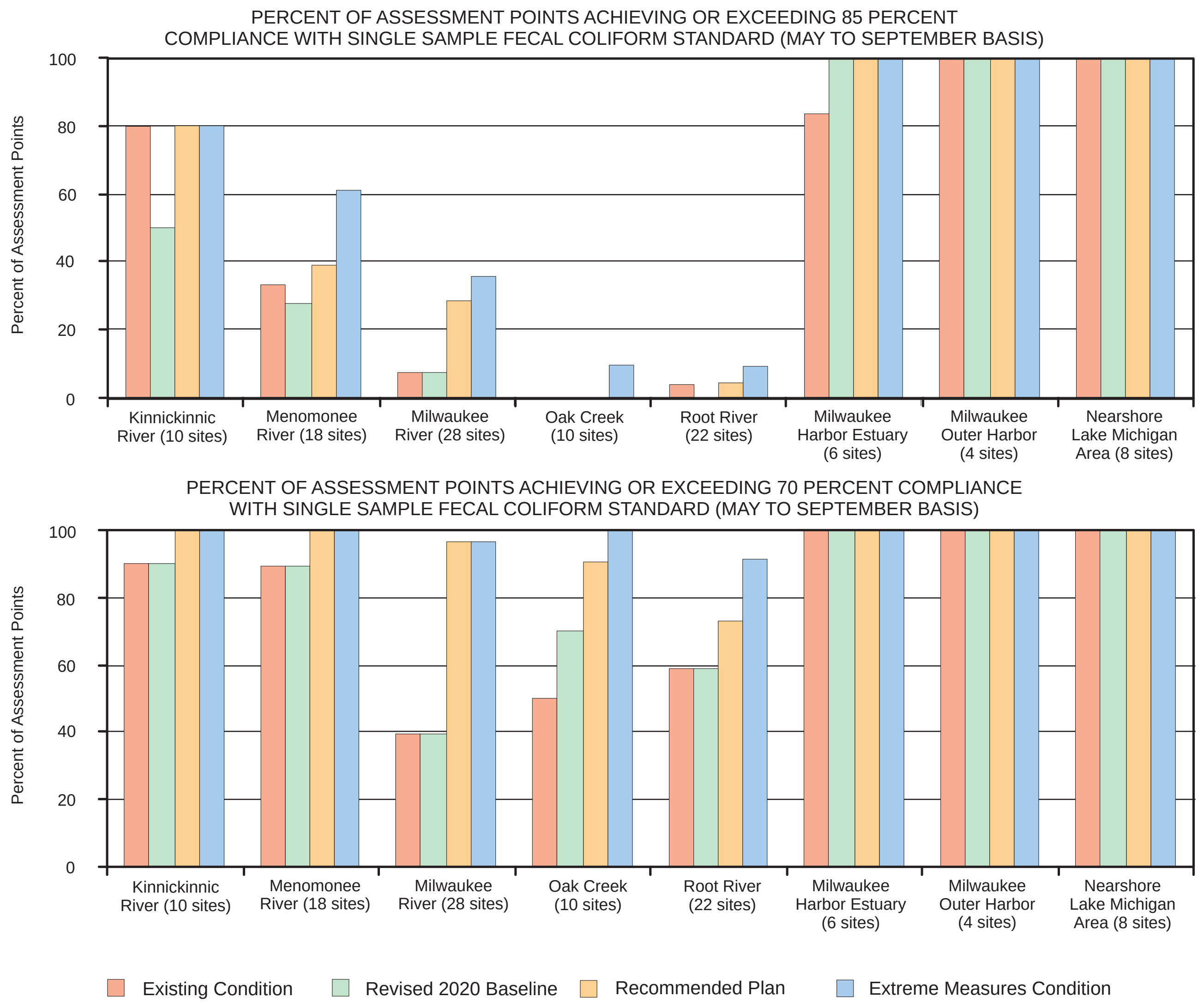


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

Figure 62

ACHIEVEMENT OF THE SINGLE SAMPLE FECAL COLIFORM BACTERIA STANDARD ASSESSED ON A MAY TO SEPTEMBER BASIS



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

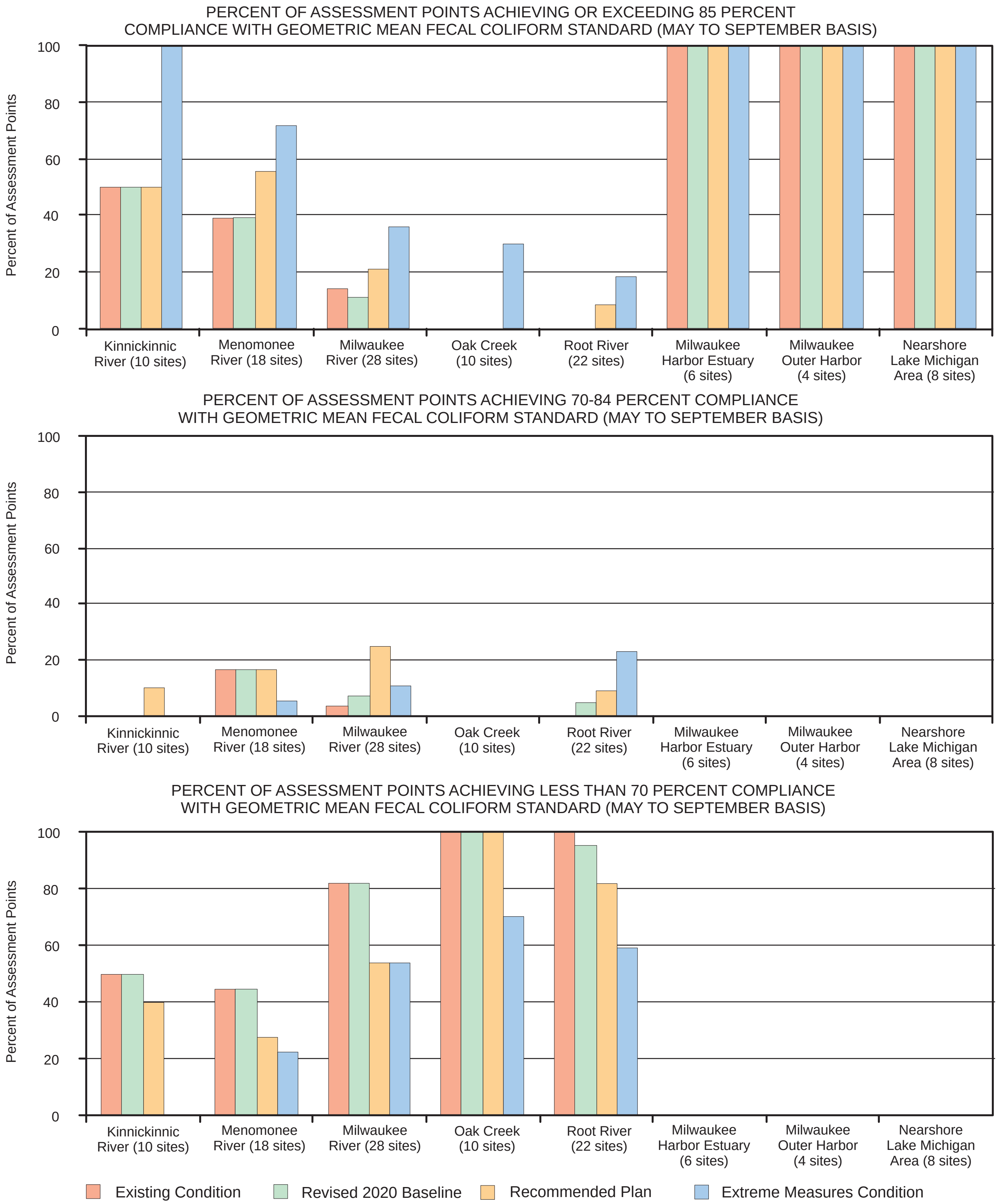
Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

- Fecal coliform bacteria for the period from May 1 through September 30,
- Dissolved oxygen,
- Total phosphorus,
- Total nitrogen,
- Total suspended solids, and
- Copper.

Continuous simulation water quality analyses were made for the 10-year model simulation period using meteorological data from the representative time period of 1988 through 1997 along with the applicable land use,

Figure 63

ACHIEVEMENT OF THE GEOMETRIC MEAN FECAL COLIFORM BACTERIA STANDARD ASSESSED ON A MAY TO SEPTEMBER BASIS

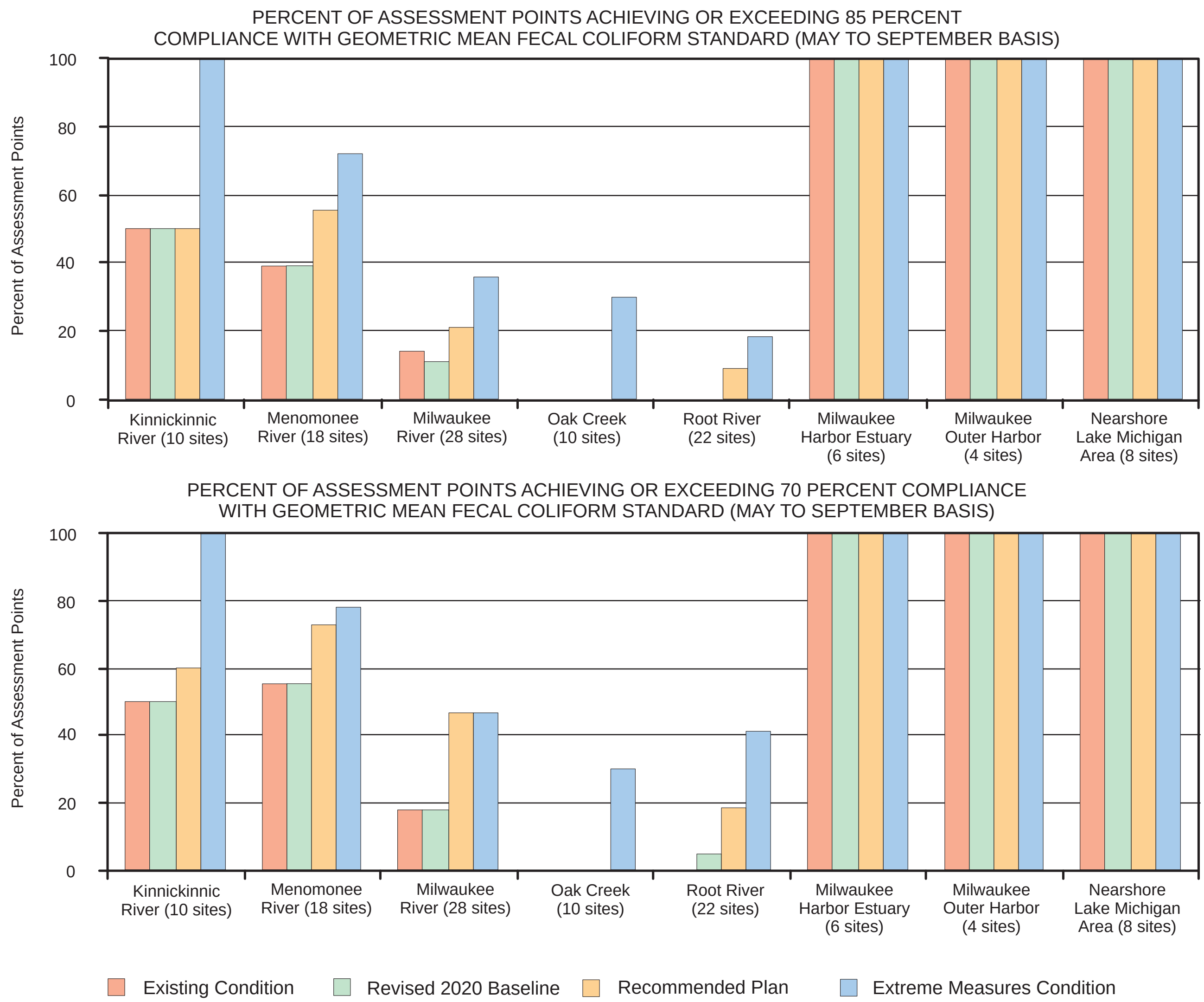


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

Figure 64

ACHIEVEMENT OF THE GEOMETRIC MEAN FECAL COLIFORM BACTERIA STANDARD ASSESSED ON A MAY TO SEPTEMBER BASIS



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

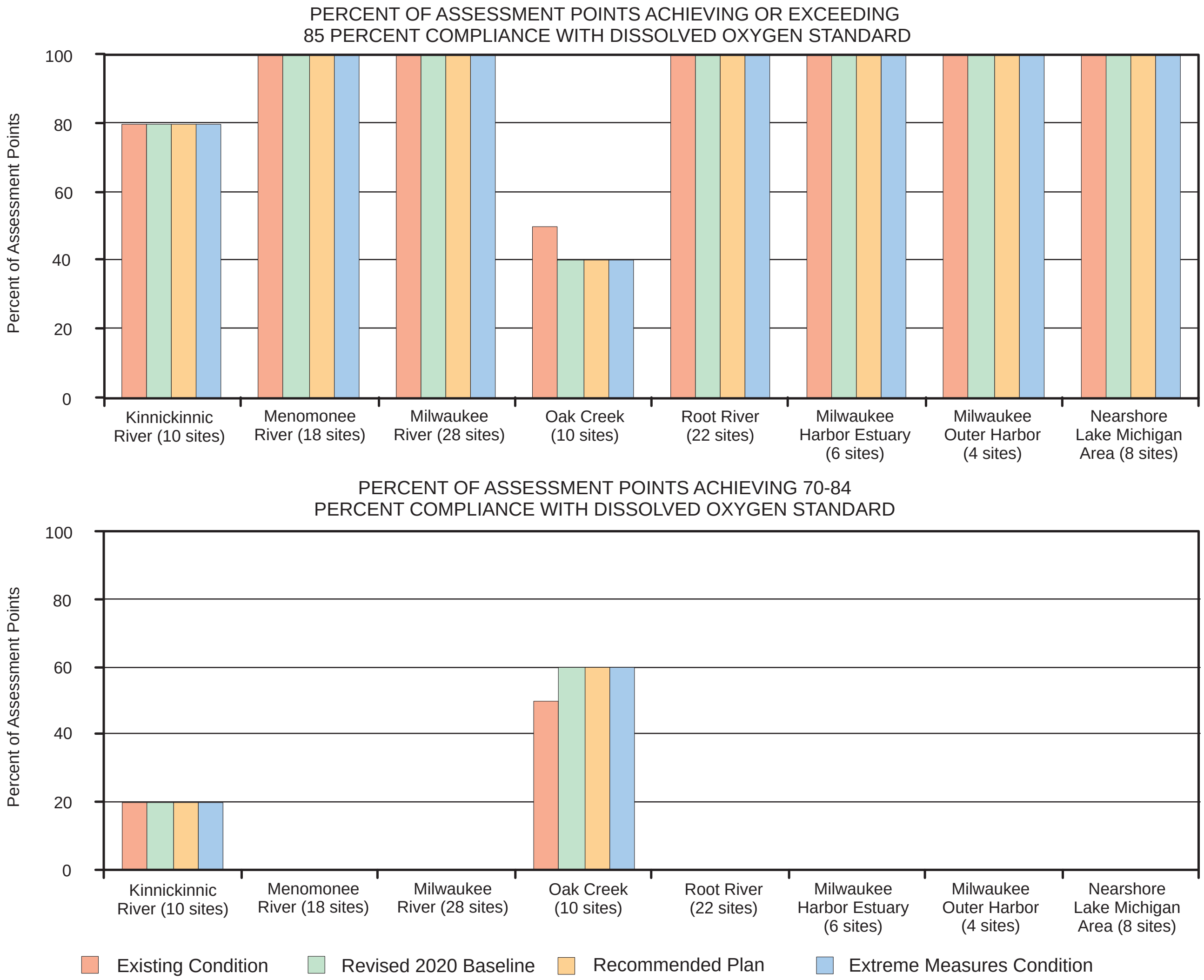
Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

stream, and sewerage system conditions. More detail on the continuous simulation modeling approach is provided in Chapter V of this report, "Water Resource Simulation Models and Analytic Methods."

Water quality statistics for each of the pollutants considered were computed on an annual basis. Because fecal coliform bacteria is intended to serve as an indicator of bacteria and pathogens that are harmful to human health, fecal coliform statistics were also computed for the May 1 through September 30 period when water-based body contact recreational activities would be most likely to occur.

Figure 65

ACHIEVEMENT OF THE DISSOLVED OXYGEN STANDARD



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

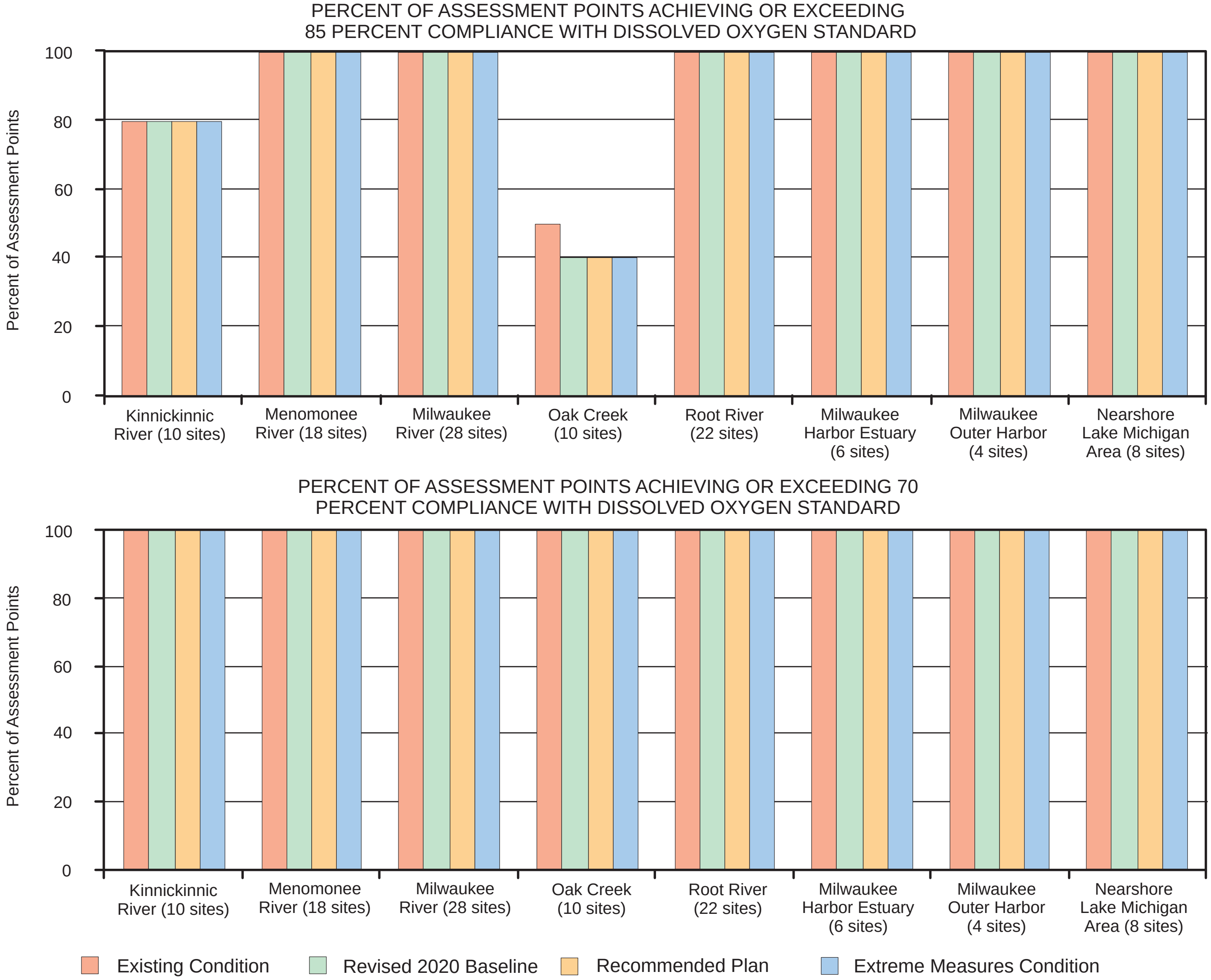
"Extreme Measures" Condition

This condition represents a level of nonpoint source pollution control in excess of that envisioned for the recommended plan.[142] It was used as a basis for evaluation of whether, with additional efforts to control water pollution beyond those included under the recommended plan, water quality standards would be more fully met throughout the study area. This condition represents an expansion of the recommended plan with the enhanced levels of control noted below. This condition was not previously described. All of the other conditions being evaluated were described earlier in this report. Pollutant loads and instream water quality statistics for this conditions are set forth in Appendices M and N.

[142]*One additional point source control was included in the extreme measures condition. That is the virtual elimination of phosphorus from industrial noncontact cooling water.*

Figure 66

ACHIEVEMENT OF THE DISSOLVED OXYGEN STANDARD



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc; and SEWRPC.

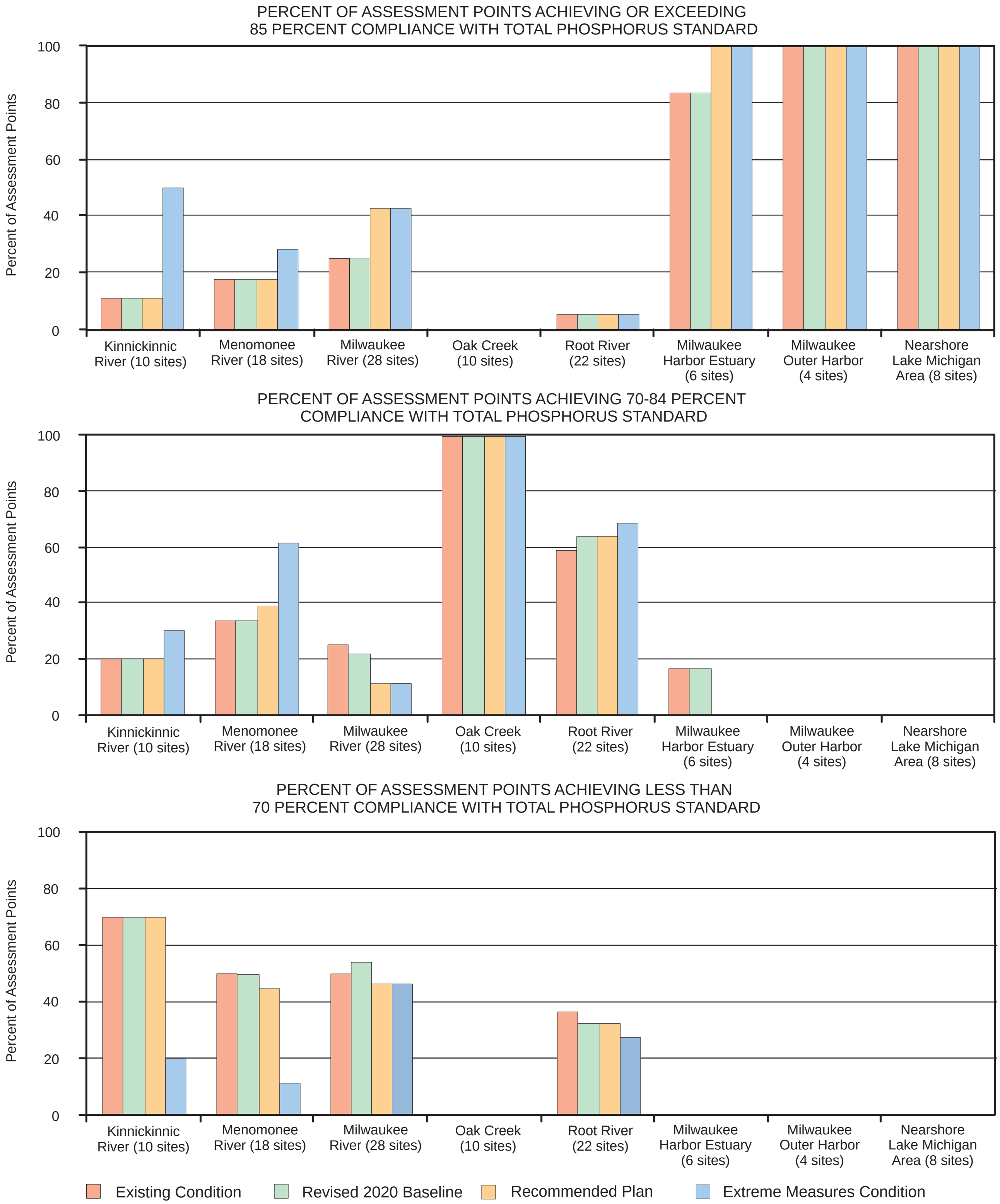
- **Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems and to Control Urban-Sourced Pathogens that are Harmful to Human Health:** Increased reduction in fecal coliform bacteria from the 33 percent reduction assumed under the recommended plan to 66 percent where applicable throughout the study area. Continued application of innovative means of identifying and controlling pathogens in stormwater runoff, subject to the results of recommended risk analyses. Extended the coordinated programs to all urban lands in the study area, adding the Lower Menomonee subwatershed, the Upper Lower Milwaukee River subwatershed, and the Lower Cedar Creek subwatershed.

- **Manure Management:** No change from recommended plan.

- **Buffers:** No change from recommended plan.

Figure 67 (revised)

ACHIEVEMENT OF THE RECOMMENDED TOTAL PHOSPHORUS PLANNING STANDARD

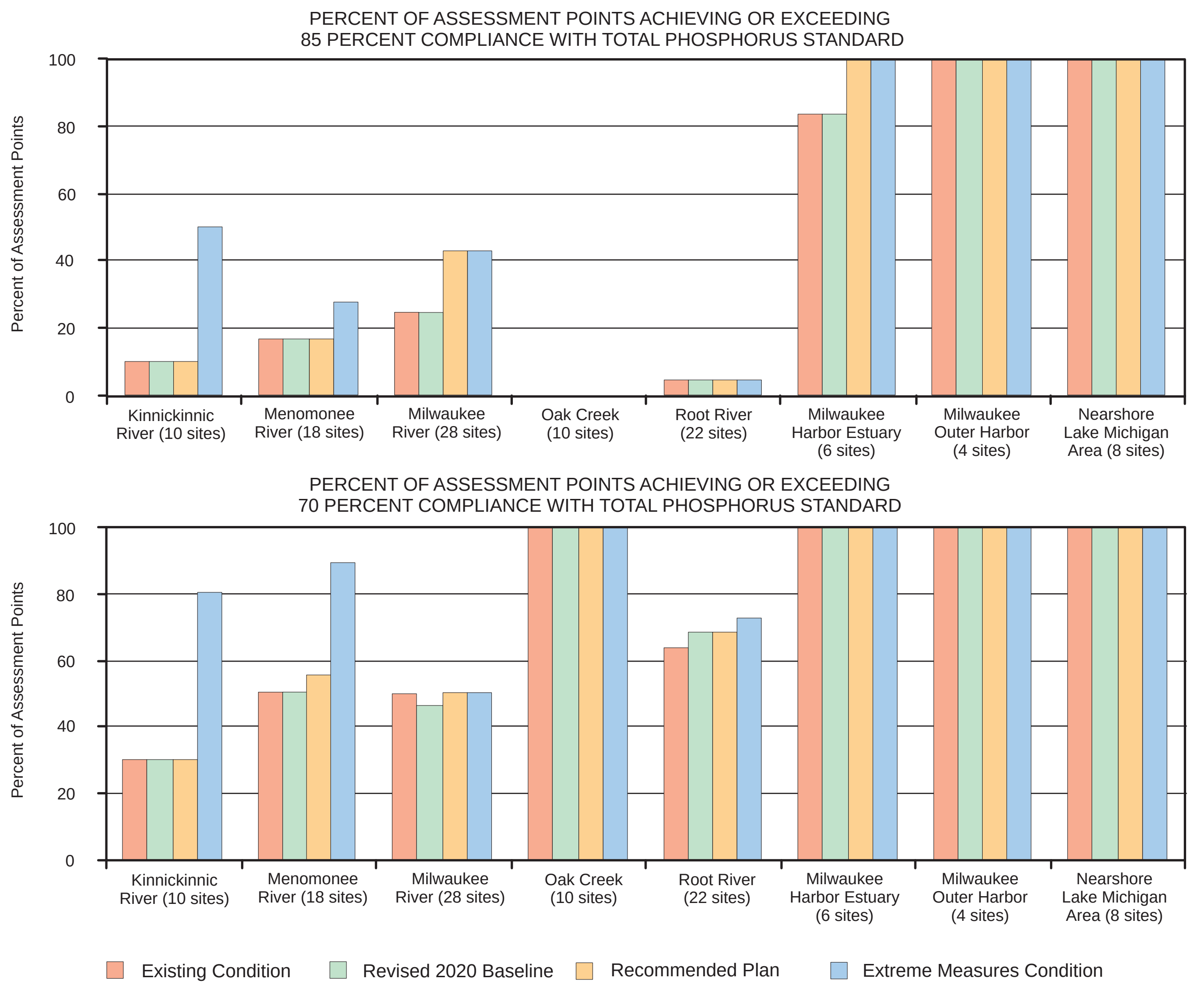


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N (revised) of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Figure 68 (revised)

ACHIEVEMENT OF THE RECOMMENDED TOTAL PHOSPHORUS PLANNING STANDARD



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N (revised) of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

- **Wetland/Prairie Restoration:** Increase conversion of cropland and pasture to prairie from the recommended 5 percent to 10 percent and increase conversion of cropland and pasture to wetland from the recommended 5 percent to 10 percent.

- **Septic System Management:** Increase reduction in fecal coliform bacteria from systems installed prior to 1980 from 10 percent under the recommended plan to 50 percent.

- **Fertilizer Management:** A 10 percent reduction in the phosphorus load from lawns was assumed under the recommended plan. The extreme measures condition applies targeted reductions of 50 percent from lawns in the Kinnickinnic, Menomonee, and Milwaukee River watersheds and 15 percent in the Oak Creek and Root River watersheds.

- **Phosphorus in Industrial Noncontact Cooling Water:** Assume that there is no significant phosphorus load to streams from noncontact cooling water discharges.

Evaluation of Water Quality Modeling Analysis Results Relative to the Adopted Water Use Objectives and Water Quality Standards/Criteria

Water quality summary statistics for 106 water quality assessment points distributed along streams throughout the 1,127-square mile study area and in the nearshore area of Lake Michigan are set forth by watershed in Tables N-1 through N-6. Mean and median concentrations are set forth for the 10-year simulation period. For pollutants that have regulatory or planning standards, the percent of time is indicated that a given stream or Lake assessment point is in compliance with the applicable standard. Geometric means are presented for fecal coliform bacteria for comparison with regulatory standards.

The following general conclusions can be drawn from review of the data presented in Tables N-1 through N-6:

- **Fecal Coliform Bacteria**
  - Marked reductions in concentration may be achieved under recommended plan conditions.
  - Improvements in compliance with the applicable standards are not as pronounced because of the existing high concentrations.
- **Dissolved Oxygen**
  - Compliance with the applicable standards is generally good under existing conditions.
  - Little change is projected to occur under the other conditions analyzed.
- **Total Phosphorus**
  - The most significant reductions in concentration generally occur under revised 2020 baseline conditions relative to existing conditions, except in stream reaches where discharges of noncontact cooling water are significant. In reaches where there are substantive noncontact cooling water discharges, the most significant total phosphorus reductions occur under the "extreme measures" condition.
  - The reductions under revised 2020 baseline conditions relative to existing conditions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and construction of MMSD committed projects.
  - Increases in concentrations are projected to occur at some locations in the upper Menomonee River watershed and the Milwaukee River watershed under revised 2020 baseline conditions. Relatively small increases in concentrations could occur at three locations in the Outer Harbor and two in the nearshore Lake Michigan area.
  - The recommended plan is projected to produce marked reductions in concentrations relative to revised 2020 baseline conditions in the Lake Michigan inner and outer harbor areas.
  - Under the extreme measures condition marked reductions in concentrations relative to recommended plan conditions could occur in the Lake Michigan inner and outer harbor areas and at some locations in the Kinnickinnic and Menomonee River watersheds, particularly in reaches with significant noncontact cooling water discharges.
- **Total Nitrogen**
  - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds and the upper portion of the Root River watershed where urban land use predominates, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
  - In the Milwaukee River watershed, the most significant reductions in concentrations occur under recommended plan conditions relative to the revised 2020 baseline conditions.
  - In the Root River Canal subwatershed and the lower Root River watershed downstream of the confluence with the Root River Canal, significant reductions in concentrations occur under both revised 2020 baseline conditions relative to existing conditions and recommended plan conditions relative to the revised 2020 baseline conditions.

- In the Lake Michigan inner and outer harbor, significant reductions in concentrations occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.
- In the nearshore Lake Michigan area little change in concentrations would be expected among the five conditions considered.

- **Total Suspended Solids**
  - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
  - These reductions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and completion of MMSD committed projects.
  - In the Milwaukee River watershed, the greatest reductions in concentrations occur under recommended plan conditions relative to revised 2020 baseline conditions.
  - In the urban areas of the Root River watershed in Milwaukee County, significant reductions in concentrations are anticipated under revised 2020 baseline conditions relative to existing conditions.
  - In the remainder of the Root River watershed and in the Lake Michigan inner and outer harbor areas, reductions in concentrations would be anticipated to occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.

- **Copper**
  - In the Kinnickinnic River, Menomonee River, Oak Creek, and Root River watersheds and in the Lake Michigan inner and outer harbor areas, the most significant reductions in concentrations generally occur under the revised 2020 baseline conditions relative to existing conditions.
  - In most locations in the Milwaukee River watershed and the nearshore Lake Michigan area no significant changes in concentrations would be expected among the five conditions considered.

Compliance with Adopted Water Quality Standards
For purposes of assessing compliance with water quality standards under this regional water quality management plan update, it was assumed that a stream reach would meet the water quality standard and attain its designated use objective if the modeled water quality results indicate compliance with the standard at least 85 percent of the time.

The data on compliance with standards as set forth in Tables N-1 through N-6 are summarized in Figures 57 through 68. For a given pollutant and standard, a pair of figures indicate the degree of compliance with applicable standards among the existing, revised 2020 baseline, recommended plan, and extreme measures conditions for each watershed in the study area, the Milwaukee harbor estuary, the outer harbor, and the nearshore Lake Michigan area. The first figure in each pair presents a set of three graphical comparisons. These comparisons consist of:

- The percentage of assessment points achieving or exceeding 85 percent compliance with the standard over the 10-year water quality simulation period,
- The percentage of assessment points achieving or exceeding 70 to 84 percent compliance with the standard over the 10-year simulation period, and
- The percentage of assessment points achieving less than 70 percent compliance with the standard over the 10-year simulation period.

Thus, for the four conditions represented, these graphs facilitate determination of the degree to which 1) a water quality standard is complied with in a given watershed (defined as compliance 85 percent of the time or greater), 2) a standard is close to being complied with (compliance 70 to 84 percent of the time), and 3) a standard is unlikely to be complied with (compliance less than 70 percent of the time). The second figure in each pair presents a pair of graphical comparisons of cumulative levels of compliance for each of the conditions indicated above. The two graphical comparisons consist of:

- The percentage of assessment points achieving or exceeding 85 percent compliance with the standard over the 10-year water quality simulation period.

- The percentage of assessment points achieving or exceeding 70 percent compliance with the standard over the 10-year water quality simulation period.

The assessments in Figures 57 through 68 are evaluated below.

- **Figures 57 and 58: Achievement of the Single Sample Fecal Coliform Bacteria Standard Assessed on an Annual Basis**
  Compliance with this standard 85 percent of the time would not be expected under existing, revised 2020 baseline, or recommended plan conditions at the assessment points in the Kinnickinnic River, Menomonee River, Oak Creek, or Root River watersheds. In the Kinnickinnic River watershed, 30 percent or less of the assessment points would be expected to achieve compliance 85 percent of the time under the extreme measures condition. In the Menomonee River, Oak Creek and Root River watersheds, none of the assessment points would be expected to achieve 85 percent compliance even under the extreme measures condition. In the Milwaukee River watershed less than 10 percent of the assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

  In the Milwaukee outer harbor and nearshore Lake Michigan area, compliance with standards was evaluated through comparison of modeled water quality results with the standards for the fish and aquatic life water use objective with full recreational use. In the Harbor estuary, compliance with the standard would be expected 85 percent of the time or more at more than 80 percent of the assessment points under the revised 2020 baseline, recommended plan, and extreme measures conditions. In the Outer harbor and nearshore Lake Michigan area 85 percent compliance with the standard would be expected at all locations.

  Substantial proportions of the total numbers of assessment points in the Kinnickinnic and Menomonee River watersheds, and to a lesser degree the Root River watershed, would be expected to achieve compliance in the 70 to 84 percent range. Large proportions of the total numbers of assessment points in the Milwaukee River, Oak Creek, and Root River watersheds, would be expected to achieve compliance less than 70 percent of the time.

  Overall, in all riverine reaches, a low degree of compliance with this standard would be expected under all conditions considered. However, a high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area.

- **Figures 59 and 60: Achievement of the Geometric Mean Fecal Coliform Bacteria Standard Assessed on an Annual Basis**
  Compliance with this standard 85 percent of the time would not be expected at a large number of assessment points in any of the watersheds under the four conditions analyzed, although, somewhat greater compliance would be expected under the extreme measures condition in the Kinnickinnic River watershed. That indicates that, if expenditures on additional point source controls could be foregone as might be possible under the recommended plan, additional resources directed toward control of nonpoint source pollution could achieve measurable improvements in water quality in that watershed.

In the Oak Creek and Root River watersheds, none of the assessment points would be expected to achieve compliance 85 percent of the time under any of the four conditions. With the exceptions of the Kinnickinnic River watershed under the extreme measures conditions only, compliance with this standard would be expected less than 70 percent of the time at a large proportion of the assessment points in all of the watersheds. In the estuary, the majority of assessment points would be expected to achieve 85 percent compliance, or better, under the revised 2020 baseline, recommended plan, and extreme measures conditions. All assessment points in the outer harbor and nearshore Lake Michigan area would be expected to achieve at least 85 percent compliance under all four conditions.

Overall, in all riverine reaches, a low degree of compliance with this standard would be expected under all conditions considered. However, a relatively high degree of compliance would be expected in the estuary and a high degree of compliance would be expected in the outer harbor, and nearshore Lake Michigan area.

- **Figures 61 and 62: Achievement of the Single Sample Fecal Coliform Bacteria Standard Assessed on a May to September Basis**
  In comparison to the previously-evaluated single sample standard assessed on an annual basis, much better compliance with this standard would be expected at assessment points in the Kinnickinnic and Menomonee River watersheds, and somewhat better compliance would be expected in the Milwaukee River watershed where implementation of the recommended plan would be expected to achieve a significant improvement relative to the revised 2020 baseline condition. For all four cases in the Root River watershed, 10 percent or fewer of the assessment points would be expected to achieve compliance 85 percent, or more, of the time. In the Oak Creek watershed, none of the assessment points would be expected to achieve compliance 85 percent of the time under any conditions except the extreme measures case, when about 10 percent of the assessment points would achieve 85 percent compliance. In the estuary, all assessment points would be expected to achieve 85 percent compliance, or better, under the revised 2020 baseline, recommended plan, and extreme measures conditions. In the outer harbor, and nearshore Lake Michigan area, all assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

  Overall, a relatively high degree of compliance with this standard would be expected in the Kinnickinnic and Menomonee River watersheds under the recommended plan and extreme measures conditions. In comparison to the single sample standard assessed on an annual basis that was evaluated above, assessment points in the Milwaukee and Root River watersheds would achieve higher levels of compliance with the standard under the recommended plan and extreme measures conditions, although those levels fall well short of what would be considered substantial compliance. Once again, the Oak Creek watershed would not be expected to achieve compliance 85 percent of the time under any conditions analyzed, except at 10 percent of the sites under the extreme measures condition. A high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area under all conditions considered.

- **Figures 63 and 64: Achievement of the Geometric Mean Fecal Coliform Bacteria Standard Assessed on a May to September Basis**
  In comparison to the previously-evaluated geometric mean standard assessed on an annual basis, much better compliance with this standard would be expected in the Kinnickinnic and Menomonee River watersheds, and somewhat better compliance would be expected in the Milwaukee River watershed. In the Menomonee and Milwaukee River watersheds, implementation of the recommended plan would be expected to result in improved water quality relative to the revised 2020 baseline condition. While not quite as pronounced as for the geometric mean standard assessed on an annual basis, for this condition there are still large percentages of assessment points in the Kinnickinnic River, Menomonee River, Milwaukee River, Root River, and Oak Creek watersheds that would be expected to achieve less than 70 percent compliance with the standard under recommended plan conditions. In the estuary, outer harbor, and nearshore Lake Michigan area, all assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

Overall, a relatively high degree of compliance with this standard would be expected at assessment points in the Kinnickinnic River watershed under the extreme measures condition and in the Menomonee River watershed under the recommended plan and extreme measures conditions. In comparison to the geometric mean standard assessed on an annual basis that was evaluated above, assessment points in the Milwaukee and Root River watersheds would be expected to achieve higher levels of compliance with the standard under the recommended plan and extreme measures conditions, although those levels fall well short of what would be considered substantial compliance. No assessment points in the Oak Creek watershed achieve compliance 85 percent of the time except under the extreme measures condition where 30 percent of the points would be expected to achieve compliance. A high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area under all conditions considered.

- **Figures 65 and 66: Achievement of the Dissolved Oxygen Standard**
  In general, 85 percent compliance with this standard, or better, would be expected under existing, revised 2020 baseline, recommended plan, and extreme measures conditions at the assessment points in the Menomonee, Milwaukee, and Root River watersheds, as well as the estuary, outer harbor, and nearshore Lake Michigan area. A somewhat lesser, but relatively high, degree of compliance would be expected in the Kinnickinnic River watershed, and a lower level of compliance would be anticipated in the Oak Creek watershed. However, at the assessment points in the Kinnickinnic River and Oak Creek watersheds, general compliance with the standard would be expected 70 percent or more of the time. Many of the assessment points in the Oak Creek watershed that are in the 70 to 84 percent of time compliance range fall in the higher end of that range.

  Overall, a high degree of compliance with this standard would be expected under all conditions considered. As noted above, compliance within the Oak Creek watershed is somewhat better than indicated by Figure 65, because, although significant percentages of the Oak Creek watershed assessment points fall in the 70 to 84 percent of time compliance range, many of the points fall in the higher end of that range.

- **Figures 67 and 68: Achievement of the Recommended Total Phosphorus Planning Standard**

  Compliance with the planning standard would be expected eighty-five percent of the time or more at:

  - About 10 percent of the assessment points in the Kinnickinnic River watershed for the existing, revised 2020 baseline, and recommended plan conditions, and about 50 percent of the points under the extreme measures condition;

  - Fifteen to 20 percent of the assessment points in the Menomonee River watershed for the existing, revised 2020 baseline, and recommended plan conditions, and about 25 percent of the points under the extreme measures condition;

  - Twenty-five percent of the assessment points in the Milwaukee River for the existing and revised 2020 baseline conditions, and at about 40 percent of the points under the recommended plan and extreme measures conditions;

  - No assessment points in the Oak Creek watershed. (However, the Oak Creek watershed is the only one where all of the assessment points would be expected to meet the planning standard 70 percent, or more, of the time.); and

  - Five percent of the assessment points in the Root River watershed under all four conditions.

  In the estuary, over 80 percent of the assessment points would be expected to achieve compliance with the planning standard 85 percent of the time or more under existing and revised 2020 baseline conditions. All assessment points would be expected to achieve 85 percent compliance, or better, under the recommended plan and extreme measures conditions. All assessment points in the outer harbor and nearshore Lake Michigan area would be expected to achieve at least 85 percent compliance under all four conditions.

Overall, with respect to the 85 percent of time bench mark, a relatively low degree of compliance with this standard would be expected in all of the watersheds under all four conditions. The assessment points in the Oak Creek watershed would be expected to achieve compliance with the planning standard more than 70 percent of the time for all four conditions. About half of the points in the Milwaukee River watershed and 60 to 70 percent of those in the Root River watershed would be expected to comply with the planning standard 70 percent or more of the time under all four conditions. About 30 percent of the assessment points in the Kinnickinnic River watershed would be expected to comply with the planning standard 70 percent or more of the time under the existing, revised 2020 baseline, and recommended plan conditions, and 80 percent of the points would comply 70 percent or more of the time under the extreme measures condition. About 50 to 55 percent of the assessment points in the Menomonee River watershed would be expected to comply with the planning standard 70 percent or more of the time under the existing, revised 2020 baseline, and recommended plan conditions, and about 90 percent of the points would comply 70 percent or more of the time under the extreme measures condition. A high degree of compliance with the planning standard would be expected in the estuary, outer harbor, and nearshore Lake Michigan area.

Comparison of Water Quality Conditions: Revised 2020 Baseline vs. Revised 2020 Baseline with Five-Year Level of Protection Against SSOs from MMSD System

The water quality assessment points in, or downstream from, the MMSD planning area that are indicated on Maps N-1 through N-6 are the only assessment points that could be affected by SSOs from the MMSD system. Outside of those locations, there is no difference in the water quality statistics between the revised 2020 baseline condition and the revised 2020 baseline with a five-year level of protection (LOP) against SSOs from the MMSD system. Comparison of the water quality conditions tabulated in Appendix N (revised) with and without the five-year LOP (at those locations where there could be SSOs from the MMSD system) indicates no significant difference in water quality under the two conditions. That conclusion supports the observation that has been stated previously in this report that further reductions in point sources of pollution would be expected to have no significant effects on water quality.

Evaluation of Water Quality Modeling Analysis Results Relative to the "Auxiliary Uses" with More-Stringent Water Quality Standards

As noted previously in this chapter, the water use objectives for streams in the study area are set forth in detail in Table 70 in Chapter VII of this report. Those objectives include both the codified objectives and auxiliary uses to be considered for planning purposes. Those auxiliary uses were generally established by the WDNR in "State of the Basin" reports, as noted in Table 70. For those waters assigned an auxiliary use objective the potential for achieving a higher objective or classification than currently codified was evaluated under the regional water quality management plan update. The evaluations of alternative classifications were done both in response to changes in conditions since the last relevant *Administrative Code* sections were promulgated and in consideration of modeled improvements in water quality under recommended plan conditions. This evaluation was made to assist in future planning and management strategies and is not intended to be directed as a change to the current regulatory framework.

Those surface waters where auxiliary upgraded water use objectives or classifications have been evaluated in the planning process are set forth in Table 89, which includes comparisons of pollutant concentrations for existing year 2000 conditions, revised 2020 baseline conditions, revised 2020 baseline conditions with a five-year level of protection against sanitary sewer overflows, recommend plan conditions, and the extreme measures condition. The locations of the assessment points are shown graphically on Maps N-1 through N-3, N-5, and N-6 in

Appendix N of this report. The locations where auxiliary use objectives were evaluated were chosen based on the satisfaction of the following two criteria:

- An auxiliary use objective is given in Table 70 in Chapter VII of this report, and
- The water quality models developed for the plan update include an output assessment point in the stream reach where the auxiliary use objective is assigned.

Based on application of these criteria, stream reaches to be evaluated were identified in the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds, including within the Kinnickinnic, Menomonee, and Milwaukee River portions of the Milwaukee Harbor estuary. At all evaluated locations in the Kinnickinnic and Menomonee River watersheds and the Milwaukee Harbor estuary, and at two of the three evaluated locations in the Milwaukee River watershed, “special variance” is the regulatory, codified water use objective and “fish and aquatic life” and “full recreational use” are the potential “auxiliary use” objectives. As shown in Table 67 in Chapter VI of this report, the only numerical water quality standards that differ between those water use objectives are for dissolved oxygen and fecal coliform bacteria. Thus, in those cases Table 89 presents comparative information on fecal coliform bacteria and dissolved oxygen concentrations. For Stony Creek, which is the one other evaluation location in the Milwaukee River watershed, the codified use is “fish and aquatic life” and the auxiliary use is “coldwater.” In that case, the dissolved oxygen concentration is the differentiating standard. For three of the four tributaries in the Root River watershed the codified use is “limited forage fish” and

Table 89

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: COMPARISON TO STANDARDS FOR "AUXILIARY USES"[a]

					Condition					
Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan	"Extreme Measures" Condition	Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
				Kinnickinnic River Watershed						
KK-10 Kinnickinnic River	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,859	4,942	4,633	3,091	1,613	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	56	58	59	65	71	No
				Geometric mean (cells per 100 ml)	842	702	686	449	230	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	18	27	27	61	185	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,401	2,999	2,470	1,634	904	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	69	71	72	78	83	No
				Geometric mean (cells per 100 ml)	498	416	398	253	130	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	12	16	16	37	109	No
			Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.3	- -
				Median (mg/l)	11.5	11.5	11.5	11.5	11.4	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	100	100	100	100	100	Yes
				Menomonee River Watershed						
MN-14 Underwood Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	8,133	6,588	6,588	4,250	2,166	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	63	64	64	65	68	No
				Geometric mean (cells per 100 ml)	691	552	552	369	195	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	58	84	84	142	218	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,964	2,460	2,460	1,332	692	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	79	79	79	81	84	No
				Geometric mean (cells per 100 ml)	351	279	279	180	96	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	24	40	40	79	134	No
			Dissolved Oxygen	Mean (mg/l)	11.0	11.1	11.1	11.1	11.1	- -
				Median (mg/l)	11.1	11.2	11.2	11.2	11.2	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	97	98	98	98	98	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition					Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
					Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan	"Extreme Measures" Condition	
MN-16 Honey Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9,286	7,761	7,761	4,864	2,156	
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	66	66	66	68	72	No
				Geometric mean (cells per 100 ml)	612	512	512	338	162	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	67	82	82	144	235	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,073	3,413	3,413	1,882	801	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	81	81	81	82	85	No
				Geometric mean (cells per 100 ml)	325	273	273	178	86	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	29	36	36	78	138	No
			Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0	- -
				Median (mg/l)	10.7	10.6	10.6	10.6	10.6	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	90	91	91	91	91	Yes
MN-17 Menomonee River	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,926	5,903	5,863	4,198	2,657	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	47	47	47	49	52	No
				Geometric mean (cells per 100 ml)	1,124	981	978	704	471	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	12	22	22	50	107	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,622	3,064	2,985	1,833	1,100	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	67	67	67	70	73	No
				Geometric mean (cells per 100 ml)	496	415	412	271	173	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	5	12	12	32	78	No
			Dissolved Oxygen	Mean (mg/l)	11.1	10.9	10.9	10.9	10.9	- -
				Median (mg/l)	11.1	11.0	11.0	11.0	10.9	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	100	100	100	100	100	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition					Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
					Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan	"Extreme Measures" Condition	
Menomonee River Watershed (continued)										
MN-18 Menomonee River	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,889	5,945	5,907	4,214	2,552	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	48	48	48	50	52	No
				Geometric mean (cells per 100 ml)	1,081	955	952	685	449	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	15	26	26	54	114	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,557	3,073	2,998	1,861	1,052	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	68	68	68	71	74	No
				Geometric mean (cells per 100 ml)	468	399	396	261	163	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	7	14	14	35	84	No
			Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.9	- -
				Median (mg/l)	11.0	10.9	11.0	10.9	10.9	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	100	100	100	100	100	Yes
Milwaukee River Watershed										
ML-22 Stony Creek	Fish and Aquatic Life	Coldwater	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	- -
				Median (mg/l)	11.5	11.5	11.5	11.5	11.5	- -
				Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[c]	100	100	100	100	100	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition					Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
					Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan	"Extreme Measures" Condition	
Milwaukee River Watershed (continued)										
ML-31 Indian Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,135	6,898	6,898	2,956	1,814	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	43	44	43	48	53	No
				Geometric mean (cells per 100 ml)	614	649	649	307	180	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	138	138	128	168	200	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,587	3,275	3,275	2,615	2,071	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	65	67	64	65	67	No
				Geometric mean (cells per 100 ml)	130	159	159	103	70	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	102	102	96	110	123	No
			Dissolved Oxygen	Mean (mg/l)	8.0	8.1	8.1	7.8	7.7	- -
				Median (mg/l)	7.8	8.0	8.0	7.7	7.6	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	87	87	87	87	86	Yes
ML-32 Lincoln Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,770	4,405	4,400	1,913	1,168	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	38	37	35	40	46	No
				Geometric mean (cells per 100 ml)	561	742	741	403	206	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	138	134	120	132	162	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,223	1,866	1,860	1,505	1,213	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	65	65	61	63	65	No
				Geometric mean (cells per 100 ml)	106	162	162	130	69	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	102	101	92	96	109	No
			Dissolved Oxygen	Mean (mg/l)	6.4	7.1	7.1	6.5	6.5	- -
				Median (mg/l)	6.3	7.0	7.0	6.5	6.5	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	72	80	80	79	78	No

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan	Condition: "Extreme Measures" Condition	Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
Root River Watershed										
RT-5 Whitnall Park Creek	Limited Forage Fish	Fish and Aquatic Life	Dissolved Oxygen	Mean (mg/l)	8.5	8.5	8.5	8.5	8.5	- -
				Median (mg/l)	8.4	8.4	8.4	8.4	8.4	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	92	92	92	92	92	Yes
RT-6 Tess Corners Creek	Limited Forage Fish	Fish and Aquatic Life	Dissolved Oxygen	Mean (mg/l)	10.3	10.3	10.3	10.3	10.3	- -
				Median (mg/l)	10.4	10.4	10.4	10.4	10.4	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	96	97	97	97	97	Yes
RT-19 Ives Grove Ditch	Limited Aquatic Life	Limited Forage Fish	Dissolved Oxygen	Mean (mg/l)	10.1	9.9	9.9	9.9	9.9	- -
				Median (mg/l)	8.8	8.8	8.8	8.7	8.7	- -
				Percent compliance with dissolved oxygen standard (>3 mg/l)[c]	95	96	96	96	96	Yes
RT-20 Hoods Creek	Limited Forage Fish	Fish and Aquatic Life	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0	- -
				Median (mg/l)	11.7	11.8	11.8	11.8	11.8	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	94	94	94	94	94	Yes
Milwaukee Harbor Estuary										
LM-1 Milwaukee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,101	863	850	428	331	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	48	51	52	63	70	No
				Geometric mean (cells per 100 ml)	175	145	144	79	50	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	164	173	173	208	231	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	457	353	328	272	241	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	77	81	81	84	87	No
				Geometric mean (cells per 100 ml)	26	22	21	16	9	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	115	121	122	133	141	Yes
			Dissolved Oxygen	Mean (mg/l)	10.0	9.9	9.9	9.9	9.9	- -
				Median (mg/l)	10.8	10.8	10.8	10.8	10.7	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	93	93	93	93	93	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan	Condition: "Extreme Measures" Condition	Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
Milwaukee Harbor Estuary (continued)										
LM-2 Menomonee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,466	3,208	3,169	2,245	1,280	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	37	38	38	42	48	No
				Geometric mean (cells per 100 ml)	595	546	542	376	233	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	118	121	122	144	172	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,250	1,111	1,040	709	418	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	62	62	63	69	78	No
				Geometric mean (cells per 100 ml)	135	119	117	79	49	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	87	90	90	106	126	No
			Dissolved Oxygen	Mean (mg/l)	9.3	9.5	9.5	9.5	9.5	- -
				Median (mg/l)	9.7	10.0	10.0	9.9	9.9	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	94	94	94	94	95	Yes
LM-3 Menomonee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	931	828	808	533	320	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	58	59	59	68	78	No
				Geometric mean (cells per 100 ml)	141	127	126	80	53	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	192	199	200	236	265	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	494	442	406	286	180	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	78	79	79	84	91	No
				Geometric mean (cells per 100 ml)	40	35	34	24	16	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	122	127	128	138	143	Yes
			Dissolved Oxygen	Mean (mg/l)	9.1	9.3	9.3	9.3	9.3	- -
				Median (mg/l)	9.7	10.0	10.0	9.9	9.9	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	94	94	94	94	94	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan	Condition: "Extreme Measures" Condition	Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
Milwaukee Harbor Estuary (continued)										
LM-4 Milwaukee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	850	731	716	401	279	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	56	57	58	68	77	No
				Geometric mean (cells per 100 ml)	147	132	131	78	54	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	188	194	195	232	260	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	399	345	319	235	167	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	80	81	81	87	92	Yes
				Geometric mean (cells per 100 ml)	37	31	31	22	15	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	123	127	128	138	144	Yes
			Dissolved Oxygen	Mean (mg/l)	9.5	9.6	9.6	9.6	9.6	- -
				Median (mg/l)	10.1	10.3	10.3	10.3	10.3	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	95	94	94	95	95	Yes
LM-5 Kinnickinnic River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	352	358	265	184	129	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	79	82	82	91	96	Yes
				Geometric mean (cells per 100 ml)	52	48	47	31	21	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	269	278	278	322	358	Yes
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	255	298	166	140	118	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	92	94	94	96	97	Yes
				Geometric mean (cells per 100 ml)	17	15	15	11	9	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	141	143	143	149	151	Yes
			Dissolved Oxygen	Mean (mg/l)	8.2	8.2	8.3	8.4	8.4	- -
				Median (mg/l)	8.7	8.7	8.8	8.9	9.0	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	92	92	92	93	93	Yes

Table 89 (continued)

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6	Auxiliary Use Objective(s) Evaluated in This Table	Water Quality Indicator	Statistic	Condition					Is Standard Met 85 Percent of Time or More Under Recommended Plan Conditions?
					Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan	"Extreme Measures" Condition	
Milwaukee Harbor Estuary (continued)										
LM-6 Mouth of Milwaukee River at Hoan Bridge at entrance to the Outer Harbor	Special Variance	Fish and Aquatic Life and Full Recreational Use	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	445	396	383	230	160	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	71	73	73	83	90	No
				Geometric mean (cells per 100 ml)	78	74	73	47	35	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	244	246	246	287	312	No
			Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	229	203	180	139	107	- -
				Percent compliance with single sample standard (<400 cells per 100 ml)[c]	88	90	90	93	96	Yes
				Geometric mean (cells per 100 ml)	26	23	23	18	14	- -
				Days of compliance with geometric mean standard (<200 cells per 100 ml)[c]	135	137	138	146	150	Yes
			Dissolved Oxygen	Mean (mg/l)	9.5	9.6	9.6	9.6	9.6	- -
				Median (mg/l)	10.0	10.1	10.1	10.1	10.1	- -
				Percent compliance with dissolved oxygen standard (>5 mg/l)[c]	99	98	98	99	99	Yes

[a] *See Table 70 for auxiliary uses to be considered for planning purposes.*

[b] *Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c] *Standard for "auxiliary use" objective.*

Source: Tetra Tech, Inc.; HydroQual, Inc.; and SEWRPC.

the auxiliary use is “fish and aquatic life.” For the fourth tributary in the Root River watershed the codified use is “limited aquatic life” and the auxiliary use is “limited forage fish.” For those uses, the dissolved oxygen concentration is also the differentiating standard.

As noted previously in this chapter, a stream or stream reach was assumed to substantially comply with numerical water quality standards or criteria if those standards or criteria were estimated to be met 85 percent of the time or more. That criterion was used to assess the possibility of a stream or stream reach meeting the auxiliary use objective under modeled recommended plan conditions. In addition, water quality data from the baseline period were compared to the standards or criteria supporting the auxiliary use objectives to determine whether a stream or stream reach is currently meeting the auxiliary use objective.[143] Fecal coliform bacteria counts were considered on an annual basis and for the 153-day swimming season from May 1 through September 30. If the bacteria criteria were met for the swimming season, it would be reasonable to conclude that the stream in question would meet the water use objective.

An evaluation of compliance with the water quality standards associated with the auxiliary use objectives under recommended plan conditions is presented in the following subsections. That evaluation included consideration of whether, for a given stream or stream reach, a recommendation could be made to 1) upgrade the existing regulatory water use objective or 2) propose a planned water use objective that might be achieved under recommended plan conditions. The evaluation of upgrading the existing regulatory water use objective was based on consideration of observed water quality data for the baseline period and the evaluation of possible planned water use objectives considered both observed and estimated future modeled water quality conditions.

In general, even though anticipated water quality conditions at some locations assessed fall short of the compliance criterion, implementation of the recommended plan would result in significant improvement in fecal coliform concentrations.

Kinnickinnic River Watershed Upstream of the Estuary
As shown in Table 89, the dissolved oxygen standard is met more than 85 percent of the time at assessment point KK-10, which is located just upstream of the Milwaukee Harbor estuary. In addition, Table 90 shows that during the baseline period, concentrations of dissolved oxygen at sampling stations upstream from the assessment point were greater than or equal to the standard in more than 85 percent of the samples collected. However, compliance with the fecal coliform bacteria standards would not be achieved 85 percent or more of the time under either recommended plan or the extreme measures condition (Table 89). In addition, during the baseline period, concentrations of fecal coliform bacteria in this reach generally exceeded the single sample standard (Table 90). While the current level of compliance with the standard for dissolved oxygen concentration, and the anticipated level of compliance with that standard under recommended plan conditions, are sufficient to support a fish and aquatic life water use objective, habitat limitations related to the presence of concrete-lined and enclosed channel in a substantial portion of the Kinnickinnic River upstream from the assessment point make it unlikely that the Kinnickinnic River upstream from the estuary could support a fish and aquatic life use objective under current channel conditions. The MMSD has initiated a study to evaluate alternatives for stream rehabilitation and possible removal of the concrete lining in the stream. Depending on the results of that study, attainment of a fish and aquatic life standard may become more viable. The anticipated improvement in fecal coliform concentrations would not be sufficient for this reach of the River to meet the standards for a full recreational use water use objective.

Menomonee River Watershed Upstream of the Estuary—Recommended Plan Conditions
The four assessment points in the Menomonee River watershed upstream of the estuary include:

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[143]*The baseline period used for the Kinnickinnic River, Menomonee River, and Oak Creek watersheds was 1998-2001. As this study progressed, data became available and were incorporated into the analyses. Because of this, the baseline period used for the Milwaukee River and Root River watersheds was 1998-2004.*

Table 90

COMPARISON OF WATER QUALITY PARAMETER CONCENTRATIONS TO STANDARDS SUPPORTING AUXILIARY USES

Stream	Sampling Stations	Samples with Concentrations of Dissolved Oxygen Greater than or Equal to Auxiliary Standard (percent)[a]	Samples with Concentrations of Fecal Coliform Bacteria Greater than or Equal to Auxiliary Standard (percent)[a,b]	
		Annual	Annual	May to September
Kinnickinnic River Watershed				
Kinnickinnic River Upstream of the Estuary	2	99.2 (130)	22.5 (129)	16.3 (80)
Menomonee River Watershed				
Menomonee River Mainstem	1	100.0 (117)	8.5 (117)	1.1 (87)
Honey Creek	5	85.9 (92)	21.7 (92)	20.5 (73)
Underwood Creek	5	87.5 (80)	46.3 (80)	46.7 (60)
Milwaukee River Watershed				
Indian Creek	4	90.6 (32)	43.8 (32)	41.7 (24)
Lincoln Creek	5	93.6 (404)	30.9 (388)	42.3 (149)
Mole Creek	1	100.0 (5)	- -	- -
Stony Creek	1	100.0 (6)	- -	- -
Wallace Creek	1	100.0 (5)	- -	- -
Milwaukee River Estuary				
Kinnickinnic River	3	72.3 (184)	56.9 (181)	47.9 (117)
Menomonee River	4	69.0 (306)	46.3 (300)	41.5 (188)
Milwaukee River	6	92.2 (408)	45.2 (403)	35.9 (256)

NOTE: The information in this table is for the "baseline period" for analysis of data, as defined in Chapter III of this report. The baseline period used for the Kinnickinnic River, Menomonee River, and Oak Creek watersheds is 1998-2001. As this study progressed, data became available and were incorporated into the analyses. Because of this, the baseline period used for the Milwaukee River and Root River watersheds is 1998-2004.

[a]*Number in parentheses indicates sample size.*

[b]*Fecal coliform bacteria compared to the single sample standard of 400 cells per 100 ml.*

Source: SEWRPC.

- MN-14 at the mouth of Underwood Creek,
- MN-16 at the mouth of Honey Creek,
- MN-17 on the mainstem of the Menomonee River just downstream of the confluence with Honey Creek, and
- MN-18 on the mainstem of the Menomonee River just upstream of the Milwaukee Harbor estuary.

DISSOLVED OXYGEN

The dissolved oxygen standard is met more than 85 percent of the time at each of the assessment points (Table 89). In addition, during the baseline period, concentrations of dissolved oxygen at sampling stations along Honey and Underwood Creeks and the mainstem of the Menomonee River just downstream of the confluence with Honey Creek were greater than or equal to the standard in more than 85 percent of the samples (Table 90). While the levels of compliance with the standard for dissolved oxygen concentration in the Menomonee River, Honey Creek, and Underwood Creek are sufficient to support fish and aquatic life water use objectives, habitat limitations related to the presence of enclosed channel and/or concrete-lined channel in a portion of the Menomonee River upstream of IH 94, in Honey Creek, and in downstream reaches of Underwood Creek make it unlikely that these stream reaches could support a fish and aquatic life use objective. However, the reaches of the Menomonee River upstream and downstream of the concrete-lined portion could attain a fish and aquatic life standard. The MMSD is considering approaches to address the remaining concrete-lined reach in the Menomonee River. Modification of that reach to improve fish passage, while not essential to the attainment of a fish and aquatic life objective in the River upstream of the concrete lining, would result in a much greater diversity of fish and other aquatic organisms in the upstream reach. Also, a planned MMSD project to remove all or portions of the concrete lining and rehabilitate the stream channel in the reach of Underwood Creek downstream of STH 100 (N. Mayfair Road) could enable attainment of the fish and aquatic life objective in that reach.

FECAL COLIFORM BACTERIA

For the assessment points in both Underwood Creek (MN-14) and Honey Creek (MN-16), while the annual compliance with the fecal coliform standards does not meet the 85 percent criterion, full implementation of the recommended plan would be expected to achieve over 80 percent compliance with the single sample standard for the May through September swimming season (Table 89). However, converting the days of compliance with the geometric mean standard for the 153-day period from May through September only yields about 50 percent compliance for each subwatershed. In addition, the levels of compliance with the single sample full recreational use standard at sampling stations along Honey and Underwood Creeks during the baseline period did not meet the 85 percent criterion (Table 90). Thus, the anticipated improvement in fecal coliform concentrations would not be sufficient for Honey and Underwood Creeks to meet the standards for full recreational use.

For the two Menomonee River mainstem sites (MN-17 and 18), despite anticipated improvements in fecal coliform bacteria concentrations under the recommended plan, compliance with the standards would not be achieved 85 percent or more of the time (Table 89). In addition, the level of compliance with the single sample full recreational use standard at the sampling stations along this reach during the baseline period did not meet the 85 percent criterion (Table 90). Thus, the anticipated improvement in fecal coliform concentrations would not be sufficient for the lower reach of the River upstream of the estuary to meet the standards for full recreational use.

Milwaukee River Watershed Upstream of the Estuary

The three assessment points in the Milwaukee River watershed include:

- ML-22 at the mouth of Stony Creek,
- ML-31 at the mouth of Indian Creek, and
- ML-32 at the mouth of Lincoln Creek.

DISSOLVED OXYGEN

As shown in Table 89, the dissolved oxygen standard is met more than 85 percent of the time at assessment points ML-22 and ML-31 under recommended plan conditions (Table 89). The levels of compliance with the standard for dissolved oxygen in Stony Creek are sufficient to support a coldwater water use objective. Dissolved oxygen concentrations from limited sampling conducted in Stony Creek during the baseline period support this conclusion (Table 90). In all of the samples collected, concentrations of dissolved oxygen were above 7.0 mg/l. While the anticipated levels of compliance with the standard for dissolved oxygen in Indian Creek (Table 89) and the levels of compliance in samples collected during the baseline period (Table 90) are sufficient to support a fish and aquatic life use objective, the presence of concrete-lined channel in reaches upstream of N. Manor Lane in the Village of Fox Point make it unlikely that these reaches could support that use objective. The reaches of Indian Creek downstream of N. Manor Lane could attain a fish and aquatic life use objective.[144]

For the assessment point in Lincoln Creek (ML-32), despite the anticipated improvements in dissolved oxygen concentrations under the recommended plan, compliance with the standard for dissolved oxygen would not be achieved 85 percent or more of the time under recommended plan conditions (Table 89). By contrast, dissolved

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[144]*MMSD recently removed about 0.75 mile of concrete cunette from Indian Creek between Port Washington Road and N. Manor Lane.*

oxygen concentrations from sampling conducted in the Creek show that compliance with the dissolved oxygen standard was achieved in 85 percent or more of the samples collected during the baseline period (Table 90); however, there are several reasons why these data may not be representative of current conditions in the Creek. First, most of the baseline period data were collected while construction activities related to the Lincoln Creek Environmental Restoration and Flood Control Project were being conducted. This project resulted in considerable changes in the stream, including widening and deepening of some sections of stream channel and removal of over two miles of concrete lining from the channel. Because construction activities began in 1998 and continued until 2002, most of the baseline period data reflect conditions during construction and not current, post-construction conditions. Second, most of the samples examined for dissolved oxygen were collected during the daytime, when dissolved oxygen concentrations would be expected to be high. Few samples were collected after sundown, when dissolved oxygen concentrations would be expected to be lower. Given this, the available data may overestimate the mean concentrations of dissolved oxygen and underestimate the frequency of events during which dissolved oxygen concentrations in the Creek dropped below the standard for fish and aquatic life. By contrast, because the model results reflect concentrations throughout the day and night, they probably give a more representative picture of the variability in dissolved oxygen concentrations in the stream. Finally, high densities of attached algae, such as *Cladophora,* were reported to be growing in some sections of the Creek during the baseline period.[145] During the day, photosynthesis by these algae will increase concentrations of dissolved oxygen in the Creek. By contrast, the respiratory requirements of these algae during dark periods can result in substantial reductions in dissolved oxygen concentrations. For these reasons, the model results most likely give a more representative picture of current and anticipated dissolved oxygen concentrations in Lincoln Creek. These results indicate that the anticipated improvements in dissolved oxygen concentrations would not be sufficient to support a fish and aquatic life use objective in Lincoln Creek.

FECAL COLIFORM BACTERIA

For the assessment points in both Indian Creek (ML-31) and Lincoln Creek (ML-32), despite anticipated improvements in fecal coliform bacteria under the recommended plan, compliance with the standards would not be achieved 85 percent or more of the time (Table 89). In addition, concentrations of fecal coliform bacteria in these streams did not achieve compliance with the single sample standard in 85 percent or more of the samples collected during the baseline period (Table 90). Thus, the anticipated improvement in fecal coliform concentrations would not be sufficient for these streams to meet the standards for full recreational use.

Limited data collected during the baseline period suggest that two other streams in the Milwaukee River watershed, Mole Creek and Wallace Creek, might be able to achieve an auxiliary use objective of “coldwater” (Table 90). While few samples were available from these streams, dissolved oxygen concentrations in all of the samples analyzed were greater than or equal to 7 mg/l. Because no assessment points were located on these streams, no model results are available for these streams to indicate anticipated levels of compliance with the dissolved oxygen standard supporting a “coldwater” water use objective under recommended plan conditions.

Root River Watershed

The four assessment points in the Root River watershed include:

- RT-5 near the mouth of Whitnall Park Creek,
- RT-6 near the mouth of Tess Corners Creek,
- RT-19 at the mouth of Ives Grove Ditch, and
- RT-20 at the mouth of Hoods Creek.

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[145]*Timothy J. Ehlinger, Craig D. Sandgren, and Lori Schacht DeThorne, “Monitoring of Stream Habitat and Aquatic Biotic Integrity: Lincoln Creek, Milwaukee County Wisconsin,” Report to the Great Lakes Protection Fund and Milwaukee Metropolitan Sewerage District, April 2003.*

The model results indicate that the dissolved oxygen standard is met more than 85 percent of the time at each of the assessment points under recommended plan conditions (Table 89). No sampling data were available for these streams.

For the assessment points in Whitnall Park Creek (RT-5), Tess Corners Creek (RT-6), and Hoods Creek (RT-20), the compliance with the standard for dissolved oxygen concentration under the recommended plan could be sufficient for those streams to meet the standards for a fish and aquatic life water use objective.

For the assessment point in Ives Grove Ditch (RT-19), the compliance with the standard for dissolved oxygen concentration under the recommended plan could be sufficient for this stream to meet the standards for a limited forage fish water use objective.

Milwaukee Harbor Estuary
The six assessment points in the Milwaukee Harbor estuary include:

- LM-1 in the Milwaukee River portion of the estuary,
- LM-2 in the Menomonee River portion of the estuary,
- LM-3 in the Menomonee River portion of the estuary just upstream of the confluence with the Milwaukee River,
- LM-4 in the Milwaukee River portion of the estuary just downstream of the confluence with the Menomonee River,
- LM-5 in the Kinnickinnic River portion of the estuary, and
- LM-6 at the mouth of the Milwaukee River at the Hoan Bridge and the entrance to the outer harbor.

DISSOLVED OXYGEN
Under anticipated plan conditions, the dissolved oxygen standard is met more than 85 percent of the time at each of the assessment points along the Milwaukee River (Table 89). Thus, the anticipated dissolved oxygen concentrations could be sufficient for the Milwaukee River portion of the estuary to meet the standards for a fish and aquatic life water use objective. Data collected during the baseline period show that dissolved oxygen concentrations in the Milwaukee River portion of the estuary were in compliance with the fish and aquatic life standard in 85 percent or more of the samples collected (Table 90). This is consistent with the results from the model which show that under existing conditions in the Milwaukee River portion of the estuary, dissolved oxygen concentrations should be greater than or equal to the fish and aquatic life standard more than 85 percent of the time.

In the Kinnickinnic River portion of the estuary, dissolved oxygen concentrations at the two downstream sampling stations, those located at Greenfield Avenue (extended) and the Jones Island Ferry, achieved compliance with the standard for fish and aquatic life in 85 percent or more of the samples collected during the baseline period. Since one of these stations, the Greenfield Avenue (extended) station, is at the same location as assessment point LM-5, it is reasonable to conclude that the model results are representative of the existing level of compliance with the fish and aquatic life standard in the lower Kinnickinnic River portion of the estuary. Farther upstream, at the S. 1st Street sampling station, dissolved oxygen concentrations did not achieve compliance with the standard for fish and aquatic life in 85 percent or more of the samples collected during the baseline period. The low level of compliance at this station accounts for the overall low level of compliance in the Kinnickinnic River portion of the estuary. It also suggests that the anticipated levels of compliance forecast by the model for assessment point LM-5 may not be representative of dissolved oxygen conditions in the Kinnickinnic River portion of the estuary upstream of LM-5. This may be the result of high levels of high oxygen demand related to decomposition of organic material in sediment in the upstream portions of this reach. As of 2007, a remediation project was ongoing for contaminated sediment in the Kinnickinnic River between S. Kinnickinnic Avenue and W. Becher Street. This reach includes the S. 1st Street sampling station. Removal of contaminated sediment from this reach is likely to remove considerable organic material and may improve dissolved oxygen conditions in the upper section of the Kinnickinnic River portion of the estuary.

The situation in the Menomonee River portion of the estuary is more complicated. For the Menomonee River, there are some differences between the levels of compliance with standards indicated by observed data and those indicated by the results of the model. [146] The model results indicate that existing dissolved oxygen concentrations in these portions of the estuary should be greater than or equal to the fish and aquatic life standard more than 85 percent of the time. As shown in Table 90, on average, dissolved oxygen concentrations in that portion of the estuary did not achieve compliance with the standard for fish and aquatic life in 85 percent or more of the samples collected during the baseline period. It is important to note that the overall lower level of compliance with the fish and aquatic life standard based on aggregating results from several sampling stations masks differences among stations in the levels of compliance achieved.

In the Menomonee River portion of the estuary during the baseline period dissolved oxygen concentrations in samples collected at the sampling station farthest upstream, N. 25th Street, achieved compliance with the standard for fish and aquatic life in 85 percent or more of the samples collected. The levels of compliance with this standard observed at each of the three other sampling stations in the downstream portions of the estuary were below 85 percent of the samples collected. The locations of two of the sampling stations in the lower Menomonee River estuary, Muskego Avenue and S. 2nd Street, correspond to the locations of assessment points LM-2 and LM-3, respectively. The results of the water quality simulation model indicate that existing dissolved oxygen concentrations at these assessment points should achieve compliance with the standard for fish and aquatic life 85 percent or more of the time (Table 89). Thus, the results of the model in the Menomonee River portion of the estuary differ from the observed sampling data in this respect. The model results also indicate that there should be little change in the Menomonee River portion of the estuary between existing conditions and recommended plan conditions in the levels of compliance achieved with the fish and aquatic life standard. If this last point is an accurate reflection of the differences that can be expected between existing and recommended plan dissolved oxygen conditions in the Menomonee River portion of the estuary, it suggests that levels of compliance in this reach may not differ substantially from those observed during the baseline period. In any case, the differences between the observed dissolved oxygen concentrations and the results of the water quality simulation model make it unclear whether this reach will achieve compliance with the fish and aquatic life standard 85 percent or more of the time under recommended plan conditions.

Fecal Coliform Bacteria

For assessment points LM-1, 4, and 6, which are located in the Milwaukee River portion of the estuary, while the annual compliance with the fecal coliform standards under recommended plan conditions does not meet the 85 percent criterion, full implementation of the recommended plan would be expected to achieve, or be very close to achieving, 85 percent or greater compliance with both the geometric mean and single sample standards for the May through September swimming season (Table 89). Thus, the anticipated improvement in fecal coliform

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[146] *The calibration and validation of the Milwaukee Harbor estuary/Lake Michigan hydrodynamic/water quality model indicated good agreement with observed dissolved oxygen concentrations at assessment points LM-2 and LM-3. The model runs were made for the observed climatological conditions from 1988 through 1997 occurring with existing (year 2000) land use and stream conditions. That climatological data period was chosen because it is representative of long-term average conditions. The baseline dissolved oxygen data were collected for a different time period, from 1998 through 2001. While comparison of the baseline observed data with the simulated values is useful in drawing conclusions regarding existing and projected future compliance with water quality standards supporting water use objectives, the observed data and simulated values may not always be directly comparable because of the different time periods represented and because the continuously simulated results reflect a greater base of information, than do the observed data that were collected at discrete, less numerous, points in time. Thus, some differences in the observed data and simulated values would be expected.*

concentrations could be considered sufficient for assessment points LM-1, 4, and 6 to meet the standards for a full recreational use water use objective during the period from May through September. During the baseline period, concentrations of fecal coliform bacteria did not achieve compliance with the single sample standard in 85 percent or more of the samples collected when examined on either an annual basis or a May-to-September basis (Table 90). While the level of compliance with this standard increased from upstream to downstream in the Milwaukee River portion of the estuary, compliance levels at all sampling stations in this reach were below 85 percent. This was the case for both annual compliance and compliance during the May through September swimming season.

For assessment point LM-5 in the Kinnickinnic River portion of the estuary, compliance with the fecal coliform bacteria standards under recommended plan conditions would be expected 85 percent or more of the time on both an annual and May through September basis (Table 89). Thus, the anticipated improvement in fecal coliform concentrations would be sufficient for the Kinnickinnic River portion of the estuary to meet the standards for a full recreational use water use objective. During the baseline period, concentrations of fecal coliform bacteria did not achieve compliance with the single sample standard in 85 percent or more of the samples collected when examined on either an annual basis or a May-to-September basis (Table 90). While the level of compliance with this standard was higher at the two downstream sampling stations, compliance levels at all sampling stations in the Kinnickinnic River portion of the estuary were below 85 percent. This was the case for both annual compliance and compliance during the May through September swimming season.

For assessment point LM-2 in the upper Menomonee River portion of the estuary, despite anticipated improvements in fecal coliform bacteria concentrations under the recommended plan, compliance with the standards would not be achieved 85 percent or more of the time (Table 89). Thus, the anticipated improvement in fecal coliform concentrations would not be sufficient for the upper Menomonee River portion of the estuary to meet the standards for a full recreational use water use objective. For assessment point LM-3 in the lower Menomonee River portion of the estuary, while the annual compliance with the fecal coliform standards does not meet the 85 percent criterion, for the May through September swimming season, full implementation of the recommended plan would be expected to achieve close to 85 percent compliance with the single sample standard and greater than 85 percent compliance with the geometric mean standard (Table 89). Thus, the anticipated improvement in fecal coliform concentrations could be considered sufficient for assessment point LM-3 to meet the standards for a full recreational use water use objective during the period from May through September. During the baseline period, concentrations of fecal coliform bacteria in the Menomonee River portion of the estuary did not achieve compliance with the single sample standard in 85 percent or more of the samples collected when examined on either an annual basis or a May-to-September basis (Table 90). While there was no longitudinal trend in the levels of compliance in this reach, compliance levels at all sampling stations in the Menomonee River portion of the estuary were below 85 percent. This was the case for both annual compliance and compliance during the May through September swimming season.

It is important to note that the results of the model show improvements under recommended plan conditions in the levels of compliance with fecal coliform bacteria standards in all portions of the estuary (Table 89).

Summary of Ability to Meet Auxiliary Water Use Objectives Under Recommended Plan Conditions
Based on the foregoing, it is concluded that under recommended plan conditions:

- The standards for a fish and aquatic life water use objective could be met at all of the assessment points within the Milwaukee River (LM-1, LM-4, and LM-6) portion of the estuary.

- While the standards for a fish and aquatic life water use objective could be met at the assessment point within the Kinnickinnic River (LM-5) portion of the estuary, it is unclear whether the upper portion of this reach could achieve compliance with the standard. It is likely the standards supporting a fish and aquatic life water use objective could be met in the lower portion of this reach.

- It is uncertain whether the standards for a fish and aquatic life water use objective could be met at the assessment points in the Menomonee River portion of the estuary (LM-2 and LM-3).

- The standards for a full recreational use water use objective could be met throughout the year at assessment point LM-5 in the Kinnickinnic River portion of the estuary.

- The standards for a full recreational use water use objective could essentially be met for the May through September period at assessment points LM-1 in the Milwaukee River portion of the estuary, LM-3 in the Menomonee River portion of the estuary just upstream of the confluence with the Milwaukee River, LM-4 in the Milwaukee River portion of the estuary just downstream of the confluence with the Menomonee River, and LM-6 at the mouth of the Milwaukee River at the Hoan Bridge.

- The standards for a fish and aquatic life water use objective could be met at assessment points MN-17 on the mainstem of the Menomonee River just downstream of the confluence with Honey Creek and MN-18 on the mainstem of the Menomonee River just upstream of the Milwaukee Harbor estuary. Thus, with the exception of a concrete-lined channel reach upstream of IH 94, the lower reaches of the Menomonee River associated with those assessment points could attain a fish and aquatic life water use objective.[147] The standards for a full recreational use water use objective could not be met at these assessment points.

- While the dissolved oxygen standards supporting a fish and aquatic life water use objective could be met at assessment points KK-10 in the Kinnickinnic River, MN-14 at the mouth of Underwood Creek, and MN-16 at the mouth of Honey Creek, the high proportions of concrete-lined and enclosed channel in these streams make it unlikely that they could support a fish and aquatic life use objective under current channel conditions. However, a planned MMSD project to remove all or a portion of the concrete lining and rehabilitate the stream channel in the reach of Underwood Creek downstream of STH 100 (N. Mayfair Road) would enable attainment of the fish and aquatic life objective in that reach. Also, depending on the results of an ongoing study of the downstream reach of the Kinnickinnic River, it may be possible to remove the concrete lining in that reach and to attain a fish and aquatic life objective at some time in the future. The anticipated improvement in fecal coliform concentrations at these assessment points would not be sufficient for Honey and Underwood Creeks to meet the standards for a full recreational use water use objective.

- The dissolved oxygen standards supporting a fish and aquatic life water use objective could be met at assessment point ML-31 at the mouth of Indian Creek. For much of the Creek, this suggests that a fish and aquatic life water use objective could be attained. The high proportions of concrete-lined channel upstream of N. Manor Drive make it unlikely that the upper reaches of this stream could support a fish and aquatic life use objective. The anticipated improvement in fecal coliform concentrations at this assessment point would not be sufficient for Indian Creek to meet the standards for a full recreational use water use objective.

- The anticipated improvement in dissolved oxygen concentrations at assessment point ML-32 would not be sufficient for Lincoln Creek to meet the standards for a fish and aquatic life water use objective. While observed dissolved oxygen concentrations in the Creek during the baseline period suggest that a fish and aquatic life water use objective might be achievable, it is unlikely that these data are representative of current conditions in the Creek due to restoration efforts that were ongoing

[147]*As noted previously, the MMSD is considering approaches to address the remaining concrete-lined reach in the Menomonee River. Modification of that reach to improve fish passage, while not essential to the attainment of a fish and aquatic life objective in the River upstream of the concrete lining, would result in a much greater diversity of fish and other aquatic organisms in the upstream reach.*

during the baseline period. The anticipated improvement in fecal coliform concentrations at this assessment point would not be sufficient for Lincoln Creek to meet the standards for a full recreational use water use objective.

- The standards for a coldwater water use objective could be met at assessment point ML-22 at the mouth of Stony Creek.

- The standards for a fish and aquatic life water use objective could be met at assessment points RT-5 near the mouth of Whitnall Park Creek, RT-6 near the mouth of Tess Corners Creek, and RT-20 near the mouth of Hoods Creek.

- The standards for a limited forage fish water use objective could be met at assessment point RT-19 at the mouth of Ives Grove Ditch.

For the stream reaches described above, Table 91 lists the proposed water use objectives that are projected to be achieved under recommended plan conditions.

Recommendations
Based upon the results described above, it is recommended that the WDNR consider pursuing changes to the existing regulatory water use objectives as set forth in Table 91. Table 91 also indicates recommended planned water use objectives that are considered to be achievable under recommended plan conditions.

Consideration of the Fecal Coliform Bacteria Standard
As noted previously in this chapter, fecal coliform bacteria were selected as one of the pollutants to be evaluated through water quality modeling analyses under the water quality planning effort 1) because, from a regulatory perspective, fecal coliform bacteria are used as an indicator of human sewage contamination and 2) a large amount of measured data on instream fecal coliform counts is available throughout the study area. In Lake Michigan, the USEPA has promulgated criteria for Wisconsin that call for application of an *Escherichia coli* (*E. coli*) standard. (*E. coli* constitute a major component of fecal coliform bacteria.)

While mainly intended as an indicator of human sewage contamination, fecal coliform bacteria and *E. coli* also are intended to serve as indicators of the possible presence of a broader range of possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes. Pathogens associated with human sewage include viruses, bacteria such as *Salmonella enteritidis, Salmonella typhi, Vibrio cholera, and Shigella dysenteries*, and protozoa such as C*ryptosporidium* and Giardia intestinalis*.* Pathogens associated with domestic and/or wild animals and livestock include *Salmonella enteritidis*, C*ryptosporidium* and Giardia intestinalis.

Because the presence of fecal coliform bacteria is not sufficient indication of a significant threat to human health, which would actually result from the presence of pathogens that are generally not directly measured, the illicit discharge detection and elimination component of the recommended plan, as described previously, calls for a coordinated program to reduce pathogens in surface waters through better identification of sources of human fecal contamination and elimination or control of those sources that would potentially be most harmful to human health.

Figures 57 and 59 indicate that, even under the extreme measures condition, it is unlikely that compliance with the regulatory single sample and geometric mean fecal coliform bacteria standards could be achieved 85 percent of the time on an annual basis. Figures 61 and 63 indicate that, even under the extreme measures condition, it is unlikely that compliance with the regulatory single sample and geometric mean fecal coliform bacteria standards could be achieved 85 percent of the time during the May through September time period when full-body contact recreation is most likely. However, under the recommended plan, compliance with the standard is considerably better during the May through September body contact recreation season than on an annual basis.

Table 91

RECOMMENDATIONS REGARDING WATER USE OBJECTIVES

Assessment Point	Regulatory Water Use Objective Evaluated in Tables N-1 through N-6[a]	Auxiliary Use Objective(s) Proposed by WDNR and Evaluated in Table 89	Recommended Existing Water Use Objective[b]	Recommended Planned Water Use Objective[b,c]
KK-10 Kinnickinnic River	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[d]
MN-14 Underwood Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[e]
MN-16 Honey Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
MN-17 and MN-18 Menomonee River from N. 70th Street to the Upstream End of the Milwaukee Harbor Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**
ML-22 Stony Creek	Fish and Aquatic Life	Coldwater	**Coldwater**[f]	**Coldwater**[f]
ML-31 Indian Creek Downstream of N. Manor Lane	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**
Indian Creek Upstream of N. Manor Lane	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
ML-32 Lincoln Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[g]
RT-5 Whitnall Park Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
RT-6 Tess Corners Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
RT-19 Ives Grove Ditch	Limited Aquatic Life	Limited Forage Fish	Limited Aquatic Life	**Limited Forage Fish**
RT-20 Hoods Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
LM-1. LM-4, and LM-6 Entire Milwaukee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Fish and Aquatic Life and Full Recreational Use**	**Fish and Aquatic Life and Full Recreational Use**
LM-2 and LM-3 Entire Menomonee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
LM-5 Kinnickinnic River Estuary from Union Pacific Railroad Swing Bridge to Confluence with the Milwaukee River	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Fish and Aquatic Life and Limited Recreational Use**	**Fish and Aquatic Life and Full Recreational Use**
Kinnickinnic River Estuary upstream from Union Pacific Railroad Swing Bridge	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[h]

[a]*Special variance use objectives include a bacteria standard that reflects a limited recreational use objective. Waters not under special variance are considered to have full recreational use objectives.*

[b]*Bold text indicates a change from the current regulatory water use objective.*

[c]*Anticipated to be achieved under recommended plan conditions.*

[d]*Subject to re-evaluation if concrete lining were removed from the stream channel.*

[e]*Subject to re-evaluation following removal of the concrete channel lining in the reach from N. Mayfair Road (STH 100) to the confluence with the Menomonee River.*

[f]*Subject to more extensive collection of temperature data.*

[g]*Re-evaluate when more dissolved oxygen data are available.*

[h]*Re-evaluate when contaminated sediment in the upper reach of the Kinnickinnic River portion of the estuary is remediated under the WDNR Kinnickinnic River Environmental Restoration Project.*

Source: Tetra Tech, Inc.; HydroQual, Inc.; and SEWRPC.

As noted previously, review of Tables N-1 through N-6 indicates that in certain cases, marked reductions in fecal coliform bacteria concentrations may be achieved under the recommended plan and extreme measures conditions, but the corresponding improvements in compliance with the standard are not as pronounced. Because, even under extreme measures conditions, the projected levels of compliance at many assessment points fall short of the 85 percent-of-time criterion adopted under this study, it is unlikely that the fecal coliform bacteria standard can reasonably be met throughout the study area.

Instead of expending significant resources to meet water quality indicator standards based on fecal coliform bacteria and *E. coli*, whose presence may not give an adequate indication of the actual risks to the environment and human health, it is recommended that the WDNR and USEPA continue, and accelerate, efforts to develop standards for other pollutants that are more-closely related to possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes. The programs to detect and eliminate illicit discharges and to control pathogens, as recommended under this plan, recognize the inadequacy of fecal coliform bacteria as a standard, and those programs contain provisions to more specifically test for the possible presence of pathogens and to assess the risk to human health from the pollutants transported in stormwater runoff.

Additional Available Options for Refining Water Quality Standards

The need to present options for refining water quality standards stems from the inability to substantially meet the fecal coliform bacteria standard for the existing, applicable, regulatory water use objectives on certain streams, or stream reaches, in the study area. The elimination of the fecal coliform bacteria and *E. coli* standards and the substitution of new water quality standards for pollutants, or indicators, that are more-closely related to possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes, are considered the main priorities relative to the refinement of water quality standards. Other existing regulatory-based mechanisms that are available for refining water quality standards include 1) conducting use attainability analyses (UAA) to determine water quality standards that can realistically be met within the ultimate, overall goal of achieving fishable and swimmable conditions under the Federal Clean Water Act and 2) the associated approach of establishing wet weather water quality standards. A risk-based approach is a third available option. These approaches to refinement of water quality standards are briefly described below.

Use Attainability Analyses

According to 40 CFR (Code of Federal Regulations) 131.10(g), a State "may remove a designated use which is not an existing use,… or establish subcategories of a use if the State can demonstrate that attaining the designated use is not feasible because:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by sections 301(b) and 306 of the (Clean Water) Act would result in substantial and widespread economic and social impact."

Additionally, according to 40 CFR 131.10 (j), "a State must conduct a use attainability analysis … whenever …:

(2) The State wishes to remove a designated use that is specified in section 101(a)(2) of the Act or to adopt subcategories of uses specified in section 101(a)(2) of the Act which require less stringent criteria."

Finally, according to 40 CFR 131.10 (h), "States may not remove designated uses if …

(2) Such uses will be attained by implementing effluent limits required under sections 301(b) and 306 of the Act and by implementing cost-effective and reasonable best management practices for nonpoint source control."

The recommended plan calls for implementation of cost-effective and reasonable best management practices for nonpoint source control, and it establishes that for specific streams, or reaches of streams, implementation of such practices would not be expected to result in full achievement of regulatory water quality standards. Thus, the State would not be constrained from removing selective designated uses under the section of the Code quoted above.

The need to conduct UAAs would be decided by the WDNR, and no recommendation is made under this study regarding conducting such analyses or implementing wet weather water quality standards. Consideration of the need to implement such approaches may be deferred pending the outcome of the recommended effort to replace the current fecal coliform bacteria and *E. coli* standards with new standards for other indicators or pollutants that are more-closely related to possible threats to human health. The adoption of a new standard associated with the designated uses being considered could result in the attainment of those uses.

Wet Weather Water Quality Standards

Wet weather water quality standards may be considered when wet weather events adversely affect water quality for relatively short periods of time during and shortly after rainfall and/or snowmelt events. Such standards are often associated with the effects on water quality of CSOs, but they may also relate to the effects of stormwater runoff pollution. The MMSD system currently meets the requirements of the "presumptive" approach to CSO control and will continue to meet those requirements under planned conditions, as described previously in this chapter and in more detail in Chapter VI of this report, "Legal Structures Affecting the Regional Water Quality Management Plan Update." Although water quality standards would not be achieved during a CSO event in stream reaches affected by the overflow(s), that nonattainment is a function of both the CSO(s) and stormwater runoff pollution. Nonpoint source pollution from stormwater runoff has been identified as a significant contributor of pollutants, including fecal coliform bacteria, to the streams of the study area. Thus, a greatly relaxed wet weather water quality standard would not be appropriate during wet weather conditions when no CSOs occurred. During CSO events, it is not possible to separate the pollutant concentrations of stormwater runoff and CSO, so it is unlikely that such standards could readily be implemented.

Risk-Based Approach

The recommended plan as described previously calls for human health and ecological risk assessments addressing pathogens in stormwater runoff to adequately assess the appropriate way to deal with bacteria sources (and the potentially associated pathogens). The components of such risk assessments, as specified by the USEPA, are described in some detail earlier in this chapter. In general they include the following:

- Hazard identification,
- Exposure assessment,
- Dose-response assessment, and
- Risk characterization.

A risk-based approach to establishing water quality standards could also be taken and would represent an improved approach to assigning water quality standards and criteria that are consistent with the threat to human and ecological health. It is recommended that a risk-based approach to establishing water quality standards and criteria be considered as standards are reevaluated by the WDNR and USEPA.

Additional Metrics to Assess Water Quality Improvement
There are other metrics besides water quality standards and criteria that can be very useful in the assessment of the ecological health of the streams of the study area. Available data on biological indicators in the streams and lakes of the study area were collated and analyzed by the SEWRPC staff and the results are presented in SEWRPC TR No. 39, the companion to this planning report. Those data comprise the start of a characterization of "baseline" conditions that should be supplemented by additional data that are recommended to be collected under this plan. Future data can then be compared to that baseline in a manner similar to the presentation of data in SEWRPC TR No. 39. Through that process, changes in the ecological health of streams and lakes in the study area can be assessed as the recommendations of this plan are implemented over time. As stated previously, this plan recommends the following biological indicator assessments:

- Fish community and macroinvertebrate assessments to be conducted at specific locations at least every two years,

- Long-term habitat monitoring stations to be established and maintained with periodic surveys conducted to assess habitat quality and streambed and streambank stability,

- Aquatic plant habitat assessments within lakes to be supported and better integrated with fishery survey assessments.

Comprehensive Monitoring and Evaluation Program
It is recommended that a comprehensive monitoring and evaluation program be developed and implemented for the greater Milwaukee watersheds. Such a program would assess the effectiveness and adequacy of recommended watershed management measures against adopted principles and standards. Comprehensive monitoring recommendations for water quality, fish, macroinvertebrates, habitat, and aquatic plants are set forth in a previous section of this report.

Further, it is recommended that every three to five years a review of the plan recommendations and the effectiveness of management measures along with an assessment of the need for refinement of both the SEWRPC regional water quality management plan update and the MMSD 2020 facilities plan be undertaken by the MMSD and SEWRPC staffs and the Advisory Committees convened under the Water Quality Initiative planning program.[148] This review should include a qualitative and quantitative assessment of progress toward plan implementation.

In addition to water quality monitoring data as collected by the MMSD, USGS, WDNR, and citizen groups, the following indicators can be used to indirectly assess changes in water quality and associated improvements in riparian/riverine environmental conditions:

- Instream and in-lake measures:
  - Physical
    - Lineal feet of stream restored (remeandered, reconnected to floodplain, re-created natural stream channels),
    - Lineal feet of streambank and lake shoreline stabilized,
    - Lineal feet of channel converted from concrete to more natural lining,

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[148]*The "Water Quality Initiative" is the term used to describe the collaboration between MMSD and SEWRPC, in partnership with the WDNR and USGS, on the 2020 facilities plan and the regional water quality management plan update.*

    - Number of dams removed,
    - Numbers of roadway obstructions removed, including elimination or redesign of culverts and bridges, and
    - Improvement in lake water clarity as an indicator of reduced total phosphorus and chlorophyll-*a* concentrations.

  - Physical/Chemical
    - Contaminated sediments that are remediated, expressed as a volume, a mass, or a percent of the total volume of contaminated sediment and
    - Changes in annual number of days of beach closings.

  - Biological
    - Numbers and diversity of fish and macroinvertebrates within any portion of the stream network and
    - Continued presence within streams of threatened or endangered aquatic species, aquatic species of special concern, and primary coldwater indicator species such as mottled sculpin and brook trout.

- Land based measures:
  - Area or lineal feet of riparian corridors established or expanded adjacent to streams;
  - Acres of land within the watershed purchased and preserved for open space and recreation;
  - Acres of environmentally sensitive lands (e.g., environmental corridors) protected, added, or lost,
  - Acres of wetland or prairie restored,
  - Number of stormwater facilities effectively providing water quality benefits (new systems and upgraded older systems),
  - Consistency with adopted land use plans; and
  - Parcels, sites, or landowners that implement conservation practices to comply with agricultural nonpoint pollution performance standards.

Chapter XI

PLAN IMPLEMENTATION

INTRODUCTION

The recommended regional water quality management plan update for the greater Milwaukee watersheds, as described in Chapter X of this report, provides a framework for the attainment of the specific water quality and related objectives formulated under the study. The final watershed plan consists of three major elements: 1) a land use element, including preservation of environmentally sensitive lands; 2) a surface water quality element, including point and nonpoint source pollution abatement subelements; and 3) a groundwater management plan element.

While the recommended regional water quality management plan update is designed to attain, to the extent practicable, the agreed upon water quality and related objectives, the plan is not complete in a practical sense until the steps required to implement the plan—that is, to convert the plan into action policies and programs—are specified. This chapter provides that information and is intended as a guide for use in the implementation of the plan. Basically, it outlines the actions which must be taken by the various levels and agencies of government in concert with private sector organizations if the recommended water quality plan is to be fully carried out by the design year. Those units and agencies of government which have plan adoption and plan implementation powers applicable to the plan are identified; necessary or desirable formal plan adoption actions are specified; and specific implementation actions are recommended for each of the units and agencies of government with respect to the land use, surface water quality management, and groundwater elements of the plan. Also, the coordinated roles of the public and private sectors are described, and financial and technical assistance programs available to implement the water quality management plan are summarized.

PRINCIPLES OF PLAN IMPLEMENTATION

The plan implementation recommendations contained in this chapter are, to the maximum extent possible, based upon and related to year 2007 government programs and private sector initiatives and are predicated upon existing enabling legislation. Because of the possibility of unforeseen changes in economic conditions, State and Federal legislation, case law decisions, governmental organization, and tax and fiscal policies, it is not possible to determine exactly how a process as complex as watershed-based water quality plan implementation should be administered and financed. In the continuing regional planning program for southeastern Wisconsin, it will, therefore, be necessary to periodically update not only the water quality management plan elements and the data and forecasts on which these plan elements are based, but the recommendations contained herein for plan implementation. That approach is consistent with the "adaptive management" approach adopted by the Milwaukee Metropolitan Sewerage District (MMSD) for implementation of the MMSD 2020 wastewater treatment facilities plan component. In addition to consideration of the possible changed conditions listed above, such updates should consider future changes to planned sewer service areas, the effects of those changes on hydrologic and hydraulic conditions, and the consequences for water quality management in the study area.

It is important to recognize that plan implementation measures must not only grow out of formally adopted plans, but must be based upon a full understanding of the findings and recommendations contained in those plans. Thus, action policies and programs must not only be preceded by formal plan adoption and, following such adoption, be consistent with the adopted plans, but must emphasize implementation of the most important and essential elements of the regional water quality management plan update and those areas of action which will have the greatest impact on guiding and shaping development in accordance with those elements. Of particular importance in this regard are those plan implementation efforts which are most directly related to achieving the basic plan objectives, especially those objectives concerned with the protection of the underlying and sustaining natural resource base and water quality control and pollution abatement.

Principal Means of Plan Implementation

There are three principal ways through which the necessary water quality plan implementation may be achieved—ways which parallel the three functions of the Regional Planning Commission: 1) inventory, or the collection, analysis, and dissemination of basic planning data on a uniform, areawide basis; 2) plan design, or the preparation of a framework of long range plans for the physical development of the Region; and 3) plan implementation, or the provision of a center for the coordination of planning and plan implementation activities. All require a receptive attitude and active planning and plan implementation programs at the local, county, State, and Federal levels of government and coordination and cooperation between public and private sector organizations with vested interests in successfully implementing the plan recommendations.

A great deal can be achieved in guiding watershed development into a more desirable pattern through the simple task of collecting, analyzing, and disseminating basic planning and engineering data on a continuing, uniform, areawide basis. Experience within the Southeastern Wisconsin Region has shown that, if this important inventory function is properly carried out, the resulting information will be used and acted upon both by local, State, and Federal agencies of government and by private investors. A wealth of definitive information about the study area, including natural and manmade features, hydrology and hydraulics, and water quality problems was assembled under the planning effort. The use of this information base in arriving at development decisions on a day-to-day basis by the public and private interests involved contributes substantially toward implementation of the recommended water quality plan.

With respect to plan preparation or design, it is essential that some of the plan elements be carried into greater depth and detail for sound plan implementation. Specifically, the plan recommendations dealing with stormwater management measures and pollution abatement facilities must be carried through preliminary engineering to the final design stages. Also the preparation of detailed plans will be needed to implement the recommendations regarding instream measures and fisheries management, dam abandonment, and inland lake and stormwater management. The preparation of such detailed plans will require the continuing development of close working relationships between the Regional Planning Commission; the Kenosha, Milwaukee, Ozaukee, Racine; Washington, and Waukesha County Boards;[1] the local units of government concerned; and certain other agencies—in particular, the Wisconsin Department of Natural Resources (WDNR) and the U.S. Environmental Protection Agency (USEPA).

To achieve a high degree of watershed plan implementation, it will be essential to effectively carry out the Regional Planning Commission's function as a center for the coordination of local, areawide, State, and Federal planning and plan implementation activities within the study area. The community assistance program, through which the Commission, upon request, actively assists local municipalities in the preparation of local plans and

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[1]*Cooperation with the Dodge, Fond du Lac, and Sheboygan County Boards, in areas which are located in the study area within the Milwaukee River watershed, but outside of the Southeastern Wisconsin Region, will also be essential to effective plan implementation on a watershedwide basis.*

plan implementation devices, is an important factor in this function. If properly utilized, this program should help make possible the full integration of regional water quality plans and local plans, adjusting the details of the latter to the broader framework of the former.

The ongoing comprehensive planning program being conducted pursuant to legislation enacted by the Wisconsin Legislature in 1999 and set forth in Section 66.1001 of the *Wisconsin Statutes* (often referred to as the State's "Smart Growth" law), provides a new framework for the development, adoption, and implementation of comprehensive plans by regional planning commissions and by county, city, village, and town units of government.[2] Those plans contain elements related to land use; utilities and community facilities; and agricultural, natural, and cultural resources which are also components of the regional water quality management plan update. Thus, there is a relationship between the comprehensive plans and the regional water quality management plan update and the implementation of the plans may be complementary.

Distinction Between the Systems Planning, Second-Level Planning/Preliminary Engineering, and Final Design and Construction Phases of the Public Works Development Process

The planning process used to prepare the regional water quality management plan update for the greater Milwaukee watersheds constituted the first, or systems planning, phase of what may be regarded as a three-phase public works development process. Second-level planning/preliminary engineering is the second phase in this sequential process, with final design being the third and last phase. Because effective implementation of the water quality management plan requires an understanding of this three-phase process, that process is briefly described below. Although emphasis is placed on use of the process in preparing the regional water quality management plan update for the greater Milwaukee watersheds and in the subsequent steps needed to advance that plan toward implementation, it is important to note that the three-phase process is applicable to any regional or subregional plan containing recommendations for the development of public works for flood control, pollution abatement, water supply, sanitary sewerage, transportation, park and open space, or other public facilities and services.

Systems Planning

The systems planning phase concentrates on the precise definition of the problems to be addressed and on the development and evaluation of alternative measures for resolution of these problems on a sound areawide basis. Systems planning is intended to permit the selection, from among the alternative measures considered, of the most effective measure to resolve the identified problems in accordance with agreed upon objectives and supporting standards. In this first or systems planning phase, each alternative plan element is developed to sufficient detail to permit a sound, consistent comparison of the technical practicality and economic feasibility of each alternative and a proper evaluation of its nontechnical and noneconomic characteristics.

Properly conducted, systems planning is comprehensive in three ways. First, it is comprehensive in that it takes into consideration the entire system and attendant rational planning area most likely to significantly influence the environmental and developmental problems of concern and the proper resolution of those problems. Water resource-related problems, for example, should be approached on a watershed basis because the watershed system

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[2]*As of the publication date of this plan, communities throughout the study were engaged in preparing comprehensive plans. Within the regional water quality management plan update study area, the Regional Planning Commission was leading those efforts in all communities in Kenosha County except the Village of Twin Lakes and the Town of Randall; all communities in Racine County; all communities in Ozaukee County except the City of Cedarburg; and in the Village of Kewaskum and the Towns of Addison, Barton, Erin, Farmington, Germantown, Hartford, Kewaskum, Polk, Trenton, and Wayne in Washington County. In addition, in Milwaukee County where local units of government are preparing plans and in Waukesha County, where the County or local units of government are preparing plans, the Counties and some municipalities are represented on the Technical Advisory Committee for the regional water quality management plan update. Also, municipalities in Waukesha and Milwaukee Counties were updated on the water quality plan through participation in the MMSD Technical Advisory Team.*

is the most rational planning area for such problems. Man's use of the land and changes in such use in one portion of a watershed can markedly influence environmental problems in other areas of the watershed.

Second, properly conducted systems planning is comprehensive in that it considers not only the immediate problem but the relationship of the problem to broad land use, socioeconomic, and environmental considerations. For example, watershed-based water quality planning recognizes that the quantity and quality of the surface waters in the watershed system are determined, in part, by existing and planned land use in the watershed system and that land use is, in turn, determined by socioeconomic conditions within as well as outside the watershed. Therefore, the regional land use plan—as detailed in the water quality planning process—is taken as a "given" in the preparation of the water quality plan so as to reflect regional land use, socioeconomic, and environmental conditions likely to influence the cause of, and solution to, water quality problems within each watershed.[3]

Third, the systems planning phase of the three-phase public works development process is comprehensive in that a full spectrum of potential solutions to the water quality and water quality-related problems are considered during the process. Because of the many measures, variations on measures, and combinations of measures that are available, it is recognized in the systems planning phase that there are an almost unlimited number of solutions to a given problem that, in effect, form a continuum of possible solutions. The key to efficient systems planning is not examining each of the many possible alternative measures but rather examining alternatives that define the boundaries of the continuum and that are truly representative of the full range of available measures within the continuum.

Second-Level Planning and Preliminary Engineering

Although systems planning requires considerable effort, it is not normally carried to the level of detail needed to permit immediate implementation of the recommended measures. In general, it is essential that the analysis of the technical, economic, environmental, and other features of the plan elements be carried into greater detail and depth as the first step toward implementation of the system plan. The second phase of the three-phase public works development process is referred to as second-level detailed planning and/or preliminary engineering and is most properly carried out, subsequent to the adoption of the areawide systems plan, by the implementing units and agencies of government concerned.

The second-level planning and preliminary engineering phase begins where the systems planning phase ends, and the analysis is no longer comprehensive. Under this phase, emphasis is placed on function and concentration is on the basic solution to the problem at hand as that problem and its solution have been identified in the systems planning phase. This phase of the three-phase public works development process presumes that the optimum solution in terms of technical practicality, economic feasibility, environmental consequences, and other considerations has been identified under the previous systems planning phase.

Depending on the nature of the systems plan recommendation that is under consideration for implementation, the next step in further developing the characteristics of that component could be either second-level planning or preliminary engineering. Those two approaches have many similar characteristics and both concentrate on examining variations of the recommended solution in order to determine the best way to carry out a specific recommendation. The main distinguishing feature is that second-level planning is generally applied to a system that functions at a larger geographic scale, such as a subwatershed, while preliminary engineering focuses on a specific function or facility. Second-level planning is applied to examine how to meet a broader objective recommended under a systems plan. It may involve consideration of more-targeted alternatives developed within the framework of an overall systems plan recommendation. Preliminary engineering concentrates on examining variations of a recommended solution in depth in order to determine the best way to carry out a more-specific solution recommended under a systems plan.

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[3]*The recommendations of this watershed study as they relate to water quality and stormwater management would be reflected in the next regional land use plan and in the forthcoming county and municipal comprehensive plans.*

Examples of second-level planning include the preparation of 1) more-detailed stormwater management plans at a watershed or subwatershed level with such plans intended to provide details as to how to meet a broader nonpoint source pollution control objective recommended under a systems plan and 2) sewerage system facilities planning for the purpose of meeting the recommendations of a systems plan regarding control of point source pollution.

In some cases, what might be considered second-level planning may be compatible with system planning and may be conducted within a system plan. An example is the MMSD 2020 facilities plan that was incorporated in the regional water quality management plan update. That approach is appropriate because of the areawide-nature of the large and complex MMSD sewerage system. For that system, the next step in the process would be preliminary engineering. In other cases, sewerage system facilities planning would be second-level planning that is conducted consistent with an overall system plan such as the water quality plan update. That would be the case for the other, somewhat less complex sewerage systems in the regional water quality management plan update study area. For those systems, it may be possible to bypass preliminary engineering and to proceed to final design following second-level facilities planning.

Final Design

Upon acceptance of the findings and recommendations of the preliminary engineering phase by the governmental units and agencies affected, the third or final design phase of the public works development process is initiated. This work should also be carried out by the implementing units and agencies of government concerned. Starting with the solution to the problem at hand as set forth in the final, approved version of the preliminary engineering report, the final design phase should move toward the development of the detailed construction plans and specifications needed to completely implement the recommended solution. In the case of a public works project involving construction, the plans and specifications should provide sufficient detail to permit potential contractors to submit bids for the project and to actually construct the recommended works. Engineers responsible for carrying out the final phase should also have responsibility for securing the necessary permits and other approvals from regulatory and review agencies, for providing supervisory and inspection services during the actual construction process, and for certifying to the governmental units and agencies involved that the construction is carried out in accordance with the design provisions and specifications.

Other Considerations

For many reasons, the three-phase public works development process does not always proceed in the simple three-step fashion as described above. In some situations, an iterative process is set in motion whereby a re-examination of an earlier step is required. For example during the preliminary engineering phase, a new alternative, based on additional information, may be developed that must be subjected to systems analysis.

Ever-changing Federal and State regulations and guidelines can disrupt the three-phase public works development process. This is particularly true if a significant change in those regulations and guidelines occurs subsequent to the systems planning phase and prior to or during the preliminary engineering phase, thus necessitating an iteration to the systems planning phase to reconsider measures studied during that phase or to analyze additional measures as may be necessitated by regulation and guideline changes. As a result of the passage of time between the systems planning phase and the preliminary engineering phase, significant changes may occur in the explicitly stated or implicitly expressed values and objectives of elected officials and concerned citizens. In an environment of changing values and objectives, a solution to an environmental problem that was originally accepted as optimal, based on systems planning techniques and an agreed upon set of objectives, could later, because of changing values and objectives, be rejected or encounter considerable opposition, necessitating an iteration to the systems planning phase.

The effective functioning of the three-phase public works development process is highly dependent on close cooperation among governmental units and agencies. For example, the systems level planning conducted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) must be acceptable to local governmental units and agencies in order to prompt them to undertake the necessary second or preliminary engineering phase and to make full use of the recommendations resulting from the first or systems planning phase of the public works development process.

In carrying out the three-phase process, there is a tendency to circumvent a critical step, usually the systems planning phase, in response to intense public concern and controversy over a pressing environmental or developmental problem. This approach sometimes achieves short-term gains in that it leads to prompt problem solving activity—for example, minor channel work to "solve" a flood problem—thereby satisfying the immediate public concern. Unfortunately, circumvention of key steps in the public works development process often leads to long-term losses as a result of the failure to fully identify and quantify the problem at hand and to determine the most effective solution to that problem in terms of technical practicality, economic feasibility, and environmental impact. Superimposition of man's works and activities on the natural resource base produces an urban ecosystem that is complicated in terms of its many and varied components and processes and the interrelationships between those components and processes—an ecosystem that usually defies simple solutions to the environmental and developmental problems that arise.

PLAN IMPLEMENTATION ORGANIZATIONS

Although the Regional Planning Commission can promote and encourage watershed plan implementation in various ways, the completely advisory role of the Commission makes actual implementation of the recommended regional water quality management plan update dependent upon action by local, areawide, State and Federal agencies of government and private organizations with an interest in improving water quality conditions in the study area. Examination of the various public agencies that are available under existing enabling legislation to implement the recommended plan reveals an array of departments, commissions, committees, boards, and districts at all levels of government. These agencies range from general-purpose local units of government such as counties, cities, villages, and towns to special-purpose districts, such as lake districts or drainage districts. These agencies also include State regulatory bodies, such as the WDNR; and Federal agencies that provide financial and technical assistance for plan implementation, such as the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS).

Because of the many and varied public agencies in existence, it becomes important to identify those agencies having the legal authority and financial capability to most effectively implement the recommended water quality plan elements. Accordingly, those agencies whose actions will have a significant effect, either directly or indirectly, upon the successful implementation of the recommended plan and whose full cooperation in plan implementation will be essential are listed and discussed below. The agencies are, for convenience, listed by level of government; however, interdependence between the various levels, as well as between agencies of government, and the need for close intergovernmental cooperation, is essential to the successful implementation of the plan recommendations.

Continuing Commission Advisory Committee Structure

Since planning at its best is a continuing function, a public body should remain on the scene to coordinate and advise on the execution of the water quality plan and to undertake plan updating and renovation as necessitated by changing events. Although the Regional Planning Commission is charged with, and will perform, this continuing areawide planning function, it cannot do so properly without the active participation and support of local governmental officials and representatives of appropriate private organizations, through an appropriate advisory committee structure.

The following three committees were convened to facilitate preparation of the regional water quality management plan update:

- **Technical Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds:** This committee guided preparation of the plan, including the companion technical report on water quality conditions and sources of pollution.[4] The Committee

[4]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

members included representatives from local and County planning, engineering, and public works staffs; County land conservation staffs; the Milwaukee Metropolitan Sewerage District (MMSD) and the City of Racine Water and Wastewater Utility; lake protection and rehabilitation districts; the USDA Natural Resources Conservation Service (NRCS); the USEPA; the U.S. Geological Survey (USGS); the WDNR; environmental organizations; private industry; and academia. A modeling subcommittee was also established which generally consists of members of the Technical Advisory Committee, or their representatives with expertise in water quality modeling. This subcommittee met periodically to review the progress and results of the water quality modeling and to offer suggestions on modeling and plan formulation issues.

- **Watershed Officials Forum (WOF):** This group is comprised of the chief elected officials of each of the counties, cities, villages, and towns located in the study area plus representatives from the MMSD, WDNR, and USEPA. This group met periodically for briefings from the SEWRPC and MMSD staffs. Meetings were called specifically for WOF members, or for WOF members in conjunction with county committees involved in the ongoing comprehensive planning process.

- **Citizens Advisory Council:** The council consists of private citizens, business and industry representatives, and special interest groups who were convened periodically for briefings from the SEWRPC and MMSD staffs regarding different aspects of the regional water quality management plan update and the MMSD 2020 facilities plan.

For the continuing regional water quality management planning program for the greater Milwaukee watersheds, it is recommended that the Technical Advisory Committee be reconstituted as a continuing advisory committee to provide a focus for the coordination of all levels of government, along with appropriate private organizations, in the implementation of the plan. The Advisory Committee would thus continue to be a creation of SEWRPC, pursuant to Section 66.0309(8) of the *Wisconsin Statutes*, and would report directly to the Commission. It is recommended that all agency representatives and individuals currently serving on the Committee remain as members of the continuing committee and that the question of committee membership be left open so that additional members could be added to the Committee as appropriate. It is also recommended that the modeling subcommittee be reconstituted as a continuing advisory committee on modeling issues that may arise during implementation of the recommended plan.

It is also recommended that the Citizens Advisory Council and the Watershed Officials Forum be dissolved with the grateful appreciation of the Commission. It is envisioned that citizens' participation efforts in continuing water quality management planning and implementation programs will be focused largely at the watershed or subwatershed level. Elected watershed officials will continue to play a key role in planning and implementation activities, but in general their involvement will also be at the watershed or subwatershed level, and the continuation of the Forum for the entire study area is not considered to be necessary.

Local-Level Agencies

Statutory provisions exist for the creation at the County and municipal level of the following agencies having planning and plan implementation powers, including police powers and acquisition, condemnation (eminent domain), and construction (tax appropriation) powers, important to water quality plan implementation.

County Park and Planning Agencies

County government has considerable latitude available in forming agencies to perform the park and outdoor recreation and zoning and planning functions within the County. Counties may organize park commissions or park and planning commissions pursuant to Section 27.02 and 59.69(2), respectively of the *Wisconsin Statutes.* Instead of organizing such commissions, counties may elect to utilize committees of the County Board to perform the park and outdoor recreation and zoning and planning functions. The powers are, however, essentially the same no matter how an individual County chooses to organize these functions. If, however, a County elects to establish a county park or county park and planning commission, these commissions have the obligation to prepare a county park system plan and a county street and highway system plan. There is no similar mandate for plan preparation when a County elects to handle these functions with committees of the County Board.

The planning, zoning, plat review, and onsite sewage disposal regulatory functions vary somewhat from county to county within the study area. The status of general, floodplain, and shoreland zoning ordinances in the Southeastern Wisconsin Region are set forth in Chapter II of the regional land use plan.[5]

County Land and Water Conservation Committees

County land and water conservation committees are responsible for land conservation programs within the County and are also responsible for implementing the State's soil and water resource management program. These committees report to the County Board. Sections 92.07 and 92.10 of the *Wisconsin Statutes* authorize the land and water conservation committees to have a broad range of powers and duties. These powers and duties include:

- Development and adoption of standards and specifications for management practices to control erosion, sedimentation, and nonpoint sources of water pollution;

- Distribution and allocation of available Federal and State cost-sharing funds relating to soil and water conservation;

- Conduct of research and educational information programs relating to soil and water conservation;

- Conduct of programs designed to prevent flood damage, drainage, irrigation, groundwater, and surface water problems;

- Provision of financial, technical, and other assistance to landowners;

- Acquisition of land and other interests and property, machinery, equipment, and supplies required to carry out various land conservation programs;

- Construction, improvement, operation, and maintenance of structures needed for land conservation, flood prevention, and nonpoint source pollution control; and

- Preparation of a long-range natural resource conservation plan for the County, including an erosion control plan and program.

As a committee of the County board, all of its activities are closely supervised by the County Board and subject to the fiscal resources made available by the County Board. Pursuant to this law, all nine counties in the study area have created Land Conservation Committees to perform these various functions. These Committees will have important responsibilities in the implementation of the regional water quality management plan update.

Municipal Planning Agencies

Municipal planning agencies include city, village, and town plan commissions and town zoning committees created pursuant to Sections 62.23(1), 61.35, and 60.61(4) of the *Wisconsin Statutes*. Such agencies are important to plan implementation at the local level. Of the 88 local units of government within the study area, 86 have established plan commissions, or zoning committees.[6]

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[5]*SEWRPC, Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

[6]*The Town of Lomira in Dodge County does not have a plan commission or zoning committee. The Town of Mitchell in Sheboygan County has no zoning ordinances, but it does regulate land uses through other existing ordinances.*

Municipal Utility and Sanitary Districts
Municipal utility districts may be created by cities, villages, and towns pursuant to Section 66.0827 of the *Wisconsin Statutes.* Town sanitary districts may be created pursuant to Section 60.71 and 60.72 of the *Wisconsin Statutes.* Such special districts are authorized to plan, design, construct, operate, and maintain various public utility systems, including sanitary sewerage, water supply, and stormwater drainage systems. At the present time, there exist within the study area all or portions of the following active sanitary or utility districts: the Caledonia East and West Utility Districts in the Village of Caledonia; the Lake Ellen Sanitary District in the Town of Lyndon; the Mount Pleasant Sewer Utility District No. 1 in the Village of Mt. Pleasant; the Silver Lake Sanitary District in the Town of West Bend; the Town of Scott Sanitary District; the Wallace Lake Sanitary District in the Towns of Barton and Trenton; the Waubeka Area Sanitary District in the Town of Fredonia; and the Yorkville Sewer Utility District No. 1 in the Town of Yorkville.[7]

Farm Drainage Districts
Chapter 88 of the *Wisconsin Statutes* authorizes landowners to petition the circuit court to establish a drainage district under the control of a county drainage board. Pursuant to Sections 88.11 and 93.07(1) of the *Wisconsin Statutes*, the Department of Agriculture, Trade and Consumer Protection (DATCP) promulgated rules regarding farm drainage districts under Chapter ATCP 48 of the *Wisconsin Administrative Code* on July 1, 1995. Those rules were amended effective September 1, 1999. The rules establish procedures for assessing drainage district costs and benefits, inspecting drainage districts, construction and maintenance projects, landowner actions affecting drainage districts, drainage district records, and enforcement and variances. Section ATCP 48.24 sets forth requirements for the establishment of district corridors with a minimum width of 20 feet from the top of each bank of a district ditch. Those corridors are for the purpose of providing vehicular and equipment access over the entire length of the district ditch and to "provide a buffer against land uses which may adversely affect water quality in the district ditch." The *Administrative Code* also allows for the establishment of a wider corridor at the discretion of the county drainage board. Drainage districts can play a role in the establishment of riparian buffers as recommended under the water quality management plan update.

Stormwater Drainage Districts
Wisconsin Act 53, which was enacted on December 19, 1997, amended and expanded Section 66.0821 of the *Wisconsin Statutes* to specifically grant municipalities the legal authority to assess service charges to users of a stormwater and surface water sewerage system. This legislation granted municipalities essential authorities for the establishment of stormwater utilities. Table 52 in Chapter IV of this report indicates which communities in the study area have established stormwater utilities, a general stormwater fund, or a stormwater fee program.

Lake Districts and Associations
Lake districts are special purpose units of government that are established to maintain, protect, and improve the quality of a lake and its watershed for the benefit of the lake, fish and wildlife habitat, and the surrounding community. The boundaries of the district include the riparian property owners but can extend to off-lake property that affects the watershed or that benefits from the lake. Chapter 33 of the *Wisconsin Statutes* enables lake districts to carry out the following roles and responsibilities:

- Land acquisition for the benefit of the watershed;

- Collection of fees in the form of a tax from affected citizens and the authority to borrow money;

- Development and preparation of surveys or studies, management of aquatic weeds, control of soil erosion, dredging, operating dams, and monitoring water quality; and

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[7]*Following incorporation of the Town of Caledonia as the Village of Caledonia, the former Caddy Vista Sanitary District and Caledonia Utility District No. 1 were combined into the Caledonia West Utility District and the former Crestview Sanitary District and the former North Park Sanitary District were combined into the Caledonia East Utility District.*

- If delegated to do so by a County, City, or Village, adopting and regulating boating activities, aircraft, and travel on ice-bound lakes.

As shown in Table 92, there are three such districts in the study area, all of which are located in the Milwaukee River watershed in Washington County. They include the Big Cedar Lake District, the Little Cedar Lake District, and the Silver Lake District. The districts will be key organizations in carrying out the recommendations of the regional water quality management plan update.

In addition to lake districts, lake associations can also be of help in plan implementation. Lake associations can carry out many of the same roles and functions of a lake district, but some key differences exist. Lake associations are not considered special purpose units of government, and as such do not have taxing authority, and cannot develop and oversee lake use regulations compared to a lake district. However, they are beneficial with regards to water quality improvement projects and some of the activities they can undertake include the following:

- Operate dams;
- Contract for aquatic plant removal or buy and operate an aquatic plant harvester;
- Apply for and receive certain lake planning and protection grants;
- Collect data on water quality, lake development, and lake use conflicts; and
- Purchase sensitive areas such as wetlands.

Lake associations in the study area are also listed in Table 92.

Areawide Agencies

Statutory provision exist for the creation of the following areawide agencies having both general and specific planning and plan implementation powers potentially applicable to the implementation of the regional water quality management plan update.

Metropolitan Sewerage Districts

There are two categories of metropolitan sewerage districts provided for under State *Statutes*—the Milwaukee Metropolitan Sewerage District (MMSD) and other metropolitan sewerage districts.

Milwaukee Metropolitan Sewerage District

As described in detail in Chapter VI of this report, the MMSD is a special-purpose unit of government directed by an appointed Commission. Sections 200.21 through 200.65 of the *Wisconsin Statutes* set forth the enabling legislation for the establishment of metropolitan sewerage districts which include first class cities. The only such district in the regional water quality management plan update study area is the MMSD. The MMSD includes all municipalities in Milwaukee County, except for portions of the City of Franklin and all of the City of South Milwaukee. The District also provides sewage conveyance, storage, and treatment services for portions of Ozaukee, Racine, Washington, and Waukesha Counties. Contract services are provided to the following municipalities or special units of government outside Milwaukee County:

- Ozaukee County: City of Mequon and Village of Thiensville.
- Racine County: That portion of the Caledonia West Utility District serving the Caddy Vista subdivision.
- Washington County: Village of Germantown.
- Waukesha County: Cities of Brookfield, Muskego, and New Berlin and Villages of Butler, Elm Grove, and Menomonee Falls.

Table 92

ORGANIZATIONS FOR MAJOR LAKES IN THE STUDY AREA

County	Lake Organization	Type
Fond du Lac	Forest Lake Improvement Association Kettle Moraine Lake Association Long Lake Fishing Club, Inc.	Lake association Lake association Lake association
Sheboygan	Lake Ellen Sanitary District No. 1 Random Lake Association, Inc.	Sanitary district Lake association
Washington	Big Cedar Lake Protection and Rehabilitation District Big Cedar Lake Property Owners Association Green Lake Property Owners of Washington County Little Cedar Lake Protection and Rehabilitation District Silver Lake Protection and Rehabilitation District Silver Lake Protective Association, Inc. Silver Lake Sanitary District Wallace Lake Sanitary District	Lake district Lake association Lake association Lake district Lake district Lake association Sanitary district Sanitary district

Source: University of Wisconsin-Extension.

The District has the authority to levy taxes to fund its capital improvement programs and operation and maintenance of its facilities.

The District has a number of important responsibilities in the area of water resources management, including the provision of floodland management programs for most of the major streams within the District and the collection, transmission, storage, and treatment of domestic, industrial, and other sanitary sewage generated in the District and its contract service areas. The 2020 District Facilities Plan was prepared in coordination with the regional water quality management plan update for the greater Milwaukee watersheds.

Other Metropolitan Sewerage Districts
Sections 200.01 through 200.15 of the *Wisconsin Statutes* set forth the enabling legislation for the creation of metropolitan sewerage districts which do not include first class cities. These sections of the Statute only apply to those portions of the study area outside the MMSD. Such districts may be created by the WDNR upon a request by resolution of the governing body of any municipality sought to be served by such a district. The WDNR is required to hold a public hearing on the proposal to create a district and, in order for the WDNR to order the creation of a district, must make certain findings. Cities and villages owning or operating sewage collection and disposal systems may object to being included in such a district in which case the WDNR must honor such objection. No metropolitan districts of this type have been created to date to serve any portion of the study area. In addition to being capable of properly carrying out projects relating to the conveyance and treatment of sanitary sewage, metropolitan sewerage districts may build stormwater drainage and flood control facilities.

Joint Sewerage Systems
As noted in Chapter VI of this report, Section 281.43 of the *Wisconsin Statutes* provides the authority for a group of governmental units, including cities, villages, and town sanitary or utility districts, to construct and operate a joint sewerage system following a hearing and approval by the WDNR. As an alternative, the jointly acting governmental units may create a sewerage commission to plan, construct, and maintain sewerage facilities for the collection, transmission, and treatment of sewage. Such a commission becomes a municipal corporation and has all the powers of a common council and board of public works in carrying out its duties. However, all bond issues and appropriations made by such a commission are subject to approval by the governing bodies of the units of government which initially formed the commission. There are two joint sewerage systems which provide sewage service to a portion of the regional water quality management plan update study area. One sewerage system is the Onion River Sewerage Commission which serves the Village of Adell, which lies within the study area. The Commission also serves the Hingham Sanitary District which is located outside the study area. The treatment

plant serving both sewer systems is located outside the study area. The other joint sewerage system is the Underwood Creek interceptor which is jointly operated by the City of Brookfield and the Village of Elm Grove.

Cooperative Contract Commissions

Section 66.0301(2) of the *Wisconsin Statutes* provides that municipalities[8] may contract with each other to form cooperative service commissions for the joint provision of any services or joint exercise of any powers that each municipality may be authorized to exercise separately. Such commissions have been given bonding powers for the purposes of acquiring, developing, and equipping land, buildings, and facilities for areawide projects. Economies can often be effected through the provision of governmental services and facilities on a cooperative, areawide basis. Moreover, the nature of certain developmental and environmental problems often requires that solutions be approached on an areawide basis. Such an approach may be efficiently and economically provided through the use of a cooperative contract commission.

Intergovernmental cooperation under such cooperative contract commissions may range from the sharing of expensive public works equipment to the construction, operation, and maintenance of major public works facilities on an areawide basis. A cooperative contract commission may be created for the purpose of plan implementation and may be utilized in lieu of any of the aforementioned areawide organizations for such implementation.

Regional Planning Commission

The Regional Planning Commission has no statutory plan implementation powers. However, in its role, as a coordinating agency for planning and development activities within the Southeastern Wisconsin Region, and using the certified plan element as a basis for review, the Commission may play an important role in plan implementation through community planning assistance services and through the review of Federal and State grant-in-aid applications, discharge permits, and sanitary sewer extensions. In addition, the Commission provides a basis for the creation and continued functioning of the Technical Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, which should remain as an important continuing public planning organization in the study area.

State-Level Agencies

The following State agencies have either general or specific planning authority and hold certain plan implementation powers important to the adoption and implementation of the regional water quality management plan update for the greater Milwaukee watersheds.

Wisconsin Department of Natural Resources

The WDNR has broad authority and responsibility in the areas of natural resources protection, water quality control, and water regulation. The WDNR has the obligation to develop long range, Statewide conservation and water resource plans. In addition, it has the authority to designate such sites as necessary to protect, develop, and regulate the use of State parks, forests, fish, game, lakes, streams, certain plant life, and other outdoor resources; and to acquire conservation and scenic easements.

Designation of State Project Areas

In its role of designating sites to protect the natural resources of the State, the WDNR can play an important part in implementing and funding the prairie and wetland restoration and stream rehabilitation components of the recommended regional water quality management plan update. The prairie and wetland restorations may be accomplished as a whole, or in part, through creation of a State Project Area within which the WDNR could acquire, develop, and manage properties. Section 23.09(2)(d) of the *Wisconsin Statues* lists purposes for which the State may acquire lands through purchase, lease, or gift. The listed purposes that may be applicable to the recommended prairie and wetland restorations include:

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[8]*The term municipality under this section of the statutes is defined to include the State, any agency thereof, cities, villages, towns, counties, school districts, and regional planning commissions.*

- State recreation areas,
- Streambank protection,
- Habitat areas and fisheries, and
- State wildlife areas.

As can be seen from Map 81, many possible prairie and wetland restoration sites are located near known natural areas and their restoration would enhance or complement those natural areas.

Chapter NR 1 of the *Wisconsin Administrative Code*, establishes priorities for WDNR acquisition of lands. The categories that are applicable to the recommended prairie and wetland restoration, in descending priority, are:

- Water-based resources,
- Lands to accommodate broad, natural resources-based outdoor recreation and State recreational trails.
- Land within 40 miles of Wisconsin's 12 largest cities. (Most of the potential restoration areas are within 40 miles of the Cities of Kenosha, Milwaukee, or Racine, each of which is among the 12 largest cities in the State.)

A proposed State Project Area is evaluated by the WDNR through preparation of a feasibility study, following which the Project Area may be approved or rejected by the Natural Resources Board and the Governor.

Certification of Areawide Water Quality Management Plans

The Department of Natural Resources has the responsibility of reviewing and approving areawide plans for water quality management and making recommendations to the Governor as to the certification of all or parts of each plan. The Governor has, pursuant to Federal planning guidelines, the responsibility of certifying to the USEPA areawide plans for water quality management.

Water Pollution Control Function

As already noted in Chapter VI of this report, the responsibility for water pollution control in Wisconsin is centered in the WDNR. The basic authority and accompanying responsibilities relating to the water pollution control function of the WDNR are set forth in Chapter 283 of the *Wisconsin Statutes.* Under that chapter, the WDNR is given broad authority regarding the following:

- Preparing water use objectives and supporting water quality standards;
- Protecting water quality through abatement of nonpoint source pollution from construction site erosion, agricultural runoff, and nonagricultural (urban) runoff;
- Protecting wetlands through enforcement of water quality standards;
- Protecting navigable waters, including authorizing municipal shoreland zoning regulations;
- Regulating groundwater withdrawals from high capacity wells to ensure that operation of such a well does not adversely affect a public water supply or, when located in a groundwater protection area, which is defined as an area within 1,200 feet of an outstanding or exceptional resource water or Class I, II, or III trout streams;[9]

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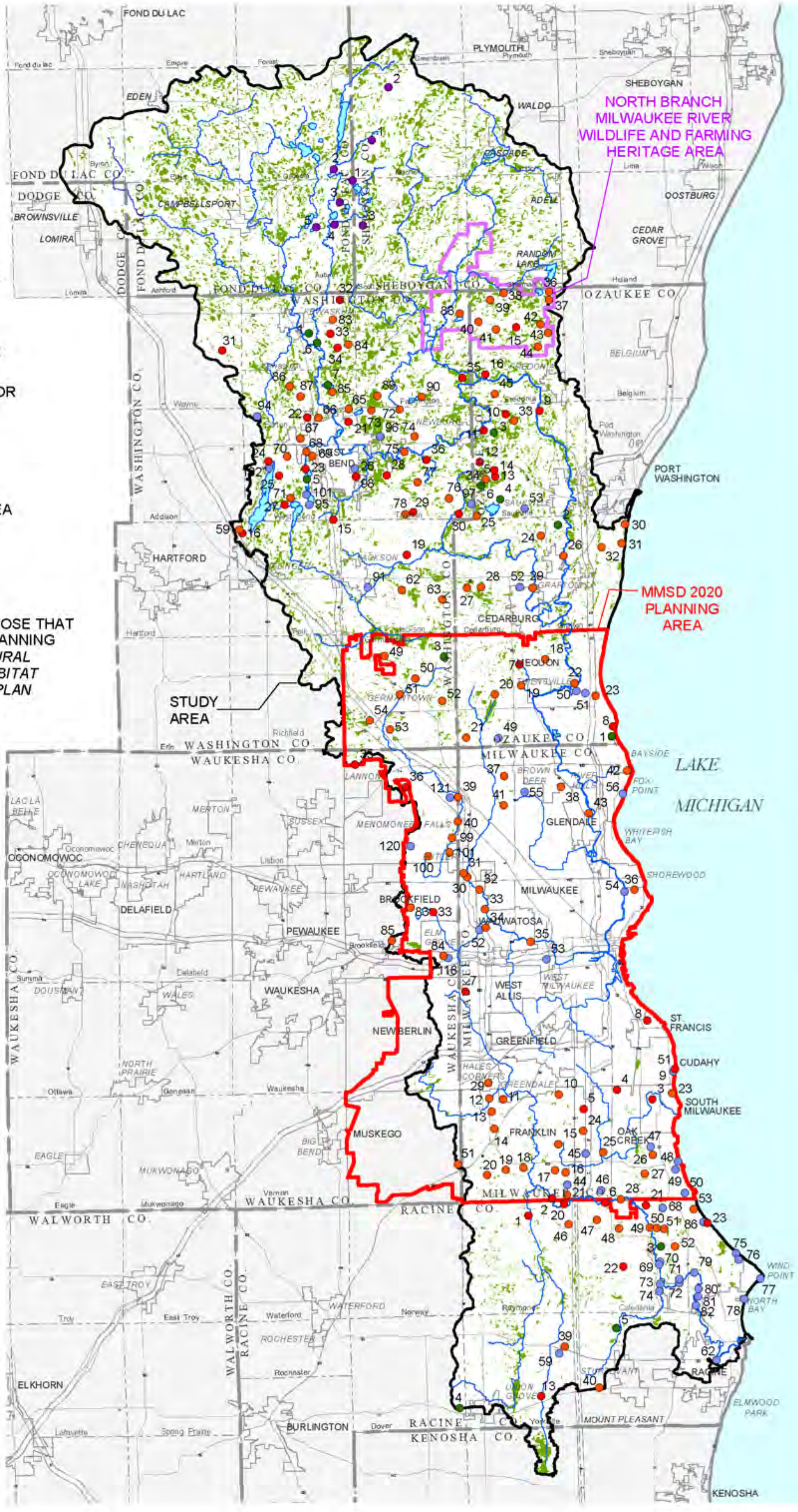
[9]*Section 281.34(5)(b)1 requires that "an environmental impact report under s. 23.11 (5) must be prepared for a proposed high capacity well located in a groundwater protection area."*

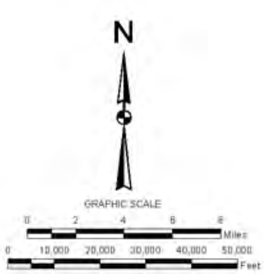
Map 81

LOCATIONS OF KNOWN NATURAL AREAS AND CRITICAL SPECIES HABITAT SITES RELATIVE TO POTENTIAL PRAIRIE OR WETLAND RESTORATION SITES WITHIN THE REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE STUDY AREA

- CANDIDATE PRAIRIE OR WETLAND RESTORATION AREA
- SURFACE WATER
- NATURAL AREA OF STATEWIDE OR GREATER SIGNIFICANCE (NA-1)
- NATURAL AREA OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (NA-2)
- NATURAL AREA OF LOCAL SIGNIFICANCE (NA-3)
- CRITICAL SPECIES HABITAT SITE
- DESIGNATED STATE NATURAL AREA BY WDNR BUREAU OF ENDANGERED RESOURCES
- 15 IDENTIFICATION NUMBER (SEE TABLE 30)

NOTE: IDENTIFICATION NUMBERS ARE THOSE THAT WERE ASSIGNED FOR SEWRPC PLANNING REPORT NO. 42, *A REGIONAL NATURAL AREAS AND CRITICAL SPECIES HABITAT PROTECTION AND MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN*, SEPTEMBER 1997.





Source: SEWRPC.

- Conserving and managing water resources through regulation of withdrawals from waters of the State;

- Reviewing and approving plans and specifications for components of sanitary sewerage systems;

- Reviewing and approving the creation of joint sewerage systems;

- Regulating the servicing of septic tanks, soil absorption fields, holding tanks, grease interceptors, privies, and other components of private sewage systems

- Regulating the disposal of septage in municipal sewerage systems;

- Performing "activities to clean up or to restore the environment in an area that is in or adjacent to Lake Michigan or Lake Superior or a tributary of Lake Michigan or Lake Superior if the activities are included in a remedial action plan that is approved by the department." (Section 281.83(1)); and

- Administering a financial assistance program for the construction of pollution prevention and abatement facilities.

Each of the above authorities is important to implementation of the recommended regional water quality management plan update, but the loans and grants available through the financial assistance program are particularly relevant, including those related to:

- Local water quality planning,

- Facilities planning, engineering design, and construction of point source pollution abatement facilities,

- Nonpoint source water pollution abatement "for the implementation of measures to meet nonpoint source water pollution abatement needs identified in areawide water quality management plans," (Section 281.65(1)(a)),

- Lake management planning, and

- River protection.

Under Chapter 243 of the *Statutes*, the WDNR is given broad authority to establish and carry out the Wisconsin Pollutant Discharge Elimination System (WPDES) program in accordance with the policy guidelines set forth by the U.S. Congress under the Federal Water Pollution Control Act Amendments of 1972 and 1987. This legislation establishes a waste discharge permit system and provides that no permit may be issued by the WDNR for any discharge from a point source of pollution which is in conflict with any areawide wastewater treatment and water quality management plan approved by the WDNR. This legislation and accompanying procedures is the primary enforcement tool of the WDNR in achieving the established water use objectives and supporting water quality standards.

Other WDNR Authority

The WDNR has the obligation to establish standards for floodplain and shoreland zoning and the authority to adopt, in the absence of satisfactory local action, shoreland and floodplain zoning ordinances. The WDNR also has authority to regulate the following: water diversions, shoreland grading, dredging, encroachments, and deposits related to navigable waters; the construction of neighboring ponds, lagoons, waterways, stream improvements, and pierhead and bulkhead lines; the construction, maintenance, and abandonment of dams; and water levels of navigable lakes and streams and lake and stream improvements, including the removal of certain lakebed materials. The WDNR also makes cost-share monies available for a number of activities including, dam removal, river protection, land and water conservation and stewardship activities, stormwater and runoff management, lake planning and protection, and aquatic invasive species control. With such broad authority for the protection of the natural resources of the State and Region, the WDNR will be extremely important to the implementation of nearly all of the major elements of the recommended regional water quality management plan update.

Wisconsin Department of Administration

The Wisconsin Department of Administration Federally approved Coastal Zone Management Program for the Great Lakes was established in 1978 under the Federal Coastal Zone Management Act and has been revised over time.

Wisconsin Department of Agriculture, Trade and Consumer Protection

Under the Wisconsin Soil and Water Conservation Law, State-level soil and water conservation responsibilities have been placed under Wisconsin DATCP authority. Within that Department, the law created a seven-member advisory Land and Water Conservation Board. The Land and Water Conservation Board reviews and comments on rules relating to soil and water conservation, administers the State's Farmland Preservation Program, reviews all County erosion control plans and the annual County and long-range County land and water conservation plans, and generally advises the Secretary of DATCP and the University of Wisconsin on matters relating to soil and water conservation. DATCP also makes cost-share monies available for land and water resource management activities such as installation of agricultural best management practices. The DATCP rules require the preparation of county land and water conservation plans and provide for partial funding of such county plans administration and implementation. As such, the Department and its Land and Water Conservation Board will have plan implementation responsibilities relative to the water quality management plan.

Wisconsin Department of Commerce

The Wisconsin Department of Commerce has responsibility for regulation of construction erosion control and private onsite wastewater treatment systems under Chapters Comm 60, "Erosion Control, Sediment Control and Storm Water Management," and Comm 83, "Private Onsite Wastewater Treatment Systems," of the *Wisconsin Administrative Code*. Department authority for construction site erosion control extends to issuing permits for single- and two-family residential building sites and commercial sites.

Wisconsin Department of Transportation

The Wisconsin Department of Transportation has important responsibilities regarding 1) nonpoint source pollution abatement related to highway construction and maintenance, 2) constructing stream crossings that permit passage of fish and other aquatic organisms, and 3) minimizing disturbance of existing natural stream channels and restoring disturbed stream channel reaches.

University of Wisconsin-Extension

A University of Wisconsin-Extension office is located within each County. Although the Extension has no statutory plan implementation powers, the Extension can aid communities in solving environmental problems by providing educational and informational programs to the general public, and by offering advice to local decision-makers and community leaders. The Extension carries out these responsibilities by conducting meetings, tours, and consultations, and by providing newsletters, bulletins, and research information.

Federal-Level Agencies

The following Federal agencies administer aid and assistance programs that may be applicable to implementation of the recommended plan. Funding from such programs may be used for land acquisition and construction of specific facilities.

U.S. Environmental Protection Agency

The USEPA administers water quality management planning grants and sanitary sewerage facility construction grants. The latter can be particularly important to implementation of the water quality management plan. In addition, this agency is responsible for the ultimate achievement and enforcement of water quality standards for all interstate waters, should the States not adequately enforce such standards. In this respect, the USEPA has delegated authority over the National Pollutant Discharge Elimination Systems (NPDES) permit issuance process whereby the WDNR issues discharge permits under both State and Federal authorities. Under guidelines promulgated by the USEPA, areawide water quality management and sanitary sewerage facilities plans must be prepared as prerequisites to the receipt of Federal capital grants in support of sewerage works construction. As noted previously, as a designated areawide water quality management planning agency under Section 208 of the Federal Water Pollution Control Act, the Regional Planning Commission is engaged in a continuing areawide water quality management planning program for southeastern Wisconsin under an ongoing cooperative program with the WDNR.

U.S. Department of Agriculture, Farm Services Agency

The USDA Farm Services Agency (FSA) administers the programs of the Federal Farm Bill which provide grants to rural landowners in partial support of carrying out approved land and water conservation practices. Grants from this program could be used for implementation of water quality plan recommendations.

U.S. Department of Agriculture, Natural Resources Conservation Service

This agency administers resource conservation and development projects and watershed projects under Federal Public Law 566 and provides technical and financial assistance to landowners through the County land conservation committees. Such assistance may include the planning and construction of measures for land treatment, agricultural water management, and flood prevention and for public fish, wildlife, and recreational development. This agency also conducts detailed soil surveys and provides interpretations as a guide to utilizing soil survey data in local planning and development. Certain programs administered by this agency, including those providing partial funding for land conservation practices, can contribute to implementation of the land management and treatment measures recommended under the regional water quality management plan. The current Natural Resources Conservation Service staff has been actively providing technical assistance and promotion of land conservation programs and practices throughout the study area and has played an important role in achieving a relatively high level of farm conservation practices planning and implementation in the greater Milwaukee watersheds.

U.S. Department of the Interior, Geological Survey

The U.S. Geological Survey (USGS) conducts continuing programs on water resource appraisal and monitoring. The programs of the U.S. Geological Survey are essential to the implementation of the water quality plan recommendations to maintain existing stream gaging and water quality monitoring capabilities and to add water quality and streamflow monitoring sites on tributary streams in the study area.

U.S. Department of the Interior, Fish and Wildlife Service

The U.S. Fish and Wildlife Service has the mission of conserving, protecting, and enhancing fish, wildlife, and plants and their habitats. Thus, the Service would have a role in implementation of the instream and riparian habitat measures recommended under the regional water quality management plan update.

U.S. Department of Transportation

The U.S. Department of Transportation, Federal Highway Administration, administers all Federal aid programs working through the Wisconsin Department of Transportation. Thus, this agency has nonpoint source pollution abatement responsibilities with regard to setting standards for highway construction and maintenance.

U.S. Army Corps of Engineers

The Corps of Engineers also administers a regulatory program relating to the discharge of dredge and fill materials into the waters of the United States and adjacent wetlands. This program is administered pursuant to Section 404 of the Federal Water Pollution Control Act as amended in 1972. The administration of this program supports the recommendations of the water quality management plan regarding preserving wetlands and dredging in the Milwaukee Harbor estuary.

Private Organizations

Land trusts and conservancies, such as the Kenosha/Racine Land Trust, the Milwaukee Area Land Conservancy, Ozaukee-Washington Land Trust, the River Revitalization Foundation, and the Waukesha Land Conservancy, purchase, or obtain conservation easements for, environmentally valuable lands through member contributions, land or easement donations, and grants obtained from other sources. These organizations can play a significant part in plan implementation through coordination of their land acquisition and easement programs with the recommendations of the plan.

In addition, organizations, such as the Milwaukee River Basin Partnership and the Root-Pike Watershed Initiative Network, can have direct roles in plan implementation through considering the interrelationship between plan recommendations and their programs to improve water quality of streams and lakes in the study area. Organizations such as the Urban Ecology Center, Riveredge Nature Center, the Schlitz Audubon Nature Center, and Friends of Milwaukee's Rivers can support plan implementation through their water quality monitoring and educational programs.

Other Tools Related to Plan Implementation

As described in Chapter I of this report, the MMSD facilities plan and the regional water quality management plan update were developed cooperatively by the WDNR, the MMSD (including its facilities plan consultant team), and SEWRPC under a February 19, 2003, Memorandum of Understanding (MOU) which effectively formed the partnership known as the Water Quality Initiative. Under the MOU, the following two separate, but coordinated and cooperative planning programs were conducted:

- The SEWRPC regional water quality management plan update for the greater Milwaukee watersheds, or Section 208 Plan, and

- The MMSD 2020 facilities plan, or Section 201 Plan

As provided in Federal and State regulations,[10] a Section 201 Plan, such as the 2020 facilities plan, must conform to the approved regional water quality management plan.[11] Similarly, the applicable recommendations of an approved facilities plan are required to be used whenever possible in a Section 208 Plan to determine an urban area's wastewater treatment needs.[12]

These planning efforts, when taken together, represent an integrated watershed water quality planning approach. The two plans were prepared using the same data and analytical models, joint public involvement, and a shared technical team. As noted in Chapter VI of this report, the USEPA encourages a watershed approach to water quality planning that is very similar to the approach that has long been followed by SEWRPC in its watershed and water quality planning work.

The analyses documented in Chapters IX and X of this report demonstrate that extensive measures to reduce pollution from nonpoint sources will be needed throughout the regional water quality management plan update study area in order to achieve significant improvements in water quality. It is logical that a water quality management plan developed holistically on a watershed basis should be implemented through an integrated, watershed-based approach that should involve the many public and private sector entities that would have roles in implementation of the plan as described previously.

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[10]*Federal Water Pollution Control Act (Clean Water Act) and the Section NR 121.05(1) (g) of the* Wisconsin Administrative Code.

[11]*In accordance with NR 110.08(4).*

[12]*In accordance with NR 121.05(1) (g).*

Because of the broad geographic and programmatic scope of the regional water quality management plan update for the greater Milwaukee watersheds, plan implementation under any institutional framework presents significant challenges. Many aspects of the plan are tied to regulatory requirements for which there is an established framework for continued implementation through the WPDES discharge permit program. However, while the watershed approach that was applied for plan development recognizes existing regulatory requirements and incorporates them as appropriate, it is not constrained by those requirements. In certain instances, the watershed approach offers an opportunity to reconsider existing regulatory requirements by logically focusing attention on measures that will achieve the greatest anticipated improvement in water quality independent of currently-applied regulations. Thus, plan implementation efforts can incorporate new regulatory paradigms, such as watershed-based permitting, watershed trading, and other concepts in an adaptive implementation scheme.

U.S. Environmental Protection Agency Approach to Watershed-Based Permitting

Watershed-based discharge permits could be used to more cost-effectively achieve improvements in water quality consistent with the recommendations of the regional water quality management plan update for the greater Milwaukee watersheds. Such permits would enable better consideration of the anticipated effects on water quality of reducing pollutant loads from point sources and certain nonpoint sources.[13] However, under the current Federal and State regulatory framework, as applied under the WPDES discharge permitting system, most agricultural nonpoint sources, with the exception of Concentrated Animal Feeding Operations (CAFOs), are not regulated through permits, although Chapter NR 151 includes manure management prohibitions and standards for abatement of agricultural nonpoint source pollution. Information on incentives for addressing agricultural nonpoint pollution sources in the context of a watershed-based permit is provided in Appendix S.

Developing watershed-based permits (in lieu of traditional individual source permits) is a relatively new concept initiated by USEPA that rethinks traditional National Pollutant Discharge Elimination System (WPDES in Wisconsin) permitting in an attempt to attain better results in improving water quality. In traditional permitting, individual sources are regulated and the interrelationship between permitted and unpermitted discharges as they affect instream water quality conditions is often not evaluated through detailed watershed modeling of the type that has been developed for the SEWRPC regional water quality management plan update and the MMSD 2020 facilities plan. In the watershed-based permitting approach, an NPDES permit could be developed for multiple sources, including urban nonpoint sources which are regulated as point sources as described previously. Through this approach, NPDES permitting authorities take into account the watershed goals and the impact of multiple pollutant sources when developing the permit. The USEPA believes that watershed-based permitting can lead to more environmentally effective results, reduce the cost of improving water quality, foster more effective implementation of watershed plans, and realize other benefits through integration of various environmental regulations (e.g., Clean Water Act and Safe Drinking Water Act programs).[14]

As described in Chapter VI of this report, the USEPA has identified the following types of watershed permits:[15]

- **Watershed-Based General Permit–Common Sources.** A permitting authority "would develop and issue this type of general permit to a category of point sources within a watershed, such as all publicly owned treatment works (POTWs) or all confined animal feeding operations (CAFOs) or all storm

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[13]*Under the 1987 amendment to the Clean Water Act, stormwater runoff pollution, which is often considered to be a nonpoint source, is regulated as a point source, since it generally is discharged to waterways through discrete outfalls such as storm sewers, culverts, or open channels.*

[14]*G. Tracy Mehan, III, Assistant Administrator, U.S. Environmental Protection Agency, Memorandum to Water Division Directors, Regions I-X, Watershed-Based National Pollutant Discharge Elimination System Permitting Policy Statement (January 7, 2003).*

[15]*U.S. Environmental Protection Agency,* Watershed-Based National Pollutant Discharge Elimination System (NPDES) Permitting Implementation Guidance, *December 2003.*

water discharges from municipal separate storm sewer systems. This is similar to current general permits, except that the geographic area covered by the permit would correspond to the watershed boundary. The most significant difference between a traditional general permit and the watershed-based general permit for common sources would be permit requirements that reflect watershed-specific water quality standards."

- **"Watershed-Based General Permit–Collective Sources.** Unlike the watershed based general permit described above, this type of permit would address all point sources within the watershed or alternatively, several subcategories of point sources within the watershed. This type of permit would be similar to the multi-sector general permit for storm water discharges associated with industrial activity with requirements being tied to categories and subcategories of discharges. Again, the distinguishing feature of this type of permit would be geographic coverage based on the watershed-boundaries and the permit requirements reflecting watershed-specific water quality standards."

- **"Watershed-Based Individual Permit–Multiple Permittees.** Similar to the approach used for Phase I MS4s (municipal separate storm sewer systems) with multiple permittees, this type of permit would allow several point sources within a watershed to apply for and obtain permit coverage under an individual permit."

- **"Integrated Municipal NPDES Permit**. This type of permit would bundle all NPDES permit requirements for a municipality (e.g., storm water, combined sewer overflows, biosolids, pretreatment, etc.) into a single municipal permit. While this type of permit would focus on municipal boundaries rather than watershed boundaries, the analysis in developing permit requirements would reflect watershed-specific water quality standards."

A watershed-based permitting approach may be attractive to some implementing agencies. Initial discussions have been held among stakeholder groups and the possibility has been raised of using a single watershed as a pilot application for the watershed-based permitting approach. When a watershed-based permit consolidates multiple individual permits, limited intermunicipal agreements between the individually permitted communities or other units of government would be required to clarify responsibilities in meeting permit conditions and additional formal agreements may have to be obtained from private sector dischargers.

Total Maximum Daily Loads

As noted in Chapter VI of this report, under the Clean Water Act, Total Maximum Daily Loads (TMDLs) are to be established for waters that are not meeting their designated water use objectives and are, therefore, listed as impaired waters by the State under Section 303(d) of the Clean Water Act. The TMDLs are to be designed "to establish the 'total maximum daily load' of a pollutant that the waterbody can assimilate and still achieve water quality standards."[16] As set forth in SEWRPC Technical Report No. 39, the companion to this report which presents information on water quality conditions and sources of pollution, each of the five riverine watersheds in the study area includes impaired streams on the 303(d) list. The WDNR is in the process of developing TMDLs for impaired waters throughout the State; however, large-scale, watershedwide TMDLs have not yet been developed within the greater Milwaukee watersheds.

The MMSD is proposing to develop third-party TMDLs for the Kinnickinnic, Menomonee, and Milwaukee River watersheds, and the Milwaukee Harbor and to coordinate that process with the WDNR and USEPA. Implementation of the recommendations of the regional water quality management plan update is an intermediate step in the process of establishing and meeting TMDL requirements throughout the study area, but will be examined in the context of the TMDL process. Mathematical water quality simulation models, such as those used for the

[16]*Association of Metropolitan Sewerage Agencies,* Creating Successful Total Maximum Daily Loads, *2004.*

regional plan update (see descriptions in Chapter V of this report), will be the foundation for establishing TMDLs that consider point and nonpoint sources of pollution.

The WDNR is responsible for developing TMDLs for impaired waterbodies. Wisconsin's list of impaired waters includes a priority ranking of impaired waters indicating the relative time frame for when TMDLs will be developed. In the most recent impaired waters list TMDL development for the mainstem of Oak Creek and the impaired reaches of the mainstem of the Root River are given a low priority, indicating likely completion of TMDLs for these waters within five to 13 years.[17] The priority ranking for the Root River Canal in the Root River watershed is given as "medium," indicating likely completion of a TMDL for this stream within a two- to five-year period.

It is recommended that local governments and other interested parties throughout the study area keep abreast of future programs to develop TMDLs, develop an understanding of what TMDL development means for their community, and participate in the development of TMDLs as appropriate.

PLAN ADOPTION, ENDORSEMENT, AND INTEGRATION

Upon adoption of the regional water quality management plan for the greater Milwaukee watersheds, in accordance with Section 66.0309(10) of the *Wisconsin Statutes*, the Commission will transmit a certified copy of the resolution adopting the plan, together with the plan itself, to all local legislative bodies within the study area and to all of the existing Federal, State, areawide, and local units and agencies of government that have potential plan implementation functions. In accordance with both Section 208 of the Federal Water Pollution Control Act as amended and with Chapter NR 121 of the *Wisconsin Administrative Code*, a certified copy will be transmitted to the WDNR with a request that the Department approve the plan as the official areawide water quality management plan for the greater Milwaukee watersheds and recommend to the Governor that the plan be certified by him and transmitted to the USEPA for that agency's approval.

Endorsement, or formal acknowledgment of the update to the regional water quality management plan by the local legislative bodies and the existing local, areawide, State, and Federal level agencies concerned is highly desirable to assure a common understanding among the several governmental levels and to enable their staffs to program the necessary implementation work. This acceptance or acknowledgment is, in some cases, required by the *Wisconsin Statutes* before certain planning actions can proceed; such a requirement holding in the case of city, village, and town plan commissions created pursuant to Section 62.23 and 61.35 of the *Wisconsin Statutes*. In addition, formal plan endorsement may also be required for State and Federal financial aid eligibility.[18] A model resolution for endorsement of the regional water quality management plan update for the greater Milwaukee watersheds is included in Appendix T. Endorsement of the recommended regional water quality management plan update by any unit or agency of government pertains only to the statutory duties and functions of the endorsing agencies and such endorsement does not and cannot in any way preempt or commit action by another unit or agency of government acting within its own area of functional and geographic jurisdiction.

Upon endorsement of the plan by a unit or agency of government, it is recommended that the policymaking body of the unit or agency direct its staff to review in detail the elements of the comprehensive watershed plan. Once such review is completed, the staff can propose to the policymaking body for its consideration and approval the

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[17]*Wisconsin Department of Natural Resources,* Approved Wisconsin 303(d) Impaired Waters List, *September 2006.*

[18]*Plan endorsement would not be required to receive funds through ongoing USDA or other land conservation programs, since those programs are not directly related to planning activities, such as the regional water quality management plan. However, the plan implementation activities will focus on identifying funding sources for the implementation actions, including land management practices. Thus, additional funding opportunities may become available during plan implementation.*

steps necessary to fully integrate the watershed plan elements into the plans and programs of the unit or agency of government. A summary of the plan elements to be implemented by various governmental units, agencies, and private organizations is set forth in Tables 93 through 99. Those tables also include prioritization of recommended plan measures.

Local-Level Agencies

1. It is recommended that the Dodge, Fond du Lac, Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha County Boards of Supervisors formally endorse the regional water quality management plan update for the greater Milwaukee watersheds by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes*, after a report and recommendation by the appropriate county committees.

2. It is recommended that the Dodge, Fond du Lac, Kenosha,[19] Ozaukee, Racine, Sheboygan, Washington, and Waukesha County Drainage Boards formally endorse the regional water quality management plan update by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes*.

3. It is recommended that the Plan Commissions of the cities, villages, and towns in the study area endorse the regional water quality management plan update as it affects them by resolution, pursuant to Section 62.23(3)(b) of the *Wisconsin Statutes*, and certify such adoption to their respective governing bodies, and that upon such certification the governing bodies also adopt the recommended plan.

4. It is recommended that the governing boards and commissions of the Caledonia East and West Utility Districts in the Villages of Caledonia; the Lake Ellen Sanitary District in the Town of Lyndon; the Mount Pleasant Sewer Utility District No. 1 in the Village of Mt. Pleasant; the Silver Lake Sanitary District in the Town of West Bend; the Town of Scott Sanitary District in the Town of Scott; the Wallace Lake Sanitary District in the Towns of Barton and Trenton; the Waubeka Area Sanitary District in the Town of Fredonia; and the Yorkville Sewer Utility District No. 1 in the Town of Yorkville endorse the regional water quality management plan update as it affects them by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes*.

5. It is recommended that the governing boards of the Big Cedar, Little Cedar, and Silver Inland Lake Protection and Rehabilitation Districts, and all such districts created in the future within the study area, endorse the regional water quality management plan update as it affects them by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes.*

Areawide Agencies

1. It is recommended that the Milwaukee Metropolitan Sewerage Commission endorse the regional water quality management plan update for the greater Milwaukee watersheds by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes*, and inform its constituent and contract municipalities of such action. Such adoption cannot, of course, preclude the MMSD from taking any actions necessary to meet regulatory requirements.

2. It is recommended that the Onion River Sewerage Commission and any other joint sewerage commission or cooperative contract commission formed for sewerage purposes in the future, endorse the regional water quality management plan update by resolution, pursuant to Section 66.0309(12)(a) of the *Wisconsin Statutes*, and inform their respective governing bodies of such action.

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[19]*As of the date of publication of this report, Kenosha County did not have an active Drainage Board.*

Table 93

LOCAL GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE POINT SOURCE POLLUTION ABATEMENT ELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Point Source Management Agency	Refine and Detail Sewer Service Area [**Low Priority**][a]	Maintain and Operate Wastewater Treatment Plant [**High Priority**][a]	Upgrade Wastewater Treatment Plant According to Recent Site Study or Facilities Plan [**High Priority**][a]	Construct and Maintain Intercommunity Trunk Sewer [**High Priority**][a]	Construct and Maintain Local Sewer System [**High Priority**][a]	Abate Combined Sewer Overflow [**Medium Priority**][a]	Evaluate the Need to Reduce Clearwater Infiltration and Inflow [**High Priority**][a]	Eliminate Discharges from All Points of Sewage Flow Relief [**High Priority**][a]	Implement CMOM Program [**High Priority**][a]	Prepare Facilities Plans [**Medium Priority**][a]
Dodge County[b]	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Village of Lomira	X	X	- -	- -	X	- -	X	- -	X	- -
Fond du Lac County[b]	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Village of Campbellsport	X	X	- -	- -	X	- -	X	- -	X	- -
Village of Eden	- -	- -	- -	- -	X	- -	X	- -	X	- -
Kenosha County										
None	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Milwaukee County	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Milwaukee Metropolitan Sewerage District	X	X	X	X	- -	X	X	X	- -	- -
City of Cudahy	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of Franklin	- -	- -	- -	X	X	- -	X	- -	X	- -
City of Glendale	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of Greenfield	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of Milwaukee	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of Oak Creek	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of St. Francis	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of South Milwaukee	X	X	X	- -	X	- -	X	X	X	- -
City of Wauwatosa	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of West Allis	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Bayside	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of Brown Deer	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Fox Point	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Greendale	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of Hales Corners	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of River Hills	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Shorewood	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of West Milwaukee	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of Whitefish Bay	- -	- -	- -	- -	X	- -	X	- -	X	- -
Ozaukee County	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of Cedarburg	- -	X	- -	- -	X	- -	X	X	X	X
City of Mequon	- -	- -	- -	- -	X	- -	X	- -	X	- -
City of Port Washington	- -	X	- -	- -	X	- -	X	- -	X	- -
Village of Fredonia	- -	X	X	- -	X	- -	X	X	X	- -
Village of Grafton	- -	X	- -	- -	X	- -	X	X	X	X
Village of Newburg	- -	X	- -	- -	X	- -	X	- -	X	X
Village of Saukville	- -	X	- -	- -	X	- -	X	X	X	- -
Village of Thiensville	- -	- -	- -	- -	X	- -	X	X	X	- -
Town of Fredonia–Waubeka Area Sanitary District	- -	- -	- -	X	X	- -	- -	- -	X	- -

Table 93 (continued)

Point Source Management Agency	Refine and Detail Sewer Service Area [**Low Priority**][a]	Maintain and Operate Wastewater Treatment Plant [**High Priority**][a]	Upgrade Wastewater Treatment Plant According to Recent Site Study or Facilities Plan [**High Priority**][a]	Construct and Maintain Intercommunity Trunk Sewer [**High Priority**][a]	Construct and Maintain Local Sewer System [**High Priority**][a]	Abate Combined Sewer Overflow [**Medium Priority**][a]	Evaluate the Need to Reduce Clearwater Infiltration and Inflow [**High Priority**][a]	Eliminate Discharges from All Points of Sewage Flow Relief [**High Priority**][a]	Implement CMOM Program [**High Priority**][a]	Prepare Facilities Plans [**Medium Priority**][a]
Racine County	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of Racine	- -	X	- -	- -	X	- -	X	X	X	X
Village of Caledonia	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Caledonia West Utility District	- -	- -	- -	- -	X	- -	X	X	X	X
Caledonia East Utility District	- -	- -	- -	- -	X	- -	X	X	X	X
Village of Mt. Pleasant	- -	- -	- -	- -	X	- -	X	X	X	X
Mt. Pleasant Utility District No. 1	- -	- -	- -	- -	X	- -	X	X	X	X
Village of North Bay	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Sturtevant	- -	- -	- -	- -	X	- -	- -	X	X	X
Village of Union Grove	- -	X	- -	- -	X	- -	X	X	X	- -
Village of Wind Point	- -	- -	- -	- -	X	- -	- -	- -	- -	- -
Town of Raymond	- -	- -	- -	- -	- -	- -	- -	- -	- -	X
Town of Yorkville Sewer Utility District No. 1	X	X	- -	- -	X	- -	X	- -	X	X
Sheboygan County[b]	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Village of Adell	X	X	- -	- -	X	- -	X	X	X	- -
Onion River Sewerage Commission	X	X	- -	- -	- -	- -	X	- -	- -	- -
Village of Cascade	X	X	- -	- -	X	- -	X	- -	X	- -
Village of Random Lake	X	X	- -	- -	X	- -	X	- -	X	- -
Town of Lyndon–Lake Ellen Sanitary District	- -	- -	- -	- -	X	- -	- -	- -	- -	- -
Town of Scott Sanitary District No. 1	X	X	- -	- -	X	- -	X	- -	X	- -
Washington County	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of West Bend	- -	X	- -	X	X	- -	X	X	X	- -
Village of Germantown	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of Jackson	- -	X	- -	- -	X	- -	X	X	X	X
Village of Kewaskum	- -	X	X	- -	X	- -	X	X	X	- -
Village of Newburg	- -	X		- -	X	- -	X	X	X	- -
Town of Trenton–Wallace Lake Sanitary District[c]	- -	- -	- -	- -	X	- -	X	- -	X	- -
Town of West Bend–Silver Lake Sanitary District	- -	- -	- -	- -	X	- -	- -	- -	X	- -
Waukesha County	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of Brookfield	- -	X	- -	- -	X	- -	X	X	X	- -
City of Muskego	- -	- -	- -	X	X	- -	X	- -	X	- -
City of New Berlin	- -	- -	- -	X	X	- -	X	- -	X	- -
Village of Butler	- -	- -	- -	- -	X	- -	X	- -	X	- -
Village of Elm Grove	- -	- -	- -	- -	X	- -	X	X	X	- -
Village of Menomonee Falls	- -	- -	- -	- -	X	- -	X	X	X	- -
Town of Brookfield	- -	- -	- -	- -	X	- -	- -	- -	X	- -

[a]*Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

[b]*For those municipalities located outside the Southeastern Wisconsin Region, the management agency designation is advisory only.*

[c]*The Wallace Lake Sanitary District also serves part of the Town of Barton.*

Source: SEWRPC.

Table 94

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE RURAL NONPOINT SOURCE POLLUTION ABATEMENT SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Rural Nonpoint Source Management Agency	Implement Practices to Reduce Cropland Soil Erosion to "T" or Below **[Medium Priority]**[a]	Manure and Nutrient Management **[High Priority]**[a]	Control Barnyard Runoff **[High Priority]**[a]	Establish Riparian Buffers **[High Priority]**[a]	Convert Marginal Cropland and Pasture to Wetlands and Prairies **[High Priority]**[a]	Restricting Livestock Access to Streams **[Medium Priority]**[a]	Managing Milking Center Wastewater **[Medium Priority]**[a]	Expanded Oversight of Private Onsite Wastewater Treatment Systems, Including Establishment of Utility Districts[b] **[Medium Priority]**[a]
Dodge County[c]	X	X	X	X	X	X	X	X
Dodge County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Lomira	- -	- -	- -	- -	- -	- -	- -	X
Fond du Lac County[c]	X	X	X	X	X	X	X	X
Fond du Lac County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Ashford	- -	- -	- -	- -	- -	- -	- -	X
Town of Auburn	- -	- -	- -	- -	- -	- -	- -	X
Town of Byron	- -	- -	- -	- -	- -	- -	- -	X
Town of Eden	- -	- -	- -	- -	- -	- -	- -	X
Town of Osceola	- -	- -	- -	- -	- -	- -	- -	X
Kenosha County	X	X	X	X	X	X	X	X
Kenosha County Drainage Board[d]	- -	- -	- -	X	- -	- -	- -	- -
Town of Paris	- -	- -	- -	- -	- -	- -	- -	X
Milwaukee County	X	- -	- -	X	X	- -	- -	- -
Milwaukee Metropolitan Sewerage District	- -	- -	- -	X	X	- -	- -	- -
City of Franklin	- -	- -	- -	- -	- -	- -	- -	X
Ozaukee County	X	X	X	X	X	X	X	X
Ozaukee County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Cedarburg	- -	- -	- -	- -	- -	- -	- -	X
Town of Fredonia	- -	- -	- -	- -	- -	- -	- -	X
Town of Fredonia–Waubeka Area Sanitary District	- -	- -	- -	- -	- -	- -	- -	X
Town of Grafton	- -	- -	- -	- -	- -	- -	- -	X
Town of Port Washington	- -	- -	- -	- -	- -	- -	- -	X
Town of Saukville	- -	- -	- -	- -	- -	- -	- -	X
Racine County	X	X	X	X	X	X	X	X
Racine County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Dover	- -	- -	- -	- -	- -	- -	- -	X
Town of Raymond	- -	- -	- -	- -	- -	- -	- -	X
Town of Yorkville	- -	- -	- -	- -	- -	- -	- -	X
Town of Yorkville Sewer Utility District No. 1	- -	- -	- -	- -	- -	- -	- -	X
Sheboygan County[c]	X	X	X	X	X	X	X	X
Sheboygan County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Greenbush	- -	- -	- -	X	- -	- -	- -	X
Town of Lyndon	- -	- -	- -	- -	- -	- -	- -	X
Town of Lyndon–Lake Ellen Sanitary District	- -	- -	- -	- -	- -	- -	- -	X
Town of Mitchell	- -	- -	- -	X	- -	- -	- -	X
Town of Scott	- -	- -	- -	- -	- -	- -	- -	X
Town of Scott Sanitary District No. 1	- -	- -	- -	- -	- -	- -	- -	X
Town of Sherman	- -	- -	- -	- -	- -	- -	- -	X

Table 94 (continued)

Rural Nonpoint Source Management Agency	Implement Practices to Reduce Cropland Soil Erosion to “T” or Below **[Medium Priority]**[a]	Manure and Nutrient Management **[High Priority]**[a]	Control Barnyard Runoff **[High Priority]**[a]	Establish Riparian Buffers **[High Priority]**[a]	Convert Marginal Cropland and Pasture to Wetlands and Prairies **[High Priority]**[a]	Restricting Livestock Access to Streams **[Medium Priority]**[a]	Managing Milking Center Wastewater **[Medium Priority]**[a]	Expanded Oversight of Private Onsite Wastewater Treatment Systems, Including Establishment of Utility Districts[b] **[Medium Priority]**[a]
Washington County	X	X	X	X	X	X	X	X
Washington County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Barton	- -	- -	- -	- -	- -	- -	- -	X
Towns of Barton and Trenton–Wallace Lake Sanitary District	- -	- -	- -	- -	- -	- -	- -	X
Town of Farmington	- -	- -	- -	- -	- -	- -	- -	X
Town of Germantown	- -	- -	- -	- -	- -	- -	- -	X
Town of Jackson	- -	- -	- -	- -	- -	- -	- -	X
Town of Kewaskum	- -	- -	- -	- -	- -	- -	- -	X
Town of Polk	- -	- -	- -	- -	- -	- -	- -	X
Town of Richfield	- -	- -	- -	- -	- -	- -	- -	X
Town of Trenton	- -	- -	- -	- -	- -	- -	- -	X
Town of Wayne	- -	- -	- -	- -	- -	- -	- -	X
Town of West Bend	- -	- -	- -	- -	- -	- -	- -	X
Waukesha County	X	X	X	X	X	X	X	X
Waukesha County Drainage Board	- -	- -	- -	X	- -	- -	- -	- -
Town of Lisbon	- -	- -	- -	- -	- -	- -	- -	X
State of Wisconsin								
Department of Agriculture, Trade and Consumer Protection	X	X	X	X	- -	X	X	- -
Department of Commerce	- -	- -	- -	- -	- -	- -	- -	X
Department of Natural Resources	X	X	X	X	X	X	- -	- -
Federal Agencies								
U.S. Department of Agriculture	- -	X	X	- -	X	- -	- -	- -
Farm Services Agency	- -	- -	- -	X	- -	- -	- -	- -
Natural Resources Conservation Service	X	- -	- -	X	- -	- -	- -	- -
Land Trusts[e]								
Kenosha/Racine Land Trust	- -	- -	- -	X	X	- -	- -	- -
Milwaukee Area Land Conservancy	- -	- -	- -	X	X	- -	- -	- -
Ozaukee-Washington Land Trust	- -	- -	- -	X	X	- -	- -	- -
Waukesha County Land Conservancy	- -	- -	- -	X	X	- -	- -	- -

[a] *Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

[b] *In some counties, existing county programs may be providing the additional oversight of POWTS recommended for town utility districts to perform. In these instances, it may not be necessary to form town utility districts for the sole purpose of providing supplemental oversight of POWTS.*

[c] *For those municipalities located outside the Southeastern Wisconsin Region, the management agency designation is advisory only.*

[d] *As of the date of publication of this report, Kenosha County did not have an active drainage board.*

[e] *While land trusts are not governmental agencies, they could play a significant role in implementing certain recommendations.*

Source: SEWRPC.

Table 95

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE URBAN NONPOINT SOURCE POLLUTION ABATEMENT SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Urban Nonpoint Source Management Agency	Implementation of Construction Erosion Control Requirements and Nonagricultural (Urban) Performance Standards of Chapter NR 151 [**High Priority**][a]	Programs to Detect Illicit Discharges to Storm Sewer Systems and Control Urban-Sourced Pathogens [**High Priority**][a]	Human Health and Ecological Risk Assessments to Address Pathogens in Stormwater Runoff [**High Priority**][a]	Chloride Reduction Programs [**High Priority**][a]	Fertilizer Management and Information and Education [**Medium Priority**][a]	Residential Roof Drain Disconnection [**Medium Priority**][a]	Beach and Riparian Debris and Litter Control [**High Priority**][a]	Pet Litter Management [**Medium Priority**][a]	Bacteria and Pathogen Research and Implementation Projects [**High Priority**][a]
Dodge County[b]	X	X	- -	X	X	- -	- -	X	- -
Village of Lomira	X	X	- -	X	- -	X	- -	X	- -
Town of Lomira	X	- -	- -	- -	- -	- -	- -	- -	- -
Fond du Lac County[b]	X	X	- -	X	X	- -	X	X	- -
Village of Campbellsport	X	X	- -	X	- -	X	X	X	- -
Village of Eden	X	X	- -	X	- -	X	X	X	- -
Town of Ashford	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Auburn	X	- -	- -	- -	X	- -	- -	- -	- -
Town of Auburn–Forest Lake Improvement Association	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Byron	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Eden	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Empire	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Forest	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Osceola	X	- -	- -	- -	X	- -	- -	- -	- -
Town of Osceola–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Osceola–Kettle Moraine Lake Association	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Osceola–Long Lake Fishing Club, Inc.	- -	- -	- -	- -	X	- -	X	- -	- -
Kenosha County	X	- -	- -	X	X	- -	X	- -	- -
Town of Paris	X	- -	- -	- -	- -	- -	- -	- -	- -
Milwaukee County	X	X	- -	X	X	- -	X	X	- -
Milwaukee Metropolitan Sewerage District	X	X	X	- -	X	X	X	- -	X
City of Cudahy	X	X	- -	X	X	X	X	X	- -
City of Franklin	X	X	- -	X	X	X	X	X	- -
City of Glendale	X	X	- -	X	X	X	X	X	- -
City of Greenfield	X	X	- -	X	X	X	X	X	- -
City of Milwaukee	X	X	- -	X	X	X	X	X	- -
City of Oak Creek	X	X	- -	X	X	X	X	X	- -
City of St. Francis	X	X	- -	X	X	X	X	X	- -
City of South Milwaukee	X	X	- -	X	X	X	X	X	- -
City of Wauwatosa	X	X	- -	X	X	X	X	X	- -
City of West Allis	X	X	- -	X	X	X	X	X	- -
Village of Bayside	X	X	- -	X	X	X	X	X	- -
Village of Brown Deer	X	X	- -	X	X	X	X	X	- -
Village of Fox Point	X	X	- -	X	X	X	X	X	- -
Village of Greendale	X	X	- -	X	X	X	X	X	- -
Village of Hales Corners	X	X	- -	X	X	X	X	X	- -
Village of River Hills	X	X	- -	X	X	X	X	X	- -
Village of Shorewood	X	X	- -	X	X	X	X	X	- -
Village of West Milwaukee	X	X	- -	X	X	X	X	X	- -
Village of Whitefish Bay	X	X	- -	X	X	X	X	X	- -

Table 95 (continued)

Urban Nonpoint Source Management Agency	Implementation of Construction Erosion Control Requirements and Nonagricultural (Urban) Performance Standards of Chapter NR 151 [**High Priority**][a]	Programs to Detect Illicit Discharges to Storm Sewer Systems and Control Urban-Sourced Pathogens [**High Priority**][a]	Human Health and Ecological Risk Assessments to Address Pathogens in Stormwater Runoff [**High Priority**][a]	Chloride Reduction Programs [**High Priority**][a]	Fertilizer Management and Information and Education [**Medium Priority**][a]	Residential Roof Drain Disconnection [**Medium Priority**][a]	Beach and Riparian Debris and Litter Control [**High Priority**][a]	Pet Litter Management [**Medium Priority**][a]	Bacteria and Pathogen Research and Implementation Projects [**High Priority**][a]
Ozaukee County	X	X	- -	X	X	- -	X	X	- -
City of Cedarburg	X	X	- -	X	X	X	X	X	- -
City of Mequon	X	X	- -	X	X	X	X	X	- -
City of Port Washington	X	X	- -	X	X	X	X	X	- -
Village of Fredonia	X	X	- -	X	- -	X	X	X	- -
Village of Grafton	X	X	- -	X	X	X	X	X	- -
Village of Newburg	X	X	- -	X		X	X	X	- -
Village of Saukville	X	X	- -	X	X	X	X	X	- -
Village of Thiensville	X	X	- -	X	X	X	X	X	- -
Town of Cedarburg	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Fredonia	X	- -	- -	- -	X	- -	X	- -	- -
Town of Fredonia–Spring Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Grafton	X	- -	- -	- -	X	- -	- -	- -	- -
Town of Port Washington	X	- -	- -	- -	- -	- -	X	- -	- -
Town of Saukville	X	- -	- -	- -	X	- -	- -	- -	- -
Town of Saukville–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Racine County	X	X	- -	X	X	- -	X	X	- -
City of Racine	X	X	- -	X	X	X	X	X	X
Village of Caledonia	X	X	- -	X	X	X	X	X	- -
Village of Mt. Pleasant	X	X	- -	X	X	X	X	X	- -
Village of North Bay	X	X	- -	X	- -	X	X	X	- -
Village of Sturtevant	X	X	- -	X	X	X	X	X	- -
Village of Union Grove	X	X	- -	X		X	X	X	- -
Village of Wind Point	X	X	- -	X	X	X	X	X	- -
Town of Dover	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Norway	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Raymond	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Yorkville	X	- -	- -	- -	- -	- -	- -	- -	- -
Sheboygan County[b]	X	X	- -	X	X	- -	X	X	- -
Village of Adell	X	X	- -	X		X	X	X	- -
Village of Cascade	X	X	- -	X		X	X	X	- -
Village of Random Lake	X	X	- -	X	X	X	X	X	- -
Village of Random Lake–Random Lake Association, Inc.	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Greenbush	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Holland	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Lyndon	X	- -	- -	- -	X	- -	- -	- -	- -
Town of Lyndon–Lake Ellen Sanitary District No. 1	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Mitchell	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Scott	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Sherman	X	- -	- -	- -	- -	- -	- -	- -	- -

Table 95 (continued)

Urban Nonpoint Source Management Agency	Implementation of Construction Erosion Control Requirements and Nonagricultural (Urban) Performance Standards of Chapter NR 151 **[High Priority]**[a]	Programs to Detect Illicit Discharges to Storm Sewer Systems and Control Urban-Sourced Pathogens **[High Priority]**[a]	Human Health and Ecological Risk Assessments to Address Pathogens in Stormwater Runoff **[High Priority]**[a]	Chloride Reduction Programs **[High Priority]**[a]	Fertilizer Management and Information and Education **[Medium Priority]**[a]	Residential Roof Drain Disconnection **[Medium Priority]**[a]	Beach and Riparian Debris and Litter Control **[High Priority]**[a]	Pet Litter Management **[Medium Priority]**[a]	Bacteria and Pathogen Research and Implementation Projects **[High Priority]**[a]
Washington County	X	X	- -	X	X	- -	X	X	- -
City of West Bend	X	X	- -	X	X	X	X	X	- -
City of West Bend–Barton Pond Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Village of Germantown	X	X	- -	X	X	X	X	X	- -
Village of Jackson	X	X	- -	X	- -	X	X	X	- -
Village of Kewaskum	X	X	- -	X	- -	X	X	X	- -
Village of Newburg	X	X	- -	X	- -	X	X	X	- -
Town of Addison	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Barton	X	- -	- -	- -	X	- -	X	- -	- -
Town of Barton–Smith Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Towns of Barton and Trenton–Wallace Lake Sanitary District	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Farmington	X	- -	- -	- -	X	- -	X	- -	- -
Town of Farmington–Lake Twelve Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Farmington–Green Lake Property Owners of Washington County	- -	- -	- -	- -	X	- -	X	- -	- -
Town of Germantown	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Jackson	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Kewaskum	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Polk	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Richfield	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Trenton	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of Wayne	X	- -	- -	- -	- -	- -	- -	- -	- -
Town of West Bend	X	- -	- -	- -	X	- -	X	- -	- -
Town of West Bend–Big Cedar Lake Protection and Rehabilitation District	- -	- -	- -	- -	X	- -	X	- -	- -
Town of West Bend–Little Cedar Lake Protection and Rehabilitation District	- -	- -	- -	- -	- -	- -	X	- -	- -
Town of West Bend–Silver Lake Sanitary District and Silver Lake Protection and Rehabilitation District	- -	- -	- -	- -	X	- -	X	- -	- -
Town of West Bend –Lucas Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	- -	- -	- -	- -	X	- -	X	- -	- -
Waukesha County	X	X	- -	X	X	- -	X	X	- -
City of Brookfield	X	X	- -	X	X	X	X	X	- -
City of Muskego	X	X	- -	X	X	X	X	X	- -
City of New Berlin	X	X	- -	X	X	X	X	X	- -
Village of Butler	X	X	- -	X	X	X	X	X	- -
Village of Elm Grove	X	X	- -	X	X	X	X	X	- -
Village of Menomonee Falls	X	X	- -	X	X	X	X	X	- -
Town of Brookfield	X	- -	- -	X	X	X	X	- -	- -
Town of Lisbon	X	- -	- -	X	X	X	X	- -	- -

Table 95 (continued)

Urban Nonpoint Source Management Agency	Implementation of Construction Erosion Control Requirements and Nonagricultural (Urban) Performance Standards of Chapter NR 151 [**High Priority**][a]	Programs to Detect Illicit Discharges to Storm Sewer Systems and Control Urban-Sourced Pathogens [**High Priority**][a]	Human Health and Ecological Risk Assessments to Address Pathogens in Stormwater Runoff [**High Priority**][a]	Chloride Reduction Programs [**High Priority**][a]	Fertilizer Management and Information and Education [**Medium Priority**][a]	Residential Roof Drain Disconnection [**Medium Priority**][a]	Beach and Riparian Debris and Litter Control [**High Priority**][a]	Pet Litter Management [**Medium Priority**][a]	Bacteria and Pathogen Research and Implementation Projects [**High Priority**][a]
State of Wisconsin									
Department of Commerce	X	- -	- -	- -	- -	- -	- -	- -	- -
Department of Natural Resources	X	- -	X	X	X	- -	- -	- -	X
Department of Transportation	X	- -	- -	X	- -	- -	- -	- -	- -
University of Wisconsin-Extension	- -	- -	- -	- -	X	- -	X	X	- -
Federal Agencies									
U.S. Department of the Interior, Geological Survey	- -	- -	X	- -	- -	- -	- -	- -	X
U.S. Environmental Protection Agency	- -	- -	- -	- -	- -	- -	- -	- -	X
U.S. Department of Transportation	- -	- -	- -	X	- -	- -	- -	- -	- -
Nongovernmental Organizations									
Keep Greater Milwaukee Beautiful, Inc.	- -	- -	- -	- -	- -	- -	X	- -	- -
Friends of Milwaukee's Rivers	- -	- -	- -	- -	- -	- -	X	- -	- -

[a]*Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

[b]*For those municipalities located outside the Southeastern Wisconsin Region, the management agency designation is advisory only.*

[c]*This lake district or association does not currently exist, but is recommended to be established.*

Source: SEWRPC.

Table 96

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE INSTREAM WATER QUALITY MEASURES SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS[a]

Management Agency	Stream Rehabilitation [**Medium Priority**][b]	Conduct Engineering Studies Related to Possible Renovation of the Kinnickinnic River Flushing Station [**Medium Priority**][b]	Require Preparation of Dam Abandonment and Associated Riverine Restoration Plans [**Low Priority**][b]	Implement Recommendations Related to Culverts, Bridges, Drop Structures, and Channelized Streams [**Medium Priority**][b]	Restoration and Remediation of Contaminated Sediment Sites and Expansion of the Milwaukee Harbor Estuary Area of Concern [**High Priority**][b]	Fisheries Protection and Enhancement [**Medium Priority**][b]	Navigational Dredging	Dredged Material Disposal	Consider Revisions to Water Use Objectives
Dodge County	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Lomira	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Lomira	- -	- -	- -	X	- -	X	- -	- -	- -
Fond du Lac County	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Campbellsport	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Eden	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Ashford	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Auburn	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Byron	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Eden	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Empire	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Forest	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Osceola	- -	- -	- -	X	- -	X	- -	- -	- -
Kenosha County	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Paris	- -	- -	- -	X	- -	X	- -	- -	- -
Milwaukee County	X	- -	- -	X	- -	X	- -	- -	- -
Milwaukee Metropolitan Sewerage District	X	X	- -	X	- -	X	- -	- -	- -
City of Cudahy	- -	- -	- -	X	- -	X	- -	- -	- -
City of Franklin	- -	- -	- -	X	- -	X	- -	- -	- -
City of Glendale	- -	- -	- -	X	- -	X	- -	- -	- -
City of Greenfield	- -	- -	- -	X	- -	X	- -	- -	- -
City of Milwaukee	- -	- -	- -	X	- -	X	- -	- -	- -
Port of Milwaukee	- -	- -	- -	- -	- -	- -	X	X	- -
City of Oak Creek	- -	- -	- -	X	- -	X	- -	- -	- -
City of St. Francis	- -	- -	- -	X	- -	X	- -	- -	- -
City of South Milwaukee	- -	- -	- -	X	- -	X	- -	- -	- -
City of Wauwatosa	- -	- -	- -	X	- -	X	- -	- -	- -
City of West Allis	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Bayside	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Brown Deer	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Fox Point	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Greendale	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Hales Corners	- -	- -	- -	X	- -	X	- -	- -	- -
Village of River Hills	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Shorewood	- -	- -	- -	X	- -	X	- -	- -	- -
Village of West Milwaukee	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Whitefish Bay	- -	- -	- -	X	- -	X	- -	- -	- -
Ozaukee County	- -	- -	- -	X	- -	X	- -	- -	- -
City of Cedarburg	- -	- -	- -	X	- -	X	- -	- -	- -
City of Mequon	- -	- -	- -	X	- -	X	- -	- -	- -
City of Port Washington	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Fredonia	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Grafton	- -	- -	- -	X	- -	X	- -	- -	- -

Table 96 (continued)

Management Agency	Stream Rehabilitation [**Medium Priority**][b]	Conduct Engineering Studies Related to Possible Renovation of the Kinnickinnic River Flushing Station [**Medium Priority**][b]	Require Preparation of Dam Abandonment and Associated Riverine Restoration Plans [**Low Priority**][b]	Implement Recommendations Related to Culverts, Bridges, Drop Structures, and Channelized Streams [**Medium Priority**][b]	Restoration and Remediation of Contaminated Sediment Sites and Expansion of the Milwaukee Harbor Estuary Area of Concern [**High Priority**][b]	Fisheries Protection and Enhancement [**Medium Priority**][b]	Navigational Dredging	Dredged Material Disposal	Consider Revisions to Water Use Objectives
Ozaukee County (continued)									
Village of Newburg	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Saukville	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Thiensville	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Cedarburg	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Fredonia	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Grafton	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Port Washington	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Saukville	- -	- -	- -	X	- -	X	- -	- -	- -
Racine County	- -	- -	- -	X	- -	X	- -	- -	- -
City of Racine	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Caledonia	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Mt. Pleasant	- -	- -	- -	X	- -	X	- -	- -	- -
Village of North Bay	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Sturtevant	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Union Grove	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Wind Point	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Dover	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Norway	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Raymond	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Yorkville	- -	- -	- -	X	- -	X	- -	- -	- -
Sheboygan County	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Adell	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Cascade	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Random Lake	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Greenbush	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Holland	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Lyndon	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Mitchell	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Scott	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Sherman	- -	- -	- -	X	- -	X	- -	- -	- -
Washington County	- -	- -	- -	X	- -	X	- -	- -	- -
City of West Bend	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Germantown	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Jackson	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Kewaskum	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Newburg	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Addison	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Barton	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Farmington	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Germantown	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Jackson	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Kewaskum	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Polk	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Richfield	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Trenton	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Wayne	- -	- -	- -	X	- -	X	- -	- -	- -
Town of West Bend	- -	- -	- -	X	- -	X	- -	- -	- -

Table 96 (continued)

Management Agency	Stream Rehabilitation [**Medium Priority**][b]	Conduct Engineering Studies Related to Possible Renovation of the Kinnickinnic River Flushing Station [**Medium Priority**][b]	Require Preparation of Dam Abandonment and Associated Riverine Restoration Plans [**Low Priority**][b]	Implement Recommendations Related to Culverts, Bridges, Drop Structures, and Channelized Streams [**Medium Priority**][b]	Restoration and Remediation of Contaminated Sediment Sites and Expansion of the Milwaukee Harbor Estuary Area of Concern [**High Priority**][b]	Fisheries Protection and Enhancement [**Medium Priority**][b]	Navigational Dredging	Dredged Material Disposal	Consider Revisions to Water Use Objectives
Waukesha County	- -	- -	- -	X	- -	X	- -	- -	- -
City of Brookfield	- -	- -	- -	X	- -	X	- -	- -	- -
City of Muskego	- -	- -	- -	X	- -	X	- -	- -	- -
City of New Berlin	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Butler	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Elm Grove	- -	- -	- -	X	- -	X	- -	- -	- -
Village of Menomonee Falls	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Brookfield	- -	- -	- -	X	- -	X	- -	- -	- -
Town of Lisbon	- -	- -	- -	X	- -	X	- -	- -	- -
State of Wisconsin									
Department of Natural Resources	- -	- -	X	X	X	X	- -	- -	X
Department of Transportation	- -	- -	- -	X	- -	X	- -	- -	- -
Federal Agencies									
U.S. Department of the Interior, Fish & Wildlife Service	- -	- -	- -	- -	- -	X	- -	- -	- -
U.S. Environmental Protection Agency	- -	- -	- -	- -	X		- -	- -	- -
U.S. Department of Transportation	- -	- -	- -	X	- -	X	- -	- -	- -
U.S. Army Corps of Engineers	- -	- -	X	X	- -	X	X	X	- -

[a] *Designation of management agencies is not required under the Federal Clean Water Act. Thus, these designations are advisory only.*

[b] *Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

Source: SEWRPC.

Table 97

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE INLAND LAKE WATER QUALITY MANAGEMENT SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS[a]

Inland Lake Management Agency	Establish a Lake Protection and Rehabilitation District or a Lake Association [**High Priority**][b]	Preparation or Updating of Lake Management Plans [**High Priority**][b]	Consider Preparation of Detailed Plans for Milwaukee County Lagoons and Implement Recommendations in Milwaukee County Lagoon Management Plan [**High Priority**][b]	Implement Washington County Lake and Stream Classification Plan [**High Priority**][b]	Implement Waukesha County Lake and Stream Classification Plan [**High Priority**][b]	Abate Nonpoint Source Pollution According to Plan Recommendations [**High Priority**][b]	Implement a Community-Based Informational Program [**High Priority**][b]	Review and Evaluate Proposed Land Use Changes for Lake-Related Impacts [**High Priority**][b]
Dodge County	- -	- -	- -	- -	- -	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -
Fond du Lac County	- -	- -	- -	- -	- -	X	- -	X
Town of Auburn	- -	- -	- -	- -	- -	- -	- -	X
Town of Auburn–Forest Lake Improvement Association	- -	X	- -	- -	- -	X	X	- -
Town of Osceola	- -	- -	- -	- -	- -	X	- -	X
Town of Osceola–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Town of Osceola–Kettle Moraine Lake Association	- -	X	- -	- -	- -	X	X	- -
Town of Osceola–Long Lake Fishing Club, Inc.	- -	X	- -	- -	- -	X	X	- -
Kenosha County	- -	- -	- -	- -	- -	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -
Milwaukee County	- -	- -	X	- -	- -	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -
Ozaukee County	- -	- -	- -	- -	- -	- -	- -	X
Town of Fredonia	- -	- -	- -	- -	- -	X	- -	X
Town of Fredonia–Spring Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Town of Saukville	- -	- -	- -	- -	- -	X	- -	X
Town of Saukville–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Racine County	- -	- -	- -	- -	- -	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -
Sheboygan County	- -	- -	- -	- -	- -	- -	- -	X
Village of Random Lake	- -	- -	- -	- -	- -	- -	- -	X
Village of Random Lake–Random Lake Association, Inc.	- -	X	- -	- -	- -	X	X	- -
Town of Lyndon	- -	- -	- -	- -	- -	- -	- -	X
Town of Lyndon–Lake Ellen Sanitary District No. 1	- -	X	- -	- -	- -	X	X	- -
Washington County	- -	- -	- -	X	- -		- -	X
City of West Bend	- -	- -	- -			X	- -	X
City of West Bend–Barton Pond Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Town of Barton	- -	- -	- -	- -	- -	X	- -	X

Table 97 (continued)

Inland Lake Management Agency	Establish a Lake Protection and Rehabilitation District or a Lake Association [**High Priority**][b]	Preparation or Updating of Lake Management Plans [**High Priority**][b]	Consider Preparation of Detailed Plans for Milwaukee County Lagoons and Implement Recommendations in Milwaukee County Lagoon Management Plan [**High Priority**][b]	Implement Washington County Lake and Stream Classification Plan [**High Priority**][b]	Implement Waukesha County Lake and Stream Classification Plan [**High Priority**][b]	Abate Nonpoint Source Pollution According to Plan Recommendations [**High Priority**][b]	Implement a Community-Based Informational Program [**High Priority**][b]	Review and Evaluate Proposed Land Use Changes for Lake-Related Impacts [**High Priority**][b]
Washington County (continued)								
Town of Barton–Smith Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Town of Barton–Wallace Lake Sanitary District		X	- -	- -	- -	X	X	- -
Town of Farmington	- -	- -	- -	- -	- -	X		X
Town of Farmington–Lake Twelve Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Town of Farmington–Green Lake Property Owners of Washington County		X	- -	- -	- -	X	X	- -
Town of West Bend	- -	- -	- -	- -	- -	X	- -	X
Town of West Bend–Big Cedar Lake Protection and Rehabilitation District	- -	X	- -	- -	- -	X	X	- -
Town of West Bend–Little Cedar Lake Protection and Rehabilitation District	- -	X	- -	- -	- -	X	X	- -
Town of West Bend–Silver Lake Sanitary District and Silver Lake Protection and Rehabilitation District	X	X	- -	- -	- -	X	X	- -
Town of West Bend–Lucas Lake Protection and Rehabilitation District (P&RD) or Lake Association[c]	X	X	- -	- -	- -	X	X	- -
Waukesha County	- -	- -	- -	- -	X	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -
State of Wisconsin								- -
Department of Natural Resources[d]	- -	X	- -	X	X	X	X	- -
University of Wisconsin–Extension	X	- -	- -	- -	- -	- -	X	- -

[a]*Designation of management agencies is not required under the Federal Clean Water Act. Thus, these designations are advisory only.*

[b]*Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

[c]*This lake district or association does not currently exist, but is recommended to be established.*

[d]*It is recommended that the WDNR develop lake management plans for Auburn, Crooked, and Mauthe Lakes, which are located in the Northern Unit of the Kettle Moraine State Forest.*

Source: SEWRPC.

Table 98

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE AUXILIARY WATER QUALITY MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS[a]

Management Agency	Maintain and Expand Public Health-Related Monitoring at Beaches [**High Priority**][b]	Identify Local Sources of Contamination by Conducting Sanitary Surveys at Beaches with High Bacteria Counts[c] [**High Priority**][b]	Implement Remedies at Beaches with High Bacteria Counts[d] [**High Priority**][b]	Waterfowl Control Where a Nuisance or Health Hazard [**High Priority**][b]	Implement and Refine the Lakewide Management Plan for Lake Michigan [**Medium Priority**][b]	Household Hazardous Waste Collection Programs [**High Priority**][b]	Pharmaceutical and Personal Care Product Collection Programs [**High Priority**][b]	Information and Education Programs Regarding Exotic Invasive Species [**Medium Priority**][b]	Develop a Policy Regarding Water Temperatures and Thermal Discharges into Waterbodies [**Medium Priority**][b]	Support and Continue Ongoing Water Quality Monitoring Programs [**High Priority**][b]
Dodge County	- -	- -	- -	- -	- -	X	X	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Fond du Lac County	X	X	- -	- -	- -	X	X	- -	- -	- -
Town of Auburn–Forest Lake Improvement Association	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Osceola–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Osceola–Kettle Moraine Lake Association	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Osceola–Long Lake Fishing Club, Inc.	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Kenosha County	- -	- -	- -	- -	- -	X	X	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Milwaukee County	- -	- -	X	X	- -	- -	- -	- -	- -	X
Milwaukee Metropolitan Sewerage District	- -	- -	- -	- -	- -	X	X	- -	- -	X
City of Cudahy	X	X	- -	- -	- -	- -	- -	- -	- -	- -
City of Milwaukee	X	X	X	- -	- -	- -	- -	- -	- -	- -
City of South Milwaukee	X	X	X	- -	- -	- -	- -	- -	- -	- -
Village of Fox Point	- -	- -	X	- -	- -	- -	- -	- -	- -	- -
North Shore Health Department[f]	X	X	- -	- -	- -	- -	- -	- -	- -	- -
Village of Shorewood	- -	- -	- -	X	- -	- -	- -	- -	- -	- -
Village of Whitefish Bay	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Shorewood-Whitefish Bay Health Department	X	X	- -	- -	- -	- -	- -	- -	- -	- -
Ozaukee County	X	X	X	X	- -	X	X	- -	- -	- -
Town of Fredonia–Spring Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Saukville–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Racine County	- -	- -	- -	- -	- -	X	X	- -	- -	- -
City of Racine	X	X	X	X	- -	- -	- -	- -	- -	X
Village of North Bay	X	X	X	X	- -	- -	- -	- -	- -	- -
Village of Wind Point	X	X	X	X	- -	- -	- -	- -	- -	- -
Sheboygan County	- -	- -	- -	- -	- -	X	X	- -	- -	- -
Village of Random Lake	X	X	- -	- -	- -	- -	- -	- -	- -	- -
Village of Random Lake–Random Lake Association, Inc.	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Lyndon–Lake Ellen Sanitary District No. 1	X	X	X	X	- -	- -	- -	- -	- -	- -

Table 98 (continued)

Management Agency	Maintain and Expand Public Health-Related Monitoring at Beaches [**High Priority**][b]	Identify Local Sources of Contamination by Conducting Sanitary Surveys at Beaches with High Bacteria Counts[c] [**High Priority**][b]	Implement Remedies at Beaches with High Bacteria Counts[d] [**High Priority**][b]	Waterfowl Control Where a Nuisance or Health Hazard [**High Priority**][b]	Implement and Refine the Lakewide Management Plan for Lake Michigan [**Medium Priority**][b]	Household Hazardous Waste Collection Programs [**High Priority**][b]	Pharmaceutical and Personal Care Product Collection Programs [**High Priority**][b]	Information and Education Programs Regarding Exotic Invasive Species [**Medium Priority**][b]	Develop a Policy Regarding Water Temperatures and Thermal Discharges into Waterbodies [**Medium Priority**][b]	Support and Continue Ongoing Water Quality Monitoring Programs [**High Priority**][b]
Washington County	X	X	- -	- -	- -	X	X	- -	- -	- -
City of West Bend	X	X	- -	- -	- -	- -	- -	- -	- -	- -
City of West Bend–Barton Pond Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Barton–Smith Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Barton–Wallace Lake Sanitary District	X	X	X	X	- -	- -	- -	- -	- -	- -
Town of Farmington–Lake Twelve Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of Farmington–Green Lake Property Owners of Washington County	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of West Bend–Big Cedar Lake Protection and Rehabilitation District	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of West Bend–Little Cedar Lake Protection and Rehabilitation District	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of West Bend–Silver Lake Sanitary District and Silver Lake Protection and Rehabilitation District	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Town of West Bend–Lucas Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	X	X	- -	- -	- -	- -	- -	- -
Waukesha County	- -	- -	- -	- -	- -	- -	X	- -	- -	X
None	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Regional Agency	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Southeastern Wisconsin Regional Planning Commission	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
State of Wisconsin										
Department of Administration, Coastal Zone Management Program	- -	- -	- -	- -	X	- -	- -	- -	- -	- -
Department of Natural Resources	X	X	X	- -	X	- -	- -	X	X	X
University of Wisconsin-Extension	- -	- -	- -	- -	- -	- -	- -	X	- -	- -
University of Wisconsin Sea Grant Program	- -	- -	- -	- -	X	- -	- -	X	- -	- -
Federal Agencies										
U.S. Department of the Interior, Fish & Wildlife Service	- -	- -	- -	X	- -	- -	- -	- -	- -	- -
U.S. Department of the Interior, Geological Survey	- -	- -	- -	- -	- -	- -	- -	- -	- -	X
U.S. Environmental Protection Agency	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
National Oceanic and Atmospheric Administration	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Nongovernmental Organizations	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Riveredge Nature Center	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
Friends of Milwaukee's Rivers	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Table 98 (continued)

Management Agency	Expand USGS Stream Gage Network to Include the Nine Short-Term Sites Established for the Regional Water Quality Management Plan Update [**High Priority**][b]	Extend Operation of USGS Gages on Wilson Park Creek (3 Gages), Holmes Avenue Creek (1 Gage), Mitchell Field Drainage Ditch (1 Gage), and the Little Menomonee River (1 Gage) [**High Priority**][b]	Establish and Maintain Long-Term Fisheries, Macroinvertebrate, and Habitat Monitoring Stations in Streams [**Medium Priority**][b]	Continue Consolidation of Water Quality Monitoring Data and Adopt Common Quality Assurance and Control Procedures Along with Standardized Sampling Protocols [**High Priority**][b]	Conduct Aquatic Plant Habitat and Fish Survey Assessments in Inland Lakes [**Medium Priority**][b]	Establish Long-Term Trend Inland Lake Water Quality Monitoring Stations [**Medium Priority**][b]	Continue to Monitor and Document the Occurrence of Exotic Invasive Species [**Medium Priority**][b]	Maintain the HSPF, FFS, Streamlined MOUSE, and MACRO Computer Models Developed Under the MMSD 2020 Facilities Plan [**Medium Priority**][b]	Maintain the LSPC, ECOMSED, and RCA Computer Models Developed Under the RWQMPU and the MMSD 2020 Facilities Plan [**Medium Priority**][b]
Dodge County	--	--	--	--	--	--	--	--	--
None	--	--	--	--	--	--	--	--	--
Fond du Lac County	--	--	--	--	--	--	--	--	--
Town of Auburn–Forest Lake Improvement Association	--	--	--	--	X	X	--	--	--
Town of Osceola–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	--	--	--	--	X	X	--	--	--
Town of Osceola–Kettle Moraine Lake Association	--	--	--	--	X	X	--	--	--
Town of Osceola–Long Lake Fishing Club, Inc.	--	--	--	--	X	X	--	--	--
Kenosha County	--	--	--	--	--	--	--	--	--
None	--	--	--	--	--	--	--	--	--
Milwaukee County	--	X	--	--	--	--	--	--	--
Milwaukee Metropolitan Sewerage District	--	X	X	X	--	--	--	X	--
City of Cudahy	--	--	--	--	--	--	--	--	--
City of Milwaukee	--	--	--	--	--	--	--	--	--
City of South Milwaukee	--	--	--	--	--	--	--	--	--
Village of Fox Point	--	--	--	--	--	--	--	--	--
North Shore Health Department[f]	--	--	--	--	--	--	--	--	--
Village of Shorewood	--	--	--	--	--	--	--	--	--
Village of Whitefish Bay	--	--	--	--	--	--	--	--	--
Shorewood-Whitefish Bay Health Department	--	--	--	--	--	--	--	--	--
Ozaukee County	--	--	--	--	--	--	--	--	--
Town of Fredonia–Spring Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	--	--	--	--	X	X	--	--	--
Town of Saukville–Mud Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	--	--	--	--	X	X	--	--	--
Racine County	--	--	--	--	--	--	--	--	--
City of Racine	--	--	--	--	--	--	--	--	--
Village of North Bay	--	--	--	--	--	--	--	--	--
Village of Wind Point	--	--	--	--	--	--	--	--	--
Sheboygan County	--	--	--	--	--	--	--	--	--
Village of Random Lake	--	--	--	--	--	--	--	--	--
Village of Random Lake–Random Lake Association, Inc.	--	--	--	--	X	X	--	--	--
Town of Lyndon–Lake Ellen Sanitary District No. 1	--	--	--	--	X	X	--	--	--

Table 98 (continued)

Management Agency	Expand USGS Stream Gage Network to Include the Nine Short-Term Sites Established for the Regional Water Quality Management Plan Update [**High Priority**][b]	Extend Operation of USGS Gages on Wilson Park Creek (3 Gages), Holmes Avenue Creek (1 Gage), Mitchell Field Drainage Ditch (1 Gage), and the Little Menomonee River (1 Gage) [**High Priority**][b]	Establish and Maintain Long-Term Fisheries, Macroinvertebrate, and Habitat Monitoring Stations in Streams [**Medium Priority**][b]	Continue Consolidation of Water Quality Monitoring Data and Adopt Common Quality Assurance and Control Procedures Along with Standardized Sampling Protocols [**High Priority**][b]	Conduct Aquatic Plant Habitat and Fish Survey Assessments in Inland Lakes [**Medium Priority**][b]	Establish Long-Term Trend Inland Lake Water Quality Monitoring Stations [**Medium Priority**][b]	Continue to Monitor and Document the Occurrence of Exotic Invasive Species [**Medium Priority**][b]	Maintain the HSPF, FFS, Streamlined MOUSE, and MACRO Computer Models Developed Under the MMSD 2020 Facilities Plan [**Medium Priority**][b]	Maintain the LSPC, ECOMSED, and RCA Computer Models Developed Under the RWQMPU and the MMSD 2020 Facilities Plan [**Medium Priority**][b]
Washington County	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of West Bend	- -	- -	- -	- -	- -	- -	- -	- -	- -
City of West Bend–Barton Pond Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	- -	- -	X	X	- -	- -	- -
Town of Barton–Smith Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	- -	- -	X	X	- -	- -	- -
Town of Barton–Wallace Lake Sanitary District	- -	- -	- -	- -	X	X	- -	- -	- -
Town of Farmington–Lake Twelve Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	- -	- -	X	X	- -	- -	- -
Town of Farmington–Green Lake Property Owners of Washington County	- -	- -	- -	- -	X	X	- -	- -	- -
Town of West Bend–Big Cedar Lake Protection and Rehabilitation District	- -	- -	- -	- -	X	X	- -	- -	- -
Town of West Bend–Little Cedar Lake Protection and Rehabilitation District	- -	- -	- -	- -	X	X	- -	- -	- -
Town of West Bend–Silver Lake Sanitary District and Silver Lake Protection and Rehabilitation District	- -	- -	- -	- -	X	X	- -	- -	- -
Town of West Bend–Lucas Lake Protection and Rehabilitation District (P&RD) or Lake Association[e]	- -	- -	- -	- -	X	X	- -	- -	- -
Waukesha County	- -	- -	- -	- -	- -	- -	- -	- -	- -
None	- -	- -	- -	- -	- -	- -	- -	- -	- -
Regional Agency	- -	- -	- -	- -	- -	- -	- -	- -	- -
Southeastern Wisconsin Regional Planning Commission	- -	- -	- -	- -	- -	- -	- -	- -	X
State of Wisconsin									
Department of Administration, Coastal Zone Management Program	- -	- -	- -	- -	- -	- -	- -	- -	- -
Department of Natural Resources	- -	X	X	X	X	X	X	- -	- -
University of Wisconsin-Extension	- -	- -	- -	X	- -	- -	- -	- -	- -
University of Wisconsin Sea Grant Program	- -	- -	- -	- -	- -	- -	- -	- -	- -
Federal Agencies									
U.S. Department of the Interior, Fish & Wildlife Service	- -	- -	- -	- -	- -	- -	- -	- -	- -
U.S. Department of the Interior, Geological Survey	X	X	X	X	- -	- -	- -	- -	- -
U.S. Environmental Protection Agency	- -	- -	- -	X	- -	- -	- -	- -	- -
National Oceanic and Atmospheric Administration	- -	- -	- -	- -	- -	- -	X	- -	- -
Nongovernmental Organizations	- -	- -	- -	- -	- -	- -	- -	- -	- -
Riveredge Nature Center	- -	- -	- -	X	- -	- -	- -	- -	- -
Friends of Milwaukee's Rivers	- -	- -	- -	X	- -	- -	- -	- -	- -

Table 98 Footnotes

[a]*Designation of management agencies is not required under the Federal Clean Water Act. Thus, these designations are advisory only.*

[b]*Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.*

[c]*Need for sanitary survey depends on results of public health monitoring.*

[d]*Need for remedies depends on results of public health monitoring and sanitary surveys.*

[e]*This lake district or association does not currently exist, but is recommended to be established.*

[f]*The North Shore Health Department includes the City of Glendale and the Villages of Brown Deer, Fox Point, and River Hills.*

Source: SEWRPC.

Table 99

GOVERNMENTAL MANAGEMENT AGENCY DESIGNATIONS AND SELECTED RESPONSIBILITIES AND PRIORITIZATION FOR THE GROUNDWATER WATER QUALITY MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS[a]

Groundwater Management Agency	Map Groundwater Recharge Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan Regarding Maintenance of Groundwater Recharge Areas [**Medium Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan in Evaluating Sustainability of Proposed Developments and in Local Land Use Planning [**Medium Priority**][b]	Map Groundwater Contamination Potential in Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider Potential Impacts on Groundwater Quality of Stormwater Infiltration from Proposed Development [**High Priority**][b]	Develop and Implement Utility-Specific Water Conservation Programs [**Low Priority**][b]
Dodge County	X	X	X	X	X	X
Village of Lomira	- -	X	X	- -	X	X
Fond du Lac County	X	X	X	X	X	X
Village of Campbellsport	- -	X	X	- -	X	X
Village of Eden	- -	X	X	- -	X	X
Town of Ashford	- -	X	X	- -	X	X
Town of Auburn	- -	X	X	- -	X	X
Town of Byron	- -	X	X	- -	X	X
Town of Eden	- -	X	X	- -	X	X
Town of Empire	- -	X	X	- -	X	X
Town of Forest	- -	X	X	- -	X	X
Town of Osceola	- -	X	X	- -	X	X
Kenosha County	- -	X	X	- -	X	X
Town of Paris	- -	X	X	- -	X	X
Milwaukee County	- -	X	X	- -	X	X
City of Cudahy	- -	X	X	- -	X	X
City of Franklin	- -	X	X	- -	X	X
City of Glendale	- -	X	X	- -	X	X
City of Greenfield	- -	X	X	- -	X	X
City of Milwaukee	- -	X	X	- -	X	X
City of Oak Creek	- -	X	X	- -	X	X
City of St. Francis	- -	X	X	- -	X	X
City of South Milwaukee	- -	X	X	- -	X	X
City of Wauwatosa	- -	X	X	- -	X	X
City of West Allis	- -	X	X	- -	X	X
Village of Bayside	- -	X	X	- -	X	X
Village of Brown Deer	- -	X	X	- -	X	X
Village of Fox Point	- -	X	X	- -	X	X
Village of Greendale	- -	X	X	- -	X	X
Village of Hales Corners	- -	X	X	- -	X	X
Village of River Hills	- -	X	X	- -	X	X
Village of Shorewood	- -	X	X	- -	X	X
Village of West Milwaukee	- -	X	X	- -	X	X
Village of Whitefish Bay	- -	X	X	- -	X	X
Ozaukee County	- -	X	X	- -	X	X
City of Cedarburg	- -	X	X	- -	X	X
City of Mequon	- -	X	X	- -	X	X
City of Port Washington	- -	X	X	- -	X	X
Village of Fredonia	- -	X	X	- -	X	X
Village of Grafton	- -	X	X	- -	X	X
Village of Newburg	- -	X	X	- -	X	X
Village of Saukville	- -	X	X	- -	X	X
Village of Thiensville	- -	X	X	- -	X	X

Table 99 (continued)

Groundwater Management Agency	Map Groundwater Recharge Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan Regarding Maintenance of Groundwater Recharge Areas [**Medium Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan in Evaluating Sustainability of Proposed Developments and in Local Land Use Planning [**Medium Priority**][b]	Map Groundwater Contamination Potential in Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider Potential Impacts on Groundwater Quality of Stormwater Infiltration from Proposed Development [**High Priority**][b]	Develop and Implement Utility-Specific Water Conservation Programs [**Low Priority**][b]
Ozaukee County (continued)						
Town of Cedarburg	- -	X	X	- -	X	X
Town of Fredonia	- -	X	X	- -	X	X
Town of Grafton	- -	X	X	- -	X	X
Town of Port Washington	- -	X	X	- -	X	X
Town of Saukville	- -	X	X	- -	X	X
Racine County	- -	X	X	- -	X	X
City of Racine	- -	X	X	- -	X	X
Village of Caledonia	- -	X	X	- -	X	X
Village of Mt. Pleasant	- -	X	X	- -	X	X
Village of North Bay	- -	X	X	- -	X	X
Village of Sturtevant	- -	X	X	- -	X	X
Village of Union Grove	- -	X	X	- -	X	X
Village of Wind Point	- -	X	X	- -	X	X
Town of Dover	- -	X	X	- -	X	X
Town of Norway	- -	X	X	- -	X	X
Town of Raymond	- -	X	X	- -	X	X
Town of Yorkville	- -	X	X	- -	X	X
Sheboygan County	X	X	X	X	X	X
Village of Adell	- -	X	X	- -	X	X
Village of Cascade	- -	X	X	- -	X	X
Village of Random Lake	- -	X	X	- -	X	X
Town of Greenbush	- -	X	X	- -	X	X
Town of Holland	- -	X	X	- -	X	X
Town of Lyndon	- -	X	X	- -	X	X
Town of Mitchell	- -	X	X	- -	X	X
Town of Scott	- -	X	X	- -	X	X
Town of Sherman	- -	X	X	- -	X	X
Washington County	- -	X	X	- -	X	X
City of West Bend	- -	X	X	- -	X	X
Village of Germantown	- -	X	X	- -	X	X
Village of Jackson	- -	X	X	- -	X	X
Village of Kewaskum	- -	X	X	- -	X	X
Village of Newburg	- -	X	X	- -	X	X
Town of Addison	- -	X	X	- -	X	X
Town of Barton	- -	X	X	- -	X	X
Town of Farmington	- -	X	X	- -	X	X
Town of Germantown	- -	X	X	- -	X	X
Town of Jackson	- -	X	X	- -	X	X
Town of Kewaskum	- -	X	X	- -	X	X
Town of Polk	- -	X	X	- -	X	X
Town of Richfield	- -	X	X	- -	X	X
Town of Trenton	- -	X	X	- -	X	X
Town of Wayne	- -	X	X	- -	X	X
Town of West Bend	- -	X	X	- -	X	X

Table 99 (continued)

Groundwater Management Agency	Map Groundwater Recharge Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan Regarding Maintenance of Groundwater Recharge Areas [**Medium Priority**][b]	Consider the Recommendations of the Regional Water Supply Plan in Evaluating Sustainability of Proposed Developments and in Local Land Use Planning [**Medium Priority**][b]	Map Groundwater Contamination Potential in Areas Outside the Southeastern Wisconsin Region [**Low Priority**][b]	Consider Potential Impacts on Groundwater Quality of Stormwater Infiltration from Proposed Development [**High Priority**][b]	Develop and Implement Utility-Specific Water Conservation Programs [**Low Priority**][b]
Waukesha County	- -	X	X	- -	X	X
City of Brookfield	- -	X	X	- -	X	X
City of Muskego	- -	X	X	- -	X	X
City of New Berlin	- -	X	X	- -	X	X
Village of Butler	- -	X	X	- -	X	X
Village of Elm Grove	- -	X	X	- -	X	X
Village of Menomonee Falls	- -	X	X	- -	X	X
Town of Brookfield	- -	X	X	- -	X	X
Town of Lisbon	- -	X	X	- -	X	X

[a]Designation of management agencies is not required under the Federal Clean Water Act. Thus, these designations are advisory only.

[b]Generalized priorities are assigned by recommendation. For certain municipalities or agencies, the priority for implementing a given recommendation may be higher or lower than the assigned priority, depending on specific circumstances and changed conditions over time.

Source: SEWRPC.

State-Level Agencies

1. It is recommended that the WDNR Board endorse the regional water quality management plan update for the greater Milwaukee watersheds as an amendment to the previously endorsed water quality management plan, recommend to the Governor that he certify the plan as an amendment to the areawide water quality management plan to the USEPA, and direct the staff of the WDNR to integrate the recommended plan elements into its broad range of agency responsibilities, as well as to assist in coordinating plan implementation activities between the publication date and the year 2020.

2. It is recommended that the Wisconsin DATCP, upon recommendation of the Land Conservation Board, endorse the regional water quality management plan update and direct the Department staff to give due consideration to the plan in the exercise of its various responsibilities governing farmland preservation and soil and water conservation.

3. It is recommended that the Wisconsin Department of Commerce endorse the regional water quality management plan update and direct the Department staff to give due consideration to the plan in the exercise of its various responsibilities governing regulation of construction erosion control and private onsite wastewater treatment systems.

4. It is recommended that the Wisconsin Department of Transportation endorse the regional water quality management plan update and direct the Department staff to give due consideration to the plan in the exercise of its various responsibilities governing construction erosion control and stormwater management related to transportation projects.

Federal-Level Agencies

1. It is recommended that the USEPA formally accept and endorse the regional water quality management plan update for the greater Milwaukee watersheds as an amendment to the regional water quality management plan upon certification as such by the Governor of the State of Wisconsin and utilize the plan recommendations in the performance of its broad range of agency responsibilities relating to water quality management.

2. It is recommended that the USDA Farm Services Agency, formally acknowledge the regional water quality management plan update and utilize the plan recommendations in its administration of the Federal agricultural and conservation programs.

3. It is recommended that the USDA Natural Resources Conservation Service formally acknowledge the regional water quality management plan update and utilize the plan recommendations in the administration of its various technical assistance programs relating to soil and water conservation.

4. It is recommended that the U.S. Department of the Interior, Geological Survey, endorse the regional water quality management plan update for the greater Milwaukee watersheds, continue its cooperative stream gaging program within the watershed, and work with municipalities, counties, utility and sanitary districts, and the Regional Planning Commission to expand the number of continuous recording streamflow and water quality monitoring stations on the tributary streams of the study area.

5. It is recommended that the U.S. Department of the Interior, Fish and Wildlife Service, endorse the regional water quality management plan update, and utilize the plan recommendations in its administration of programs related to the use of surface waters, wetlands, floodlands, and shorelands for fish and other wildlife habitat.

6. It is recommended that the U.S. Department of Transportation, Federal Highway Administration, endorse the regional water quality management plan update, and utilize the plan recommendations as appropriate in setting standards for highway construction and maintenance activities.

7. It is recommended that the U.S. Army Corps of Engineers (USCOE) formally acknowledge the regional water quality management plan update, use the land use and environmental corridor elements of the plan in carrying out its regulatory program relative to the placement of fill and the conduct of other activities in wetlands, and integrate the recommendations of the plan regarding dredging in the Milwaukee harbor estuary.

SUBSEQUENT ADJUSTMENT OF THE PLAN

No plan can be permanent in all of its aspects or precise in all of its elements. The very definition and characteristics of areawide planning suggest that an areawide plan, such as the regional water quality management plan update for the greater Milwaukee watersheds, to be viable and of use to local, State, and Federal units and agencies of government, be continually adjusted through formal amendments, extensions, additions, and refinements to reflect changing conditions. The Wisconsin Legislature clearly foresaw this when it gave to regional planning commissions the power to ". . . amend, extend, or add to the master plan or carry any part or subject matter into greater detail . . . " in Section 66.0309(9) of the *Wisconsin Statutes*.

Amendments, extensions, and additions to the regional water quality management plan update will be forthcoming not only from the work of the Commission under various continuing regional planning programs but also from State agencies as they adjust and refine statewide plans and from Federal agencies as national policies are established or modified, as new programs are created, or as existing programs are expanded or curtailed. Adjustments must also come from local planning programs which, of necessity, must be prepared in greater detail and result in greater refinement of the plan. This is particularly true of the land use element of the plan. Areawide adjustments may come from subsequent regional or State planning programs, which may include additional comprehensive or special purpose planning efforts, such as the preparation of regional sanitary sewerage service plans, regional water supply plans, and regional biosolids plans.

All of these adjustments and refinements will require cooperation by local, areawide, State, and Federal agencies of government, as well as coordination by SEWRPC, which has been empowered under Section 66.0309(8) of the *Wisconsin Statutes* to act as a coordinating agency for programs and activities of the local units of government. To achieve this coordination between local, State, and Federal programs most effectively and efficiently and, therefore, to assure the timely adjustments of the water quality management plan, it is recommended that all of the State, areawide, and local agencies having various plan and plan implementation powers advise and transmit all subsequent planning studies, plan proposals and amendments, and plan implementation devices to SEWRPC for consideration as to integration into, and adjustment of, the water quality management plan. Of particular importance in this respect will be the continuing role of the Technical Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds in intergovernmental coordination.

LAND USE PLAN ELEMENT IMPLEMENTATION

The implementation of the land use plan element—including the overall land use and open space preservation components—of the regional water quality management plan update for the greater Milwaukee watersheds is of central importance to the realization of the objectives of the overall plan. This element requires cooperation between the local units of government and the areawide, State, and Federal agencies concerned if the watershed development objectives are to be fully achieved. This is true not only because the land use plan elements are closely interrelated in nature and support and complement one another, but because they are closely related to water quality management. The various means of implementing the regional land use plan are discussed in detail in Chapter VII of SEWRPC Planning Report No. 48, *A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.[20] Specific aspects of land use plan implementation that are particularly related to the regional water quality management plan update are described below.

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[20]*As noted in Chapters VIII, IX, and X of this report, the year 2035 regional land use plan was used to estimate year 2020 conditions for specific applications in the regional water quality management plan update.*

Sanitary Sewer Extension Review

The WDNR must review and approve all locally proposed extensions of public sanitary sewers, while the Wisconsin Department of Commerce has similar oversight responsibilities for private sewers. It is recommended that these agencies review all such extensions against the basic land use recommendations contained in the recommended land use plan element, ensuring that the development proposed to be served by extended sanitary sewers is compatible with the plan recommendations.

Wetland Regulation

It is recommended that the WDNR and the USCOE, in the administration of their various wetland regulatory programs, take into account the land use development, open space preservation and protection, and floodland management recommendations contained in the regional water quality management plan. The plan recommends the preservation and protection of existing wetlands and the creation or restoration of wetlands on lands that are not currently designated as wetlands. It is accordingly recommended that the State and Federal agencies concerned recognize the comprehensive nature of the water quality management plan, making agency decisions on wetland regulation in a manner consistent with that plan. It is also recommended that the counties, cities, and villages in the study area—all of which are mandated by State law to enact protective wetland zoning attendant to all wetlands five acres or more in size within shoreland areas—ensure that their local zoning regulations continue to protect wetlands in a manner consistent with the recommended plan.

Open Space Preservation Plan Element

Implementation of the recommendations of the regional land use plan relating to zoning and other regulatory measures for the protection of environmentally sensitive and agricultural lands will substantially contribute to implementation of the open space preservation plan element. The plan recommends that primary environmental corridors be preserved in essentially natural, open uses and it encourages the preservation of secondary environmental corridors and isolated natural resource areas in a similar manner. Such preservation has been and will continue to be accomplished through public or public-interest ownership, State-local floodplain and shoreland-wetland zoning, State administrative rules governing sanitary sewer extensions within planned sanitary sewer service areas; and local land use regulations. In addition, the plan recommends additional public-interest acquisition to permanently protect identified natural areas and critical species habitat sites that are not in existing public or public-interest ownership. Under the plan, the primary responsibility for acquisition of natural areas and critical species habitat sites would rest with the WDNR, with the expectation that they would gradually acquire selected lands in the years ahead.

SURFACE WATER QUALITY MANAGEMENT PLAN ELEMENT[21]

The major surface water quality management recommendations relate to the abatement of point and nonpoint sources of pollution; instream water quality measures, inland lake water quality management measures; and auxiliary measures related to beaches, control of waterfowl, the coastal zone, household hazardous wastes, exotic invasive species, and an expanded water quality monitoring program. The recommended actions discussed under this plan element are summarized in Table 82 in Chapter X of this report. Capital and operation and maintenance costs for this plan element are set forth in Table 100, which includes estimates for public and private sector costs. In Appendix R, public sector costs are apportioned among municipalities in the study area and agencies with plan implementation responsibilities.

Implementation of the Point Source Pollution Abatement Plan Subelement

Section 208 of the Federal Water Pollution Control Act (Clean Water Act) requires that management agencies be designated and responsibilities be defined for all aspects of the areawide water quality management plan. These

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[21]*While the plan recommendations are specifically related to the greater Milwaukee watersheds and the adjacent nearshore Lake Michigan area, those recommendations are consistent with the 2006 WDNR* Wisconsin Great Lakes Restoration and Protection Strategy, *and their implementation will serve to further the goals of the Wisconsin Great Lakes strategy.*

Table 100

PRIVATE AND PUBLIC SECTOR COSTS FOR COMPONENTS OF THE RECOMMENDED REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE

Plan Element	Plan Subelement	Description	Component	Public Sector Capital Cost (thousands)	Public Sector Annual Operation and Maintenance Cost (thousands)	Private Sector Capital Cost (thousands)[a]	Private Sector Annual Operation and Maintenance Cost (thousands)[a]	Total Capital Cost (thousands)	Total Annual Operation and Maintenance Cost (thousands)
Surface Water Quality Plan Element	Point Source Pollution Abatement Plan Subelement	Public Wastewater Treatment Plants and Associated Sewer Service Areas	3. Implementation of the Village of Kewaskum WWTP Facilities Plan	$ 3,440	$ 97	- -	- -	$ 3,440	$ 97
			4. Prepare facilities plans for the Villages of Jackson and Newburg	200	- -	- -	- -	200	- -
			5. Prepare facilities plans for the City of Cedarburg and Village of Grafton, including consideration of merging operations into a single, regional treatment facility	175	- -	- -	- -	175	- -
			6. Prepare facilities plan for City of Racine and environs upon completion of amendment to sewer service area	250	- -	- -	- -	250	- -
			7. Capacity, Management, Operations, and Maintenance (CMOM) programs for municipalities outside of the MMSD service area	1,425	- -	- -	- -	1,425	- -
			8. City of West Bend Northwest Interceptor	4,091	3	- -	- -	4,091	3
			9. Force main from Waubeka in the Town of Fredonia to the Village of Fredonia sewerage system	1,549	11	- -	- -	1,549	11
			10. Ryan Creek interceptor sewer	51,386	70	- -	- -	51,386	70
			11. Implementation of MMSD 2020 Facilities Plan as Recommended under the RWQMPU	954,900	900	- -	- -	954,900	900
			12. Implementation of wastewater treatment plant upgrades for City of South Milwaukee	4,298	575	- -	- -	4,298	575

Table 100 (continued)

Plan Element	Plan Subelement	Description	Component	Public Sector Capital Cost (thousands)	Public Sector Annual Operation and Maintenance Cost (thousands)	Private Sector Capital Cost (thousands)[a]	Private Sector Annual Operation and Maintenance Cost (thousands)[a]	Total Capital Cost (thousands)	Total Annual Operation and Maintenance Cost (thousands)
Surface Water Quality Plan Element (continued)	Nonpoint Source Pollution Abatement Plan Subelement	Recommended Rural Nonpoint Source Pollution Control Measures	2. Provide six months of manure storage for livestock operations	- -	- -	$ 47,050	$ 3,072	$ 47,050	$ 3,072
			3. Prepare and/or implement nutrient management plans	- -	- -	1,526	1,308	1,526	1,308
			5. Control barnyard runoff	- -	- -	2,280	- -	2,280	- -
			6. Expand riparian buffers	- -	- -	1,747	389	1,747	389
			7. Convert marginal cropland and pasture to wetlands and prairies	- -	- -	72,253	16,250	72,253	16,250
			8. Restrict livestock access to streams	- -	- -	969	48	969	48
			9. Manage milking center wastewater	- -	- -	3,799	83	3,799	83
			10. Expand oversight and maintenance of private onsite wastewater treatment systems (POWTS)	- -	- -	113,660	663	113,660	663
		Recommended Urban Nonpoint Source Pollution Control Measures	1. Implementation of the nonagricultural (urban) performance standards of Chapter NR 151	121,720	8,625	75,256	23,583	196,976	32,208
			2. Programs to detect and eliminate illicit discharges and control pathogens that are harmful to human health	19,524	- -	- -	- -	19,524	- -
			3. Chloride reduction programs	499	1,496	- -	- -	499	1,496
			4. Implement fertilizer management programs	160	- -	- -	- -	160	- -
			5. Disconnect residential roof drains from sanitary and combined sewers and infiltrate roof runoff	- -	- -	22,171	350	22,171	350
			7. Beach and riparian litter and debris control	- -	596	- -	- -	- -	596

Table 100 (continued)

Plan Element	Plan Subelement	Description	Component	Public Sector Capital Cost (thousands)	Public Sector Annual Operation and Maintenance Cost (thousands)	Private Sector Capital Cost (thousands)[a]	Private Sector Annual Operation and Maintenance Cost (thousands)[a]	Total Capital Cost (thousands)	Total Annual Operation and Maintenance Cost (thousands)
Surface Water Quality Plan Element (continued)	Instream Water Quality Measures Plan Subelement	Hydrologic and Hydraulic Management	1. Concrete channel renovation and rehabilitation	$ 175,200	- -	- -	- -	$ 175,200	- -
			2. Renovation of the MMSD Kinnickinnic River flushing station	3,400	$ 600	- -	- -	3,400	$ 600
			3. Dam abandonment and restoration plans	1,800	- -	- -	- -	1,800	- -
			5. Increase the dredged material storage volume of the Jones Island Confined Disposal Facility	3,500	12	- -	- -	3,500	12
	Inland Lakes Water Quality Measures Plan Subelement	- -	1. Lake management plans for 17 major lakes	850	- -	- -	- -	850	- -
			2. Implement trophic state monitoring programs for 20 major lakes	- -	120	- -	- -	- -	120
	Auxiliary Water Quality Management Plan Subelement	Public Beaches	1. Continue current public health monitoring programs and expand to all public beaches in the study area	- -	31	- -	- -	- -	31
			3. Continue and expand current beach grooming programs	- -	710	- -	- -	- -	710
		Waterfowl Control	1. Implement programs to discourage unacceptably high numbers of waterfowl from congregating near beaches and other water features	- -	165	- -	- -	- -	165
		Water Pollution Control	1. Continue collection programs for household hazardous wastes and expand such programs to communities that currently do not have them	- -	374	- -	- -	- -	374
		Emerging Issues	2. Implement collection programs for expired and unused household pharmaceuticals	- -	40	- -	- -	- -	40

Table 100 (continued)

Plan Element	Plan Subelement	Description	Component	Public Sector Capital Cost (thousands)	Public Sector Annual Operation and Maintenance Cost (thousands)	Private Sector Capital Cost (thousands)[a]	Private Sector Annual Operation and Maintenance Cost (thousands)[a]	Total Capital Cost (thousands)	Total Annual Operation and Maintenance Cost (thousands)
Surface Water Quality Plan Element (continued)	Auxiliary Water Quality Management Plan Subelement (continued)	Water Quality Monitoring	2. Continue and possibly expand USGS stream gauging program	$ 145	$ 126	- -	- -	$ 145	$ 126
			3. Establish long-term water quality monitoring programs for areas outside of MMSD service area	- -	156	- -	- -	- -	156
			4. Establish long-term fisheries and macro-invertebrate monitoring stations	- -	100	- -	- -	- -	100
			5. Establish long-term aquatic habitat monitoring stations	- -	59	- -	- -	- -	59
		Maintenance of the Regional Water Quality Manage-ment/MMSD 2020 Facilities Plan Modeling System	1. Continue maintenance of MMSD conveyance system modeling tools	- -	15	- -	- -	- -	15
			2. Continue maintenance of watershedwide riverine water quality models (LSPC) and Milwaukee Harbor estuary/nearshore Lake Michigan hydro-dynamic (ECOMSED) and water quality (RCA) models	- -	15	- -	- -	- -	15
Groundwater Management Plan Element	Plan Recommenda-tions Related to Groundwater	Groundwater Recharge Areas	1. Extend groundwater recharge area mapping to those portions of the study area located outside of the Southeastern Wisconsin Region	25	- -	- -	- -	25	- -
		Mapping Groundwater Contamination Potential	1. Extend mapping of groundwater contamination potential for shallow aquifers to those portions of the study area located outside of the Southeastern Wisconsin Region	25	- -	- -	- -	25	- -
			Total	$1,348,562	$14,897	$340,712	$45,746	$1,689,274[b]	$60,643[c]

[a]Some private-sector costs for rural nonpoint source pollution control measures may be offset by State or Federal grant funds.

[b]Includes $196,976,000 for implementation of the NR 151 urban standards. Eliminating that amount yields the $1,492 billion capital cost for new measures recommended under the regional water quality management plan update.

[c]Includes $32,208,000 for implementation of the NR 151 urban standards. Eliminating that amount yields the $28.4 million annual operation and maintenance cost for new measures recommended under the regional water quality management plan update.

Source: SEWRPC.

designations are comprised of all of the units and agencies of government that currently provide centralized sanitary sewer service in the study area.

Designated Management Agencies

Section 208 of the Federal Water Pollution Control Act requires that management agencies be designated and responsibilities defined for all aspects of the areawide water quality management plan. The local governmental management agencies for the point source pollution abatement element of the recommended regional water quality management plan update are identified in Table 93. These designations are comprised of all of the units and agencies of government that currently provide centralized sanitary sewer service in the study area. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge County, the Village of Lomira, which currently provides centralized sanitary sewer service, is designated.

In Fond du Lac County, the Villages of Campbellsport and Eden, which currently provide centralized sanitary sewer service, are designated.

In Kenosha County, no management agencies are designated.

In Milwaukee County, a total of 20 agencies have been designated. All 20 of these agencies, which consist of the 19 local units of government in the County and the Milwaukee Metropolitan Sewerage District, already provide centralized sanitary sewer service.

In Ozaukee County, a total of nine agencies have been designated. These include the Cities of Cedarburg, Mequon, and Port Washington; the Villages of Fredonia, Grafton, Newburg, Saukville, and Thiensville, each of which currently provides centralized sanitary sewer service.[22] In addition, the Waubeka Area Sanitary District in the Town of Fredonia is designated as a management agency. That District was created in the late 1970s for the purpose of conducting facilities planning work that would lead to the construction of a local sewer system in the Waubeka area, with treatment to be provided at the Village of Fredonia wastewater treatment plant. That District still exists, but it currently provides no centralized sanitary sewer service. This plan recommends the construction of an intercommunity trunk sewer connecting the Waubeka area with the Village of Fredonia wastewater treatment plant.

In Racine County, a total of eleven management agencies have been designated. These include the City of Racine; the Villages of Mt. Pleasant, North Bay, Sturtevant, Union Grove, and Wind Point; the Caledonia East Utility District, which includes the former Crestview and North Park Sanitary Districts; the Caledonia West Utility District, which includes the former Caddy Vista Sanitary District and Caledonia Utility District No. 1;[23] the Mount Pleasant Sewer Utility District No. 1; and the Town of Yorkville Sewer Utility District No. 1, each of which currently provide centralized sanitary sewer service. It is recommended that one new utility district be formed in the Town of Raymond to be responsible for centralized sanitary sewer service in those areas of the Town that were not in a sewer service area as of December 31, 2006, but may eventually be connected to the Racine Water and Wastewater Utility wastewater treatment plant based on future facilities and sewer service area planning efforts.

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[22]*Wastewater from the most densely developed areas of the City of Mequon and from the Village of Thiensville is treated by the MMSD.*

[23]*Wastewater from the Caddy Vista portion of the Caledonia West Utility district is treated by the MMSD.*

In Sheboygan County, six management agencies have been designated. These include the Villages of Adell, Cascade, and Random Lake, the Town of Scott Sanitary District No. 1, the Town of Lyndon Lake Ellen Sanitary District, and the Onion River Sewerage Commission, each of which currently provides centralized sanitary sewer service.

In Washington County, seven management agencies have been designated. These include the City of West Bend; the Villages of Germantown,[24] Jackson, Kewaskum, and Newburg; the Wallace Lake Sanitary District in the Town of Trenton; and the Silver Lake Sanitary District in the Town of West Bend, each of which currently provides centralized sanitary sewer service.

In Waukesha County, a total of seven management agencies have been designated. These include the Cities of Brookfield, Muskego, and New Berlin; the Villages of Butler, Elm Grove, and Menomonee Falls; and the Town of Brookfield, each of which currently provides centralized sanitary sewer service.[25]

For the study area as a whole, then, a total of 62 management agencies have been designated for point source pollution abatement purposes.[26] Of this total, all but one agency currently exists. The new agency would be in the Town of Raymond and would be responsible for centralized sanitary sewer service in those areas of the Town that were not in a sewer service area as of December 31, 2006, but may eventually be connected to the Racine Water and Wastewater Utility wastewater treatment plant. Of the 62 existing management agencies, 61 already provide centralized sanitary sewer service. In addition to the foregoing local government management designations for point source pollution abatement purposes, the WDNR is designated as the management agency with primary responsibility for ensuring the full implementation of the entire point source pollution abatement plan element. It is envisioned that the primary mechanism to be used by WDNR to ensure plan implementation would continue to be the waste discharge permit process established under the Wisconsin Pollutant Discharge Elimination System (WPDES). Certain other important tasks would, however, be attendant to the role of the Department in implementation of the plan. The development of detailed sewerage facilities plans will require effluent limitation (waste load allocation) studies by the Department to refine and detail the allowable effluent limits for specific sewage treatment plants so that the recommended water use objectives and supporting standards in the plan are met.

The major responsibilities of the designated management agencies in carrying out the regional water quality management plan are also identified in Table 93. As shown in the table, these management agency responsibilities include the refinement and detailing of sanitary sewer service areas; the construction, maintenance, and operation of wastewater treatment plants; the construction and maintenance of intercommunity trunk sewers and local sewer systems; the abatement of combined sewer overflows; the determination of the best means of reducing clear water infiltration and inflow; the elimination of all overflows of untreated sewage; implementation of capacity, management, operations, and maintenance programs; and preparation of facilities plans. Not all agencies will be assigned all of these responsibilities. A more detailed discussion of the specific responsibilities assigned to the designated management agencies with regard to the point source pollution abatement element of the plan is set forth below.

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[24]*Wastewater from the Village of Germantown is treated by the MMSD*

[25]*Within the study area, wastewater from the Cities of Brookfield, Muskego, and New Berlin and the Villages of Butler, Elm Grove, and Menomonee Falls is treated by the MMSD.*

[26]*Because the Village of Newburg is located in both Ozaukee and Washington Counties, it is listed above under each county, but it is only counted once in determining the total number of designated management agencies in the study area.*

Implementation Schedules—Public Wastewater Treatment Plants and Intercommunity Trunk Sewers

In order to provide a point of departure for intergovernmental discussions and negotiations involving the development of necessary areawide sanitary sewerage systems and to further provide a basis for Federal and State agency programming, including the issuance of waste discharge permits and the allocation of grant in-aid monies, implementation schedules for the sewerage facility recommendations of the point source pollution abatement element of the recommended plan were considered. In general, it should be recognized that the actual timing of implementation will depend upon the rate of urban growth and development in various subareas of the greater Milwaukee watersheds study area, upon the availability of local matching, as well as Federal and State grant-in-aid, monies, and upon the phasing of the five-year cycle embodied in the waste discharge permits issued by the WDNR to operators of wastewater treatment plants.

The implementation schedule for the recommended components of the MMSD 2020 facilities plan, including intercommunity trunk sewers, is set forth below in the subsections of this report that describe implementation of that facilities plan. The time frames for other recommended facilities planning efforts outside the MMSD planning area are also set forth below.

The northwest interceptor in the City of West Bend and environs is scheduled to be constructed from 2011 through 2015. It is recommended that the intercommunity trunk sewer to connect the Waubeka area with the Village of Fredonia sewerage system be constructed between 2008 and 2020 should the Waubeka Sanitary District decide to install a system of local collector sewers.

It is recommended that each identified management agency use the implementation schedule provided as a point of departure in the preparation of a refined schedule for the programming of needed facility construction. It is further recommended that the WDNR and the USEPA utilize the schedule in preparing time tables of compliance for each owner and operator of a waste source seeking a wastewater discharge permit under the WPDES.

Public Wastewater Treatment Plants and Associated Sewer Service Areas

As noted previously in this report, SEWRPC, the WDNR, and the local communities have conducted sewer service area planning studies to refine and update sanitary sewer service areas throughout the study area since the regional water quality management plan was adopted in 1979. Map 73 in Chapter X of this report shows the planned sanitary sewer service areas within the study area and the MMSD planning area outside the study area. With the exception of most of the MMSD service area within Milwaukee County; the City of South Milwaukee service area; the Villages of Adell, Campbellsport, Cascade, Lomira, and Random Lake; the Town of Scott Sanitary District No. 1 service area; and the Town of Yorkville Sanitary District No. 1 service area, all sewer service areas within the greater Milwaukee watersheds have been refined. It is recommended that the MMSD, South Milwaukee, Adell, Campbellsport, Cascade, Lomira, Random Lake, Scott, and Yorkville service areas be refined through the preparation of local sewer service area plans. Each sewer service area refinement would be a joint effort involving the municipality; the appropriate regional, county, or local agencies; and the WDNR.

Public Wastewater Treatment Systems Outside of the Milwaukee Metropolitan Sewerage District Planning Area

It is recommended that the Villages of Newburg and Jackson monitor development and population levels in their sewer service areas and that they prepare facilities plans prior to 2020 in order to provide adequate treatment capacity to meet future needs. It is also recommended that facilities planning to meet the wastewater treatment needs of the City of Cedarburg and the Village of Grafton be undertaken prior to 2020, and that, when facilities planning is initiated, the plan include cost-effectiveness analyses to evaluate upgrading the individual treatment plants versus construction of a new regional wastewater treatment plant to serve both communities.

As noted in Chapter X of this report, the Village of Caledonia recently completed a study to determine the most cost-effective way to provide sanitary sewer service to portions of the Village that are anticipated to be developed by the year 2035. The study also involved the City of Racine, Villages of Mt. Pleasant and Sturtevant, and the Towns of Raymond and Yorkville. Wastewater from the City of Racine and the Villages of Caledonia, Mt. Pleasant, and Sturtevant is currently treated at the plant operated by the Racine Water and Wastewater Utility. Wastewater flows from the Town of Yorkville sewer service area are treated at the plant operated by Town of

Yorkville Sanitary District No. 1. It is recommended that detailed facilities planning be undertaken to establish what new conveyance, pumping, and storage facilities would be needed to serve the City of Racine and environs.

As stated in Chapter X, it is recommended that the entire Yorkville system be connected to the sewerage system tributary to the Racine wastewater treatment plant and that the Yorkville plant be abandoned when the Yorkville plant reaches the end of its useful life. Projected population and sewage flow information indicates that the Yorkville plant would still have adequate treatment capacity in 2020. Thus, unless the physical condition of the plant dictates the need for significant upgrades prior to 2020, in which case connection to the Racine system should be considered, abandonment of the Yorkville plant may not occur until after the year 2020.

RECOMMENDED INTERCOMMUNITY TRUNK SEWERS

Map 73 in Chapter X of this report shows proposed new intercommunity trunk sewers. Table 93 indicates the designated management agencies that are assigned responsibility for the construction and maintenance of those sewers.

IMPLEMENTATION OF LOCAL PROGRAMS TO ENSURE MAINTENANCE OF ADEQUATE SEWAGE COLLECTION SYSTEM CAPACITY

As indicated in Table 93, it is recommended that the municipalities outside the MMSD service area implement locally designed programs similar to the Capacity, Management, Operations, and Maintenance (CMOM) program that is currently being promoted by the USEPA as a means of evaluating and maintaining sewage collection systems.

2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District

The recommended 2020 facilities plan for the Milwaukee Metropolitan Sewerage District is generally incorporated in the regional water quality management plan update as described in Chapter X of this report.[27]

The MMSD facilities plan sets forth the following two schedules for plan implementation:

- An Adaptive Implementation Schedule (AIS), which recognizes that projected growth in population and land use may not occur as assumed under the plan and described in detail in Chapter VIII of this report and

- A Full Implementation Schedule (FIS), which is based on growth in population and land use occurring as projected.

The following subsections describe features of the MMSD 2020 facilities plan that are directly related to plan implementation, and they present the adaptive and full implementation schedules. The recommended facilities plan components are generally presented below in the sequence in which they are described in Chapter X of this report.

WET WEATHER CONTROL PLAN

The following facilities improvements are recommended for construction or implementation by MMSD in order to maximize capture and treatment of sewage during wet weather.

Increase Capacity to Pump from the Inline Storage System (ISS) to the Jones Island Wastewater Treatment Plant

The AIS calls for the rehabilitation to occur from 2008 through 2014 and the construction of some of the facilities in the period from 2015 to 2020, with the remainder of the facilities assumed to be constructed after 2020.

The FIS shows the rehabilitation occurring from 2008 through 2014 and the construction of all the facilities in the period from 2012 to 2020. The FIS assumes completion of both the upgrade and the capacity expansion by 2020.

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[27]The MMSD facilities plan is documented in the report entitled *2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District*, June 2007.

The MMSD initiated a project in November 2006 to develop a conceptual design for rehabilitation and upgrading the ISS Pump Station as well as expanding it in conformance with the recommended facilities plan. The proposed rehabilitation work is scheduled to occur from 2008 through 2014 under both the AIS and FIS.

Increase South Shore Wastewater Treatment Plant (SSWWTP) Capacity

Under the AIS, the initiation of this demonstration project is planned for 2013 through 2016. The initiation of construction to increase SSWWTP capacity is assumed to occur after 2020, unless population growth or other circumstances require a change to this schedule. As noted in Chapter X of this report, the need for capacity expansion is dependent upon many factors, including:

- MMSD operational measures to control sanitary sewer overflows (SSOs), including the volume reserved for separate sewer inflow (VRSSI) management;
- The results of the SSWWTP capacity study;
- The results of the physical-chemical treatment demonstration project;
- The recommended evaluation of blending at the SSWWTP;
- The timing and amount of population growth in the MMSD sewer service area; and
- The potential success of MMSD and its satellite municipalities in reducing year 2000 infiltration and inflow (I/I) levels through the implementation of the Capacity, Management, Operations, and Maintenance (CMOM) program, the progress of the Wet Weather Peak Flow Management Plan, and the enactment of the revisions to Chapter 3 of the MMSD Rules and Regulations.

Under the FIS, the demonstration project is planned from 2008 through 2011 and the design and construction of the expansion facilities would begin in 2011 and proceed to 2019.

In addition to the demonstration project, an evaluation is necessary to determine if increasing the metropolitan interceptor system (MIS) flow rate to the SSWWTP will require control system refinements and structural modifications at the S. 6th Street and W. Oklahoma Avenue diversion chamber to the ISS. If an increase in treatment capacity at the SSWWTP is found to be needed and physical-chemical treatment with chemical flocculation is found to be feasible, the evaluation of the modifications to the diversion chamber should be initiated at the same time as the design of the physical-chemical treatment system because they are interdependent (i.e., an increase in flow to the SSWWTP may necessitate modifications to the diversion chamber).

If the SSWWTP capacity improvements are not implemented within the planning period, the need for an increase in the capacity of the Ryan Road MIS for the five-year level of protection (LOP) should be re-evaluated. Under the five-year LOP recommended plan, the Ryan Road MIS capacity increase is not needed because the SSWWTP capacity improvements will lower the hydraulic grade line in this segment of the MIS such that critical elevations are not exceeded. However, if the SSWWTP improvements are not implemented, the hydraulic grade line in the Ryan Road MIS will be higher. An evaluation would be needed to assess whether the higher hydraulic grade line would exceed any critical elevations. If it was determined that critical elevations would be exceeded, the Ryan Road MIS capacity increase may be necessary for the five-year LOP condition.

Add Metropolitan Interceptor Sewer Capacity as Necessary

A list of MIS locations where hydraulic capacity upgrades may be required is set forth in Table 83 in Chapter X of this report and those MIS segments are shown graphically on Map 73,[28] also in Chapter X. Additional flow

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[28]*The recommended projects have the capacity to convey both the year 2020 full growth and buildout condition flows.*

monitoring to verify current flows and to assess future growth of flows will be necessary to verify whether MIS capacity enhancements are actually needed at these locations. To verify current flows, flow monitoring should be conducted for a representative period of time in order to assess the performance of the MIS during a variety of rainfall events, as well as during dry weather. Longer-term flow monitoring over several years in conjunction with monitoring of population growth and development is needed to assess whether growth projected during the facilities planning process does actually occur, thereby generating a need for MIS capacity enhancements. For a given segment of the MIS, if flow monitoring confirms that an increase in capacity would be needed, preliminary engineering should be performed to identify the most appropriate conveyance system enhancement.

The preliminary engineering effort should include an assessment of whether the provision of free outlet conditions for local sewers is needed in each of these project areas. In some cases, the local connections are very deep; limited surcharging of these connections can most likely be tolerated without posing a risk of basement backups. If it is verified that limited surcharging of connections can be tolerated, some of the projects listed in Chapter X may be reduced in scope or eliminated.

Priority should be given to implementing those projects that are not driven by future growth in population and land use (i.e., driven by current capacity restrictions as verified by additional flow monitoring), provided that near-term flow monitoring verifies the need for these projects. This includes the following MIS capacity projects listed in Table 83 and shown on Map 73 in Chapter X of this report:

- Milwaukee River,
- Range Line Road,
- River Hills,
- Green Bay Avenue and Mill Road,
- Menomonee River,
- S. 81st Street, and
- S. Howell Avenue.

Strategies for sequencing and coordinating the construction of the potential recommended projects have been identified in the MMSD facilities plan. The Milwaukee River MIS and the River Hills MIS are hydraulically and physically connected. The River Hills MIS connects into the Milwaukee River MIS at the intersection of W. Greenwood Road and N. Pierron Avenue on the west side of the Milwaukee River. In order to minimize both the disturbance of the area and interruption of traffic due to construction, the two projects should be combined into one project and constructed at the same time, when the need for these projects is confirmed.

The Green Tree Pump Station may be upgraded for the Green Bay Avenue and Mill Road project. However, because flow to the Green Tree Pump Station is from the Milwaukee River MIS, the pumping capacity of the Green Tree Pump Station should be rated for flow from the Milwaukee River MIS. Additionally, the pump station should provide the peak capacity at a head that will not surcharge the Milwaukee River MIS above the crown of the pipe. This will provide a free outlet condition along the Milwaukee River MIS when the pumps are at full capacity. Finally, any planned modifications to the Green Tree Pump Station should be coordinated with MMSD’s current pump station upgrade project, which is addressing general facility upgrade needs.

Because of the interrelationships between the recommended facilities for the Milwaukee River MIS, the River Hills MIS, and the Green Bay Avenue/Mill Road MIS projects, a single preliminary engineering evaluation should be performed to address all of these projects.

The recommended changes to the real time control (RTC) operations of the ISS gates[29] are needed to use the full capacity of the possible treatment capacity upgrade at the SSWWTP. Structural improvements to the ISS gates may be required in conjunction with the RTC operation changes. Therefore, both the structural improvements and the RTC changes need to be coordinated with implementation of the increased SSWWTP capacity, if that capacity increase is determined to be needed.

IMPLEMENT IMPROVEMENTS TO FLOW MONITORING AND RAIN GAUGE SYSTEM

As a part of the Wet Weather Peak Flow Management Program (WWPFMP), the MMSD has already begun to make improvements to its flow monitoring system to assist in I/I management. The AIS and FIS both call for this ongoing project anticipated to continue from 2008 through 2013. However, the MMSD may need to continue to update and modify this system beyond 2013.

Perform Capacity Analysis of South Shore Wastewater Treatment Plant

The MMSD facilities plan recommends that the capacity analysis of the SSWWTP begin as soon as possible. Both the AIS and the FIS call for this analysis to be completed in 2008.

Hydraulic Analysis of the Jones Island Wastewater Treatment Plant (JIWWTP)

The 2020 FP recommends that a hydraulic analysis of the JIWWTP be conducted in 2008.

Fully Implement Milwaukee Metropolitan Sewerage District's Wet Weather Peak Flow Management Plan to Control the Growth of Infiltration and Inflow

This project has been underway since 2004.

Implement MMSD's Capacity, Management, Operations and Maintenance Program

The Capacity, Management, Operations and Maintenance (CMOM) program is a regulatory program initiated by the USEPA that promotes a flexible, dynamic framework for municipalities to identify and incorporate widely accepted wastewater industry practices in order to accomplish the following:

- Better manage, operate, and maintain collection systems.
- Investigate capacity constrained areas in the collection system.
- Respond to SSO events.

The MMSD has completed its CMOM Strategic Plan and is now in the process of implementing the program. The System Evaluation and Capacity Assurance Plan (SECAP) component of the CMOM plan was completed in 2007.

Implement Capacity, Management, Operations, and Maintenance Programs for Member and Contract Municipalities and for Milwaukee County

The MMSD has already begun to work with the satellite municipalities to develop plans similar to MMSD's CMOM program.

Implement System Evaluation and Capacity Assurance Plan for MMSD Municipalities

The MMSD will lead and support the implementation of SECAPs for the 28 satellite municipalities it serves as a part of its comprehensive CMOM program. If a municipality needs a SECAP to be prepared, MMSD can require the municipality to complete the SECAP.

IMPLEMENT FLOW MONITORING FOR HIGH PRIORITY AREAS

In 2004, the MMSD began monitoring high priority sewersheds where high levels of I/I are expected. In October 2006, 25 new portable area/velocity flow meters were purchased and 30 meters were installed to monitor flows

[29] *MMSD location DC0103.*

from 53 sewersheds that were identified by the 2020 technical team as having excessive I/I during wet weather conditions. These meters were installed in an effort to ascertain the accuracy of the modeled flow assignments in these areas. The 2020 facilities plan recommends that flow monitoring be continued to verify modeled values and assist in controlling I/I.

Continue Operation of Real-Time Control System

The 2020 facilities plan recommends that the operation of the real-time control system be continued and enhanced in order to use all wet weather event data and further improve the prediction algorithm.

Complete Preliminary Engineering Analysis for Additional Force Main

Under both the AIS and FIS the preliminary engineering analysis for this project is planned to occur from 2011 through 2012. If recommended after completion of the preliminary engineering analysis, the construction of this system is scheduled to begin in 2016 and continue to 2020.

Evaluation of Jones Island Wastewater Treatment Plant Aeration System

Under both the AIS and FIS the preliminary engineering analysis for this project is planned to occur in 2008. Under the AIS, the construction of this system is scheduled to begin in 2018. Under the FIS, the construction is planned to occur from 2012 through 2016.

Ongoing Treatment and Conveyance Upgrades

It is recommended that MMSD continue to fund routine ongoing treatment and conveyance upgrades that are necessary to provide adequate sewage conveyance and treatment.

Geotechnical/Structural Analysis of Wastewater Treatment Plants

The analysis is planned to occur from 2011 through 2014 under the AIS and from 2012 through 2015 under the FIS.

BIOSOLIDS PLAN

The interim biosolids plan analysis and evaluation recommendations, including development of a final biosolids recommended plan, are scheduled to occur in 2008 under the AIS and from 2008 through 2009 under the FIS.

The MMSD facilities plan includes schedules for the implementation of facilities improvements; however, the initiation of construction of those improvements will be dependent on the recommendations of the final biosolids plan.

WATERCOURSE-RELATED PLAN ELEMENTS

The following four elements are recommended as a part of the 2020 facilities plan in order to improve water quality, reduce municipal I/I, and enhance flood mitigation. More details are presented in Chapter 10 of the facilities plan.

Watercourse Management Plan

A watercourse flood mitigation plan is needed not only to manage flooding but also to control municipal I/I, thus assisting in the control of SSOs.

The following projects are in various stages of implementation by MMSD:

- Milwaukee River mainstem flood management project to provide flood control primarily in the Cities of Glendale and Milwaukee;
- Indian Creek flood management project to primarily provide flood control benefits in the Village of Fox Point;
- Lower Wauwatosa flood control, stream restoration, and floodproofing project along the Menomonee River mainstem;

- Milwaukee County Grounds detention basin to provide flood control for portions of Underwood Creek and the Menomonee River mainstem in the Cities of Milwaukee and Wauwatosa; and

- Western Milwaukee flood management project along the mainstem of the Menomonee River.

The schedules for these projects are not impacted by the 2020 AIS or FIS.

Concrete Channel Renovation and Rehabilitation
Recommendations regarding concrete channel renovation and rehabilitation are set forth in Chapter X of this report under the instream water quality management plan subelement.

Proposed MMSD projects to remove concrete channel linings along portions of Underwood Creek and the Menomonee River are scheduled to be completed prior to 2020 under both the AIS and FIS. Projects for other reaches of Underwood Creek, the South Branch of Underwood Creek, Honey Creek, Woods Creek, the Kinnickinnic River, and Wilson Park Creek are only included in the FIS for implementation in the time frame of 2008 through 2020.

Conservation and Greenway Connection Plans
Implementation of the MMSD Greenseams program is ongoing and is dependent to some degree on the availability of grant funds, the MMSD annual budget, and negotiations with landowners for the sale of properties. This program will be an important component of the regional water quality management plan update recommendations regarding establishment of riparian buffers and restoration of prairies and wetlands on agricultural lands.

Renovation of the Kinnickinnic River Flushing Station
The Kinnickinnic River flushing station rehabilitation is planned to occur from 2012 through 2014 under both the AIS and FIS.

NEW MILWAUKEE METROPOLITAN SEWERAGE DISTRICT SEWER SEPARATION POLICY
Implementation of this policy is to begin in 2008 and is to be ongoing throughout the planning period.

OTHER EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT PROGRAMS AND POLICIES TO BE CONTINUED
The long-term control plan to address combined sewer overflows, the stormwater reduction program, the stormwater disconnection program, the industrial waste pretreatment program, and wet weather blending at the Jones Island Wastewater Treatment Plant[30] are ongoing MMSD programs that are to be continued.

Skimmer Boat Operation
Currently, the skimmer boat is owned and operated by Polacheck Property Management with funding from the Milwaukee Riverwalk District, the City of Milwaukee, and the MMSD. It is recommended that operation continue under that arrangement.

Watercourse Operations
The MMSD facilities plan recommends that MMSD continue to exercise its watercourse jurisdictional responsibilities in implementing the following programs:

- Jurisdictional stream inspections

- Culvert inspections

- Flow-impeding debris removal

[30]*In accordance with permit.*

- Debris removal from natural or concrete channels on MMSD property
- Vegetative maintenance on MMSD property
- Repairs to structural controls such as channel linings, flow devices, and habitat devices
- Repairs to mechanical and electrical controls
- Repairs to concrete and natural channels

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT COMMITTED PROJECTS

The MMSD facilities plan recommends that MMSD complete all committed projects that are either identified in the 2002 Stipulation with WDNR, but have not yet been completed, or that are under construction.

Management of Infiltration and Inflow for MMSD Satellite Communities

The 28 satellite communities served by the MMSD are assigned responsibility to implement measures to ensure that infiltration and inflow in each community do not grow beyond existing levels.

Wastewater Treatment for the City of South Milwaukee

The City of South Milwaukee should continue the construction of recommended upgrades to its wastewater treatment plant to meet the requirements of the 2004 court-ordered stipulation and it should continue to operate and maintain its plant according to the requirements of its WPDES permit.

Private Sewage Treatment Facilities

There are two private plants in the Milwaukee River watershed—one serving the Long Lake Recreational Area in the Town of Osceola in Fond du Lac County and one serving the Kettle Moraine Correctional Institution in the Town of Greenbush in Sheboygan County.[31] There is one private plant serving an isolated enclave of urban land use in Fonks Mobile Home Park in the Town of Yorkville in Racine County in the Root River watershed. These facilities are located beyond the current limits of planned public sanitary sewer service areas and are recommended to be retained. The need for upgrading these plants and the level of treatment should be formulated on a case-by-case basis as part of the WPDES permitting process.

Industrial Noncontact Cooling Water Discharges

An additional point source issue identified under the regional water quality management plan update is that of phosphorus loads from some industrial noncontact cooling water discharges. Since the industries involved do not normally add phosphorus to their cooling waters, it is believed that the phosphorus is contained in the source water since some utilities add orthophosphate or polyphosphate as a corrosion control to prevent certain metals from leaching from the distribution system and building plumbing materials into the treated water. It is recommended that water utilities in the study area give further consideration to changing to an alternative technology that does not result in increased phosphorus loading.

Implementation of the Nonpoint Source Pollution Abatement Plan Subelement

The nonpoint source pollution abatement subelement of the recommended regional water quality management plan update addresses both rural and urban nonpoint sources of water pollution. Implementation of the recommended plan facilities and measures in those two categories are described below.

The recommended plan calls for full implementation of the urban runoff management standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code* and a level of implementation of controls on soil erosion from agricultural lands consistent with the NR 151 standard. The plan also calls for additional urban and rural

[31]*The Kettle Moraine Correctional Institution plant discharges to groundwater of the Watercress Creek subbasin within the East Branch Milwaukee River subwatershed.*

nonpoint source abatement measures that are directed at improving instream and in-lake water quality and meeting the applicable water quality standards and criteria to the degree practicable. Chapters NR 151 and ATCP 50 of the *Wisconsin Administrative Code* do not allow local adoption of ordinances more restrictive than the standards set forth in those rules without approval of either the WDNR or DATCP. More restrictive ordinance provisions may be approved if either agency finds that the more restrictive provisions are necessary to achieve compliance with water quality standards, and that compliance cannot reasonably be achieved by less restrictive means. Based on the modeling conducted for the regional water quality management plan update, certain stream reaches have been identified where more restrictive measures, as recommended under this plan, may be needed to improve the degree of compliance with water quality standards. Thus, counties and municipalities could consider the adoption of more restrictive ordinance requirements in an effort to achieve levels of urban and rural nonpoint source pollution control consistent with the recommendations of this plan. However, it is not recommended that such requirements be enacted unless the State of Wisconsin provides additional funding that is adequate to implement the higher levels of control. In the absence of such increased funding, it is recommended that voluntary incentive programs be considered.

In addition, Section NR 151.004, "State targeted performance standards," allows for the promulgation by rule of targeted performance standards intended to attain water quality standards for specific waterbodies that are not expected to meet water quality standards through implementation of the Chapter NR 151 standards alone. It is not recommended that the WDNR consider establishing such targeted standards relative to implementing the recommendations of this plan unless adequate additional State funding is provided.

Implementation of the Rural Nonpoint Source Pollution Abatement Plan Component

Designated Management Agencies

The governmental management agencies designated to implement the rural nonpoint source pollution abatement component of the recommended water quality plan are identified in Table 94. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only. Certain nongovernmental organizations that would have roles in plan implementation are also identified.

Implementation of those components of the recommended plan that are consistent with the agricultural runoff control standards and prohibitions of Chapter NR 151 of the *Wisconsin Administrative Code* could be accomplished through execution of a memorandum of understanding (MOU) between a given county and the WDNR. Within the study area, such an MOU has been executed with the Washington County Land and Water Conservation Division.

In general, it is recommended that the Dodge, Fond du Lac, Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha County Land Conservation Committees and Departments be the lead agencies in rural nonpoint source pollution control. The county committees and departments are recommended to coordinate implementation of the regional water quality management plan update by integrating the recommendations for nonpoint source pollution abatement into the local county land and water resource management plans over time. In addition, those county committees and departments would assist farmers in obtaining additional Federal and local grants that might be combined with additional State funds to implement rural nonpoint source pollution abatement measures.

The County Drainage Boards in Dodge, Fond du Lac, Kenosha,[32] Ozaukee, Racine, Sheboygan, Washington, and Waukesha Counties are designated as management agencies to be involved in the establishment of riparian buffers on agricultural lands.

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[32]*The Commissioners of the Kenosha County Farm Drainage Board resigned in 1990 and replacement Commissioners were not appointed.*

In Dodge County, three management agencies have been designated, including a new town utility district that would be responsible for oversight of private onsite wastewater treatment systems in the Town of Lomira.

In Fond du Lac County, seven management agencies have been designated, including five new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems in the Towns of Ashford, Auburn, Byron, Eden, and Osceola.

In Kenosha County, three management agencies have been designated, including a new town utility district that would be responsible for oversight of private onsite wastewater treatment systems in the Town of Paris.

In Milwaukee County, three management agencies have been designated.

In Ozaukee County, eight management agencies have been designated, including five new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems in the Towns of Cedarburg, Fredonia, Grafton, Port Washington, and Saukville. The Fredonia-Waubeka Area Sanitary District is designated to assume responsibility for oversight of private onsite wastewater treatment systems until such time that it develops a centralized sanitary sewerage system and connects to the Village of Fredonia wastewater treatment plant.

In Racine County, six management agencies have been designated. It is recommended that one new utility district be formed in the Town of Raymond to be responsible for oversight of private onsite wastewater treatment systems and, as noted previously, for future centralized sanitary sewer service. It is also recommended that two new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems be formed in the Towns of Dover and Yorkville.

In Sheboygan County, nine management agencies have been designated, including four new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems in the Towns of Greenbush, Lyndon, Mitchell, and Sherman. Also, the Lake Ellen Sanitary District in the Town of Lyndon and the Town of Scott Sanitary District No. 1, both of which currently provide centralized sanitary sewer service, are recommended to be expanded to include oversight of private onsite wastewater treatment systems throughout the Towns.

In Washington County, 13 management agencies have been designated, including eight new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems in the Towns of Farmington, Germantown, Jackson, Kewaskum, Polk, Richfield, Wayne, and West Bend. Also, the Wallace Lake Sanitary District in the Towns of Barton and Trenton, which currently provides centralized sanitary sewer service, is recommended to be expanded to include oversight of private onsite wastewater treatment systems throughout the Towns.

In Waukesha County, three management agencies have been designated, including one new town utility district that would be responsible for oversight of private onsite wastewater treatment systems in the Town of Lisbon.

For the study area as a whole, a total of 61 governmental management agencies, including State and Federal agencies listed in Table 94, have been designated for rural nonpoint source pollution abatement purposes. Of that total, 28 designated agencies are new town utility districts that would be responsible for oversight of private onsite wastewater treatment systems.[33] In addition to the foregoing local government management designations

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[33]*In general, all towns where a utility district could be formed for oversight of POWTS are designated. However, in some counties, existing county programs may be providing the additional oversight of POWTS recommended for town utility districts to perform. In these instances, it may not be necessary to form town utility districts for the sole purpose of providing supplemental oversight of POWTS. Also, the Towns of Empire and Forest in Fond du Lac County, Norway in Racine County, Holland in Sheboygan County, Addison in Washington County, and*
(Footnote Continued on Next Page)

for rural nonpoint source pollution abatement purposes, the Wisconsin Departments of Natural Resources; Commerce; and Agriculture, Trade and Consumer Protection and the U.S. Department of Agriculture (USDA), the USDA Farm Services Agency, and the USDA Natural Resources Conservation Service are designated as the management agencies with responsibility for ensuring the full implementation of the rural nonpoint source pollution abatement plan element. The Kenosha/Racine Land Trust, the Milwaukee Area Land Conservancy, the Ozaukee-Washington Land Trust, and the Waukesha County Land Conservancy are also identified as having a role in implementation of the rural nonpoint source pollution control recommendations.

Reduction in Soil Erosion from Cropland

The recommended plan calls for practices to reduce soil loss from cropland to be expanded to attain erosion rates less than or equal to T by 2020. This could be accomplished through a combination of practices, including, but not limited to, expanded conservation tillage, grassed waterways, and riparian buffers. The applicable measures should be determined by the development of farm management plans which are consistent with the county land and water resources plans. The development of such plans should be coordinated by county land conservationists in conjunction with NRCS.

Manure and Nutrient Management

In Chapter X of this report, it is recommended that all livestock operations in the study area with 35 combined animal units or greater as defined in Chapter NR 243, "Animal Feeding Operations," of the *Wisconsin Administrative Code* provide six months of manure storage, enabling manure to be spread on fields twice annually during periods when the ground would not be frozen prior to spring planting and after summer and fall harvest.[34] It is recommended that the WDNR request that additional State cost-share funds be made available to farmers to enable existing manure storage facilities to be upgraded to meet the recommendation to provide six months storage.

Another plan recommendation calls for application to cropland of manure and any supplemental nutrients in accordance with a nutrient management plan consistent with the requirements of Sections ATCP 50.04, 50.48, and 50.50 and Section NR 151.07 of the *Wisconsin Administrative Code*. The USDA Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that supports agriculture and environmental quality as compatible goals. Incentive payments and cost share payments may also be made through EQIP to encourage a farmer to adopt land management practices such as nutrient management, manure management, integrated pest management, or wildlife habitat management. It is recommended that the USDA continue to make such payments available to farmers to meet the manure and nutrient management recommendations of the regional water quality management plan update.

Finally, it is recommended that nutrient management requirements for concentrated animal feeding operations (CAFOs) in the study area be based on the WPDES permit conditions established by the WDNR for those operations.[35]

(Footnote Continued from Previous Page)
Brookfield in Waukesha County each only has very small land area in the study area. Thus, those towns were not listed as candidates for establishment of utility districts.

[34]*Section NR 243.05 sets forth two methods for calculating animal units: one method based on "combined animal units" and one based on "individual animal units." In determining the number of animals for which the manure storage recommendation of the regional water quality management plan applies, it is recommended that the method be applied that yields the lowest number of animals for a given category. For example, based on that approach, 35 animal units are equivalent to 25 milking cows; 35 steers; 87 55-pound pigs; and 1,050 to 4,375 chickens, depending on the type and whether the manure is liquid or nonliquid.*

[35]*Chapter NR 243, "Animal Feeding Operations," of the* Wisconsin Administrative Code *sets forth nutrient management requirements for CAFOs.*

Barnyard Runoff

Existing livestock operations are excluded from the NR 151 performance standards regarding barnyard runoff if cost-share funding is not available. Because of the limited amount of such funding that is available annually, many livestock operations are not compelled to comply with *Administrative Code* provisions related to barnyard runoff. In order to attain a greater level of control of barnyard runoff, it is recommended that the WDNR consider increasing levels of cost-share funding to enable a higher level of implementation of the best management practices needed to meet the NR 151 performance standards, and that county land conservation departments assist farmers in obtaining additional Federal and local grants that might be combined with additional State funds to implement controls on barnyard runoff.

Riparian Buffers

The recommended plan calls for the establishment, or expansion, of riparian buffers on crop and pasture lands to a minimum 75-foot-wide zone on either side of streams in the study area. Fond du Lac, Ozaukee, Sheboygan, and Washington Counties currently have programs for the establishment of riparian buffers. Fond du Lac, Ozaukee, and Sheboygan Counties are aggressively promoting the creation of such buffers through the USDA Conservation Reserve Enhancement Program (CREP). In general, under the CREP program, a landowner would initially contact the USDA FSA which would evaluate eligibility for enrollment. The NRCS and the local conservation district would then consider technical issues related to the appropriate buffer width. Next, the county land conservation department would assist with applications to DATCP. The WDNR may also be involved in the CREP process. Within the study area, the program currently applies to Dodge, Fond du Lac, Ozaukee, Sheboygan, Racine, and Waukesha Counties. It is recommended that those counties work with the FSA, NRCS, WDNR, and DATCP to aggressively promote enrollment of agricultural land in CREP, with emphasis on those lands identified on Maps 74 through 76 in Chapter X of this report, as being candidates for the establishment or expansion of riparian buffers.[36]

Under the Conservation Security Program (CSP), which is a comprehensive Federal program "to promote natural resource conservation on working agricultural lands,"[37] farmers can receive credit for enrolling land in CREP and in the Conservation Reserve Program with those credits, enabling higher funding levels under CSP. Thus, the potential for higher funding under CSP is an incentive to establish buffers through the CREP program. Landowners can also seek cost-share funding for the establishment of buffers through the program described in Chapter NR 154, "Best Management Practices and Cost Share Conditions," of the *Wisconsin Administrative Code.*

One of the requirements for buffers funded under CREP is that the soil loss from the cropland tributary to the buffer be at or below the tolerable rate "T". Thus, implementation of the water quality management plan recommendation regarding reducing soil erosion from cropland is important for achieving the maximum eligibility for enrollment in CREP.

Conversion of Cropland and Pasture to Wetlands and Prairies

This plan recommends that a total of 10 percent of existing farmland and pasture be converted to either wetland or prairie conditions, focusing that effort on marginally productive land, as generally shown on Map 81.

[36]*There is the potential for up to $240 million in funding for CREP in Wisconsin through the end of 2007, and there is a possibility that the Federal farm bill will extend the deadline for participation in the program through 2008. Of the $240 million funding amount, $198 million is provided by the USDA and $45 million is provided through bonds issued by the State of Wisconsin.*

[37]*Tim Gieseke,* Conservation Security Program Drives Resource Management: An Assessment of CSP Implementation in Five Midwestern States, *The Minnesota Project in collaboration with Illinois Stewardship Alliance, Land Stewardship Project, Michael Fields Agricultural Institute, Missouri Rural Crisis Center, and Practical Farmers of Iowa, April 2007.*

The WDNR North Branch Milwaukee River Wildlife and Farming Heritage Area is located in the regional water quality management plan study area and is also shown on Map 81.[38] The feasibility study for the North Branch Area sets forth goals for establishing grasslands and restoring wetlands, while maintaining the viability of farming in the area. The North Branch Area feasibility study notes that "[a]ll townships in the North Branch study area are identified as critical habitat within the Southeast Focus Area of the Upper Mississippi River and Great Lakes Region Joint Venture of the North American Waterfowl Management Plan (1992).[39] As such, the area has been selected to receive grants through the North American Wetland Conservation Act because of the potential for, and value to wildlife of, restoring grasslands and wetlands and because some of the highest waterfowl breeding densities come from this area of the state."

It is recommended that the WDNR actively explore opportunities to attain State Project Area designation, similar to that for the North Branch Area,[40] for other land areas recommended for prairie and wetland restoration under this plan. If such designation is achieved, the WDNR should assume the lead role in obtaining, developing, and managing the restoration areas and work with the counties, the NRCS, the Kenosha/Racine Land Trust, the Milwaukee Area Land Conservancy, the Ozaukee-Washington Land Trust, the Waukesha County Land Conservancy, local communities, and local landowners to determine the best land acquisition/easement approach for properties that are considered for wetland and prairie restoration.[41]

The WDNR Milwaukee River Basin Wetlands Assessment Project included development of a Potentially Restorable Wetlands (PRW) data layer that identifies wetland restoration opportunities within the Milwaukee, Menomonee, and Kinnickinnic River watersheds.[42] The PRW data layer could be applied to identify and prioritize possible wetland restoration sites.

MMSD Conservation and Greenway Connection Plans

Implementation of the MMSD Greenseams program is addressed in the previous subsection on implementation of the MMSD 2020 facilities plan.

Restricting Livestock Access to Streams

It is recommended that farmers restrict livestock access to streams through fencing or other means. It is recommended that the WDNR consider increasing levels of cost-share funding to implement such measures.

Management of Milking Center Wastewater

It is recommended that farmers implement measures to ensure proper handling and treatment of milking center wastewater. State cost share funding should be pursued as provided for under Chapter ATCP 50, "Soil and Water Resource Management Program" of the *Wisconsin Administrative Code.*

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[38]*Wisconsin Department of Natural Resources,* North Branch Milwaukee River Wildlife and Farming Heritage Area Feasibility Study*, March 2003.*

[39]*More information on the North American Waterfowl Management Plan can be found on the U.S. Fish and Wildlife Service website at: http://www.fws.gov/birdhabitat/NAWMP/index.shtm.*

[40]*Additional existing WDNR streambank and riparian management areas in the Milwaukee River watershed include the Cedar Creek Streambank Protection Project, the North Branch Milwaukee River Streambank Protection Project, and the Cedarburg Habitat Preservation Project.*

[41]*The Federal Pension Protection Act of 2006 provides tax incentives for donations of conservation easements. At the time of publication of this report, the incentives provided under the Act were scheduled to expire on December 31, 2007 unless extended by Congress. Such tax incentives would be useful in implementing the recommended wetland and prairie restoration measures.*

[42]*Wisconsin Department of Natural Resources,* Milwaukee River Basin Wetland Assessment Project*, June 2006.*

Expanded Oversight and Maintenance of Private Onsite Wastewater Treatment Systems (POWTS)
It is recommended that, at a minimum, county-enforced inspection and maintenance programs be implemented for all new or replacement POWTS constructed after the date on which the counties adopted private sewage system programs. It is also recommended that voluntary county programs be instituted to inventory and inspect POWTS that were constructed prior to the dates on which the counties adopted private sewage system programs. It is recommended that 1) counties continue to regulate POWTS as called for under the *Wisconsin Statutes* and 2) that within each county consideration be given to establishing town utility districts to complement and supplement the activities of the county sanitarian relative to POWTS.[43] Such utility districts would have the authority to impose special assessments and to levy a tax on property or charge fees for the purpose of funding the inspection and maintenance of POWTS.[44] In a situation where a county does not take responsibility for retroactive inventory and enforced maintenance of POWTS constructed prior to the county adoption of a private sewage system program (typically around 1980), the town utility district should consider undertaking such responsibility.[45]

Implementation of the Urban Nonpoint Source Pollution Abatement Plan Component
Designated Management Agencies
The governmental management agencies designated to implement the urban nonpoint source pollution abatement component of the recommended water quality management plan are identified in Table 95. In addition, certain nongovernmental organizations that would have roles in plan implementation are identified. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge County, three management agencies have been designated.

In Fond du Lac County, 14 management agencies have been designated. That total includes one new lake protection and rehabilitation district that is proposed to be established for Mud Lake in the Town of Osceola.

In Kenosha County, two management agencies have been designated.

In Milwaukee County, 21 agencies have been designated.

In Ozaukee County, 16 agencies have been designated. That total includes two new lake protection and rehabilitation districts that are proposed to be established for Spring Lake in the Town of Fredonia and Mud Lake in the Town of Saukville.

In Racine County, 12 agencies have been designated.

In Sheboygan County, 12 agencies have been designated.

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[43]*As noted previously, in some counties existing county programs may be providing the recommended level of oversight of POWTS, and, in these instances, it may not be necessary to form town utility districts.*

[44]*A possible model for establishment of town utility districts is the Town of Bailey's Harbor in Door County. A Town ordinance requires that all POWTS and holding tank waste be brought to the Town wastewater treatment plant. The town requires all septic tanks to be pumped at least every three years. Waste haulers only charge property owners for pumping and hauling. The town charges property owners for treatment based on a flat rate each time the septic or holding tank is pumped plus a charge based on the wastewater volume delivered to the treatment plant. In the case of the towns in the study area, arrangements for treatment of pumped waste would have to be made with nearby wastewater treatment plants.*

[45]*The administration of such oversight programs may be aided by emerging technologies for identification of failing POWTS through remote sensing using color infrared aerial photographic surveys.*

In Washington County, 26 agencies have been designated. That total includes four new lake protection and rehabilitation districts that are proposed to be established for Barton Pond in the City of West Bend, Smith Lake in the Town of Barton, Lake Twelve in the Town of Farmington, and Lucas Lake in the Town of West Bend.

In Waukesha County, nine agencies have been designated.

For the study area as a whole, a total of 121 management agencies have been designated for urban nonpoint source pollution abatement purposes, including State and Federal agencies listed in Table 95.[46] Of this total, all but seven agencies currently exist. The seven new agencies would be lake protection and rehabilitation districts. In addition to the foregoing local government management designations, the WDNR is designated as the management agency with primary responsibility for ensuring the implementation of a major component of the urban nonpoint source pollution abatement plan element through the WPDES permitting process for municipal separate storm sewer systems. The Wisconsin Departments of Commerce and Transportation, the University of Wisconsin-Extension, the U.S. Geological Survey, the U.S. Environmental Protection Agency, and the U.S. Department of Transportation, along with two nongovernmental organizations, Keep Greater Milwaukee Beautiful, Inc., and Friends of Milwaukee's Rivers, would also have roles in implementing urban nonpoint source pollution control recommendations.

Implementation of the Nonagricultural (Urban) Performance Standards of Chapter NR 151

It is recommended that municipalities in the study area implement urban nonpoint source pollution controls consistent with the standards of Chapter NR 151 of the *Wisconsin Administrative Code*. Such controls address construction site erosion; control of stormwater pollution from areas of existing and planned urban development, redevelopment, and infill; and infiltration of stormwater runoff from areas of new development.

Almost all of the cities and villages and many towns in the study area are, or will be, required to meet NR 151 standards to the maximum extent practicable under the conditions of their WPDES municipal stormwater discharge permits. The means of funding such a program is considered to be a local decision. In general, communities have funded such programs through establishment of stormwater utilities, imposition of stormwater fees, or through the *ad valorem* property tax. As set forth in Table 100, about 60 percent of the capital cost and 25 percent of the annual operation and maintenance cost of implementing the controls will be borne by the public sector.

Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems and to Control Urban-Sourced Pathogens that are Harmful to Human Health

To address the threats to human health and degradation of water quality resulting from human-specific pathogens and viruses entering stormwater systems, it is recommended that each municipality in the study area implement a program to detect and eliminate illicit discharges to storm sewer systems as outlined in Chapter X of this report.[47] In addition, to adequately assess the appropriate way to deal with bacteria in stormwater runoff (and the potentially associated pathogens), it is recommended that human health and ecological risk assessments be conducted to address pathogens in stormwater runoff.

It is anticipated that the program outlined above would also identify cases where illicit connections are not the primary source of bacteria, indicating that stormwater runoff is the main source. To adequately assess the appropriate way to deal with such bacteria sources (and the potentially associated pathogens), it is recommended that human health and ecological risk assessments addressing pathogens in stormwater runoff be conducted. It is

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[46]*Because the Village of Newburg is located in both Ozaukee and Washington Counties, it is included above in the total for each county, but it is only counted once in determining the total number of designated management agencies in the study area.*

[47]*Such a program, coupled with the instream monitoring program described in a subsequent subsection, may be useful to better establish the sources of high fecal coliform loads from urban areas.*

not expected that municipalities would conduct individual risk assessments. It is envisioned that such assessments would be done at a watershed scale. Such assessments would be a logical outgrowth of the ongoing MMSD Corridor Study Database program conducted by the MMSD and USGS, and the WDNR could also play a role. In addition to funding provided under that program, additional grant funding could be sought for risk assessment programs to assess sources of pollution.

Depending on the findings of the risk assessments, consideration should be given to pursuing innovative means of identifying and controlling possible pathogen sources in stormwater runoff. If the risk assessments determine that harmful pathogens in stormwater were likely to be present in large enough amounts to present a risk to human health and/or the environment, the identification and control of pathogens in stormwater should be incorporated in the WPDES stormwater discharge permitting program through a cooperative effort of WDNR and permitted units of government, and WDNR should seek additional State grant funding for these purposes under the State Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program.[48]

Chloride Reduction Programs
It is recommended that the municipalities and counties in the study area continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose. It is also recommended that municipalities consider alternatives to current ice and snow control programs, such as applying a sand/salt mix to local roads with enhanced street sweeping in the spring of the year to remove accumulated sand.

Finally, it is recommended that local education programs be implemented to provide information about alternative water softening media and the use of more-efficient water softeners which are regenerated based upon the amount of water used and the quality of the water.

Fertilizer Management
Because the washoff of fertilizer into inland lakes is a significant factor contributing to lake eutrophication, it is recommended that the use of low- or no-phosphorus fertilizers be encouraged in areas tributary to inland lakes and ponds, and that lake protection and rehabilitation districts work with municipalities that include inland lakes to consider adopting low- or no-phosphorus fertilizer ordinances in those areas. It is also recommended that information and education programs required under municipal WPDES stormwater discharge permits promote voluntary practices that optimize urban fertilizer application consistent with the requirements of WDNR Technical Standard No 1100, "Interim Turf Nutrient Management." The University of Wisconsin-Extension and the land conservation staffs of each county should assist in educating the public about fertilizer and pesticide application.

Residential Roof Drain Disconnection from Sanitary and Combined Sewers and Infiltration of Roof Runoff
In an effort to reduce clearwater flows in the separate and combined sewer systems in the study area, it is recommended that programs be implemented to achieve a practical level of disconnection of the residential roof drains that are currently connected to sanitary and combined sewers. It is also recommended that roof drains that are not directly connected to sanitary or combined sewers, but which discharge to impervious areas be redirected to pervious areas where feasible. The number and location of the roof drains which are to be disconnected should be determined with technical advice and guidance from municipalities and residents to consider impacts on private and public sewer infiltration and inflow, residence foundation and basement structural considerations, and icing conditions. It is recommended that consideration be given to directing those roof drains which are to be disconnected to rain barrels and/or rain gardens, with the runoff from those roofs ultimately being infiltrated. The implementation of roof drain disconnection programs is primarily the responsibility of municipalities.

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[48]*That program is described in a subsequent section of this chapter.*

Beach and Riparian Litter and Debris Control Programs
It is recommended that existing litter and debris control programs along Lake Michigan beaches, inland lake beaches, and along the urban streams of the study area be continued and that opportunities to expand such efforts be explored. Existing programs are conducted by several environmental organizations in cooperation with numerous citizen volunteers and volunteer organizations. This recommendation should be implemented through the continued programs of Keep Greater Milwaukee Beautiful, Inc., and its corporate sponsors who stage annual river cleanup programs in Milwaukee, Ozaukee, Washington, and Waukesha Counties; the Friends of Milwaukee's Rivers, who also organize periodic river cleanups; and the counties and municipalities with publicly owned riparian and lakeshore land. The University of Wisconsin-Extension and the land conservation staffs of each county should assist in educating the public about litter control.

Pet Litter Management
It is recommended that all municipalities in the study area have pet litter control ordinance requirements and that those requirements be enforced. The University of Wisconsin-Extension and the land conservation staffs of each county should assist in educating the public about pet waste control.

Marina Waste Management Facilities
To avoid the direct discharge of sewage from holding tanks in recreational boats to the waters of Lake Michigan it is recommended that the Milwaukee County McKinley Marina, the Milwaukee Yacht Club, and the South Shore Yacht Club in the City of Milwaukee, and the Racine Reef Point Marina and other boating facility operators continue to maintain pump-out stations for disposal of those wastes through the public sanitary sewerage system and upgrade or expand those stations as necessary. As noted in a subsequent report section on grants, private marinas or local units of government may apply to the U.S. Fish and Wildlife Service through the WDNR under the Federal Clean Vessel Act for grants to construct, maintain, and operate pump-out and dump stations.

Research and Implementation Projects
The MMSD currently promotes and funds bacteria and pathogen research related to Lake Michigan beaches and characterization of discharges from storm sewer outfalls and it is currently developing and implementing stormwater best management practices (BMP) projects that demonstrate the benefits of BMPs on managing the volume, rate, and quality of stormwater runoff. It is recommended that the MMSD and others continue to support targeted research on bacteria and pathogens and research and implementation of stormwater BMP techniques and programs. It is recommended that research to develop and apply more direct methods of identifying sources of pathogens important to human health also be supported.

Overall Considerations Related to Implementation of Recommendations for Abatement of Pollution from Nonpoint Sources
The implementation of the nonpoint source pollution abatement recommendations of this plan can best be achieved through the WPDES stormwater discharge permitting program; implementation of the related components of the county and municipal comprehensive plans prepared pursuant to Section 66.1001 of the *Wisconsin Statutes*; implementation of the Land and Water Resource Management Plan (LWRMP) programs for the counties in the study area; participation in the USDA Natural Resources Conservation Service and Farm Services Agency agricultural assistance programs; and participation in the WDNR targeted runoff management and urban nonpoint source and stormwater programs. The counties and municipalities in the study area should work together to develop an overall strategy to implement the necessary controls and to involve each of these agencies along with the general public.

Individual landowners are eligible to receive cost-share and technical assistance for nonpoint source pollution abatement measures through County LWRMP programs. These programs utilize funding from DATCP and have provisions for cost-sharing of between 50 and 70 percent of the cost of certain nonpoint source projects provided that the project area is located within an unincorporated portion of the county. Practices that are eligible for cost sharing utilizing State funding are presented in Table 101. The NRCS and FSA have several programs designed to help landowners reduce agricultural nonpoint source pollution. These programs typically share 50 to 100 percent

Table 101

AGRICULTURAL CONSERVATION PRACTICES ELIGIBLE FOR COST-SHARE FUNDING[a]

Conservation Practice	Description
Manure Storage Systems	Manure storage facility and related practices that environmentally and safely store manure
Manure Storage System Closure	Permanently disabling and sealing a leaking or improperly sited manure storage system
Barnyard Runoff Control Systems	Practices used to contain, divert, retard, or control the runoff from concentrated areas of livestock
Access Roads and Cattle Crossings	Road or path to confine or direct livestock or farm equipment
Animal Trails and Walkways	Travel land to facilitate movement of livestock
Contour Farming	Farming along the established grades with the topography
Critical Area Stabilization	Planting vegetation along steep slopes to stabilize soil and prevent erosion
Cover and Green Manure Crops	Close growing vegetation planted after the primary crop to provide cover on the soil surface during the nongrowing season to retard soil erosion
Diversions	A structure used to divert surface runoff to an area where it can be discharged without causing excessive soil erosion
Field Windbreaks	A strip of trees planted adjacent to a cropped field to reduce the impacts of wind erosion
Filter Strips	A strip of grassed vegetation planted to capture sediment and other contaminants
Grade Stabilization Structures	A structure which stabilizes the grade in a channel and helps to prevent gully erosion
Heavy Use Area Protection	Installation of material to control runoff and erosion in areas subject to concentrated or frequent livestock activity. Can be vegetative, or concrete, stone, or geotextile material
Lake Sediment Treatment	Chemical, physical, or biological treatment of polluted lake sediments
Livestock Fencing	Fencing to prevent livestock from accessing erodible areas or to prevent human access from manure storage structures
Livestock Watering Facilities	A means of supplying water to livestock using either a tank, trough, pipe, well, or other means
Milking Center Waste Control Systems	A containment system used to control the discharge of milkhouse waste
Nutrient and Pesticide Management	Controlling the amount and location of applied plant nutrients and pesticides used in crop production
Prescribed Grazing	A grazing system which divides pastures into multiple cells each of which is grazed intensively and then protected from grazing
Relocating or Abandoning Animal Feeding Operations	Disabling or moving a feedlot that is on an environmentally sensitive site
Residue Management	Maintaining vegetative residue to resist soil erosion
Riparian Buffers	An area in which vegetation is enhanced or established to control sedimentation and discharge of nutrients into surface and groundwater resources
Roofs	A structure that shields an animal lot or manure storage structure from precipitation
Roof Runoff Systems	Facilities designed to collect, divert, and dispose of runoff from roofs
Sediment Basins	Permanent basins designed to capture soil, manure, sediment, and other debris
Shoreline Habitat Restoration for Developed Areas	Establishment of a shoreline buffer zone of diverse native vegetation that extends inland from the ordinary high water mark
Sinkhole Treatment	Modifying a sinkhole or the adjacent area to reduce erosion, prevent expansion of the hole, and reduce water pollution
Streambank and Shoreline Protection	Use of vegetation or structures to protect streambanks, lakes, and other shorelines from the effects of scour and erosion

Table 101 (continued)

Conservation Practice	Description
Strip-Cropping	Growing alternating crops adjacent to one another in small strips, so that legumes or grasses are planted next to traditional row crops or fallow land
Subsurface Drains	A conduit installed below the surface to collect drainage and convey it to a suitable outlet
Terrace Systems	System of ridges and channels installed on the contour designed to shorten the slope length and reduce the impacts of erosion
Underground Outlets	A conduit installed below the surface to collect drainage and convey it to a suitable outlet
Waste Transfer Systems	The components used to convey manure and milking center wastes to storage structures, loading or treatment areas
Wastewater Treatment Strips	An area of herbaceous vegetation used to remove pollutants from animal lot runoff or wastewater
Water and Sediment Control Basins	An earthen embankment installed across a slope or minor channel to collect water and trap sediment
Waterway Systems	A grassed watercourse that is graded and shaped and is designed to help prevent rill and gully erosion
Well Decommissioning	Permanently disabling and sealing a well to prevent groundwater contamination
Wetland Development or Restoration	The construction of berms or the destruction of tile lines to create conditions suitable for wetland vegetation

[a]*According to Chapter ATCP 50 and Chapter NR 154 of the* Wisconsin Administrative Code*.*

Source: Wisconsin Department of Agriculture, Trade, and Consumer Protection; Wisconsin Department of Natural Resources; and SEWRPC.

of the cost of installation of a best management practice, depending on the type of program. Specific details on USDA NRCS and FSA programs are presented in Tables 102 and 103.

Municipalities are eligible for nonpoint source pollution abatement program funding through the WDNR targeted runoff management grant program and the urban nonpoint source and stormwater grant program. Under these programs, projects are evaluated through a competitive process, with a maximum State cost-share rate of up to 70 percent of eligible urban and rural projects. It is recommended that individual landowners and municipalities take advantage of these programs to help reduce the effects of nonpoint source pollution. It is also recommended that the nonpoint source pollution abatement plan be coordinated with local, detailed stormwater management plans for urban and urbanizing subwatersheds.

Implementation of the Instream Water Quality Measures Plan Subelement

Designated Management Agencies

The governmental management agencies designated to implement the instream water quality measures component of the recommended water quality management plan are identified in Table 96. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge County, three management agencies have been designated.

In Fond du Lac County, 10 management agencies have been designated.

In Kenosha County, two management agencies have been designated.

In Milwaukee County, 22 agencies have been designated.

In Ozaukee County, 14 agencies have been designated.

Table 102

CHARACTERISTICS OF USDA FINANCIAL ASSISTANCE PROGRAMS

Program	Contract Length	Sign-Up Period	Cost-Share	Rental or Tillage Payments	Practices Suitable for Program	Amount of Land
Conservation Reserve Program (CRP)	10 or 15 years	Continuous or once a year	50 percent	A specified dollar amount per acre based upon soil type	Permanent pasture, buffer strips, grassed waterways, windbreaks, trees	Small sensitive areas along stream corridors to large tracts of land
Conservation Reserve Enhancement Program (CREP)	15 years or perpetuity	Continuous, expiring on December 21, 2007, unless extended	110 percent plus lump sum incentive payments depending on length of easement.	135 to 160 percent of the dry land cash rental rate for the county in question	Permanent introduced and/or native grasses, grassed waterways, filter strips, riparian buffers, wetland restoration, rare and declining habitat, wildlife habitat on marginal pasture land	Site-specific; small to large areas
Environmental Quality Incentive Program (EQIP)	Five to 10 years	Twice a year	Up to 75 percent	$18.50 per acre for three years	Livestock waste management, erosion and sediment control, habitat improvement, groundwater protection	Designed for the whole farm, not just small areas of the farm
Wildlife Habitat Incentives Program (WHIP)	10 years	Continuous	Up to 75 percent	- -	Instream structures for fish habitat, prairie restoration, wildlife travel lanes, wetland scrapes	Site- and species-specific; small to large areas
Wetland Reserve Program (WRP)	10 years, or 30-year and permanent easements	Continuous	Up to 100 percent	Variable; up to $1,000 per acre of assessed value if placed into a permanent easement (one time payment)	Wetland restoration	Variable

Source: U.S. Department of Agriculture Natural Resources Conservation Service and SEWRPC.

In Racine County, 12 agencies have been designated.

In Sheboygan County, 10 agencies have been designated.

In Washington County, 17 agencies have been designated.

In Waukesha County, nine agencies have been designated.

For the study area as a whole, a total of 104 management agencies have been designated for instream water quality management purposes, including State and Federal agencies listed in Table 96.[49] All of those agencies

[49]*Because the Village of Newburg is located in both Ozaukee and Washington Counties, it is included above in the total for each county, but it is only counted once in determining the total number of designated management agencies in the study area.*

Table 103

CONSERVATION PRACTICES AND AVAILABLE USDA PROGRAMS

Conservation Practice	CRP	CREP	EQIP	WRP	WHIP
Vegetative Buffers or Riparian Buffers	X	X	X	- -	- -
Grassed Waterways	X	X	- -	- -	- -
Contour Grass Strips	X	- -	- -	- -	- -
Permanent Pasture	X	X	X	- -	- -
Conservation Tillage	X	- -	X	- -	- -
Conservation Cropping	- -	- -	X	- -	- -
Contour Farming	- -	- -	X	- -	- -
Cover Crops	- -	- -	X	- -	- -
Diversions	- -	- -	X	- -	- -
Fish Habitat Improvement	- -	- -	X	- -	X
Windbreaks	X	- -	X	- -	- -
Nutrient Management	- -	- -	X	- -	- -
Pest Management	- -	- -	X	- -	- -
Wetland Restoration	- -	X	X	X	- -
Stream Fencing	- -	- -	X	- -	- -
Manure Management	- -	- -	X	- -	- -
Upland Habitat	- -	X	X	X	X
Wetland Habitat	- -	X	X	X	X
Wildlife Ponds	X	- -	X	X	- -

Source: U.S. Department of Agriculture Natural Resources Conservation Service, Wisconsin Department of Natural Resources, and SEWRPC.

currently exist. The Wisconsin Departments of Natural Resources and Transportation and the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, the U.S. Department of Transportation, and the U.S. Army Corps of Engineers would also have roles in implementing the recommended instream measures.

Hydrologic and Hydraulic Management

Concrete Channel Renovation and Rehabilitation

Recommendations regarding the implementation of the proposed MMSD concrete channel renovation and rehabilitation projects were previously set forth in the section on implementation of the MMSD 2020 facilities plan.

Renovation of the MMSD Kinnickinnic River Flushing Station

Implementation considerations for the Kinnickinnic River flushing station were previously set forth in the section on implementation of the MMSD 2020 facilities plan.

Dams

Historically, consideration of dam abandonment and removal has usually come about because of a failure incident or as the result of a WDNR inspection which found significant defects that require major repairs to correct. Thus, the WDNR is the primary agency responsible for ordering dam abandonments and for permitting such abandonments, which are implemented in conjunction with individual dam owners. It is recommended that WDNR require that abandonment and associated riverine area restoration plans be prepared as part of the design of new, or reconstructed, dams and prior to abandonment of existing dams.

Culverts, Bridges, Drop Structures, and Channelized Stream Segments

The plan recommendations regarding culverts, bridges, drop structures and channelized stream segments can be summarized as:

- Stream crossings and management strategies should be limited to the extent practicable,

- Where crossings are required, they should be designed to allow the passage of aquatic organisms,

- When opportunities arise, such as at the time of reconstruction of roadways and highways, "ecosystem-friendly" design standards such as those set forth in Appendix P should be considered,

- Barriers to fish passage such as culverts and drop structures should be removed where practicable, and

- To the extent practicable, existing hydraulic structures should be replaced with "ecosystem-friendly" structures based on the design standards and criteria included in Appendix P.

The WDNR as the permitting authority under Chapters 30 and 31 of the *Wisconsin Statutes*; the Wisconsin Department of Transportation; the U.S. Department of Transportation, Federal Highway Administration; and County and local engineering and public works departments should consider these recommendations in the design, review, and approval of projects involving culverts, bridges, drop structures, and stream channelization.

Restoration and Remediation Programs
It is recommended that the WDNR be the lead agency responsible for management of the following contaminated sediment sites:

- A five-mile segment of Cedar Creek in Cedarburg, Zeunert Pond in Cedarburg,

- Thiensville Millpond,

- Estabrook Impoundment,

- The Milwaukee Harbor Estuary Area of Concern, and

- The ongoing remediation projects for the Moss-American Superfund site along the Little Menomonee River and the Kinnickinnic River Environmental Restoration Project located in the Kinnickinnic River between S. Kinnickinnic Avenue and W. Becher Street.

Ideally, remediation efforts should be coordinated from upstream to downstream to minimize downstream transport of contaminants; however, this concern alone should not serve as a barrier should an opportunity arise to remediate a downstream site. In support of this, it is recommended that WDNR give consideration to extending the Milwaukee Harbor Estuary Area of Concern to include the Moss-American Superfund site and the contaminated portions of Cedar Creek in Cedarburg. It is also recommended that implementation of the Milwaukee Estuary Remedial Action Plan be continued and supported.

Fisheries Protection and Enhancement
The following recommendations are made to supplement or reinforce related recommendations set forth above to control point and nonpoint sources of pollution, to establish riparian buffers, and to restore and rehabilitate stream channels where feasible. Implementation of the recommendations would help to protect and reestablish a high-quality native warmwater and/or coldwater fishery where appropriate.

1. To the extent practicable, protect remaining natural stream channels, including small tributaries and shoreland wetlands.

2. Restore wetlands, woodlands, and grasslands adjacent to the stream channel and establish minimum buffers 75 feet in width to reduce pollutant loads entering the stream and protect water quality.[50]

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[50]*See the previous subsections in this chapter regarding implementation considerations for riparian buffers and conversion of cropland and pasture to wetlands and prairies.*

3. Restore, enhance, and/or rehabilitate stream channels to provide increased quality and quantity of available fisheries habitat—through improvement of water quality, shelter/cover, food production, and spawning opportunities—using management measures that include, but are not limited to:[51]

    - Minimize the number of stream crossings and other obstructions to limit fragmentation of stream reaches.

    - Stabilize stream banks to reduce erosion.

    - Limit instream sedimentation and selectively remove excessive silt accumulations.

    - Reestablish instream vegetation and bank cover to provide fish with shelter from predators, food, spawning areas, and protection from floods.

    - Realign channelized reaches of streams and remove concrete lining to provide heterogeneity in depth (e.g., alternating riffle and pool habitat), velocity or flow regime, and bottom substrate composition.

    - As opportunities arise when roadways crossing streams are replaced or reconstructed, remove or retrofit obstructions such as culverts, dams, and drop structures that limit the maintenance of healthy fish and macroinvertebrate populations.

4. Monitor fish and macroinvertebrate populations in order to evaluate the effectiveness of the water quality management program.[52]

5. Consider more intensive fisheries manipulation measures—in terms of removal of exotic carp species and/or stocking of gamefish or other native species—where warranted based upon specific goals and objectives established for each project site, reach, or subwatershed, based on detailed local level planning, throughout the study area.

In general, it is recommended that the WDNR assume overall responsibility for implementing the recommended measures for fisheries protection and enhancement. However, successful implementation of the fishery and stream restoration measures will require the active participation of Federal and State agencies, county and local governments, and landowners. As stated previously in this chapter, Dodge, Fond du Lac, Ozaukee, Racine, and Waukesha Counties should work with the FSA, NRCS, WDNR, and DATCP to aggressively promote enrollment of agricultural land in CREP, with emphasis on those lands identified on Maps 74 through 76 in Chapter X of this report, as being candidates for the establishment or expansion of riparian buffers. Landowners can seek cost-share funding for the establishment of buffers through the program described in Chapter NR 154 of the *Wisconsin Administrative Code.*

As noted previously, it is recommended that the WDNR actively explore opportunities to attain State Project Area designation for the recommended prairie and wetland restoration areas, and that the WDNR work with the counties, the NRCS, the Kenosha/Racine Land Trust, the Milwaukee Area Land Conservancy, the Ozaukee-Washington Land Trust, the Waukesha County Land Conservancy, local communities, and local landowners to determine the best land acquisition/easement approach for properties that are considered for wetland and prairie restoration.

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[51]*See the previous subsections in this chapter regarding implementation considerations for watercourse-related plan elements.*

[52]*See the "Water Quality Monitoring" subsection of the auxiliary water quality management plan subelement.*

Finally, as roadways crossing streams are replaced or reconstructed, the Wisconsin Department of Transportation and county and local public works departments should consider removal or modification of obstructions to the passage of aquatic life along streams

Implementation of the Inland Lake Water Quality Measures Plan Subelement

Designated Management Agencies

The governmental management agencies designated to implement the inland lake water quality measures component of the recommended water quality management plan are identified in Table 97. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge, Kenosha, and Racine Counties, no management agencies have been designated.

In Fond du Lac County, seven management agencies have been designated. That total includes one new lake protection and rehabilitation district that is proposed to be established for Mud Lake in the Town of Osceola.

In Milwaukee County, one agency has been designated.

In Ozaukee County, five agencies have been designated. That total includes two new lake protection and rehabilitation districts that are proposed to be established for Spring Lake in the Town of Fredonia and Mud Lake in the Town of Saukville.

In Sheboygan County, five agencies have been designated.

In Washington County, 14 agencies have been designated. That total includes four new lake protection and rehabilitation districts that are proposed to be established for Barton Pond in the City of West Bend, Smith Lake in the Town of Barton, Lake Twelve in the Town of Farmington, and Lucas Lake in the Town of West Bend.

In Waukesha County, one agency has been designated.

For the study area as a whole, a total of 35 management agencies have been designated for inland lake management purposes, including State agencies listed in Table 97. Of this total, all but seven agencies currently exist. The seven new agencies would be lake protection and rehabilitation districts. The WDNR and the University of Wisconsin-Extension would also have important roles in implementing inland lake management measures.

Implementation Recommendations

The regional water quality management plan update recommendations regarding inland lakes, which are set forth in Appendix Q or previously in this chapter in the subsection on nonpoint source pollution abatement, can be summarized as follows:

- It is recommended that lake plans be prepared for the 17 major lakes within the greater Milwaukee watersheds for which such plans have not been prepared. Those lakes include Auburn, Crooked, Forest, Kettle Moraine, Long, Mauthe, and Mud Lakes in Fond du Lac County; Mud and Spring Lakes in Ozaukee County; Lake Ellen and Random Lake in Sheboygan County; and Barton Pond, Lake Twelve, and Green, Lucas, Smith, and Wallace Lakes in Washington County. Lake plans have been prepared for Big Cedar, Little Cedar, and Silver Lakes in Washington County, and those plans should be updated in the future as necessary.

- The preparation of lake plans should also be considered for minor lakes of less than 50 surface acres in areal extent, including the Milwaukee County ponds and lagoons, where such measures are deemed important for purposes of water quality protection.

- It is also recommended that Milwaukee County pursue implementation of the recommendations in its 2005 pond and lagoon management plan.

- The recommendations of the Washington and Waukesha County lake and stream classification projects are incorporated by reference in the regional water quality management plan update.

- It is recommended that 1) the priority watershed pollutant reductions for areas tributary to the lakes described in Appendix Q be achieved for the applicable pollutants and 2) the reductions recommended under the initial regional water quality management plan be achieved for other nonpoint source pollutants.

- It is recommended that the use of low- or no-phosphorus fertilizers be encouraged in areas tributary to inland lakes and ponds,

- It is recommended that long-term-trend lake monitoring programs be established or continued for the major lakes of the study area (see Appendix Q and the subsequent monitoring subsection of this chapter for further detail regarding monitoring),

- It is recommended that a community-based informational program be implemented, and

- It is recommended that land use changes be reviewed and evaluated for potential lake-related impacts at the time planning and zoning decisions are made.

Implementation of many of these recommendations could best be achieved through the actions of Lake Protection and Rehabilitation Districts, Sanitary Districts, Lake Associations, "friends" groups, or property owners associations. Agencies designated for implementation are indicated in Table 97. Those lakes for which at least one of those entities have been established are set forth in Table 92. Those lake organizations should take the lead in preparing lake management plans, incorporating the recommendations of this regional water quality management plan update in those plans, and in implementing the recommendations of this plan and of future lake management plans. It is recommended that the University of Wisconsin Extension (UWEX) Lakes Partnership take the lead in promoting the establishment of appropriate lake organizations for Mud Lake (Fond du Lac County); Mud Lake (Ozaukee County); Spring Lake; Barton Pond; Lake Twelve; and Green, Lucas, and Smith Lakes. Because most, or all, of the shorelines of Auburn, Crooked, and Mauthe Lakes are located in the Northern Unit of the Kettle Moraine State Forest, it is recommended that WDNR take responsibility for preparation of management plans for those lakes. Applicable grant funding sources for preparation of lake plans are described in a subsequent section of this chapter dealing with financial and technical assistance.

Lake communities, through municipal governments or lake organizations, should develop and deliver informational and educational programs involving both the community and local schools. Many informational materials are available without charge or at a nominal charge from various agencies and organizations, such as the WDNR and UWEX. Project WET, or Water Education for Teachers, is run through the WDNR. The educational programming may involve periodic seminars and other programs for homeowners and landscape contractors, among others, at which environmentally friendly design options applicable to shoreland zones are presented.

Consistent with the overall recommendations of the regional water quality management plan update regarding maintenance and expansion of water quality monitoring programs within the study area, lake associations and public inland lake protection and rehabilitation districts should continue to participate in the WDNR Self-Help Monitoring Program as administered through the UWEX Citizen Lake Monitoring Program. These programs as applied to individual lakes should be conducted by lake organizations, with some of the monitoring program costs ideally being offset through grant programs, such as the Chapter NR 190 lake management planning grant program.

Lake organizations should work with municipalities that include inland lakes to consider adopting low- or no-phosphorus fertilizer ordinances.

City, village, and town plan commissions and county planning departments, as appropriate, should consider lake-related impacts when zoning decisions are made.[53]

Implementation of Auxiliary Water Quality Management Plan Subelement

Designated Management Agencies

The governmental management agencies designated to implement the auxiliary lake water quality measures component of the recommended water quality management plan are identified in Table 98. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge County, one management agency has been designated.

In Fond du Lac County, five management agencies have been designated. That total includes one new lake protection and rehabilitation district that is proposed to be established for Mud Lake in the Town of Osceola.

In Kenosha County, one management agency has been designated.

In Milwaukee County, 10 management agencies have been designated.

In Ozaukee County, three agencies have been designated. That total includes two new lake protection and rehabilitation districts that are proposed to be established for Spring Lake in the Town of Fredonia and Mud Lake in the Town of Saukville.

In Racine County, four agencies have been designated.

In Sheboygan County, four agencies have been designated.

In Washington County, 11 agencies have been designated. That total includes four new lake protection and rehabilitation districts that are proposed to be established for Barton Pond in the City of West Bend, Smith Lake in the Town of Barton, Lake Twelve in the Town of Farmington, and Lucas Lake in the Town of West Bend.

In Waukesha County, one agency has been designated.

For the study area as a whole, a total of 49 management agencies have been designated for auxiliary water quality management purposes, including Regional, State, and Federal agencies listed in Table 98. Of this total, all but seven agencies currently exist. The seven new agencies would be lake protection and rehabilitation districts. The Wisconsin Department of Administration Coastal Zone Management Program, WDNR, the University of Wisconsin-Extension, the University of Wisconsin Sea Grant Program, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, the U.S. Environmental Protection Agency, and the National Oceanic and Atmospheric Administration, along with two nongovernmental organizations, the Riveredge Nature Center and Friends of Milwaukee's Rivers, would also have roles in implementing auxiliary water quality management measures.

Public Beaches

The recommendations regarding public beaches may be summarized as follows:

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[53]*The civil division in which each major lake in the study area is located is given in the lake descriptions set forth in Appendix Q.*

- Current public health monitoring programs at public beaches along Lake Michigan and inland waterbodies should be maintained, and where possible, expanded to include public beaches that are not currently monitored,

- Beaches with high frequencies of closings and water quality advisories should be evaluated for local sources of contamination, and appropriate remedies should be implemented,

- Sanitary surveys to identify sources of pollution should be performed at beaches with high bacteria counts, and

- Current programs of beach grooming should be continued and expanded to beaches currently not groomed.

The monitoring and sanitary survey recommendations should be implemented by local health departments and implementation of remedies and beach grooming should be the responsibility of municipal or county departments of parks, public works, and/or engineering. Grant funding for beach water quality monitoring and notification should be available to the State of Wisconsin and municipalities through the Beaches Environmental Assessment and Coastal Health Act grant program.

Waterfowl Control
Programs to discourage unacceptably high numbers of waterfowl from congregating near beaches and other water features should be implemented by the municipal agencies responsible for maintenance of the beaches and water features.

Coastal Zone Management
The USEPA, in partnership with the WDNR Office of the Great Lakes, the Wisconsin Department of Administration Coastal Zone Management Program, the University of Wisconsin Sea Grant Program, and other Great Lakes states, should continue to implement and refine the Lakewide Management Plan.

Water Pollution Control
Household Hazardous Waste Collection
It is recommended that collection programs for household hazardous wastes such as those currently conducted by MMSD and most counties and several municipalities within the greater Milwaukee watersheds be continued and supported. In addition, it is recommended that those communities not served by such programs consider developing and instituting them.

Emerging Issues
Pharmaceuticals and Personal Care Products
It is recommended that the MMSD continue to fund its programs conducted with the USGS to assess and evaluate the significance for human health and for aquatic and terrestrial wildlife of the presence of pharmaceuticals and personal care products in surface waters. MMSD should also continue to support the periodic collection of pharmaceuticals as part of its Household Hazardous Waste Collection program and counties and municipalities not included in the MMSD program should consider implementing such collection programs.

Exotic Invasive Species
Programs to educate the public about exotic invasive species and to reduce the spread of exotic invasive species to inland waters should be continued and supported. The WDNR should continue its responsibility for such programs through its Watercraft Inspection and Clean Boats and Clean Waters Programs, and the University of Wisconsin-Sea Grant Institute, University of Wisconsin-Extension, and the Wisconsin Association of Lakes should continue to sponsor aquatic invasive species educational materials, workshops, and the outreach programs. The Southeastern Wisconsin Cooperative Invasive Species Management Area program may also be able to provide assistance in coordinating activities to reduce the spread of invasive species to inland waters.

Water Temperature and Thermal Discharges
It is recommended that the WDNR develop a policy regarding water temperatures and thermal discharges into waterbodies.

Global Climate Change
When this plan is updated in the future, the Regional Planning Commission should consider data on precipitation patterns and frequency and streamflow data gathered after the time period for this plan and compare those data to the historical record in an effort to represent effects of climate change in the analyses which support the planning effort.

Water Quality Monitoring
As described in detail in Chapter X of this report and in SEWRPC Technical Report No. 39, *Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*, considerable effort is currently being expended on monitoring in some portions of the greater Milwaukee watersheds study area. The MMSD has conducted a long-term monitoring program in the areas that it serves since 1979, compiling an extensive database that has been supplemented by the MMSD/USGS Corridor Study. The data that would be obtained by continued monitoring at the stations in this network is vital both for evaluating the effectiveness of this plan and for designing future refinements of this plan.

The U.S. Geological Survey (USGS) monitors stream flow at several gages in the greater Milwaukee watersheds study area. The USGS also conducts water quality monitoring at several sampling sites.

The WDNR currently conducts water quality sampling and samples fish and macroinvertebrate populations at sites within the study area as a part of its statewide baseline monitoring and at specifically targeted sites. In addition, the WDNR monitors water quality at two sites within the study area as part of its “long term trend for ambient water quality monitoring program.”

Additional surface water quality monitoring has been conducted by a number of organizations including local units of government, lake and stream groups, and colleges and universities, though much of this monitoring has been conducted on a short-term basis.

The surface water quality monitoring programs currently being conducted by the WDNR, the USGS, and the MMSD should be supported and continued, and those agencies should refine their monitoring strategies to address some of the data gaps identified in Chapter X. This refinement should give priority to maintaining long-term trend stations prior to the addition of new monitoring sites.

The USGS should seek continued and expanded funding from cooperating agencies to maintain its existing stream gauging program and to expand that program to include water quality and quantity stream gauging monitoring programs at the USGS sampling stations established or reinstated in the Milwaukee and Root River watersheds for this update of the regional water quality management plan.[54] Those stations are shown on Maps 46 and 48 in Chapter V of this report. It is recommended that the agencies listed in Table 104 as cooperators with the U.S. Geological Survey continue to fund half of the operating cost of the continuous streamflow gages indicated in the table.

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[54]*A pilot study to examine current water quality monitoring in the Lake Michigan basin was underway as of the date of publication of this report. The study results will contribute to the development of the National Water Quality Monitoring Network for U.S. Coastal Waters and their Tributaries (also known as the National Monitoring Network (NMN)). The Great Lakes Commission was coordinating the study through the Lake Michigan Monitoring Coordination Council in partnership with the USEPA, USGS, and the Great Lakes Observing System. This study and anticipated follow-up studies may present opportunities to expand the water quality monitoring network in the greater Milwaukee watersheds study area.*

Table 104

STREAMFLOW GAGING STATIONS IN THE STUDY AREA: 2007

Gaging Station Number	Gaging Station Name	Cooperating Agency
040871488	Whitnall Park Creek	Milwaukee County
040871473	Whitnall Park Creek	Milwaukee County
040871475	Whitnall Park Creek	Milwaukee County
040871476	Holmes Avenue Creek	Milwaukee County
04086600	Milwaukee River at Pioneer Road	Milwaukee Metropolitan Sewerage District
04087000	Milwaukee River at Milwaukee	Milwaukee Metropolitan Sewerage District
04087030	Menomonee River at Menomonee Falls	Waukesha County
04087088	Underwood Creek at Wauwatosa	Milwaukee Metropolitan Sewerage District
04087120	Menomonee River at Wauwatosa	Milwaukee Metropolitan Sewerage District
04087159	Kinnickinnic River at Milwaukee	Milwaukee Metropolitan Sewerage District
04087204	Oak Creek at South Milwaukee	Milwaukee Metropolitan Sewerage District
04087220	Root River near Franklin	Milwaukee Metropolitan Sewerage District
04087233	Root River Canal near Franklin	Milwaukee Metropolitan Sewerage District
04087240	Root River at Racine	City of Racine
04086500	Cedar Creek at Cedarburg	Wisconsin Department of Natural Resources
04087170	Milwaukee River at Jones Island	Wisconsin Department of Natural Resources

Source: U.S. Geological Survey and SEWRPC.

The USGS and its cooperators (Milwaukee County, MMSD, and WDNR) should consider extending operation of short-term sampling stations on Mitchell Field Drainage Ditch, Wilson Park Creek, Holmes Avenue Creek, and the Little Menomonee River to provide long-term data.

As described in Chapter X to maximize the usefulness of the data collected, the USGS, MMSD, and WDNR should obtain data on water temperature and pH whenever ammonia is sampled. Similarly, it is recommended that samples assessed for concentrations of cadmium, chromium, copper, lead, nickel, or zinc also be examined for hardness. In addition, it is recommended that those water quality parameters that can be assessed at relatively low cost and effort should always be examined in any sampling. Examples of these parameters include those that can be examined through the use of electronic meters such as dissolved oxygen, pH, specific conductance, and temperature as well as those that can be examined through the use of relatively inexpensive equipment, such as Secchi depth.

The WDNR, in cooperation with the USGS and MMSD, should establish and maintain 1) long-term fisheries monitoring stations and should conduct fisheries surveys to assess species composition and toxicant loads at least every two years and 2) long-term macroinvertebrate monitoring stations and should conduct periodic sampling to assess species composition of invertebrates at least every two years. Also, the WDNR should establish and maintain long-term habitat monitoring stations and should conduct surveys at these stations periodically to assess habitat quality and streambed and streambank stability.

Lake organizations and the WDNR should conduct aquatic plant habitat assessments within lakes and should strive to integrate those assessments with fishery survey assessments. Where aquatic plant management measures are being implemented, aquatic plant surveys should be conducted and updated every three to five years, consistent with the requirements for aquatic plant harvesting operations as set forth in Chapter NR 109 of the *Wisconsin Administrative Code*. The WDNR and lake organizations in conjunction with the USGS should establish long-term trend inland lake monitoring programs. Lake organizations should seek funding for such monitoring through the Chapter NR 190 lake management planning grant program.

The WDNR and the National Oceanic and Atmospheric Administration Great Lakes Environmental Research Laboratory should continue to monitor and document the occurrence and spread of exotic and invasive species in streams, inland lakes, and Lake Michigan.

The USEPA, USGS, WDNR, MMSD, and citizen-based water quality monitoring programs[55] should continue to consolidate data from various monitoring programs to facilitate evaluation of temporal and spatial variation and trends in water quality and should adopt common quality assurance and quality control procedures and sampling and analysis protocols should be standardized across monitoring programs, including both agency programs and citizen-based programs.

The findings of those monitoring programs should be set forth in reports prepared on an annual basis, and the monitoring data should be made available to agencies involved in plan implementation in a form that is readily usable and can be integrated with data from other monitoring programs. Within the MMSD planning area, it is recommended that data collected by the MMSD, USGS, USEPA, and WDNR, and from citizen-based monitoring programs, as sampling protocols and quality control procedures are upgraded over time, continue to be incorporated in the MMSD/USGS Corridor Study database.

Maintenance of the Regional Water Quality Management Plan Update/MMSD 2020 Facilities Plan Modeling System

Models of the MMSD System

The MMSD should continue to maintain the conveyance system modeling tools, use them for subsequent analysis, and update them at least every 10 years. The modeling tools developed as a part of the 2020 facilities plans include the Hydrological Simulation Program - FORTRAN (HSPF) model, the Flow Forecasting System (FFS) model, the Streamlined-MOUSE model, and the MACRO model.

Watershedwide Models Developed for the Regional Water Quality Management Plan

The watershedwide riverine water quality model (LSPC), and the hydrodynamic (ECOMSED) and water quality (RCA) models of the Milwaukee Harbor estuary and the nearshore Lake Michigan area should be maintained by SEWRPC and updated or refined under future water quality management planning efforts in the study area. It is also recommended that the MMSD and SEWRPC coordinate maintenance of the watershedwide and MMSD models so that the ability is maintained to transfer data from the MMSD system models to the watershed models.

GROUNDWATER QUALITY MANAGEMENT PLAN ELEMENT

The major groundwater quality management recommendations relate to groundwater recharge areas, groundwater sustainability, mapping of groundwater contamination potential, stormwater management measures affecting groundwater quality, issues related to the effects of emergency and unregulated contaminants on groundwater quality, and water conservation. The recommended actions discussed under this plan element are summarized in Table 82 in Chapter X of this report. Capital costs for this plan element are set forth in Table 100. In Appendix R, public sector costs are apportioned among municipalities in the study area and agencies with plan implementation responsibilities.

Implementation of the Groundwater Management Plan Element

Designated Management Agencies

The governmental management agencies designated to implement the groundwater management component of the recommended water quality management plan are identified in Table 99. For those municipalities located outside the Southeastern Wisconsin Region in Dodge, Fond du Lac, and Sheboygan Counties, the management agency designation is advisory only.

In Dodge County, two management agencies have been designated.

In Fond du Lac County, 10 management agencies have been designated.

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[55]*Citizen-based programs include the WDNR's Wisconsin Citizen Lake Monitoring Network, the UW-Extension's Water Action Volunteers Program, Riveredge Nature Center's Testing the Waters Program, and the Friends of Milwaukee's Rivers monitoring program.*

In Kenosha County, two management agencies have been designated.

In Milwaukee County, 20 agencies have been designated.

In Ozaukee County, 14 agencies have been designated.

In Racine County, 12 agencies have been designated.

In Sheboygan County, 10 agencies have been designated.

In Washington County, 17 agencies have been designated.

In Waukesha County, nine agencies have been designated.

For the study area as a whole, a total of 95 management agencies have been designated for groundwater management purposes.[56] All of those agencies currently exist.

Relationship to Other Regional Planning Efforts
As noted in Chapter III of this report, "Existing and Historical Surface Water and Groundwater Conditions," and in Chapter XI, "Groundwater Quality Conditions and Sources of Pollution in the Study Area," of SEWRPC Technical Report No. 39, this regional water quality management plan update was conducted concurrently with the regional water supply study documented in SEWRPC Planning Report No. 52, *A Regional Water Supply Plan for Southeastern Wisconsin*. In general, the recommendations of the regional water supply plan related to sustainable groundwater management are adopted by reference in the plan described herein.

Specific plan implementation considerations related to groundwater recharge areas, groundwater sustainability, mapping of groundwater contamination potential, stormwater management measures affecting groundwater quality, issues related to the effects of emergency and unregulated contaminants on groundwater quality, and water conservation are set forth below.

Groundwater Recharge Areas
Because of the interchange of flow between the shallow aquifer and the streams and lakes of the study area, maintaining the quality and quantity of groundwater in the shallow aquifer has a direct bearing on the quality of surface water resources. The most important groundwater recharge areas in that portion of the study area within the Region were identified and mapped under the SEWRPC regional water supply plan.

It is recommended that the groundwater recharge area mapping be extended to those portions of the regional water quality management plan update study area outside of the Southeastern Wisconsin Region. It is recommended that Dodge, Fond du Lac, and Sheboygan Counties consider a cooperative effort to map recharge areas in the Milwaukee River watershed within those counties. The Wisconsin Geological and Natural History Survey (WGNHS) and the U.S. Geological Survey (USGS) may be of assistance in that effort. It is also recommended that all municipalities and counties in the study area consider following the recommendations of the regional water supply plan regarding maintenance of groundwater recharge areas in the study area.

Groundwater Sustainability
As described in Chapter X, under the regional water supply planning process, groundwater sustainability analyses were made for six selected demonstration areas, each selected to represent a range of hydrogeologic conditions. It is recommended that the groundwater sustainability guidance results be considered by municipalities in the

[56]*Because the Village of Newburg is located in both Ozaukee and Washington Counties, it is included above in the total for each county, but it is only counted once in determining the total number of designated management agencies in the study area.*

regional water quality plan update study area in evaluating the sustainability of proposed developments and in conducting local land use planning.

Mapping Groundwater Contamination Potential

As shown on Map 42 in Chapter IV of this report, the groundwater contamination potential of shallow aquifers in the Southeastern Wisconsin Region was mapped under the SEWRPC regional groundwater program. It is recommended that the groundwater contamination potential of the shallow aquifers be mapped in Dodge, Fond du Lac, and Sheboygan Counties. Once again, the WGNHS and the USGS may be of assistance in that effort

Stormwater Management Measures Affecting Groundwater Quality

It is recommended that municipalities and counties in the study area consider the potential impacts on groundwater quality when reviewing the design of stormwater management facilities that directly or indirectly involve infiltration of stormwater. Such consideration should include application of the WDNR post-construction stormwater management technical standards for site evaluation for stormwater infiltration facilities, including special safeguards to avoid adverse effects of chlorides on groundwater quality.

Groundwater Quality Issues Related to Disposal of Emergency and Unregulated Contaminants

Implementation of the previously stated recommendation that counties and municipalities not included in the MMSD program to collect potentially harmful pharmaceuticals and personal care products consider establishing such collection programs would serve to help protect groundwater quality as well as surface water quality.

Water Conservation

Consistent with the regional water supply plan, this water quality management plan update recommends that utility- or community-specific water conservation programs be developed and implemented based upon a number of factors, including the composition of the community water users, the operational characteristics of the utility, the level of efficiency already being achieved, the water supply infrastructure in place, that is needed to meet future demands, and the sustainability of the water supply. Another factor which should be considered is the need to develop water conservation programs which are consistent with current and anticipated future rules, regulations, and policies.

FINANCIAL AND TECHNICAL ASSISTANCE[57]

Following adoption of the recommended land use, water quality management, instream water quality measures, inland lake water quality measures, and auxiliary water quality plan elements of the recommended regional water quality management plan for the greater Milwaukee watersheds, it is important for the units of government within the study area to effectively utilize all available sources of financial and technical assistance for the timely execution of the recommended plan. In addition to using current tax revenue sources, such as property taxes, fees, fines, public utility earnings, highway aids, and State-shared taxes, the local units of government can make use of such revenue sources as borrowing, special taxes and assessments, establishment of stormwater utilities, State and Federal grants, and gifts.

Various types of technical assistance useful in plan implementation are also available from county, State, and Federal agencies. The type of assistance available includes possible State and Federal cost-share funding for nonpoint source pollution control and habitat projects; technical advice on land and water management practices

[57]*The financial assistance programs described in this section and the accompanying appendices were active as of the date of publication of this report. Such programs are subject to modification or elimination based on budget considerations, and additional programs may be enacted over time to address emerging issues. As this plan is implemented, information on grant program changes should be collated as necessary. The Catalog of Federal Domestic Assistance Programs can be accessed at http://12.46.245.173/cfda/cfda.html. Additional information on grants can be accessed through the University of Wisconsin-Madison Libraries Grants Information collection at: http://grants.library.wisc.edu.*

provided by the NRCS staff and county land conservation staffs; and educational, advisory, and review services offered by the University of Wisconsin-Extension Service and the Regional Planning Commission.

Borrowing

Local units of government are normally authorized to borrow so as to effectuate their powers and discharge their duties. Chapter 67 of the *Wisconsin Statutes* generally empowers counties, cities, villages, and towns to borrow money and to issue municipal obligations not to exceed five percent of the equalized assessed valuation of their taxable property, with certain exceptions, including school bonds and revenue bonds. Such borrowing powers which are related directly to implementation of the regional water quality management plan update include the following:

1. Counties may issue bonds for County park and related open space land acquisition and development.

2. Cities and Villages may borrow and issue bonds for the construction of wastewater treatment plants and for park and related open space land acquisition and development.

Special Taxes and Assessments

Counties and cities have special assessment powers for park and parkway acquisition and improvements under Sections 27.065 and 27.10(4), respectively, of the *Wisconsin Statutes.* Counties are empowered under Section 27.06 of the *Wisconsin Statutes* to levy a mill tax to be collected and placed into a separate fund and to be paid out only upon order of the County Park Commission for the purchase of land and other Commission expenses. Farm drainage boards, town sanitary districts, metropolitan sewerage districts, cities, and villages also have taxing and special assessment powers under Sections 88.35, 33.32 (5), 200.13(1), 66.0827(2), and 62.18(16) of the *Wisconsin Statutes.*

Grant and Loan Programs

The identification of potential funding sources, including sources other than solely local-level sources, is an integral part of the implementation of a successful plan. The following description of funding sources includes those that appear to be applicable as of the year 2007. Funding programs and opportunities are constantly changing. Accordingly, the involved local staffs need to continue to track the availability and status of potential funding sources and programs. It is intended that this list facilitate the implementation of the activities set forth in the recommended plan. Some of the programs described herein may not be available under all envisioned conditions for a variety of reasons, including local eligibility requirements or lack of funds in Federal and/or State budgets at a given time. Nonetheless, the list of sources and programs should provide a starting point for identifying possible funding sources for implementing the watershed plan recommendations.

There are numerous grant and loan programs offered through both public and private sources for many aspects of plan implementation. Table U-1 in Appendix U summarizes many of the major grant and assistance programs that are available to municipalities and individuals under the areas of wildlife and fish habitat, water quality, land acquisition for park and open spaces, and other areas such as education and sustainable development that have the potential to indirectly affect the quality of the water resources of the study area. Appendix V lists contacts for details about grant programs.

Funding to implement the recommendations of this plan may be obtained through many of the grant and loan programs listed in this report subsection and the accompanying appendices. In addition, trading of water quality credits may be useful in providing financial incentives for implementing controls on agricultural runoff. However, to fully meet the substantial costs associated with attaining the plan objectives, it is recommended that the State Legislature significantly increase levels of cost-share funding for key WDNR grant programs, particularly the Targeted Runoff Management (TRM) Grant Program and the Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program, and also for DATCP programs to implement agricultural best management practices. Increased funding for the TRM and DATCP programs would accelerate the ability to implement the agricultural nonpoint source pollution control standards as set forth in Chapter NR 151 of the *Wisconsin Administrative Code* as well as to implement recommended projects that call for additional levels of pollution control in lieu of or beyond the NR 151 standards. More funding for the urban program would assist municipalities in meeting NR 151 standards and WPDES stormwater discharge permit requirements and in implementing plan recommendations that call for measures beyond those requirements. In order to achieve levels of agricultural nonpoint source pollution control commensurate with the recommendations of this plan, the Legislature would either have to provide the recommended substantial increases in TRM fund and ATCP grants, or it would have to revise Chapters NR 151 and ATCP 50 to require implementation of agricultural controls regardless of the availability of grant funds. Because implementation of plan recommendations could place a large financial burden on smaller, family farming operations, increasing State cost-share funding is considered to be preferable to the alternative of making compliance with the NR 151 and ATCP 50 standards mandatory even if cost share funds are not available.

The grant and funding programs listed in the following subsections are categorized relative to their relationship to specific water quality management plan recommendations; however, some programs may have a primary relationship to a given recommendation category and a secondary relationship to another category. Thus, some programs may be applied to implement recommendations in multiple categories.

Possible Funding Sources for Establishment of Riparian Buffers, Prairie and Wetland Restoration, and Instream Measures

Applicable programs are described below.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) funds several programs for wildlife and fish habitat improvement. These programs are described below.

GREAT LAKES FISH AND WILDLIFE RESTORATION ACT GRANT PROGRAM

This Federal grant program is funded under the Great Lakes Fish and Wildlife Restoration Act of 2006, and it provides grants on a competitive basis to states, tribes and other interested entities to encourage cooperative conservation, restoration and management of fish and wildlife resources and their habitat.

WILDLIFE CONSERVATION AND APPRECIATION PROGRAM

The Wildlife Conservation and Appreciation program was designed 1) to identify specific fish and wildlife habitat concern areas and ways to protect and conserve wildlife species and their habitats, and 2) to help facilitate a greater appreciation and enjoyment of the public for fish and wildlife through nonconsumptive uses. State fish and wildlife agencies and private organizations and individuals through those agencies are eligible for cost-share funding for eligible practices. The program is competitive, as the funding is somewhat limited. Total funding available for this program has been approximately $768,000 annually.

PARTNERS FOR FISH AND WILDLIFE HABITAT RESTORATION PROGRAM

This program was developed to help assist individual landowners with habitat restoration by providing cost-share and technical assistance. Landowners are eligible for assistance on projects such as restoration of degraded wetlands, prairie restoration, and stream and riparian restoration. Individuals must sign a 10 year contract with the FWS to receive a maximum amount of $25,000 in Federal cost-share funds. In addition to funding, technical assistance is also provided.

PARTNERSHIP FOR WILDLIFE

The Partnership for Wildlife program is administered by the FWS but also receives funds from the National Fish and Wildlife Foundation (NFWF) and other sources to help fund this program. The FWS contributes $768,000 nationwide annually to this program, which is expected to be matched by State and private sources. State and local agencies, private nonprofit organizations, and individuals are eligible to receive funding for approved projects. This program is specifically designed to help restore habitat and protect nongame fish and wildlife species.

North American Wetlands Conservation Fund[58]

The North American Wetlands Conservation Act of 1989 provides matching grants to organizations and individuals who have developed partnerships to carry out wetlands conservation projects for the benefit of wetlands-associated migratory birds and other wildlife. There is a Standard and a Small Grants Program. Both are competitive grants programs and require that grant requests be matched by at least an equal partner contribution. The Standard Grants Program involves the long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. This program has been receiving 50 percent of the total available funding for Act-supported projects each fiscal year. In recent years, this amount has been approximately $35 million annually. The Small Grants Program supports the same type of projects and adheres to the same selection criteria and administrative guidelines as the Standard Grants Program. However, project activities are usually smaller in scope and involve fewer project dollars. Grant requests may not exceed $75,000, and funding priority is given to grantees or partners new to the Act's Grants Program.

U.S. Department of Agriculture

The Federal government, through the USDA NRCS and the Farm Service Agency offers programs which are directed at restoring wildlife habitat and reclaiming wetlands that have been in agricultural use. There are several programs available to the agricultural producer and landowner that can help to offset the cost of implementing wildlife habitat restoration practices, and one program that is available to State and local units of government. The applicable USDA programs are described below. Characteristics of USDA financial assistance programs are summarized in Table 102. Conservation practices eligible for funding under various USDA programs are set forth in Table 103.

Wildlife Habitat Incentives Program

The Wildlife Habitat Incentives Program is directed towards protecting habitat for specific targeted species of wildlife. This program applies to upland, lowland, and aquatic species of wildlife. For example, a producer could establish a continuous travel lane for wildlife along a fence row, which would also function to reduce soil erosion. Additionally, if a producer or owner had property that was not in production due to wetness problems, a wetland scrape or wildlife pond could be established. This program would also be suitable for restoration of fish habitat in the study area. The USDA will cost-share up to 75 percent of the installation practices for approved structures. The length of the contract is 10 years. It is the landowner's responsibility to maintain the structures over the life of the contract.

Conservation Reserve Program

The Conservation Reserve Program was enacted to protect lands which are sensitive to erosion and to take all highly erodible land, including land along riparian corridors, out of agricultural production and place the land into long-term vegetative cover for a period of 10 to 15 years. Land is eligible for inclusion under the program if it has been in agricultural production for at least two of the preceding five years and the applicant has owned the property for at least one full year. Some of the practices that are eligible for CRP funding include riparian buffer strips, permanent pasture, windbreaks, grassed waterways, and contour grass strips. The USDA pays an annual rental rate for the land taken out of production for these practices, based upon soil type. Additionally, it will also cost-share 50 percent of the expenses for the establishment of these conservation practices.

At present, there are two types of CRP enrollments: general CRP and continuous CRP. The general CRP enrollment is geared for larger tracts of land, and is a competitive process. Landowners have a six-week window, once a year, to apply for a set amount of funding. Continuous CRP is not competitive, and is targeted towards smaller, more sensitive tracts of land, such as riparian lands, or lands susceptible to ephemeral or gully erosion. Additionally, landowners can apply for this type of CRP throughout the year.

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[58]*In Wisconsin, the WDNR Bureau of Wildlife Management assists with this program, and private organizations such as Ducks Unlimited and the Kenosha-Racine Land Trust, the Milwaukee Area Land Conservancy, Ozaukee-Washington Land Trust, and the Waukesha Land Trust may also be candidates to implement projects funded under this program.*

Conservation Reserve Enhancement Program

The Conservation Reserve Enhancement Program (CREP) is an outgrowth of the CRP that is designed to protect water quality and improve wildlife habitat through the establishment of filter strips, riparian buffers, grassed waterways, and, in designated grassland project areas, the establishment of permanent introduced or native grasses. The program also involves the development and restoration of wetlands. Funding for the program may come through the USDA Farm Service Agency; the Wisconsin DATCP; and private conservation organizations. Eligibility and contract requirements are similar to those for the CRP; however, the CREP is targeted at areas where it has been determined that the benefits of program implementation are most needed.

Wetland Reserve Program

The Wetland Reserve Program is a program that is well suited to marginal cropland in the study area. This program is targeted towards lands that historically were wetlands, have since been cultivated or drained for agricultural production, and, thus, are classified by the NRCS as farmed wetlands or prior converted croplands. This program would be a viable option for landowners that have farmland that is subject to routine flooding over the years, or is consistently wet. However, the land must be restorable to its original wetland condition. Under this program, the landowner retains full privileges for the use and enjoyment of the property, and the land remains in his private ownership. No crop production on the land is permitted over the term of the easement; however, haying, grazing, and timber harvesting may be allowed, depending on the requirements of the wetland reserve plan of operation agreed to by the owner and the NRCS. Currently, the following three options are available to landowners participating in the WRP:

- The first option is a 10-year agreement under which the landowner is eligible to receive Federal funds covering up to 75 percent of the restoration cost. No easements would be placed on the property, however, the landowner would be responsible for maintaining the restored wetland.

- The second option involves a 30-year easement. Under this option the landowner receives a one-time payment equal to 75 percent of the assessment for the land taken out of production. The maximum assessed value of the land under this program is $1,000 per acre. The USDA also pays for the full restoration cost and associated titling fees.

- The final WRP option involves the establishment of a permanent easement. In this situation, the landowner receives 100 percent of the assessment, up to a maximum of $1,000 per acre, and the USDA also pays for the full restoration cost and associated titling fees.

Once the cropland has reverted back to a wetland, there should be an associated tax decrease on the property. This would be especially true for the 30-year and permanent easements.

Watershed Protection and Flood Prevention Program

This program is designed for smaller watersheds which do not exceed 250,000 acres in size. The program provides for cost-share funding for large-scale projects that are designed to prevent flooding and protect the watershed. Eligible projects could include wetland restoration, flood prevention, water supply, erosion and sediment control, water quality, and fish and wildlife habitat enhancement. Projects implemented by State and local units of government are typically eligible for Federal funding typically ranging from about $3.5 to $5.0 million; in addition, technical assistance is also provided.

Emergency Watershed Protection Program

This program was designed to help mitigate cropland flooding by removing farmland from production in areas that are in floodplains and have a history of repeated flooding. The landowner retains most of the property rights associated with ownership, however, the USDA has the authority to restore the floodplain to its original function and value. This program could be applied to implement the riparian buffer and wetland and prairie restoration components of the recommended water quality management plan. Individual landowners must have a sponsor such as a local unit of government and are eligible for one of three types of payments for land taken out of production. Those options include payment based on a geographic rate, payment based on an assessment from crop productivity, and payment based on a sale price suggested by the landowner. Landowners are eligible to receive up to 75 percent of the cost of the appraised value of the land in Federal cost-share assistance, with the remaining 25 percent, expected to be matched by the landowners' local sponsor.

EMERGENCY CONSERVATION PROGRAM

This program is designed to help agricultural producers restore land conditions to pre-flooding or pre-disaster conditions. Individual landowners are eligible for up to 64 percent Federal cost-share funding for projects such as regrading and shaping farm fields, removing and redistributing to eroded soil from uplands that has been deposited in downslope areas, clearing debris, and restoring conservation practices. This funding is available only when there has been a declared disaster such as a flood event.

U.S. Army Corps of Engineers

The following Corps of Engineers programs are potential sources of funding for implementing the instream water quality management and habitat-related recommendations of this plan, subject to projects meeting Corps economic feasibility criteria.

WATER RESOURCES DEVELOPMENT AND FLOOD CONTROL ACTS

These two congressional acts contain several individual programs that can be used for flood mitigation projects. Such projects generally incorporate measures to enhance, or mitigate, instream channel stability and habitat-related conditions. These programs could apply to possible projects to remove concrete channel linings, such as those being pursued by MMSD. Some of the programs involved include the following: Small Flood Control Projects Program; Snagging and Clearing for Flood Control Program; and the Emergency Bank Protection Program. Projects that could be potentially funded include small flood control practices, clearing channels of debris and snags, bank protection measures from flood induced conditions, emergency streambank and shoreline protection, and water resources planning assistance. In addition, flood mitigation projects may include an environmental restoration component that could apply to restoration and/or establishment of wetland and/or prairie conditions in a project area. Federal cost-share assistance for these programs is available for 50 to 75 percent of the cost of implementation depending on the project, requiring a 25 to 50 percent local match.

AQUATIC ECOSYSTEM RESTORATION PROGRAM

This program, which is part of the 1996 Water Resources Development Act, allows for State and local levels of government to restore degraded aquatic systems so that they are returned to a more natural condition. Eligible projects can receive up to 65 percent Federal cost-share assistance, with a maximum Federal cost-share amount of $5 million. However, grant recipients are responsible for maintenance after the project is completed.

FLOOD HAZARD MITIGATION AND RIVERINE ECOSYSTEM RESTORATION PROGRAM

This program can provide up to 50 percent cost-sharing for floodland management studies and up to 65 percent for project implementation. The program was specifically designed to look at alternative floodland mitigation measures that are designed to help restore a riverine ecosystem. Eligible projects can include relocation of threatened structures, conservation or restoration of wetlands and natural floodwater storage areas, and planning activities to determine future responses to flood situations.

U.S. Environmental Protection Agency

The EPA Five Star Restoration Program could be used in restoration of habitat for wildlife. This program is further described below.

FIVE-STAR RESTORATION PROGRAM

The Five-Star Restoration program was designed to bring public and private organizations together to support community based restoration projects. The EPA has a total funding level of approximately $500,000 annually for this program of which individual projects could be eligible to receive up to $20,000 in Federal funding. In addition, technical assistance is also provided. Potential projects must have at least five contributing partners and must be part of a larger watershed and have community support. Eligible projects include wetland and riparian restoration.

U.S. Department of Transportation

The U.S. Department of Transportation (DOT) has one program that could potentially be used to help implement the water quality recommendations set forth in this report. The details of this program are described below.

TRANSPORTATION ENHANCEMENT PROGRAM

The Transportation Enhancement Program is available to State and local units of government to assist with projects designed to enhance the transportation system and mitigate some of the effects of the transportation network. Potential projects could include wetland preservation and restoration, stormwater treatment systems to help address runoff, and natural habitat restoration. Eligible projects can receive up to 80 percent in Federal cost-share assistance, requiring a 20 percent local match.

Wisconsin Department of Natural Resources

STEWARDSHIP GRANT PROGRAM

The administrative rules for the State of Wisconsin Stewardship Grant Program are set forth in Chapters NR 50 and 51 of the *Wisconsin Administrative Code.* The WDNR's Urban Green Space (UGS) program which is a component of the Stewardship Grant Program provides 50 percent matching grants to cities, villages, towns, counties, public inland lake protection and rehabilitation districts, and qualified nonprofit conservation organizations for the acquisition of land. Funding for streambank protection projects may also be available through the Stewardship Grant Program.

STEWARDSHIP INCENTIVES PROGRAM

The Stewardship Incentives Program is administered by WDNR utilizing USDA Forest Service funding. The program is designed to help individual landowners maintain private tracts of woodland for several purposes. Individual landowners are eligible to receive up to 65 percent Federal cost-share assistance with a maximum of $5,000 for individual projects. Potential projects could include riparian buffer establishment, stream habitat enhancements, reforestation, forest improvement, tree planting, wind break and hedgerow establishment, development of a forest management plan, and nest boxes.

URBAN RIVERS GRANTS PROGRAM

The WDNR's Urban Rivers Grants Program (URGP) provides 50 percent matching grants to municipalities to acquire lands, or rights to land, on or adjacent to rivers that flow through urban areas. This program is intended to preserve or restore urban rivers or riverfronts for the purposes of economic revitalization and the encouragement of outdoor recreational activities.

RIVER PROTECTION GRANT PROGRAM

The River Protection Grant program as set forth in Chapter NR 195 of the *Wisconsin Administrative Code* was designed to assist local governments, lake districts and associations, and other nonprofit organizations in improving and protecting water quality in rivers. The funding that is available is a 75 percent State cost-share, with a 25 percent local match. Cost-share funding cannot exceed $10,000 for any one planning project, or $50,000 for a management project. The types of projects that are eligible for cost-share assistance include planning activities such as organizational projects related to forming or sustaining river management organizations, education projects, and management plan development, and management activities such as land acquisition, easement establishment, ordinance development, installation of nonpoint source pollution abatement projects, river restoration projects, and river plan implementation projects.

STATE WILDLIFE GRANTS PROGRAM

Congress passed the State Wildlife Grants program in 2001 with appropriations of typically $1.0 to $1.5 million annually. This program is designed to assist states by providing Federal funds for developing and implementing programs that benefit wildlife (including fish and invertebrates) and their habitats. Proposed projects must help to implement the Wisconsin's Wildlife Action Plan, approved by the Natural Resources Board in August 2005, to receive funding.

Small and Abandoned Dam Removal Grant Program

This program provides grant funds to counties, cities, villages, towns, tribes, public inland lake protection and rehabilitation districts, and private dam owners to remove small or abandoned dams. Small dams are those with a hydraulic height of less than 15 feet and an impoundment of 100 surface acres or less at normal pool. Abandoned dams are those declared abandoned using the process under Chapter 31 of the *Wisconsin Statutes*. The WDNR will fund 50 percent of eligible project costs, with a maximum grant award of $50,000. Eligible project costs include labor, materials, and equipment directly related to planning the dam removal and the restoration of the impoundment.

County Conservation Aids

Funds are available to enhance county fish and wildlife programs as per Section 23.09(12) of the *Wisconsin Statutes* and NR 50 of the *Wisconsin Administrative Code*. County and tribal governing bodies participating in county fish and wildlife programs are eligible to apply to the WDNR. The State may pay a maximum of 50 percent of the eligible actual project cost. The current statewide annual allocation of funds is $150,000.

Land and Water Conservation Fund Grants Program

The WDNR administers the Land and Water Conservation Fund Grants program utilizing funding from the U.S. Department of Interior. Local units of government and State agencies can apply to the WDNR for projects involving planning for the acquisition of State and local parks, land acquisition for open space, estuaries, forests, wildlife, and natural resource areas, and supporting facilities that enhance recreational opportunities. There is approximately $40 million available annually and projects are eligible to receive up to 50 percent cost-share funding.

Municipal Flood Control Grants

Under Chapter NR 199, “Municipal Flood Control Grants,” of the *Wisconsin Administrative Code* municipalities, including cities, towns, and villages, as well as metropolitan sewerage districts are eligible for cost-sharing grants from the State for projects such as acquisition and removal of structures; floodproofing and elevation of structures; riparian restoration projects; acquisition of vacant land, or purchase of easements, to provide additional flood storage or to facilitate natural or more efficient flood flows; construction of facilities for the collection, detention, retention, storage, and transmission of stormwater and groundwater for flood control and riparian restoration projects; and preparation of flood mapping projects. The components of this program that relate to implementation of the water quality management plan include those related to riparian restoration projects and acquisition of vacant land, or purchase of easements, to provide additional flood storage or to facilitate natural or more efficient flood flows, both of which could apply to buffer establishment/expansion and prairie/wetland establishment. Municipalities and metropolitan sewerage districts are eligible for up to 70 percent State cost-share funding for eligible projects, and would have to provide at least a 30 percent local match. Applications are due on July 15 of each calendar year.

Wisconsin Coastal Management Program

The Wisconsin Coastal Management Grant Program

This program is dedicated to preserving and making accessible the natural and historic resources of Wisconsin’s Great Lakes coasts. The program works cooperatively with State, local, and tribal government agencies and nonprofits in managing the ecological, economic and aesthetic assets of the Great Lakes and their coastal areas. Grants are available for coastal land acquisition, wetland protection and habitat restoration, nonpoint source pollution control, coastal resources and community planning, Great Lakes education, and public access, and historic preservation. Approximately $1.5 million is available through the program annually.

National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation offers the following programs.

Great Lakes Watershed Restoration Program

This program provides funding for projects that address priority areas identified by the Great Lakes Regional Collaboration’s Habitat/Species Strategy Team. The program is administered in cooperation with the USEPA, the U.S. Fish and Wildlife Service, The National Oceanic and Atmospheric Administration, the U.S. Forest Service, and the U.S. Natural Resources Conservation Service. The project eligibility criteria specify that, where applicable, projects should be coordinated with local and regional watershed management plans that address water quality, fish, or wildlife needs in the Great Lakes. The regional water quality management plan update is such a plan. Eligible projects include those that restore, enhance, and protect fish communities, wetlands, tributaries to the Great Lakes, and shoreline and upland habitats. Grant amounts range from $35,000 to $100,000, with a 50 percent non-Federal match required.

CHALLENGE GRANT PROGRAM

The Challenge Grant program is made available to units of government, educational institutions, and nonprofit organizations for the enhancement of wildlife habitat. Projects most likely to receive funding would be those that focus on restoring and protecting habitat on private lands, conservation educational programs, and programs that work to develop sustainable communities through conservation. The program provides 50 percent cost-share assistance for eligible projects, provided that the remaining match comes from non-Federal sources. The average funding level for a project is between $25,000 and $75,000.

Kenosha/Racine Land Trust, the Milwaukee Area Land Conservancy,
Ozaukee-Washington Land Trust, and Waukesha Land Conservancy

These land trusts and conservancies purchase, or obtain conservation easements for, environmentally valuable lands through member contributions, land or easement donations, and grants obtained from other sources.

Eastman Kodak

Eastman Kodak Company has one small grant program available to enhance greenway areas. The program is described below.

AMERICAN GREENWAY GRANTS PROGRAM

The American Greenway Grants program is a small grant program providing only limited funds. However, these funds can be used for a wide variety of projects so long as they are used to enhance and develop greenway areas. Funding is made available to land trusts, local units of government, and nonprofit organizations for a maximum amount of $2,500. Potential projects include ecological assessments, mapping and surveying, planning activities, and other activities that help to establish greenways in communities. Projects must have matching funds from other sources and provide evidence that the project can be successfully completed.

Possible Funding Sources for Implementing Rural and Urban
Nonpoint Source Pollution Abatement Recommendations

There are several sources of funding that can potentially be used for carrying out the urban and rural nonpoint source pollution abatement recommendations of the water quality management plan update. The principal agencies that offer applicable funding programs include the WDNR; the Wisconsin DATCP; the USDA; and the USEPA. Some of these Federal and State grant programs may be coordinated to provide cost share funding necessary for implementing agricultural practices under Chapter NR 151 of the *Wisconsin Administrative Code*.

The major funding programs available for plan implementation are described below.

U.S. Department of Agriculture

ENVIRONMENTAL QUALITY INCENTIVE PROGRAM

Federal cost-sharing funds available under this program have primarily been targeted towards areas of the State outside the Southeastern Wisconsin Region. However, there is some funding available that can be directed towards whole farm planning and conservation management. This program is highly competitive, so the more conservation practices a producer incorporates on his farm, the more likely he will be eligible for funding. EQIP focuses on several areas, including animal waste management; soil erosion and sediment control, which encompasses nutrient and manure management, wildlife habitat management, and conservation tillage.

If a farm is eligible for EQIP funding, the USDA will cost-share up to 75 percent of the cost for installation of conservation practices, but limited resource producers and beginning farmers may be eligible for cost-shares up to 90 percent. The program will also pay $18.50 per acre for conservation tillage. These tillage payments occur for a maximum of three years during the length of the contract, which is typically five years, but can be extended to 10 years.

WATER QUALITY SPECIAL RESEARCH GRANTS PROGRAM

The purpose of this program is to identify and resolve agriculture-related degradation of water quality. Proposals should provide watershed-based information that can be used to assess sources of water quality impairment in targeted watersheds; develop and/or recommend options for continued improvement of water quality in targeted watersheds; and evaluate the relative costs and benefits associated with cleanup to all responsible sectors (e.g., farming, processing, urban runoff, and municipal wastewater treatment).

U.S. Environmental Protection Agency

The USEPA has several programs that could potentially be used to fund water quality related plan recommendations. These programs are further described below.

U.S. ENVIRONMENTAL PROTECTION AGENCY CLEAN WATER STATE REVOLVING FUND

The USEPA Clean Water State Revolving Fund provides funds to States for construction of municipal wastewater treatment facilities, nonpoint source pollution abatement projects, and estuary protection projects. Grants are provided to the State of Wisconsin Clean Water Fund (CWF) and a 20 percent match is provided by the State.[59] Additional contributions to the CWF may be made from the proceeds from tax-exempt revenue bonds, investment earnings, and loan repayments. The Wisconsin Departments of Administration and Natural Resources jointly administer the CWF loan program. Cities, towns, villages, counties, town sanitary districts, public inland lake protection and rehabilitation districts, metropolitan sewerage districts, and Federally recognized tribal governments are eligible to apply.

WATER POLLUTION CONTROL PROGRAM GRANTS

Section 106 of the Clean Water Act authorizes the USEPA to provide Federal assistance to states (including Indian Tribes) and interstate agencies to establish and implement ongoing water pollution control programs, including permitting, pollution control activities, surveillance, monitoring, and enforcement; advice and assistance to local agencies; and the provision of training and public information. The Water Pollution Control Program encourages a watershed protection approach at the State level by looking at states' water quality problems holistically, and targeting the use of limited finances available for effective program management.[60]

WATERSHED ASSISTANCE GRANTS PROGRAM

The Watershed Assistance Grants program provides funds to help organize and develop watershed and river partnerships and organizations. USEPA funding is made available through River Network to local units of government and nonprofit conservation organizations. Grant applications must be made directly to River Network. There is approximately $365,000 available nationwide for partnership development. Grants are made in two categories: those that are less than $4,000 and those that are between $4,000 and $30,000.

TARGETED WATERSHED GRANTS PROGRAM

The Targeted Watershed Grants Program is intended to promote community-based programs to protect water resources. The program is directed toward implementing projects that have been identified through watershed assessments and/or plans.

PESTICIDE ENVIRONMENTAL STEWARDSHIP GRANTS PROGRAM

The Pesticide Environmental Stewardship Grants program is funded by the USEPA with grants being distributed to partners and supporters of this program. Any organization, group, or business is eligible to become a partner provided they are committed to reducing the environmental risk from pesticide use. Partners are eligible for grants

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[59]*The Wisconsin Clean Water Fund is part of the State Environmental Improvement Fund.*

[60]*USEPA, http://www.epa.gov/owm/cwfinance/pollutioncontrol.htm.*

up to a maximum of $50,000. Potential projects could involve implementation of pollution control measures and plan development, which includes strategies to reduce pesticide risk.

Wisconsin Department of Agriculture, Trade and Consumer Protection
The Wisconsin DATCP is one of the State's primary funding agencies for agricultural nonpoint source pollution guidance and funding. There are two forms of DATCP funding that can be utilized in implementing the recommendations of the plan. They are: 1) the land and water resource management program and 2) the farmland preservation program. Cost-share funding is available to landowners for agricultural best management practices through the land and water resource management plan program, and a tax incentive is associated with the farmland preservation program. These programs are further described below.

LAND AND WATER RESOURCE MANAGEMENT PROGRAM
In 1997, Wisconsin Act 27 was passed and Chapter 92 of the *Wisconsin Statutes* was revised. This change in Wisconsin State Law initiated a redesign of the State's nonpoint source pollution abatement program. As a result of this redesign, Chapter ATCP 50 of the *Wisconsin Administrative Code* requires each county in Wisconsin to develop a land and water resource management plan to address both rural and urban nonpoint source problems. Upon development of these plans, counties become eligible to receive cost-share funding for land conservation practices, as well as funding for staff. All counties in the watershed have land and water resource management plans, and as a result, have access to cost-share funding for rural best management practices. The DATCP grant funding program for agricultural best management practices is described in ATCP 50, *Soil and Water Resource Management Program.* A comprehensive list of agricultural best management practices eligible for cost-share funding is presented in Table 101.

FARMLAND PRESERVATION PROGRAM
The farmland preservation program has been available to farmers in counties that have adopted an agricultural preservation plan that is certified by the State Land and Water Conservation Board. All counties in the study area have certified plans. The program provides a property tax credit for farmers who have entered into farmland preservation agreements or who are located in an agricultural preservation or transition area in a county or municipality that has adopted an exclusive agricultural use zoning ordinance. Under the farmland preservation agreement, farmers are required to follow a farm management plan to reduce farm erosion to the "tolerable" soil loss rate referred to as the "T-value." This plan is developed between the landowner, producer, and the county conservationist. This program is not directly related to any Federal programs and must have a separate farm plan on file with the county. The tolerable soil loss rates are established by the Federal government for individual soil types. If the landowner decides to leave the program, he must wait a period of 10 years before he can rezone the property out of agriculture, or he will have to repay the tax incentives he received over the years.

Wisconsin Department of Natural Resources
The WDNR grant programs that may serve as potential funding sources for water quality improvement efforts, including Targeted Runoff Management grants and Urban Nonpoint Source and Storm Water grants.[61] These programs are further described below.

TARGETED RUNOFF MANAGEMENT GRANT PROGRAM
The Targeted Runoff Management Grant program (see Chapter NR 153 of the *Wisconsin Administrative Code*) has had limited funds in the past; however, it is expected that this will become a more viable source for funding as priority watershed projects close and a portion of those funds are redirected towards this program. Local units of government and lake districts and associations are eligible to receive up to 70 percent of State cost-share dollars provided that there is a 30 percent local match. Rural projects have a maximum cap of $30,000 and urban projects have a maximum cap of $150,000. Potential projects could include installing practices that ensure compliance with the State nonpoint source performance standards as set forth in Chapter NR 151, improving threatened or

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[61]*Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," sets forth cost-share conditions for eligible urban and agricultural best management practices.*

impaired waters as designated under Section 303(d) of the Federal Clean Water Act, protecting outstanding water resources, complying with a notice of discharge from animal feeding operations, and addressing water quality concerns for a waterbody of national or statewide importance such as the Upper Mississippi River.

URBAN NONPOINT SOURCE WATER POLLUTION ABATEMENT AND STORM WATER MANAGEMENT GRANT PROGRAM
This program, which is set forth in Chapter NR 155 of the *Wisconsin Administrative Code,* assists municipalities in designated urban areas[62] with designing and implementing urban nonpoint source best management practices. The program will fund eligible technical assistance and planning costs to a maximum of 70 percent and includes projects such as ordinance development and enforcement, educational activities, and planning and design activities. In addition, construction costs of best management practices are also eligible for up to 50 percent cost-share. Eligible projects could include detention basins, streambank stabilization, and shoreline stabilization. There is no maximum project limit for this grant program.

LAND RECYCLING LOAN (BROWNFIELDS) PROGRAM
Counties, towns, cities, and villages are eligible to apply for no interest loans to remedy environmental contamination of sites or facilities at which environmental contamination has affected groundwater or surface water or threatens to affect groundwater or surface water as per Section 281.60 of the *Wisconsin Statutes.* A municipality must send the WDNR a notice of its intent to apply for assistance to be in the application process. Applications are approved following a project priority ranking, eligibility determination and a determination by the Department of Administration that the applicant meets financial conditions. Applications are funded as they appear on a funding list that ranks projects based on their priority ranking.

Wisconsin Coastal Management Program
THE WISCONSIN COASTAL MANAGEMENT GRANT PROGRAM
As noted above in more detail under the buffers/prairie/wetland/instream subsection, this program is dedicated to preserving and making accessible the natural and historic resources of Wisconsin's Great Lakes coasts. Grants are available for coastal land acquisition and nonpoint source pollution control, among other projects. Approximately $1.5 million is available through the program annually.

Possible Funding Sources for Implementing Point Source Pollution Abatement Recommendations
USEPA Clean Water State Revolving Fund and State of Wisconsin Clean Water Fund Program
As described previously in the subsection on funding programs for urban and rural nonpoint source pollution abatement, the USEPA Clean Water State Revolving Fund provides funds to States for construction of municipal sewerage and wastewater treatment facilities, nonpoint source pollution abatement projects, and estuary protection projects. Grants are provided to the State of Wisconsin Clean Water Fund (CWF) and a 20 percent match is provided by the State.[63] Additional contributions to the CWF may be made from the proceeds from tax-exempt revenue bonds, investment earnings, and loan repayments. The Wisconsin Departments of Administration and Natural Resources jointly administer the CWF loan program. Cities, towns, villages, counties, town sanitary districts, public inland lake protection and rehabilitation districts, metropolitan sewerage districts, and Federally recognized tribal governments are eligible to apply.

The planning, design, and construction work needed for wastewater infrastructure is generally eligible for a low-interest, 20-year loan from the Clean Water Fund program. The current interest rate for projects necessary to maintain permit compliance is 2.475 percent. The interest rate is adjusted with each State bond issuance for the Clean Water Fund Program. For projects with total costs less than $1 million, the small loan portion of the Clean Water fund provides a source of loans. Further reduction in interest rates to as low as 0 percent and, if needed, grants for up to 70 percent of a wastewater project cost are available to municipalities that qualify for hardship financial assistance.

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[62]*Defined as an area having population density of greater than 1,000 people per square mile.*

[63]*The Wisconsin Clean Water Fund is part of the State Environmental Improvement Fund.*

Direct Federal Line-Item Grant

The U.S. Congress has provided Federal, site-specific, line-item grants for wastewater projects for each of the last seven years. The grants come from the State and Tribal Assistance Grant portion of the USEPA budget. Through 2006, MMSD has received $11.8 million in USEPA grant assistance for its Harbor Siphons Project. Direct Federal line-item grants for MMSD construction projects constitute another funding source for plan implementation.

U.S. Department of Agriculture

WATER AND WASTE DISPOSAL SYSTEMS FOR RURAL COMMUNITIES

The USDA provides assistance to rural communities and local levels of government by providing a funding program designed to help ensure that safe water supplies are provided to communities and that waste disposal systems in those communities are maintained properly. Eligible candidates for funding include municipalities, counties, local units of government, and nonprofit corporations. Federal funding is provided both in the form of grants and loans. Grants and loans range in size from a few thousand dollars to over a million dollars. Eligible projects include the installation, expansion, or repair of rural water supply facilities and rural waste disposal facilities.

Possible Funding Sources for Implementing Inland Lake and Lake Michigan Water Quality Recommendations

U. S. Environmental Protection Agency

BEACH ACT GRANTS

This program provides grants for beach water-quality monitoring and public notification programs. Beach water-quality monitoring helps local authorities identify what steps to take to reduce pollution that leads to advisories or closures when bacteria concentrations reach unhealthy levels. For 2007 Wisconsin was allocated $225,960 in grants under this program. In future years, the USEPA may award more grants to eligible states, tribes, territories and local governments to support the development and implementation of monitoring and notification programs.

U.S. Fish and Wildlife Service

FEDERAL CLEAN VESSEL ACT

Funds are available to construct pump-out and dump stations to dispose of sewage from recreational boaters as per Section 5604 of the Federal Clean Vessel Act of 1992. Under this program, the WDNR applies for Federal funds and distributes them to applicants. Contracts and use agreements may be negotiated with local units of government and private marinas. To receive funds, an applicant sends a letter of application including 1) description of the project; 2) explanation of why the project is needed; 3) a detailed cost breakdown; 4) a proposed timetable for completion of the project; and 5) a site map and location map of the project. There is a 25 percent local match required. Priority is given to projects located on the Great Lakes. Eligible projects include education/information materials and construction, renovation, operation and maintenance of pump-out and dump stations, including floating restrooms, not connected to land or structures connected to land or structures connected to the land, used solely by boaters.

U.S. Army Corps of Engineers

ESTUARY HABITAT RESTORATION PROGRAM

The riparian and nearshore areas of the Great Lakes are considered to be estuaries under this program. Eligible habitat restoration activities include the re-establishment of chemical, physical, hydrologic, and biological features and components associated with the estuary. The non-Federal sponsor must provide the land necessary for implementation, operation, maintenance, repair, rehabilitation and replacement of the project. Estimated Federal costs must be in the range from $100,000 to $1 million. The Federal share will generally not exceed 65 percent of the cost of an estuary habitat restoration project.

Wisconsin Department of Natural Resources

LAKE PROTECTION GRANT PROGRAM

The Lake Protection Grant program as set forth in Chapter NR 191 of the *Wisconsin Administrative Code* was designed to assist local governments, lake districts and associations, and other nonprofit organizations in improving and protecting water quality in lakes. The funding that is available is a 75 percent State cost-share, with a 25 percent local match. Cost-share funding for any one project cannot exceed $200,000. The types of projects that are eligible for cost-share assistance include land acquisition for easement establishment, wetland restoration, and various lake improvement projects such as those involving pollution prevention and control, diagnostic feasibility studies, and lake restoration.

LAKE PLANNING GRANT PROGRAM

The Lake Planning Grant program was designed to assist local governments, lake districts and associations, and nonprofit organizations with funding for activities that are involved with planning aspects of lake management. Organizations are eligible to receive up to 75 percent State cost-share funding with a maximum of $10,000 for individual projects. For each lake receiving funding under this program, there is a maximum funding level of $100,000 for different projects. The types of projects that are eligible for funding include developing a lake management plan, compiling and interpreting water quality data for waterbodies, describing adjacent land use, reviewing jurisdictional boundaries and evaluating ordinances that relate to zoning, and gathering and analyzing information from lake property owners and lake users.

LAKE CLASSIFICATION GRANT PROGRAM

Through this program, counties are eligible to apply for up to $50,000 to develop a countywide classification program for lakes.

AQUATIC INVASIVE SPECIES CONTROL GRANTS

Counties, cities, towns, villages, tribes, public inland lake protection and rehabilitation districts, and town sanitary districts and other local governmental units as defined in Section 66.0131 (1)(a) of the *Wisconsin Statutes*, qualified lake associations as defined in Section 281.68 (1)(b) of the *Wisconsin Statutes*, qualified school districts, qualified nonprofit conservation organizations, and river management organizations, are eligible to apply for funding for an aquatic invasive species control project for any waters of the State including lakes, rivers, streams and the Great Lakes. Grant awards may fund up to 50 percent of project costs up to a maximum grant amount of $75,000, except for Early Detection and Rapid Response projects which are eligible for a maximum grant of 50 percent of project costs up to a maximum of $10,000. Eligible projects may include: education, prevention and planning projects, established infestation control projects, and early detection and rapid response projects.

Great Lakes Protection Fund

The Great Lakes Protection Fund is a private, nonprofit corporation formed by the Governors of the Great Lakes states. The fund supports collaborative projects that directly produce tangible benefits to the environmental and economic health of the Great Lakes ecosystem, but it does not support projects that duplicate ongoing initiatives. Grant applicants may be government agencies, nonprofit organizations, businesses, and individuals. The Fund may support projects through grants, loans, or program-related investments. Fund efforts are directed toward projects that address biological pollution or ecosystem restoration, use market mechanisms to improve the environment, or restore natural flow regimes.

Possible Funding Sources for Implementing Water Quality Monitoring Recommendations

U.S. Geological Survey

The U.S. Geological Survey cooperative stream gaging program could be used to help implement the water quality recommendations set forth in this plan. The costs of stream gage maintenance are shared evenly by the USGS and a cooperating agency for each gage. Such cooperators are generally State agencies, sewerage system and wastewater treatment plant operators, or other units of government.

Education Funding Sources

There are other funding sources that are available which could potentially fund miscellaneous projects in the study area which would indirectly enhance the water resources of the study area. The funding agencies and their programs are described below.

U.S. Environmental Protection Agency

ENVIRONMENTAL EDUCATION GRANTS PROGRAM

The USEPA offers a grant program designed to specifically address the educational aspect of environmental enhancement. Potential projects could include improving environmental education teaching skills, education on human health problems, increasing capacity for environmental programs, and educating communities through print, broadcast, or other media. State and local units of government, colleges and nonprofit organizations are eligible for three ranges of funding for eligible projects: up to $5,000; $5,000 to $25,000; and $25,000 to $100,000.

CONTINUING AREAWIDE WATER QUALITY MANAGEMENT PLANNING PROGRAM

As noted earlier in this chapter, it is essential that a planning body remain in place to coordinate and advise on the execution of the recommended water quality management plan update for the greater Milwaukee watersheds and to undertake plan updating and extension efforts as may be necessitated by changing events. As the designated areawide water quality management planning agency, under Section 208 of the Federal Water Pollution Control Act, the Regional Planning Commission is charged with the responsibility of conducting this continuing areawide water quality management planning program, and has been conducting that program in collaboration with the WDNR, metropolitan sewerage districts, utility and sanitary districts, cities, villages, and towns since the initial regional water quality management plan was adopted in 1979. The following discussion concerns the general nature and scope of that continuing planning effort, as well as a recommendation concerning the best means of providing the necessary financial support for that effort.

Nature and Scope of Continuing Planning Effort

The continuing areawide water quality management planning effort is based on the conduct of six major planning functions. These six functions are: plan surveillance; plan reappraisal; plan expansion; service and plan implementation; procedural development; and documentation. These functions have provided the basis for the continuing water quality management work program and they will continue to do so in the future. Each of these functions is briefly discussed below.[64]

Plan Surveillance

Under the plan surveillance function, regional development is to be carefully monitored in relation to the recommended water quality management plan update. The extensive data base created by the inventories conducted as part of this planning effort will have to be maintained and kept up to date. Of particular importance in this respect are the maintenance of the inventories of existing water quality as summarized in this report and set forth in detail in SEWRPC Technical Report No. 39, and the updating of those inventories as additional water quality, fishery, macroinvertebrate, and habitat data are collected under the recommended monitoring program. While it is not envisioned that the Commission itself will be involved in large-scale, primary water quality data collection activities, considerable staff effort will be required to analyze the data collected by the MMSD, USGS, USEPA, and WDNR, along with citizen-based groups, to determine whether progress is being made toward meeting the water quality standards that support the recommended water use objectives.

In addition, careful monitoring will be required of secondary data sources with respect to existing sources of water pollution. Of particular importance in this respect will be the monitoring of waste discharge permits issued by the WDNR in order to determine the extent to which the permit requirements seek to implement the plan. Finally, those factors pertaining to general regional development will have to be carefully monitored, including data pertaining to the amounts and spatial locations of changes in population, economic activity, and land use development. It is intended that the annual work program of the Commission will specify the precise scope of the plan surveillance function in any given year.

[64]*These functions have been incorporated in the implementation and adaptation of the areawide water quality management program since its adoption. The following subsections specifically describe the relationship of these functions to continuing water quality management planning in the greater Milwaukee watersheds.*

Plan Reappraisal

Under the plan reappraisal function, the areawide water quality management plan elements and the forecasts and assumptions underlying these plan elements are to be continually reappraised in light of changes in actual regional development as those changes are revealed by the surveillance function. This function is embodied in the "adaptive management" process that has been adopted for implementation of the MMSD 2020 facilities plan, and such an approach is also appropriate for implementation of the regional water quality management plan update as a whole. Plan amendments may be issued to adjust plan recommendations based on the findings of the plan surveillance function. Major plan updates and revisions are proposed to be undertaken periodically, subject to the availability of funding. Those reappraisals would examine the continued validity of the regional water quality management plan update in light of possible identified changes in the water use objectives and standards, as well as in any basic assumptions and forecasts upon which the plan is based.

Plan Expansion

In a broad program like the regional water quality management plan update for the greater Milwaukee watersheds, it is necessary to limit the initial plan development to consideration of the most urgent and highest priority needs. Under the plan expansion function of the continuing program, the scope of the initial planning effort can be expected to be expanded to address additional problems. It is envisioned, for example, that additional detailed inland lake water quality studies will be undertaken. In addition, it is possible that the program could include development of a regional biosolids plan that would include the greater Milwaukee watersheds. Also, it is possible that the problems associated with the disposal of toxic substances could be addressed. Whether or not the plan is expanded into these additional areas will be largely dependent upon the availability of local, State, and Federal funding.

Service and Plan Implementation

Under the service and plan implementation function, the data and forecasts upon which the water quality management plan update is based are to be made available to the designated management agencies as a basis for making day-to-day water quality management decisions, thereby promoting integration of Federal, State, and local planning and plan implementation efforts. The service and plan implementation function is extremely important because, to be of use in decision making, the adopted plan requires almost constant interpretation. In addition, the inventory data, analyses, and forecasts on which the plan is based must be made available on request for review and utilization in subsequent planning and plan implementation efforts. In addition, detailed facilities planning, necessary to refine the regional water quality management plan update, must be fully coordinated with the regional plan.

Procedural Development

Under the procedural development function, the techniques and procedures used for water quality management planning are to be evaluated, improved upon, and, where necessary, replaced through the development of new techniques and procedures. This function includes maintaining a current state-of-the-art of water quality management planning capability at the regional level.

Documentation

The documentation function is used to meet the continuing need to provide an important historical record of the entire water quality management planning process for the greater Milwaukee watersheds, within the context of the overall areawide water quality management plan. The documentation effort under the continuing planning program will consist of the following: plan amendment documents; major planning reports documenting the plan reappraisal and expansion efforts; community assistance planning reports documenting the more detailed local planning efforts of communities in the Region, particularly in lake areas; technical reports and technical records documenting any procedural development activities; and annual reports setting forth a record of the salient water quality management planning and plan implementation activities in the Region. Such annual reports will be included in the Commission's statutorily required *Annual Report*.

Financial Support for Continuing Planning Effort

The Federal statutes and regulations governing the areawide water quality management planning process require that a means be found to ensure a sustaining source of non-Federal funding for continuing areawide water quality management planning efforts.

In order to meet this Federal planning requirement, the Commission considered a number of ways in which to fund a continuing water quality management planning effort for the greater Milwaukee watersheds. Those funding mechanisms considered include local property taxes, local sales taxes, user fees as established through surcharges on sewerage system bills and on private onsite wastewater treatment system permits, and direct Federal and State funding. Federal funding administered by the State has been available for certain plan amendment and revision activities over the years since adoption of the initial areawide water quality management plan; however, no additional State funding is currently available and the total amount of funding has not been sufficient to fully cover the cost of continuing plan-related activities nor to enable major plan reevaluations to be made at a sufficient level of frequency. In recent years the level of Federal funding, which had remained constant, has declined and no State funding has been provided to make up any shortfalls. After careful consideration of the various sources of non-Federal funding support that are available, the Commission believes that the main approach to funding continuing water quality planning should be to supplement the existing Federal funding by seeking direct State funding through the WDNR. This belief is based upon considerations of equity, the statewide nature and importance of the planning effort, and ease of administration.

In light of the fact that recent trends in Wisconsin have sought to relieve local property taxes and not add to such taxes, for all practical purposes the property tax is effectively eliminated from consideration as a funding source for new and/or expanded water quality planning programs. The existing statewide structure for income, sales, and other taxes is already well established and can be used to secure funds on a statewide basis to conduct continuing areawide water quality management planning efforts. Accordingly, it is recommended that the WDNR ask the State Legislature to establish direct State funding of all continuing areawide water quality management planning efforts in the State, with that funding supplementing funds obtained by the State from the USEPA. The amount to be secured for each designated planning agency should be based upon an agreed-upon overall work program prepared and approved annually, and should be related to the budget cycle currently followed by the State and Federal governments. It is recommended that the overall level of effort of the ongoing SEWRPC water quality planning program be increased to enable the Commission to continue to effectively exercise its role as the designated water quality planning agency for southeastern Wisconsin, including the possibility of preparing plan updates for other watersheds in the Region. Based on recent SEWRPC budgets for water quality planning, large portions of which have come from the seven-county property tax levy and service contracts, it is recommended that the total annual amount budgeted for water quality planning be increased to $1.2 million, that the cost of funding that planning work be split evenly with half being provided by the Regional Planning Commission and half coming from State/Federal funding, and that the amount be adjusted over time to reflect increasing costs and/or responsibilities. As noted previously, certain specific, local programs may be funded through other means such as taxation, special assessments, sewerage service charges, issuance of revenue and/or general obligation bonds, and Federal, State, and private grant programs.

SUMMARY

This chapter has presented the recommended means for implementing the regional water quality management plan update for the greater Milwaukee watersheds. The chapter includes the designation of management agencies, identification of implementation costs and schedules, and assignment of plan implementation responsibilities for point source pollution abatement, rural nonpoint source pollution abatement, urban nonpoint source pollution abatement, instream water quality measures, inland lake water quality measures, auxiliary measures, and groundwater management measures.

Designated Management Agencies

The local, regional, State, and Federal government management agencies, along with certain nongovernmental organizations that would have a role in plan implementation is set forth by plan element, or subelement, in Tables 93 through 99, and can be summarized as follows:

- Point source pollution abatement (62 agencies),
- Rural nonpoint source pollution abatement (61 agencies and four private land trusts),
- Urban nonpoint source pollution abatement (121 agencies and two nongovernmental organizations),
- Instream water quality measures (104 agencies),
- Inland lake water quality management (35 agencies),
- Auxiliary water quality management (49 agencies and two nongovernmental organizations), and
- Groundwater quality management (95 agencies).

All but 35 of the designated management agencies currently exist. The potential new agencies consist of 28 Town utility districts and seven lake protection and rehabilitation districts. Depending on how many counties in the study area have adequate existing programs to provide the additional oversight of private onsite wastewater treatment systems (POWTS) that is recommended to be performed by existing or new town utility districts, those 28 new utility districts would be established to provide additional oversight of POWTS.

Targeting of Financial Resources

Tables 93 through 99 include prioritization of recommendations as “high,” “medium,” or “low.” Financial resources should generally be targeted according to this prioritization. Because of the broad scope of the recommended plan, it is difficult to more specifically indicate where to target resources at the systems planning level. However, as individual watershed action plans are developed during the plan implementation phase, it is anticipated that resources will be more specifically targeted to implementation actions within the overall context provided by the regional water quality management plan update.

This chapter includes information on the financial and technical assistance available to designated management agencies in carrying out their various assigned responsibilities, and it includes recommendations that:

- To fully meet the substantial costs associated with attaining the plan objectives, the State Legislature significantly increase levels of cost-share funding for key WDNR grant programs, particularly the Targeted Runoff Management (TRM) Grant Program and the Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program, and also for DATCP programs to implement agricultural best management practices, and
- The WDNR ask the State Legislature to establish direct State funding of all continuing areawide water quality management planning efforts in the State, with that funding supplementing funds obtained by the State from the USEPA.

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Chapter XII

SUMMARY

INTRODUCTION

This report documents an update to the Southeastern Wisconsin Regional Planning Commission's (SEWRPC) regional water quality management plan for the greater Milwaukee watersheds, as well as the process used to arrive at that plan. The plan update is for the design year 2020 and represents a major amendment to the regional water quality management plan for Southeastern Wisconsin.[1] This plan was prepared in conjunction with the Milwaukee Metropolitan Sewerage District's (MMSD) 2020 Facilities Plan. That joint planning effort is designated as the "Water Quality Initiative."

The regional water quality management plan update for the greater Milwaukee watersheds includes major plan elements addressing 1) land use, 2) surface water quality, including point and nonpoint source pollution abatement, and 3) groundwater management.

STUDY AREA

The 1,127 square mile greater Milwaukee watersheds study area, as shown on Map 1 in Chapter I of this report, includes all or part of:

- The Kinnickinnic River watershed,
- The Menomonee River watershed,
- The Milwaukee River watershed,
- The Oak Creek watershed,
- The Root River watershed,
- The Lake Michigan direct drainage area, and
- The Milwaukee Harbor estuary and nearshore Lake Michigan area.

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[1]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin—2000, *Volume One,* Inventory Findings, *September 1978; Volume Two,* Alternative Plans, *February 1979; and Volume Three,* Recommended Plan, *June 1979.*

About 861 square miles of these watersheds, or about 76 percent of the study area, are located within the seven-county Southeastern Wisconsin Region, representing about 32 percent of the Region. Within the Region, the study area includes all or part of Kenosha, Milwaukee, Ozaukee, Racine, Washington, and Waukesha Counties. In addition, approximately 266 square miles of the greater Milwaukee watersheds, or about 24 percent of the study area, are located outside of the Region. This portion of the study area consists of the upper reaches of the Milwaukee River watershed, located in Dodge, Fond du Lac, and Sheboygan Counties. The greater Milwaukee watersheds are drained by approximately 1,010 miles of stream, including the Kinnickinnic River and its tributaries, the Menomonee River and its tributaries, the Milwaukee River and its tributaries, Oak Creek and its tributaries, and the Root River and its tributaries, as well as several smaller streams draining directly to Lake Michigan.

AUTHORITY FOR PLAN PREPARATION

The Southeastern Wisconsin Regional Planning Commission is, pursuant to State legislation, the official planning agency for the seven-county Southeastern Wisconsin Region. The Commission is charged by law with the duty of preparing and adopting a comprehensive plan for the development of the Region. The Commission is also the State-designated and Federally recognized areawide water quality management planning agency for Southeastern Wisconsin.

During 2002, the MMSD initiated work on a third-generation sewerage facilities planning effort in response to a court-ordered stipulation requiring the facilities plan to be completed by June 30, 2007. The resultant facilities plan is consistent with Section 201 of the Federal Clean Water Act. As the facilities planning program was conceptualized, the MMSD proposed to utilize the watershed approach to plan development consistent with evolving U.S. Environmental Protection Agency (USEPA) policies. That approach was further defined to be conducted cooperatively with a coordinated and integrated comprehensive regional water quality management planning effort undertaken by SEWRPC. Such an approach built consensus among stakeholders and is sound public planning practice, as well as being consistent with the requirements of Section 208 of the Federal Clean Water Act.

The approach to cooperatively carrying out the MMSD facilities planning program and the SEWRPC regional water quality management plan updating program was developed cooperatively by the Wisconsin Department of Natural Resources (WDNR), the MMSD (including its facilities plan consultant team), and SEWRPC and was conceptually formalized under a February 19, 2003, WDNR/MMSD/SEWRPC Memorandum of Understanding. Two separate, but coordinated and cooperative planning programs were conducted. These planning efforts, when taken together, represent an integrated watershed water quality planning approach incorporating facilities planning.

This report documents the regional water quality management plan update effort that has been integrated with the MMSD facilities planning effort to form an integrated watershed water quality management plan. The regional water quality management plan update is designed to form a basis for future development of watershed-based, total maximum daily pollution loads, and possibly water quality standard use attainability analyses and reports consistent with the evolving policies of the WDNR and USEPA.

STUDY PURPOSE AND ORGANIZATION

The primary purpose of the update of the regional water quality management plan is to develop a sound and workable plan for the abatement of water pollution within the greater Milwaukee watersheds so as to meet the plan objectives that are described in Chapter VII of this report. More specifically, the planning program is intended to set forth a framework plan for the management of surface water for the greater Milwaukee watersheds incorporating measures to abate existing pollution problems and elements intended to prevent future pollution problems. It should be recognized that plan implementation will be dependent upon local actions, including, but not limited to: refinement and detailing of sanitary sewer service areas; the development of stormwater management plans and sewerage system facilities plans; and the integration of the plan recommendations into

County land and water resource planning as a means for implementing the rural land management recommendations.

Summary of Previous Regional Water Quality Planning Efforts

The areawide water quality management plan for southeastern Wisconsin which was completed by SEWRPC in 1979, adopted by the Wisconsin Department of Natural Resources (WDNR) Board, and approved by the U.S. Environmental Protection Agency (USEPA) is documented in SEWRPC Planning Report No. 30, *A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volumes One through Three. That plan was designed, in part, to meet the Congressional mandate that the waters of the United States be made to the extent practicable "fishable and swimmable." In accordance with the requirements of Section 208 of the Federal Clean Water Act, the plan provides recommendations for the control of water pollution from such point sources as wastewater treatment plants, points of separate and combined sewer overflow, and industrial waste outfalls and from such nonpoint sources as urban and rural stormwater runoff. The plan also provided the necessary framework for the preparation and adoption of the 1980 MMSD facilities plan.

Pursuant to the recommendation of the areawide plan that the water resources of the Milwaukee Harbor estuary be considered in more-detailed, site-specific studies, SEWRPC prepared an amendment to the regional water quality management plan which addressed water quality issues in the estuary. That plan, which was adopted in 1987, is documented in SEWRPC Planning Report No. 37, *A Water Resources Management Plan for the Milwaukee Harbor Estuary*, Volumes 1 and 2. The estuary plan set forth recommendations to abate water pollution from combined sewer overflows, including a determination of the level of protection to be provided by such abatement, and from other point and nonpoint sources of pollution in the tributary watersheds, including recommendations for instream measures, that might be needed to achieve established water use objectives.

In 1995, SEWRPC completed a report documenting the implementation status of the regional water quality management plan as amended over the approximately 15 years since the initial adoption of the plan. This report, SEWRPC Memorandum Report No. 93, *A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995, provides a comprehensive restatement of the regional water quality management plan as amended. The plan status report reflects implementation actions taken and plan amendments adopted since the initial plan was completed. The status report also documents, as available data permitted, the extent of progress which had been made toward meeting the water use objectives and supporting water quality standards set forth in the regional water quality management plan.

Since completion of the initial regional water quality management plan, SEWRPC and the WDNR have cooperatively conducted a continuing water quality management planning effort which has focused on sanitary sewer service area planning, groundwater inventories and analyses, and selected plan implementation activities.

In addition to providing clear and concise recommendations for the control of water pollution, the adopted areawide plan, including subsequent plan updates, provides the basis for the continued eligibility of local units of government for Federal and State grants and loans in partial support of sewerage system development and redevelopment, for the issuance of waste discharge permits by the WDNR, for the review and approval of public sanitary sewer extensions by that Department, and for the review and approval of private sanitary sewer extensions and large onsite wastewater disposal systems and holding tanks by the Wisconsin Department of Commerce.

Although certain elements of the areawide plan have been updated since 1979, and although many of its key recommendations have been implemented, the plan has now been updated to provide a needed framework for the preparation of the 2020 MMSD facilities plan and to update recommendations intended to improve water quality conditions throughout the greater Milwaukee watersheds.

Approach to Updating the Regional Water Quality Management Plan

The regional water quality management plan update employed a seven-step planning process through which the principal functional relationships existing within the planning area related to water quality management were accurately described, and the effect of different courses of action with respect to land use and facility development were tested and evaluated. The seven steps involved in this planning process are: 1) study organization; 2) formulation of objectives and standards; 3) inventory; 4) analysis and forecast; 5) preparation, test, and evaluation of alternative plans; 6) plan selection; and 7) plan implementation. Report preparation and public involvement are additional steps which were integrated throughout the process. The principal steps in the process are described in the following sections.

Relationship to the Recommended MMSD 2020 Facilities Plan
Point source pollution controls as established under the MMSD 2020 facilities plan are a component of the recommended regional water quality management plan. The MMSD must submit a facilities plan that meets regulatory requirements, particularly those related to control of combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs).[2] With regard to SSOs, the water quality information set forth in Chapter IX of this report, "Development of Alternative Plans: Description and Evaluation," demonstrates that there would be no significant improvement in overall instream and in-Lake water quality resulting from implementation of additional measures (beyond those that are already in place or that are committed to be implemented) to control SSOs from the MMSD Metropolitan Interceptor System (MIS). This is the case largely because of the significant MMSD sewerage system and wastewater treatment system upgrades that have been implemented, such as construction of the ISS, and system improvements which are under construction or otherwise committed to, along with system upgrades by other communities in the study area. These improvements, which were driven by regulatory requirements for control of sanitary and combined sewer overflows, have substantially reduced the frequency and volume of overflows. While some overflows will remain, of far greater significance is stormwater runoff pollution from both urban and rural areas.

Relationship to Other Planning Programs
In addition to the regional water quality management plan update and MMSD facilities planning programs, the current regional water quality management plan update is directly, or indirectly, related to a number of past or ongoing planning programs. These include, among others, County land and water resource management plans; the ongoing and anticipated future comprehensive or "smart growth" plans being prepared at the regional, county, and local units of government level; and the basin planning being carried out by the Wisconsin Department of Natural Resources (WDNR). In addition, the extensive water resources data base recently collected and collated by the MMSD in conjunction with the U.S. Geological Survey (USGS), in cooperation with the WDNR and others, is directly related and was used as the basic water quality data source. The analysis and evaluation of those water resource data is set forth in SEWRPC Technical Report No. 39, which is a companion report to this one.[3] In addition to the planning programs specifically noted above, there are other local planning programs which are relevant to the regional water quality management plan update which were considered, as appropriate, during the planning process. These plans include local sewerage system facilities plans, local stormwater management plans, local land use plans, and water resource management plans which have been prepared for selected areas.

Organizational Structure for the Plan Update
For selected work activities the work on the regional water quality management planning program and the MMSD facilities plan was carried out under a single, coordinated work effort using shared staff. These activities included three specific areas: 1) watercourse modeling, 2) Milwaukee Harbor estuary and nearshore Lake Michigan water quality modeling, and 3) state-of-the-art evaluation and report on pollution abatement practices. These three work elements were conducted under a cooperative effort involving SEWRPC, the MMSD, and the MMSD 2020

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[2]*SSOs are releases to waters of the State of untreated wastewater from a sanitary sewer system. CSOs are releases to waters of the State of untreated stormwater and wastewater from a combined sanitary sewer system that receives both wastewater flow and stormwater runoff. Combined sewers are only located in portions of the City of Milwaukee and the Village of Shorewood.*

[3]*SEWRPC Technical Report No. 39,* Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, *November 2007.*

facilities planning consultant team. The MMSD 2020 consultant team conducted the modeling work involved, with oversight being provided by SEWRPC and MMSD staffs. The work was developed in an integrated manner to meet the needs of both the regional plan update and the MMSD facilities plan.

Also, SEWRPC, with assistance from the WDNR and USEPA, contracted with the USGS to conduct water quality monitoring and analyses at six locations in the upper portion of the Milwaukee River watershed and three locations in the lower portion of the Root River watershed.

Public Involvement for the Plan Update

Public involvement activities were an important component of the plan preparation. Appendix A of this report documents the committee and public and local official informational meetings conducted during the plan preparation period. The public involvement activities were focused through the use of advisory committees, cooperative actions with other related ongoing public involvement activities, and other public involvement and watershed education programming. The SEWRPC plan update documented herein was prepared under the guidance of a Technical Advisory Committee, drawing members from a wide range of organizations dealing with water quality issues. The water quality modeling effort was periodically reviewed with a Modeling Subcommittee that was convened by SEWRPC and which provided valuable input. A joint MMSD/SEWRPC Citizens Advisory Council met periodically to receive updates on both the regional water quality management plan update and the MMSD facilities plan, and to provide input to the planning process. Finally, a Watershed Officials Forum, including the chief elected officials or their representative from the 88 cities, villages, or towns and the nine counties in the study area was established.

Scheme of Presentation

Following Chapter I, the introductory chapter, Chapter II presents updated information regarding the demographic and economic base, the natural environment, and land use and other aspects of the man-made environment of the watersheds, including information that is essential to the planning process. Chapters III and IV present a summary of the information set forth in SEWRPC Technical Report No. 39 relating to existing and historic water quality and pollution sources in the watersheds. Chapter V describes the water quality simulation models and other important analytic methods employed in the planning process. Chapter VI summarizes the legal structures or regulations affecting the study area. Chapter VII presents the planning objectives and standards adopted for use in the planning program. Chapter VIII presents land use and related population, household, and employment levels anticipated for the study in the year 2020. Chapter IX presents a description and evaluation of alternative water quality management plans. Chapter X presents a recommended water quality management plan designed to accommodate the year 2020 conditions. Chapter XI describes the actions which should be taken by the concerned units and agencies of government to facilitate implementation of the recommended plan. Finally, this chapter, Chapter XII, summarizes the major findings and recommendations of the planning study.

PLANNING OBJECTIVES

Objectives must be logically sound, related in a demonstrable and measurable way to alternative physical development proposals, and must be consistent with, and grow out of, regionwide development objectives. This is essential if the watershed water resources plans are to comprise integral elements of a comprehensive plan for the physical development of the Region and if sound coordination of regional and watershed development is to be achieved.

SEWRPC has, in its planning efforts to date, adopted, after careful review and recommendation by various advisory and coordinating committees, a number of regional development objectives relating to land use, housing, transportation, sewerage, water quality management, air quality management, flood control, and recreation and open space preservation. These objectives, together with their supporting principles and standards, are set forth in previous SEWRPC planning reports. Some of these objectives and standards are directly applicable to the current water quality planning effort and are hereby recommended for adoption as development objectives for the study area. Some of these objectives have been refined based upon broader input on the plan objectives from the committees established to participate in the planning process. In addition, that broader input resulted in the creation of five new objectives. The recommended plan objectives are listed below. More detailed descriptions of the objectives, along with the associated principles and standards are presented in Appendix G of this report.

Land Use Development Objectives
The land use development objectives adopted under the regional water quality management plan update program are:

1. Achievement of a Balanced Land Use Allocation

2. Protection and Wise Use of Natural Resources

3. Land Use Compatible with Economical Provision of Public Services

4. Preservation of Land for Agriculture, Habitat, and Orderly Development

Water Quality Management Objectives
Four water quality management objectives similar to those adopted by SEWRPC under its comprehensive watershed and regional water quality management planning program are directly applicable to the regional water quality management plan update effort. These are:

1. Development of Facilities, Programs, and Policies to Serve the Regional Development Pattern

2. Development of Policies and Practices to Meet Water Use Objectives

3. Enhancement of the Quality of Natural and Man-Made Environments

4. Reduction of Sedimentation, Other Water Pollution, and Eutrophication

Outdoor Recreation and Open Space Preservation Objectives
Two outdoor recreation and open space preservation objectives similar to those adopted by SEWRPC under its regional park and open space planning program and under county planning programs are directly applicable to the regional water quality management plan update planning program. These are:

1. Provision of Outdoor Recreation Sites

2. Preservation of Open Space

Water Control Facility Development Objective
One water control facility development objective similar to that adopted by SEWRPC in its watershed planning program has been adopted for use in the current plan. It is:

1. Development of a System to Reduce Flood Damage

Plan Structure and Monitoring Objectives
Six plan structure and monitoring objectives have been developed for use in the current planning program. The first two of these objectives are similar to an objective adopted by SEWRPC under its comprehensive watershed and regional water quality management planning programs. The other four objectives were developed in response to the public input received under the current planning program. These objectives are:

1. Development of Economical and Efficient Programs

2. Development of Strong Institutions for Plan Implementation

3. Support of Economic Development and Job Creation

4. Responsiveness of Adaptive and Flexible Plans

5. Improvement of Assessment and Management

6. Support of a Collaborative Approach to Water Quality Management

Educational and Informational Programming Objectives
One educational and informational programming objective has been developed for use in the current planning program in response to the public input received under the current planning program. It is:

1. Support of an Informed and Educated Public

Water Use Objectives/Classification and Water Quality Standards/Criteria
Section 281.15(1) of the *Wisconsin Statutes* requires that the WDNR prepare and adopt water use objectives and supporting water quality standards, or criteria, that apply to all surface waters of the State. Such authority is essential if the State is to meet the requirements of the Clean Water Act. As described and documented in Chapter VI, the WDNR currently has developed standards, or criteria, for the following water use objectives or classifications relating to fish and aquatic life for the study area watershed stream and lake system: 1) Great Lakes communities, 2) coldwater communities, 3) warmwater sport fish community, 4) warmwater forage fish community, 5) limited forage fish, and 6) limited aquatic life. In addition, the WDNR has developed standards, or criteria, for two recreational use classifications: 1) full recreational use and 2) limited recreational use; and it has developed standards, or criteria, for public health and welfare and for wildlife protection. The objectives or classifications for fish and aquatic life for all of the streams in the study area are set forth on Maps 51 through 56 and in Table 70 in Chapter VII of this report. All of the fish and aquatic life categories are considered to be in the full recreational use category, except where a special variance is noted.

The WDNR has also applied special-use designation to selected surface waters. These uses are "outstanding resource waters" and "exceptional resource waters," as set forth in Chapter NR 102 of the *Wisconsin Administrative Code*. The classification of "outstanding resource waters" applies to designated national and scenic rivers. The classification of "exceptional resource waters" applies to surface waters which provide valuable fisheries or other unique features. All Class I trout waters are included in the "exceptional resource waters" classification. Several streams with the "exceptional resource waters" classification are located in the Upper Milwaukee River watershed.

For selected surface waters in the study area, the regional water quality management plan update has evaluated the potential for achieving a higher objective or classification than currently codified. Those surface waters where an auxiliary upgraded water use objective or classification has been evaluated in the planning process and the basis for the auxiliary recommendations are set forth in Table 70 in Chapter VII of this report. The evaluation of alternative classifications is largely being done in response to changes in conditions since the last relevant *Administrative Code* sections were promulgated.

The water use objectives and supporting water quality standards and criteria for the greater Milwaukee watersheds are documented in Chapter IV of this report. As shown in Table 48 and on Maps 37 through 42 in Chapter IV of this report, most of the stream reaches in these watersheds are designated for fish and aquatic life and full recreational uses and are subject to standards under which dissolved oxygen concentrations are not to be less than 5.0 mg/l and fecal coliform bacteria counts may not exceed 200 cells per 100 ml as a geometric mean based on not less than five samples per month, nor exceed 400 cells per 100 ml in more than 10 percent of all samples during any month.

A few streams in the Milwaukee River watershed are designated for coldwater uses. Auburn Lake Creek upstream from Auburn Lake, Chambers Creek, Gooseville Creek, Melius Creek, Nichols Creek, and Watercress Creek are all considered coldwater streams and subject to standards under which dissolved oxygen concentrations are not to be less than 7.0 mg/l during spawning and 6.0 mg/l during the rest of the year.

The other exceptions to the fish and aquatic life and full recreational use designations are subject to variances under Chapter NR 104 of the *Wisconsin Administrative Code*. The mainstem of the Kinnickinnic River in the Kinnickinnic River watershed; Honey Creek, Underwood Creek from Juneau Boulevard in the Village of Elm Grove downstream to the confluence with the Menomonee River, and the mainstem of the Menomonee River downstream from the confluence with Honey Creek in the Menomonee River watershed; and Indian Creek, Lincoln Creek, and the mainstem of the Milwaukee River downstream from the site of the former North Avenue dam in the Milwaukee River watershed are subject to special variances under which dissolved oxygen is not to be less than 2.0 mg/l and counts of fecal coliform bacteria are not to exceed 1,000 cells per 100 ml. Burnham Canal and the South Menomonee Canal in the Menomonee River watershed are subject to special variances that impose the same requirements with the additional requirement that the water temperature shall not exceed 89ºF. In the Milwaukee River watershed, Silver Creek (Sheboygan County) downstream from the Random Lake wastewater treatment plant to the first crossing of Creek Road is designated for limited forage fish and is subject to a variance under which dissolved oxygen concentrations are not to be less than 3.0 mg/l. The East Branch of the Root River Canal from STH 20 to the confluence with the West Branch of the Root River Canal, Hoods Creek, Tess Corners Creek, the West Branch of the Root River Canal between STH 20 and CTH C, and Whitnall Park Creek downstream from the site of the former Hales Corners wastewater treatment plant are designated for limited forage fish and subject to variances under which dissolved oxygen concentrations are not to be less than 3.0 mg/l. The East Branch of the Root River, the East Branch of the Root River Canal upstream from STH 20, Ives Grove Ditch, the West Branch of the Root River Canal upstream from CTH C, and an unnamed tributary of the Root River downstream from the site of the former New Berlin Memorial Hospital wastewater treatment plant in the Root River watershed are designated for limited aquatic life and are subject to variances under which dissolved oxygen concentrations are not to be less than 1.0 mg/l.

The standards that apply to the Milwaukee outer harbor and adjacent nearshore Lake Michigan area are not as specifically defined as are the standards for the riverine areas. The Beach Act of 2000 requires that water quality advisories be issued at designated bathing beaches when the concentration of *E. coli* in a single sample exceeds 235 cells per 100 ml. This standard was used to assess whether water quality at beaches and in the nearshore Lake Michigan area was suitable for full recreational use. For other water quality parameters, it was decided to compare water quality in the outer harbor to the standards for fish and aquatic life.

ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

Screening Alternatives

The screening alternatives considered in the planning process were designed to address two basic issues: upgrades to the MMSD sewage conveyance, storage, and treatment system to eliminate overflows, and widespread implementation of best management practices (BMP) for treatment of nonpoint source pollution. These screening alternatives were intended to broadly assess certain approaches to improving water quality and to establish a framework through which alternative water quality management plans could be developed for the entire study area. A total of four screening alternatives addressing separate and combined sewer overflow reductions were evaluated. One screening alternative was evaluated that addressed implementation of a high level of BMP controls.

The five screening alternatives were each developed by building from a baseline condition that is described in detail in Chapter IX of this report. The baseline condition measures include certain committed projects and regulatory programs. Components of the baseline condition and the individual screening alternatives, along with their associated costs, are set forth in Table 74 in Chapter IX of this report.

Tabular comparisons of pollutant loading for the screening alternatives are presented in Appendix H, and comparisons of water quality conditions are set forth in Appendix I. Assessment of the water quality impact of the screening alternatives was made through comparison to the future 2020 land use baseline. The locations of the receiving water assessment points are shown on Maps 57 through 62 in Chapter IX of this report. Many of the assessment points also correspond with the location of MMSD water quality sampling sites that were included in the water quality assessment presented in Chapter III. A cross-reference between the assessment point designations shown on the maps and the MMSD sampling site designations is provided in Table 75 in Chapter IX of this report.

Screening Alternative 1A: Elimination of Separate Sewer Overflows (SSOs) and Combined Sewer Overflows (CSOs) Using Sewer Separation

This screening alternative assumes elimination of SSOs and CSOs through sewer separation within the MMSD combined sewer area to the maximum extent practicable, supplemented with enhanced wastewater treatment, storage, and pumping. Under this approach, a total of 89 percent of the combined sewer area would be converted into a separate sewer area with separate collection systems for sanitary sewage and stormwater runoff. The remaining 11 percent, located within the central portion of the combined sewer area, would remain unchanged.[4] Within the area to be separated, the existing combined sewers would be used to convey stormwater runoff only, while new sewers would be laid to convey sanitary sewage.

It was assumed under this screening alternative that the more heavily polluted "first flush" of stormwater from the separated area, which comprises a significant portion of the annual stormwater runoff pollutant loading, would continue to be diverted to the Inline Storage System (ISS), from which it would be pumped to the MMSD wastewater treatment plants. That approach would maintain a portion of the current water quality benefit from treating stormwater runoff from the combined sewer area. Excess stormwater runoff would overflow to the receiving streams or Lake Michigan.

In order to achieve the goal of eliminating SSOs and CSOs, this screening alternative would also require additional wastewater treatment capacities of 200 million gallons per day (mgd) and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 234 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Hydraulic restrictions were also identified at 42 locations within the Metropolitan Interceptor System (MIS). In order to avoid SSOs it was assumed that parallel relief sewers would be constructed at these locations. These 42 relief sewers are a common element of screening alternatives 1A through 1C.

This screening alternative has an estimated capital cost of $5.136 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $406.3 million.

Screening Alternative 1B: Elimination of SSOs and CSOs Using Enhanced Treatment and Storage

This screening alternative assumes elimination of SSOs and CSOs solely through a combination of enhanced wastewater treatment, storage, and pumping. The most cost effective combination of these measures calls for additional wastewater treatment capacities of 200 mgd and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 1,622 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Parallel relief sewers would also be required at 42 locations along the MIS in order to avoid SSOs during the more extreme wet weather events.

This screening alternative has an estimated capital cost of $5.807 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $444.9 million.

Screening Alternative 1C: Elimination of SSOs Using Enhanced Treatment and Storage

This screening alternative was designed to eliminate SSOs only, using a combination of enhanced wastewater treatment, storage, and pumping. The major difference from Screening Alternative 1B is in the level of enhancements needed, since this screening alternative is not designed to reduce CSOs. Under this screening

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[4]*That area comprises the central business district of the City of Milwaukee. Sewer separation in that area was considered to potentially be too disruptive to include in the screening alternative.*

alternative, the most cost effective combination of measures calls for additional wastewater treatment capacities of 200 mgd and 100 mgd for the South Shore and Jones Island treatment plants, respectively. An additional 153 million gallons of storage would be added to the ISS, while the pumping capacity from the ISS to the Jones Island WWTP would be increased by 100 mgd. Parallel relief sewers would also be required at 42 locations along the MIS in order to avoid SSOs during the more extreme wet weather events.

Although designed to eliminate only SSOs, this screening alternative does have some incidental benefits in reducing the anticipated volume of CSOs as well. This benefit results from the increased treatment capacity and is most effective during wet weather events that are characterized by extended periods of runoff, such as those related to snowmelt or extended periods of moderate rainfall.

This screening alternative has an estimated capital cost of $2.217 billion and an annual operation and maintenance cost of $75.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $221.4 million.

Screening Alternative 1D: Elimination of SSOs through Infiltration and Inflow Reduction

This screening alternative was designed to eliminate SSOs by reducing infiltration and inflow (I/I) to sanitary sewers within the separate sewer area. In order to achieve this, a multi-step process was followed in which the sewersheds that were identified as having the highest levels of I/I were targeted first. Progressive expansion of the I/I removal was carried out within the separate sewer area until all SSOs were eliminated based on the 64.5-year model simulation period.

In order to eliminate all SSOs, reduction efforts would need to reduce I/I so that the wastewater flow rates from all sewersheds would be less than 2,000 gallons per acre per day for the five-year recurrence interval peak wastewater flow. This would require I/I reduction efforts within about 93 percent of the separate sewer area that would exist under planned year 2020 land use conditions. These reduction efforts would focus mainly on disconnection of foundation drains and lateral rehabilitation on private properties.

In addition to achieving elimination of SSOs, this screening alternative would also have some effect on reducing the number and volume of CSOs that may be expected to occur. This reduction would be the result of having less inflow from the separate sewer area to store and treat, freeing up capacity for the storage and treatment of inflow from the combined sewer area. For the entire 64.5-year simulation period, it is anticipated that CSO volume would be reduced by about 12 percent, while the number of actual CSO events would be reduced by about 3 percent.

This screening alternative has an estimated capital cost of $7.705 billion and an annual operation and maintenance cost of $68.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $577.2 million.

Screening Alternative 2: Implementation of a High Level of Best Management Practices to Control Nonpoint Source Pollution

In contrast to the previous four screening alternatives that looked at reducing or eliminating sanitary sewage overflows, this screening alternative was designed to test the impact on water quality of solely implementing a high level of best management practices (BMPs) aimed at reducing urban and rural nonpoint source pollutant loads. Under this alternative it was assumed that there would be no further measures involving enhanced treatment, storage, or I/I reduction to limit the number and volume of separate and combined sewer overflows beyond those included under the future 2020 land use baseline condition. The level of BMP implementation assumed, while deemed achievable, would be well above that which would be anticipated to be implemented under the current regulatory and institutional frameworks.

In selecting the BMPs to be included and assigning their levels of implementation, an initial consideration was given to those measures that were used to represent compliance with State and local requirements governing nonpoint source runoff. Using the information developed for the state-of-the-art report, additional technologies and increased levels of compliance were then added to the baseline condition to make up this screening alternative. The measures applied under this screening alternative and their assumed levels of implementation are listed in Table 74 in Chapter IX of this report.

This screening alternative has an estimated capital cost of $2.004 billion and an annual operation and maintenance cost of $111.7 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this screening alternative is $242.7 million.

Comparison and Evaluation of Screening Alternatives

The relative equivalent annual costs and water quality effects of the five screening alternatives were compared to provide guidance on the most effective components to include in the next step of the plan development process—synthesis of alternative water quality management plans. Comparison of the cost information set forth in Table 74 in Chapter IX of this report, and the water quality data in Appendix I indicates that Screening Alternative 1C: Eliminate SSOs Using Enhanced Treatment and Storage has the lowest estimated equivalent annual cost while providing water quality benefits similar to Screening Alternatives 1A, 1B, and 1D. Screening Alternative 2: High Level of Implementation of Best Management Practices to Control Nonpoint Source Pollution has the second lowest estimated equivalent annual cost and would result in achievement of the best instream water quality conditions. Screening Alternatives 1A, 1B, and 1D have significantly higher equivalent annual costs compared to Screening Alternatives 1C and 2. The alternative plans described in the following section were developed in consideration of both the regulatory requirements regarding SSOs and CSOs and the potential for achieving the largest improvements in water quality through implementation of controls on nonpoint source pollution.

Description and Evaluation of Alternative Water Quality Management Plans

Five alternative water quality management plans were considered to abate the existing water quality problems described in Chapter III of this report, and to meet the water use objectives and supporting standards presented in Chapter VII. The first plan considered was used as a baseline condition, against which to assess the effectiveness of the other four plans. This baseline, or alternative future situation, included the effect of implementing projects that are already committed, including current regulatory programs, while also taking into account future population and land development projections. The remaining four plans—as well as the five screening alternatives described above—each included the components of the baseline alternative and were grouped into two distinct categories: regulatory-based alternatives and water quality-based alternatives. A description of each alternative plan is presented below. Individual features of the plans are set forth in Table 76 in Chapter IX of this report.

Alternative A: Baseline Alternative

This alternative includes only those measures that are already committed by various agencies within the study area, particularly those projects committed to be carried out by the MMSD by the design year of 2020. Also included are actions required under current regulatory programs, including State and local rules governing nonpoint pollutant runoff.

This alternative has an estimated capital cost of $1.035 billion and an annual operation and maintenance cost of $68.0 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $134.4 million.

The components of this alternative are described in the following subsections.

Land Use

The screening alternatives, the baseline alternative, and the alternative water quality management plans reflect planned year 2020 land use conditions throughout the study area. Within the MMSD planning area, 2020 population and land use estimates were developed by the SEWRPC staff based on detailed consultation with officials and staff of the MMSD communities. Specific, anticipated future land use conditions were identified by each community and the SEWRPC staff translated those conditions to household and population projections and land use distributions by sewershed. Outside of the MMSD planning area, information developed under the SEWRPC 2020 land use plan was used to obtain household, population, and land use projections.[5]

Following development of the screening alternatives and the alternative water quality plans, the regional land use plan for the year 2035 was completed.[6] The water quality planning process as initially established recognized that completion of the 2035 plan would offer an opportunity to revise year 2020 population and land use projections based on the 2035 estimates. Such revisions were made and that information was used in evaluating possible study area sewage treatment plant needs and MMSD system storage and treatment components to be included in this plan. Sewage flows based on the original 2020 population and land use information as developed from community estimates were used to size MMSD conveyance facilities under all aspects of the planning process—screening alternatives, alternative water quality plans, and the recommended plan. To distinguish between the two 2020 land use and population conditions, the community-determined condition applied for the screening alternatives and the alternative water quality plans is referred to as the "**original 2020 population and land use condition**." The year 2020 condition derived from the 2035 regional land use plan data is referred to as the "**revised 2020 population and land use condition.**" A detailed explanation of the land use plan element is provided in Chapter VIII.

Urban Stormwater Management

The baseline alternative assumes compliance with all of the nonagricultural performance standards in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code,* which sets forth rules for the control of nonpoint pollution from agricultural and nonagricultural areas, construction sites, and transportation projects.

Chapter 13, "Surface Water and Storm Water," of the MMSD Discharge Regulations and Enforcement Procedures is intended to limit the increase in runoff due to new development within its service area. The baseline alternative includes consideration of these rules and their impact on reducing stormwater runoff and associated pollutant loads within the MMSD planning area.

Rural Land Management

The performance standards governing control of nonpoint pollution from agricultural lands that are set forth in Chapter NR 151 cover the areas of cropland sheet, rill, and wind erosion control, manure storage, clean water diversions, and nutrient management. For existing land that does not meet the NR 151 standards and that was cropped or enrolled in the U.S. Department of Agriculture Conservation Reserve or Conservation Reserve Enhancement Programs as of October 1, 2002, agricultural performance standards are only required to be met if cost sharing funds are available. Given the current lack of public cost share funding, it is unlikely that compliance with the standards will be achieved by the plan design year of 2020. Inventories carried out during this planning effort indicate that the majority of croplands in the study area already meet the standards for cropland sheet, rill, and wind erosion control. Thus, a level of soil erosion control consistent with all cropland being in compliance by the design year 2020 was assumed. This partial level of implementation of the NR 151 agricultural requirements is considered to be consistent with the anticipated level of funding, assuming no change in the structure of the current grant program.

Sewerage Systems (Committed Facilities)

The basis of the specific committed sewerage system facilities included in the baseline condition alternative was the MMSD 2006 Capital Budget and Six-Year Capital Improvements Program.[7] Major projects incorporated under the baseline condition include improving the wet weather flow capacity at the Jones Island and South Shore

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[5]*SEWRPC Planning Report No. 45,* A Regional Land Use Plan for Southeastern Wisconsin: 2020, *December 1997.*

[6]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

[7]*Milwaukee Metropolitan Sewerage District,* 2006 Annual Budget.

WWTPs, constructing the Jones Island Inline Pump Station and the Harbor Siphons, and additional storage capacity projects including the recently completed Northwest Side Relief Sewer, and the West Wisconsin Avenue relief sewer, the Port Washington Road relief sewer, and the Range Line Road relief sewer.[8]

Under this baseline condition, it was also assumed that effluent characteristics of all public and private wastewater treatment plants within the project area would remain the same as under existing conditions, with the volume of effluent from these plants adjusted to reflect the increased contributions due to future development as set forth in the year 2020 land use plan. Therefore, future system upgrades that may be implemented to handle the increase in loading from new development are accounted for. It was also assumed that the level of SSOs for sewerage systems outside of the MMSD service area would remain at the current levels.

For the baseline condition it was assumed that the current MMSD operating procedures for the ISS would be maintained with 177 million gallons of the ISS storage reserved for separate sewer inflow, while the remaining 255 million gallons would be available to store inflow from the combined sewer service area. The 177 million gallons reserved storage was found to be the optimum value in terms of minimizing the occurrence of CSOs, based on application of the MMSD conveyance system model that was described in Chapter V.[9]

As described in Chapter IX of this report, under certain circumstances, MMSD uses blending to prevent basement backups, raw sewage overflows, and damage to the Jones Island WWTP.[10] Under the baseline condition, it was assumed that the current rate of blending would continue at the Jones Island WWTP. No additional blending was assumed for the Jones Island WWTP and no blending was assumed at the South Shore WWTP.

Management of Infiltration and Inflow

It was assumed that conveyance system I/I would be maintained at current levels through sanitary sewer system maintenance measures.

Other Point and Nonpoint Sources of Pollution

In addition to public and private wastewater treatment plants and separate and combined sewer overflows, the water quality assessment also considered point source contributions from industrial sources. It was assumed that the existing industries would continue to discharge at the current rates.

Although not explicitly represented in the water quality simulation models used, discharges from malfunctioning private onsite waste treatment systems (POWTs) was accounted for through an increase in pollutant concentrations associated with groundwater. Under the future baseline condition, it was assumed that the current level of pollutant contribution from POWTs would be maintained.

Watercourse Management

In addition to construction and maintenance of facilities for the conveyance and treatment of wastewater, the MMSD also has discretionary authority to maintain waterways within the watersheds located within its service

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[8]*Subsequent to the adoption of the MMSD 2006 Capital Budget, the West Wisconsin Avenue and Port Washington Road relief sewer projects were dropped in favor of the North 27th Street ISS, which was found to provide the same level of relief.*

[9]*The actual amount of storage that is reserved varies by event depending on weather forecasts and the amount of available storage in the ISS at the time.*

[10]*Blending is the practice of diverting diluted wastewater flows that exceed the wet weather capacity of the wastewater treatment plant around secondary treatment during peak wet weather events, in an effort to avoid significant damage to biological treatment units and loss of treatment capability. The diverted flows are then normally recombined with flows from the fully utilized secondary treatment units for further treatment, including disinfection, prior to discharge.*

area. Management measures implemented under MMSD watercourse projects include structure acquisition and removal, channel modification, floodplain lowering, floodwater storage, and floodwalls and levees. The baseline alternative assumes that all of the MMSD watercourse projects that have either been completed or are committed to be completed by the year 2020 will be implemented. Committed projects are those outlined in the MMSD 2006 Capital Budget.

No other specific new watercourse management projects were identified in the study area.

Continued Dredging of Bottom Sediments for Maintenance of Navigation
Maintenance dredging is carried out for that portion of the Milwaukee Harbor estuary used for waterborne commerce through the combined efforts of the Federal government, the City of Milwaukee, and private riparian property owners. As part of the baseline and all subsequent alternative water quality management plans, it was assumed that maintenance dredging for commercial navigation would continue to be conducted as needed.

Alternative B1: Regulatory-Based Alternative
Under this alternative it was assumed that all current regulations governing discharge from municipal sanitary sewer overflows and control of nonpoint source pollution would be met. This alternative was built on baseline Alternative A.

A five-year recurrence interval level of protection (LOP) from SSOs was assumed. This level of occurrence is tied to the frequency of overflow events, and not to rainfall frequency. In order to meet the five-year LOP SSO restriction, this alternative includes the following additional measures:

- Add 100 mgd of pumping capacity from the MMSD ISS to the Jones Island WWTP.
- Add 185 mgd of treatment capacity to the South Shore WWTP.
- Add 40 million gallons of storage capacity to the ISS.
- Upgrade the MIS conveyance capacity at identified hydraulic restrictions.

In addition to the CSO and SSO control measures noted above, this alternative also includes full compliance with both the urban and rural nonpoint source control performance standards as outlined in Chapter NR 151 of the *Wisconsin Administrative Code*. This is a departure from Alternative A, which assumed only partial implementation of the NR 151 agricultural standards due to funding constraints. Under Alternative B1, it was assumed that adequate funding would be made available.

Additional measures aimed at reducing the volume of stormwater runoff from within the combined sewer service area would also be implemented. These include downspout disconnection with rain barrel installation at 15 percent of homes in the area, downspout disconnection with rain gardens at a different 15 percent of homes in the area, provision of 14 million gallons of rooftop storage in the City of Milwaukee central business district, provision of 15 million gallons of street storage through installation of storm sewer inlet restrictors, and provision of stormwater trees.

This alternative has an estimated capital cost of $1.999 billion and an annual operation and maintenance cost of $91.3 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $223.1 million.

Alternative B2: Regulatory-Based Alternative with Revised ISS Operating Procedure
This alternative is similar in concept to Alternative B1, with the exception of a change in the operation of the ISS so that volume does not always need to be reserved for wastewater from the separate sewer systems. In this way, the use of the ISS may be maximized, with the intent of reducing the total volume of overflows from both combined and separate sewers.

As previously stated, current regulations do not allow for separate sewer overflow discharges except in special situations. The change in operating procedures under this alternative would result in a reduction in the number and volume of CSOs at the expense of an increase in the number and volume of SSOs. Implementation of this alternative would require a change in Federal law with regard to SSOs; however, neither this alternative, nor such a change in Federal law, is recommended.

In order to provide a consistent basis of comparison with Alternative B1 in terms of water quality impacts, this alternative also includes the same MMSD system improvements as that alternative, full compliance with both the urban and rural nonpoint source control performance standards as outlined in Chapter NR 151, and the same additional measures aimed at reducing the volume of stormwater runoff from within the combined sewer service area.

This alternative also has an estimated capital cost of $1.999 billion and an annual operation and maintenance cost of $91.3 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $223.1 million.

Alternative C1: Water Quality-Based Alternative

This alternative and Alternative C2 were developed with an emphasis on maximizing compliance with water quality standards and criteria, rather than simply meeting regulatory requirements. To this end, both of these alternatives emphasized control of nonpoint source pollution. As with Alternatives B1 and B2, this alternative was built on Alternative A and includes the same features regarding future committed projects and the common package.

The measures that make up Alternative C1 are identified in Table 76 in Chapter IX of this report. Under this alternative, it was assumed that the current MMSD operational measures to control the occurrence of SSOs and CSOs would be maintained. There would be no further measures employed to reduce the level of SSOs and CSOs over and above the committed actions that were assumed under the future baseline condition (Alternative A).

Alternative C1 assumes the application of nonpoint source control measures that would exceed those required to meet the current regulatory mandate as identified in Chapter NR 151. For rural areas, these measures include providing buffer strips with a minimum width of 50 feet on existing crop and pasture lands along streams, implementation of manure management programs for all livestock operations, and increased inspections of privately owned wastewater treatment systems. For urban areas, measures to be employed include extending the infiltration capacity performance standards set forth in Chapter NR 151 to industrial and commercial development with less well-drained soils and tripling the amount of infiltration to be achieved for new development in areas with well-drained soils. Other urban area measures include increasing the application of modular end-of-pipe water quality treatment devices, installing storm sewer outfall disinfection units, implementing chloride reduction programs, downspout disconnections in conjunction with either rain barrels or rain gardens, and applying street and rooftop storage within the combined sewer service area.

This alternative has an estimated capital cost of $2.564 billion and an annual operation and maintenance cost of $116.5 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $293.7 million.

Alternative C2: Water Quality-Based Alternative with Green Measures

This alternative differs from Alternative C1 in that it includes more emphasis on "green" technologies that more directly address reduction of sources of pollution. The measures that make up Alternative C2 are identified in Table 76 in Chapter IX of this report. As seen in that table, all of the measures set forth in Alternative C1 would also be included under Alternative C2. One exception is in the application of storm sewer outfall disinfection units. Under Alternative C1, it was assumed that the units would utilize a chlorine-based system for disinfection. For Alternative C2, disinfection would be achieved utilizing ultraviolet light, which is significantly less expensive than chlorine-based systems.

For rural areas, additional measures that would be employed are the conversion of a total of 10 percent of existing crop or pasture land to either wetland or prairie. A 50-50 split was assumed, with 5 percent of the land being converted to wetland and 5 percent to prairie. Marginally productive farmland would be targeted for such conversion.

Within urban areas, this alternative assumes that 50 percent of new industrial and commercial development would employ Leadership in Energy and Environmental Design (LEED) features.[11]

This alternative has an estimated capital cost of $2.227 billion and an annual operation and maintenance cost of $113.2 million. Based upon an analysis period of 50 years and an annual interest rate of 6 percent, the estimated equivalent annual cost of this alternative is $279.8 million.

Comparative Evaluation of Alternative Water Quality Management Plans

Chapter IX includes a detailed comparison of the major features of the alternative water quality management plans, including consideration of the pollutant loading analyses, water quality conditions and the ability of a given alternative to meet water use objectives, economic characteristics, and implementability. That evaluation was the basis for the development of a preliminary recommended plan which was refined to represent the final recommended water quality management plan.

RECOMMENDED WATER QUALITY MANAGEMENT PLAN

The recommended plan calls for the implementation of a comprehensive set of specific actions devised to ensure the enhancement and/or preservation of the surface water quality of the streams and lakes in the greater Milwaukee watersheds study area, including Lake Michigan, and to preserve the quality of the groundwater which provides the baseflow for those streams and lakes and also serves as a source of drinking water in the Southeastern Wisconsin Region. A primary consideration in the selection of the components of the recommended plan was the degree to which those measures, functioning together as a watershed-based system, would be expected to achieve the agreed-upon water use objectives in a cost-effective manner. The selection of the recommended plan followed an extensive review by the Technical Advisory Committee of the technical feasibility, economic viability, environmental impacts, potential public acceptance, and practicality of the various alternative water quality management plans considered. Those factors were also considered, with an emphasis on the technical aspects of the water quality models, by the Modeling Subcommittee. In addition, as described in Appendix A of this report, public input was solicited over the course of the planning period and that input was considered in formulating the screening alternatives, the alternative water quality management plans, and the recommended plan that was built from those alternatives.

The development of the recommended plan focused primarily on identifying cost-effective ways to meet the water use objectives and supporting water quality standards to the degree possible. Consideration was also given to the existing regulatory framework regarding wastewater discharges and abatement of nonpoint source pollution. Accordingly, the plan was developed to include all components of the future baseline condition (Alternative A) along with elements from both Alternative B-1 (regulatory-based) and the C alternatives (water quality-based). The plan incorporates most actions identified in the MMSD 2020 facilities plan, as well as additional measures directed towards improving water quality through reducing point and urban and rural nonpoint source pollutant loads.

The comprehensive recommended plan is comprised of the following major elements that are presented in this chapter:

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[11]*The LEED Green Building Rating System is a voluntary, consensus-based national standard for developing high performance, sustainable buildings, with an emphasis on state-of-the-art strategies for sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality.*

- A land use plan element,
- Surface water quality plan elements, including point and nonpoint source pollution abatement subelements, and
- A groundwater management plan element.

A detailed analysis of the estimated costs of plan implementation is presented in Chapter X as is an evaluation of the ability of the recommended plan to meet the adopted water resource management goals, objectives, and standards as set forth in Chapter VII and Appendix G of this report, with particular emphasis on the ability to meet the surface water use objectives and water quality standards. No water resource plan element can fully satisfy all desirable water resource objectives. The recommended comprehensive plan, therefore, consists of a combination of individual plan elements, with each element contributing to the satisfaction of the plan objectives. The recommended plan elements are complementary in nature, and the recommended water quality management plan represents a synthesis of carefully coordinated individual plan elements which together are intended to achieve the adopted plan objectives to the degree practicable.

Approaches to Developing the Recommended Plan

Two approaches were considered in developing the recommended water quality management plan for the greater Milwaukee watersheds. The first approach stems from the necessity that the MMSD 2020 facilities plan meet regulatory requirements. That approach is termed the "Regulatory Watershed-Based Approach" (regulatory approach). The second approach has its genesis in the finding that because of significant and effective past or committed actions by the operators of wastewater systems, other point source dischargers throughout the study area, and measures implemented under WDNR regulatory programs, additional point source controls would result in no significant improvement in overall instream and in-Lake water quality. That approach, which is called the "Integrated Watershed-Based Approach," is predicated on the concepts that if certain, limited components of the MMSD recommended 2020 facilities plan were not implemented 1) there would be a reduction in costs to implement the MMSD facilities plan with no significant change in water quality and 2) the cost savings from elimination of the specific facilities plan components could be applied to nonpoint source pollution control measures that would be more effective in improving instream water quality.[12] The components of those two approaches are generally the same. The similarities and differences between the two approaches are described in Chapter X. A single recommended plan was finally selected by the committee.

Land Use Plan Element

The most fundamental and basic element of the regional water quality management plan update is the land use element. The future distribution of urban and rural land uses will largely determine the character, magnitude, and distribution of nonpoint sources of pollution and ultimately, the quality of surface waters in the greater Milwaukee watersheds. Consequently, the selection of a land use plan for the study area is the first and most basic step in synthesizing the water quality plan. The process for developing the planned land use data that form the land use element of the plan is described in Chapter VIII of this report. Detailed information on planned land use in the portion of the study area within the Southeastern Wisconsin Region is set forth in SEWRPC Planning Report No. 45, *A Regional Land Use Plan for Southeastern Wisconsin: 2020*, December 1997 and SEWRPC Planning Report No. 48, *A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006. Planned land use information for areas outside the Southeastern Wisconsin Region was obtained from available State, county, and local land use plans, land preservation plans, and related documents. Information from all of those planning

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[12] *Although a cost saving would accrue to the MMSD if certain components of the MMSD 2020 facilities plan were foregone, the additional funds that could be applied to more effective nonpoint source pollution control measures would not necessarily be provided by MMSD. Chapter XI, "Plan Implementation," provides information on funding sources and assigns responsibilities for implementing the various components of the plan.*

efforts were used in developing the land use plan element for the water quality management plan. The land use plan element described in this report subsection is common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Population and Land Use in the Study Area

One of the major elements of the regional water quality management plan update is the incorporation of updated land use information, including both an inventory of existing (2000) development and the identification of planned year 2020 development. In addition, projections of buildout land use conditions were developed for municipalities within the MMSD planning area. A summary of existing development is presented in Chapter II, while a discussion of planned future development is set forth in Chapter VIII.

Year 2020 and buildout population and land use estimates were initially developed by the SEWRPC staff and the communities served by the MMSD based on future land use information provided by those communities. Planned land use data from the SEWRPC 2020 regional land use plan and available county and local land use information for the area outside the Southeastern Wisconsin Region were applied for communities in the study area that are not served by MMSD. Those initial year 2020 population and land development assessments were used for sizing the conveyance components of the MMSD Metropolitan Interceptor System under both the year 2020 MMSD facilities plan and the recommended regional water quality management plan update. When data from the SEWRPC 2035 regional land use plan became available, 2020 land use and population estimates for the MMSD communities were revised using a 2020 stage of those data and the revised data were used to develop the wastewater treatment components called for under the recommended MMSD 2020 facilities plan which is incorporated in the regional plan. Similarly refined population estimates were used for the 2020 condition evaluation of all of the public sewage treatment plants in the study area. Revised 2020 industrial and commercial land use estimates were also applied for the development of revised nonpoint source pollution loads used in modeling the instream and in-lake water quality conditions under revised future year 2020 and recommended water quality plan conditions.

Year 2020 planned land uses for the greater Milwaukee watersheds, based on the original 2020 land use data provided by the communities within the MMSD planning area and on the SEWRPC 2020 regional land use plan and available State, county, and local plans outside the MMSD area, are set forth on Maps 63 through 69 in Chapter X of this report, which provide data for the entire study area and for each watershed in that area. Original year 2020 land use data are provided by watershed in Table 81 in Chapter X of this report.

Environmentally Significant Lands

Recommendations Regarding Environmentally Significant Lands

Consistent with the objectives and standards adopted under this regional water quality management plan update, it is recommended that primary environmental corridors be preserved in essentially natural, open uses, forming an integrated system of open space lands in the study area. Also, in the design of the recommended land use plan, other than for a limited number of exceptions, incremental urban and rural development was not allocated to primary or secondary environmental corridors or isolated natural resource areas.

Consistent with the regional land use plan, the regional water quality management plan update recommends the preservation of all of the identified natural areas and critical species habitat sites and, as called for under the regional natural areas and critical species habitat protection and management plan, it recommends acquisition of those sites not in existing public or public-interest ownership.

Highly Productive Agricultural Land

The regional water quality management plan update land use objectives and standards call for the preservation, to the extent practicable, of the most productive farmland, identified as farmland covered by agricultural capability Class I and Class II soils as classified by the U.S. Natural Resources Conservation Service.

Surface Water Quality Plan Elements

This report section describes the recommended point and nonpoint source pollution control measures, instream water quality measures, and auxiliary measures for the greater Milwaukee watersheds, all of which are directed toward improving surface water quality conditions in the study area.

Point Source Pollution Abatement Plan Subelement

This subelement includes recommendations related to public wastewater treatment and associated sewer service areas, private wastewater treatment plants, and other point sources of pollution. The recommended point source pollution control measures described in this report subsection are components of the Regulatory Watershed-Based Approach. Recommendations related to the provision of additional treatment capacity at the MMSD South Shore wastewater treatment plant were changed for the Integrated Watershed-Based Approach as described below.

Public Wastewater Treatment Plants and Associated Sewer Service Areas

Map 73 in Chapter X of this report shows the planned sanitary sewer service areas within the study area and the MMSD planning area outside the study area. With the exception of most of the MMSD service area within Milwaukee County; the City of South Milwaukee service area; the Villages of Adell, Campbellsport, Cascade, Lomira, and Random Lake; the Town of Scott Sanitary District No. 1 service area; and the Town of Yorkville Sanitary District No. 1 service area, all sewer service areas within the greater Milwaukee watersheds have been refined. It is recommended that the MMSD, South Milwaukee, Adell, Campbellsport, Cascade, Lomira, Random Lake, Scott, and Yorkville service areas be refined through a joint effort involving the municipalities; the appropriate regional, county, or local agencies; and the WDNR.

Public Wastewater Treatment Systems Outside of the Milwaukee Metropolitan Sewerage District Planning Area

It is recommended that communities in the study area, but outside of the MMSD planning area continue to assess their wastewater conveyance and treatment systems so as to provide the capacity necessary to allow for future development as it occurs while adhering to the conditions of their operating permits. The regional water quality management plan update evaluates facilities planning needs based on a criterion that facilities planning should be initiated when the average daily flow to a wastewater treatment plant reaches 80 percent of the plant design capacity. As shown in Table 80 in Chapter IX of this report, it is estimated that by the year 2020, assuming existing wastewater treatment plant design capacities:

- Sewage flows to the Village of Grafton plant would be nearing 80 percent of the plant design capacity,
- Sewage flows to the Village of Kewaskum and Village of Newburg plants would have exceeded the 80 percent threshold and would be approaching, or equaling, the plant design capacities, and
- Sewage flows to the City of Cedarburg and Village of Jackson plants would have exceeded plant design capacities.

The Village of Kewaskum has recently prepared a facilities plan for upgrades to its wastewater treatment system. Depending on the rate of growth of population and the rate of expansion of commercial and industrial land, the Village may have to undertake additional facilities planning prior to 2020.

While average annual sewage flows to the wastewater treatment plants for the Villages of Newburg and Jackson have not yet reached the 80 percent threshold, because they are projected to exceed the threshold sometime between now and 2020, it is recommended that those municipalities monitor development and population levels in their sewer service areas and that they prepare facilities plans prior to 2020 in order to provide adequate treatment capacity to meet future needs.

Based on the information in Table 80 in Chapter IX of this report, it is estimated that facilities planning for the City of Cedarburg may be warranted prior to 2020[13] and facilities planning for the Village of Grafton may be warranted in about the year 2020. The City and the Village have given preliminary consideration to constructing a new regional wastewater treatment plant at such future time that expansion of the existing treatment capacity for those communities is warranted. It is recommended that, when facilities planning is first initiated for either of the municipalities, that the plan include cost-effectiveness analyses to evaluate upgrading the individual treatment plants versus construction of a new regional wastewater treatment plant to serve both communities.

A wastewater treatment facilities plan was recently prepared by the Village of Fredonia. The facilities plan does not call for the Fredonia plant to treat wastewater from the Waubeka area because that area has not yet been provided with a sanitary sewerage system and there are no imminent plans to do so. The regional water quality management plan update recommends eventual connection of the Waubeka area to the Fredonia wastewater treatment plant; however, in the absence of a sanitary sewerage system to serve Waubeka, it is considered to be consistent with the regional plan for Fredonia to exclude the Waubeka area from its planning area at this time.

The Village of Caledonia recently completed a study to determine the most cost-effective way to provide sanitary sewer service to portions of the Village that are anticipated to be developed by the year 2035. The study also involved the City of Racine, Villages of Mt. Pleasant and Sturtevant, and the Towns of Raymond and Yorkville. Wastewater from the City of Racine and the Villages of Caledonia, Mt. Pleasant, and Sturtevant is currently treated at the plant operated by the Racine Water and Wastewater Utility. Wastewater flows from the Town of Yorkville sewer service area are treated at the plant operated by the Town of Yorkville Sanitary District No. 1. Pursuant to the cost-effectiveness analysis, a sewer service area amendment was adopted that expands the boundaries of the sewer service area for the City of Racine and environs to include additional areas in the Villages of Caledonia and Mt. Pleasant.[14] Future amendments may expand the sewer service area to other parts of the study area. At some time following adoption of the sewer service area amendments for Racine and environs, it is recommended that detailed facilities planning be undertaken to establish what new conveyance, pumping, and storage facilities would be needed to provide service.

The Town of Yorkville Sanitary District No. 1 service area was not included in the refined Racine sewer service area; however, consistent with SEWRPC Community Assistance Planning Report No. 147 (2nd Edition), *Sanitary Sewer Service Area for the City of Racine and Environs*, which was adopted by the Regional Planning Commission on June 18, 2003, it is recommended that the entire Yorkville system be connected to the sewerage system tributary to the Racine wastewater treatment plant and that the Yorkville plant be abandoned when the Yorkville plant reaches the end of its useful life. The population and sewage flow information set forth in Table 80 in Chapter IX of this report indicates that the Yorkville plant would still have adequate treatment capacity in 2020. Thus, unless the physical condition of the plant dictates the need for significant upgrades prior to 2020, in which case connection to the Racine system should be considered, abandonment of the Yorkville plant may not occur until after the year 2020.

Recommended Intercommunity Trunk Sewers

Map 73 in Chapter X of this report shows a proposed new intercommunity trunk sewer, designated as the Northwest Interceptor by the City of West Bend, which is anticipated to be constructed in the City and the Town of Barton from 2011 through 2015. Map 73 also shows a recommended force main that would connect urban development in the Waubeka area with the Village of Fredonia sewerage system. That intercommunity trunk

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[13]*In 2000, the City retained a consultant to study the hydraulic capacity of the existing wastewater treatment plant. That study indicated that the plant capacity may be considerably greater than 2.75 mgd. Before undertaking future facilities planning, the City would pursue officially rerating the plant to reflect the higher capacity.*

[14]*SEWRPC,* Amendment to the Regional Water Quality Management Plan—Villages of Caledonia and Mt. Pleasant, *June 2007.*

sewer was originally recommended in 1979 under the initial regional water quality management plan. The costs for these recommended trunk sewers are set forth in Table 82 in Chapter X of this report.

Implement Local Programs to Ensure Maintenance of Adequate Sewage Collection System Capacity
In order to ensure the maintenance of adequate sanitary sewage collection system capacity, it is recommended that the municipalities outside the MMSD service area implement locally-designed programs similar to the Capacity, Management, Operations, and Maintenance (CMOM) program that is currently being promoted by the U.S. Environmental Protection Agency as a means of evaluating and maintaining sewage collection systems.

Recommended 2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District
As noted in the introduction to this chapter, the regional water quality management plan update was prepared as part of a coordinated planning effort that also involved preparation of the 2020 facilities plan for the MMSD. A detailed description of the development of the recommended MMSD facilities plan is set forth in Chapters 9 and 10 of the facilities plan report.[15]

The following facilities, programs, operations, and policies that are recommended under the MMSD facilities plan are also incorporated as components under the regional water quality management plan update:

- Facilities recommended under the wet-weather control plan that is designed to meet MMSD's discharge permit requirements,
- MMSD programs and policies to maximize capture and treatment of sewage during wet weather,
- Improvement of existing MMSD facilities to ensure the continued provision of adequate sewage treatment,
- A biosolids plan,
- Watercourse projects directed toward improving instream water quality and reducing municipal infiltration and inflow (I/I) through reducing overland flooding in developed areas,
- Best management practice (BMP) demonstration projects intended to assess the effectiveness of specific BMPs in reducing nonpoint source pollution and improving water quality consistent with the urban nonpoint source pollution control recommendations of the regional water quality management plan,
- New MMSD programs and policies implemented to support other elements of the recommended plan,
- Existing MMSD programs and policies that are to be continued,
- Existing MMSD operations that are to be continued,
- MMSD committed projects, and
- Community-based components.

A summary of these plan components is provided below and more detail is given in Chapter X of this report.

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[15]*The MMSD facilities plan is documented in the report entitled* 2020 Facilities Plan for the Milwaukee Metropolitan Sewerage District, *June 2007. Companion reports to the facilities plan include the MMSD Treatment Report, the MMSD Conveyance Report, and the State-of-the-Art Report.*

WET WEATHER CONTROL PLAN

The wet weather control plan is designed to meet State and Federal regulatory requirements regarding sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs).

The following projects are incorporated into the MMSD facilities plan to be constructed or further improved in order to maximize capture and treatment of sewage during wet weather. These recommended facilities would have the primary function of reducing overflows from either the separate sewer area or the combined sewer area.

- Increase capacity to pump from the inline storage system (ISS) to the Jones Island wastewater treatment plant
- Increase South Shore wastewater treatment plant capacity[16]
- Add metropolitan interceptor system sewer capacity as necessary

The MMSD facilities plan recommends that the following MMSD operational and monitoring programs be implemented and hydraulic analyses be performed as part of the program to maximize capture and treatment of sewage during wet weather.

- Implement improvements to flow monitoring and rain gauge system
- Perform capacity analysis of the South Shore wastewater treatment plant
- Perform hydraulic analysis of the Jones Island wastewater treatment plant

The MMSD facilities plan recommends that the following MMSD programs and policies be implemented as part of the program to maximize capture and treatment of sewage during wet weather.

- Fully implement the MMSD's wet weather peak flow management plan to control the growth of infiltration and inflow
- Implement MMSD's Capacity, Management, Operations, and Maintenance (CMOM) Program
- Implement CMOM Programs for MMSD member and contract municipalities and for Milwaukee County
- Implement System Evaluation and Capacity Assurance Plans for MMSD municipalities
- Implement flow monitoring for high-priority areas
- Continue operation of real-time control system

The MMSD facilities plan recommends that the following rehabilitation projects, routine facility upgrades, and engineering studies and evaluations be implemented in order to continue to provide adequate sewage treatment for the MMSD service area.

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[16]*This is the only component of the MMSD 2020 facilities plan listed herein that was modified under the recommended regional water quality management plan update. The regional plan recommendations relative to the South Shore plant are set forth in the section of Chapter X of this report that is entitled "Recommended Water Quality Management Plan."*

- Rehabilitate dewatering and drying systems at the Jones Island wastewater treatment plant

- Complete preliminary engineering study for additional force main from the ISS pump station to diversion chamber DC0103 at S. 6th Street and W. Oklahoma Avenue

- Evaluation of Jones Island wastewater treatment plant aeration system

- Ongoing treatment and conveyance upgrades

- Geotechnical/structural analysis of wastewater treatment plants

BIOSOLIDS PLAN

The MMSD currently recycles the biosolids that are a normal byproduct of the wastewater treatment process. The biosolids from the Jones Island wastewater treatment plant are converted to and sold as Milorganite®, a popular natural organic fertilizer. The biosolids at the South Shore plant are processed into Agri-Life®, a natural organic product that is applied to the soil at farms to provide nutrients for the crops. Any remaining biosolids not used for the production of Milorganite® or Agri-Life® are made into filter cake. Milorganite® production, and corresponding sales and revenue, are expected to decrease in the coming years due to the decrease in flows from wet industries with high organic loads. Therefore, the MMSD 2020 facilities plan included an analysis of the long-term trends in Milorganite® production and a future plan for biosolids. A detailed description of the alternatives evaluation and the selection of the recommended plan is provided in Chapter 9 of the MMSD Treatment Report.

The recommended MMSD facilities plan calls for continuing existing biosolids operations during the period from 2007 through 2008, or beyond if necessary for the preparation of additional analyses needed to assess biosolids options. The facilities plan recommends that the following analyses be conducted during the assessment period:

- An evaluation of the Milorganite® nitrogen balance using data from 2006 and beyond on the wasteloads from the Jones Island and South Shore plants,

- A study to address marketing Milorganite® with a nitrogen content less than the currently guaranteed 6 percent,[17]

- An overall assessment report on energy, energy management, and power supply/power generation (energy costs are a significant percentage of the costs to process biosolids).

Following completion of the preceding recommended analyses, the MMSD facilities plan recommends developing a final biosolids plan through modification and reevaluation of the following alternatives:

- Glass furnace technology,

- Selling Milorganite® with less than 6 percent nitrogen,

- Selling Milorganite® with 6 percent nitrogen and land apply the rest,

- Combination of Milorganite® and glass furnace technology, and

- Combination of Milorganite® and landfill.

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[17]*The recent loss of the wasteload from LeSaffre Yeast has resulted in decreases in the nitrogen content of Milorganite®.*

The MMSD facilities plan also recommends specific facilities and operational improvements needed to continue the current biosolids program during the interim evaluation. Those improvements are described in Chapter 9 of the MMSD Treatment Report.

WATERCOURSE-RELATED PLAN ELEMENTS

The MMSD facilities plan recommends that MMSD 1) implement the flood mitigation projects that have been identified under its watercourse system planning program, 2) implement projects to remove concrete linings from stream channels and to rehabilitate those channels where such removal can be accomplished without creating flood or erosion hazards, 3) continue implementation of the Greenseams conservation and greenway connection plan to acquire land for flood management and water quality protection, and 4) renovate the Kinnickinnic River flushing station. The implementation of the watercourse-related plan will improve water quality and instream and riparian habitat, reduce municipal I/I, and enhance flood mitigation.

Specific projects which are currently in various stages of planning and design include:

- Milwaukee River mainstem flood management project to provide flood control primarily in the Cities of Glendale and Milwaukee;
- Indian Creek flood management project to primarily provide flood control benefits in the Village of Fox Point;
- Lower Wauwatosa flood control, stream restoration, and floodproofing project along the Menomonee River mainstem;
- Milwaukee County Grounds detention basin to provide flood control for portions of Underwood Creek and the Menomonee River mainstem in the Cities of Milwaukee and Wauwatosa; and
- Western Milwaukee flood management project along the mainstem of the Menomonee River.

NEW MILWAUKEE METROPOLITAN SEWERAGE DISTRICT SEWER SEPARATION POLICY

The MMSD facilities plan recommends that MMSD develop a policy supporting the long-term implementation of selective cost-effective sewer separation in the combined sewer service area (CSSA), including identification of the best management practices needed to treat the runoff that would no longer be captured and treated at a wastewater treatment plant as it is under current combined sewer conditions.

OTHER EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT PROGRAMS AND POLICIES TO BE CONTINUED

The MMSD facilities plan recommends that the following existing MMSD programs and policies be continued.

- Long-term control plan to address combined sewer overflows
- Stormwater reduction program
- Stormwater disconnection program
- Industrial waste pretreatment program

OTHER EXISTING MILWAUKEE METROPOLITAN SEWERAGE DISTRICT OPERATIONS TO BE CONTINUED

The MMSD facilities plan recommends that the following existing MMSD operations be continued. Because these are ongoing operations, no costs are assigned under the recommended water quality management plan.

- Jones Island wastewater treatment plant wet weather blending
- Skimmer boat operation
- Watercourse operations

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT COMMITTED PROJECTS

The MMSD facilities plan recommends that MMSD complete all committed projects that are either identified in the 2002 Stipulation with WDNR, but have not yet been completed, or that are under construction.[18]

Management of Infiltration and Inflow for MMSD Satellite Communities

The MMSD facilities plan and the regional water quality management plan update both recommend that the 28 satellite communities served by the MMSD implement measures to ensure that infiltration and inflow do not grow beyond existing levels

Recommendations of the Regional Water Quality Management Plan Relative to the MMSD South Shore Wastewater Treatment Plant

As noted previously in this chapter, the MMSD 2020 facilities plan must meet regulatory requirements. The MMSD 2020 facilities plan defines a process for evaluating the need to upgrade the capacity of the South Shore wastewater treatment plant in a manner that meets regulatory requirements and is consistent with MMSD's current operating permit. The recommended regional water quality management plan update recommends a similar approach with the exception that the possibility of blending at the South Shore plant is included in the approach outlined under the regional plan. The regional water quality management plan update calls for the following relative to the MMSD South Shore plant:

- The need for physical-chemical treatment with chemical flocculation should be evaluated at a later date, following determination of 1) the degree to which MMSD can successfully implement a variable volume reserved for sanitary sewer inflow (VRSSI) operating strategy, 2) actual system capacities at the Jones Island and South Shore plants, 3) actual population and land use changes within the planning area, and 4) the success of the wet weather peak flow management planning effort. If it were found that additional treatment capacity was not needed, a capital cost saving of from $97 million to $152 million could be realized through not adding physical-chemical treatment.

- Continued efforts by MMSD to successfully implement a variable VRSSI operating strategy based on refinement and improvement of the prediction algorithm developed under the MMSD Real Time Control Project and with upgraded pumping capacity from the ISS. As indicated previously, the MMSD system is an integrated system and the current regulatory bifurcation with regard to CSOs and SSOs makes MMSD's operation of its system very complex and difficult. The regulatory requirement that a distinction be drawn between SSOs and CSOs from the MMSD system creates a situation under which the capacity of the ISS may be underutilized despite MMSD's best efforts to apply a variable VRSSI operating strategy to avoid overflows. Therefore, it is recommended that MMSD and its customer communities work with the WDNR and USEPA to obtain formal regulatory recognition of the integrated nature of the MMSD system, perhaps extending to elimination of the present distinction between ISS-related SSOs and CSOs.

- Consideration of additional study of blending at the South Shore plant, perhaps as part of the recommended capacity study and/or the long-term demonstration project. This recommendation is consistent with the previously-stated facilities plan recommendation calling for evaluation of blending as a means to prevent possible basement backups under certain conditions.

- Possible implementation of physical-chemical treatment to increase the treatment capacity of the South Shore plant if it were ultimately found that additional capacity was needed at South Shore and favorable results were obtained from the recommended long-term demonstration project of physical-chemical treatment with chemical flocculation. As indicated previously, this element may not be needed if favorable results are obtained from further analyses of the variable VRSSI operating strategy and the capacity of the South Shore plant.

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[18] *The list of these projects is presented in Chapter 8 of the MMSD 2020 facilities plan.*

- Possible implementation of blending at the South Shore plant if it were ultimately found that additional capacity was needed and the recommended long-term demonstration project of physical-chemical treatment with chemical flocculation results in a conclusion that such a treatment option is not feasible. The estimated capital, annual operation and maintenance, and equivalent annual costs of blending are $60 million, $1.0 million, and $6.1 million, respectively, less than the corresponding costs of the other remaining option, which is physical-chemical treatment with ballasted flocculation. In this case, it is recommended that additional funds be spent on achieving water quality improvements through control of nonpoint source pollution at a level beyond that of the base nonpoint source pollution control component of the regional plan, rather than on physical-chemical treatment with ballasted flocculation.[19] Once again, this element may not be needed depending on the results of analyses of the variable VRSSI operating strategy and the capacity of the South Shore plant.

- Revision of the USEPA draft policy regarding blending to specifically establish that it is acceptable to evaluate the water quality impacts of blending as part of a watershed-based approach to water quality management and to use that evaluation as a factor to be considered in determining if blending is to be allowed.

Cost-Effectiveness Analysis of Wastewater Treatment Options for the City of South Milwaukee

The City of South Milwaukee is the only community in Milwaukee County that maintains its own wastewater treatment facility and does not belong to the Milwaukee Metropolitan Sewerage District. Chapter X of this report includes a detailed analysis prepared under the regional water quality management plan update to determine if it would be more cost effective for the City to continue to maintain its own treatment facility or to abandon it and connect to the MMSD system.

The South Milwaukee wastewater treatment plant (WWTP) is designed to handle an average flow rate of six mgd, with a designed peak capacity of 25 mgd. Effluent from the plant is discharged to Lake Michigan. As a result of several effluent violations, the City agreed in June 2004 to a court-ordered stipulation that requires a number of improvements and upgrades to be implemented by 2014. Those improvements and upgrades include increasing the raw sewage pump capacity to meet a design peak flow of 30 mgd with the largest unit out of service, installing two new secondary clarifiers, and replacing the ultraviolet disinfection system.

APPROACH TO UPGRADING THE EXISTING CITY OF SOUTH MILWAUKEE WASTEWATER TREATMENT PLANT

In May 2006 a site study for the facility was completed by Applied Technologies under contract to the City. That study developed a plan for implementation of the court-ordered upgrades. That study also identified other potential needs based on a 20-year planning period. Included in the report were cost estimates for the recommended upgrades and improvements. The total estimated capital cost of the recommended measures is $4.30 million dollars. Current annual operation and maintenance costs for the facility are estimated at $1.60 million. As set forth in Table 85 in Chapter X of this report, assuming a 50-year economic life and an annual interest rate of 6 percent, the estimated equivalent annual cost of continuing to operate the facility, including implementing the required upgrades, would be $1.93 million.

ALTERNATIVES CALLING FOR CONNECTION TO THE MMSD SOUTH SHORE WASTEWATER TREATMENT PLANT

An alternative to maintaining its own treatment facility would be for the City to abandon its facility and connect to the MMSD sewerage system. Under that scenario, sewage from the City would be conveyed to the MMSD South Shore WWTP by a new force main to be constructed along 5th Avenue. The South Shore plant would have sufficient capacity to handle the additional flow from South Milwaukee during most conditions. However, assuming that peak flows from the South Milwaukee system coincide with peak flows to the South Shore plant

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[19]*Although a cost savings would accrue to the MMSD if certain components of the MMSD 2020 facilities plan were foregone, the additional funds that could be applied to more effective nonpoint source pollution control measures would not necessarily be provided by MMSD.*

from the MMSD system, an expansion of the wet-weather peak capacity would be required to treat flow from the South Milwaukee sewerage system.

That expansion could be made in accordance with the high rate treatment options already under consideration for the MMSD 2020 facilities plan. In addition, the existing two primary clarifiers, four activated sludge units, and two secondary clarifiers at the South Milwaukee plant could provide 2.85 million gallons of storage that could be used to reduce the peak flow from South Milwaukee to the South Shore plant from 30 mgd to 17 mgd. With that reduced peak flow, the costs of pumping and conveyance to South Shore, and of additional treatment, would be reduced.

Analysis and Evaluation of Alternative Plans

The following alternatives were initially analyzed:

- Alternative No. 1—Upgrade the existing South Milwaukee WWTP according to the 2006 site study,
- Alternative No. 2—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using physical-chemical treatment (PCT) with ballasted flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant,
- Alternative No. 3—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and not utilizing existing storage at the South Milwaukee plant,
- Alternative No. 4—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with ballasted flocculation at South Shore and utilizing existing storage at the South Milwaukee plant, and
- Alternative No. 5—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP using PCT with chemical flocculation at South Shore and utilizing existing storage at the South Milwaukee plant.

Based on the cost evaluation set forth in Chapter X, Alternative No. 1—Upgrade the Existing South Milwaukee WWTP and Alternative No. 5—Connect the South Milwaukee WWTP to the MMSD South Shore WWTP Using PCT with Chemical Flocculation at South Shore and Utilizing Existing Storage at the South Milwaukee WWTP are considered to be essentially equal in cost.

Conclusions

The regional water quality management plan update does not recommend providing additional treatment capacity at the South Shore WWTP in the near future. It does, however recommend that additional studies be conducted to evaluate the capacity that can actually be attained at South Shore under existing conditions and that a demonstration project be conducted to evaluate the feasibility of expanding the South Shore plant capacity through PCT with chemical flocculation. If in the future it was determined that 1) the treatment capacity at South Shore would have to be increased to meet anticipated flows from the communities that are currently served by MMSD and 2) implementation of physical-chemical treatment with chemical flocculation was feasible at the South Shore plant, then, considered in isolation, connection of the South Milwaukee plant (utilizing existing tanks for storage) to the MMSD system would be equally cost-effective as the option of upgrading the South Milwaukee wastewater treatment plant to meet the requirements of the court-ordered stipulation.

However, because the analysis of the May 2004 wastewater flows as described in Chapter X establishes that the additional flow from South Milwaukee cannot be adequately treated at the MMSD South Shore WWTP without an increase in treatment capacity at South Shore, connection of the South Milwaukee system to the South Shore plant would not be feasible in the near term under the implementation schedule set forth in the MMSD 2020 facilities plan. Because the 2004 court-ordered stipulation requires the City of South Milwaukee to implement actions from 2004 through 2014, with major plant modifications to commence in 2007, it is unlikely that the City would know the results of the MMSD South Shore PCT demonstration project soon enough to consider those results in its program to comply with the court order.

Thus, it is recommended that:

- The City of South Milwaukee continue its program of wastewater treatment plant upgrades established under the court stipulation.

- The City of South Milwaukee discuss with the WDNR the likelihood of an ammonia limit being required under the next permit which is to be issued in 2011. Should it appear likely that such a limit will be imposed, the City should conduct detailed facilities planning to evaluate all reasonable alternatives.

Private Wastewater Treatment Facilities

There are no private wastewater treatment plants currently in operation within the Kinnickinnic and Menomonee River watersheds, the Oak Creek watershed, and the Lake Michigan direct drainage area. There are two private plants in the Milwaukee River watershed—one serving the Long Lake Recreational Area in the Town of Osceola in Fond du Lac County and one serving the Kettle Moraine Correctional Institution in the Town of Greenbush in Sheboygan County.[20] There is one private plant serving an isolated enclave of urban land use in Fonks Mobile Home Park in the Town of Yorkville in Racine County in the Root River watershed. These facilities are located beyond the current limits of planned public sanitary sewer service areas and are recommended to be retained. The need for upgrading these plants and the level of treatment should be formulated on a case-by-case basis as part of the WPDES permitting process.

Regulation of Wastewater Treatment Facilities and Industrial Discharges

It is recommended that these sources of wastewater continue to be regulated and their effluent concentrations be controlled to acceptable levels on a case-by-case basis through the operation of the WPDES.

Industrial Noncontact Cooling Water Discharges

An additional point source issue identified under the regional water quality management plan update is that of phosphorus loads from some industrial noncontact cooling water discharges. The industries involved do not normally add phosphorus to their cooling waters. It is believed that the phosphorus is contained in the source water since some water utilities, such as the Cities of Cudahy, Milwaukee, New Berlin, and South Milwaukee, add orthophosphate or polyphosphate as a corrosion control to prevent certain metals from leaching from distribution systems and building plumbing materials into the treated water. Given the public health benefits involved and the reliability of the current technology, the Milwaukee Water Works has indicated that it would not consider changing its current practice. Recognizing the benefits involved, it is not recommended that the water utilities end their current practice. It is, however, recommended that water utilities in the study area give further consideration to changing to an alternative technology that does not result in increased phosphorus loading if such a technology is both effective in controlling corrosion in pipes and cost-effective for the utility to implement.

Nonpoint Source Pollution Abatement Plan Subelement

The recommended nonpoint source pollution control measures described in this report are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach as described previously in this chapter.

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[20]*The Kettle Moraine Correctional Institution plant discharges to groundwater of the Watercress Creek subbasin within the East Branch Milwaukee River subwatershed.*

Recommended Rural Nonpoint Source Pollution Control Measures

The recommended best management practices to control rural nonpoint source pollution were developed by the SEWRPC staff and the consultant team staff[21] under the guidance of both the SEWRPC Technical Advisory Committee for the plan and the SEWRPC Modeling Subcommittee comprised of technical and modeling experts and with input from the County Land Conservationists from throughout the study area and from WDNR. Input was also solicited from the joint MMSD/SEWRPC Citizens Advisory Council and the SEWRPC Watershed Officials Forum that was established to provide information regarding the regional water quality management plan update to local elected officials and to solicit comments on various aspects of the plan from those officials.

The recommended rural nonpoint source control measures and their associated costs are set forth in Table 82 in Chapter X of this report. In some instances, based on the modeled water quality results for 1) the screening alternatives, 2) the alternative water quality plans, and 3) the rural nonpoint source sensitivity analyses, the plan includes measures that go beyond what would be necessary to meet the performance standards of Chapter NR 151, "Runoff Management," and Chapter ATCP 50, "Soil and Water Resource Management Program," of the *Wisconsin Administrative Code*. Descriptions of each of those recommended measures, including the recommended level of implementation and/or the anticipated level of reduction in nonpoint source pollution loads, are set forth below.

Reduction in Soil Erosion from Cropland

The recommended plan calls for practices to reduce soil loss from cropland to be expanded to attain erosion rates less than or equal to T by 2020. This could be accomplished through a combination of practices, including, but not limited to, expanded conservation tillage, grassed waterways, and riparian buffers. The applicable measures should be determined by the development of farm management plans which are consistent with the county land and water resources plans.

Manure and Nutrient Management

Based on input from County Land Conservationists and the Technical Advisory Committee for this water quality plan and on the identified need to control fecal coliform bacteria from both urban and rural sources, it was decided to recommend that all livestock operations in the study area with 35 combined animal units or greater as defined in Chapter NR 243, "Animal Feeding Operations," of the *Wisconsin Administrative Code* provide six months of manure storage, enabling manure to be spread on fields twice annually during periods when the ground would not be frozen prior to spring planting and after summer and fall harvest. It is also recommended that manure and any supplemental nutrients be applied to cropland in accordance with a nutrient management plan consistent with the requirements of Sections ATCP 50.04, 50.48, and 50.50 and Section NR 151.07 of the *Wisconsin Administrative Code*. Finally, it is recommended that nutrient management requirements for concentrated animal feeding operations (CAFOs) in the study area be based on the WPDES permit conditions for those operations.

Barnyard Runoff

As noted in Chapter VI of this report, because existing livestock operations are excluded from the requirements of Chapters NR 151 and ATCP 50 if cost-share funding is not available and because of the limited amount of such funding that is available annually, many livestock operations are not compelled to comply with *Administrative Code* provisions related to barnyard runoff. Therefore, it is recommended that consideration be given to increasing levels of cost-share funding to enable a higher level of implementation of the best management practices needed to meet the NR 151 performance standards.

Riparian Buffers

Fond du Lac, Ozaukee, Sheboygan, and Washington Counties currently have programs for the establishment of riparian buffers. Fond du Lac, Ozaukee, and Sheboygan Counties are aggressively promoting the creation of such buffers through the U.S. Department of Agriculture (USDA) Conservation Reserve Enhancement Program

[21]*Technical staff from HNTB and Tetra Tech.*

(CREP). Washington County has adopted a minimum 75-foot setback for all development in unincorporated areas adjacent to lakes and streams as part of its lake and stream classification program and related zoning.

Based on review of the literature related to the effectiveness of riparian buffers in controlling nonpoint source pollution, it was decided that a minimum 75-foot riparian buffer width along each side of streams flowing through current crop and pasture land would be optimal for the control of nonpoint source pollution. Stream reaches for which the establishment or expansion of riparian buffers are to be considered are indicated on Maps 74 through 76 in Chapter X of this report.

It is recommended that:

- In general, where existing riparian buffers adjacent to crop and pasture lands are less than 75 feet in width they be expanded to a minimum of 75 feet;
- The procedures for targeting buffers to locations where they would be most effective as developed under the Wisconsin Buffer Initiative[22] be considered in the implementation of the riparian buffer recommendation made herein;
- Opportunities to expand riparian buffers beyond the recommended 75-foot width be pursued along high-quality stream systems including those designated as outstanding or exceptional resource waters of the State, trout streams, or other waterways that support and sustain the life cycles of economically important species such as salmon, walleye, and northern pike; and
- The number of stream crossings be limited and configured to minimize the fragmentation of streambank habitat.

Conversion of Cropland and Pasture to Wetlands and Prairies

Consistent with the land use planning principle and standard set forth in Appendix G of this report which encourage efforts to restore farmland and other open space land to more natural conditions, such as wetlands, prairies, grasslands, and forest, it is recommended that a total of 10 percent of existing farmland and pasture be converted to either wetland or prairie conditions, focusing that effort on marginally productive land.

MMSD CONSERVATION AND GREENWAY CONNECTION PLANS

The MMSD conservation and greenway connection plans program (Greenseams) provides for the purchase, from willing sellers, of natural wetlands to retain stormwater with the intention of reducing the risk of flooding, protecting riparian land from development, and providing increased public access. The MMSD facilities plan recommends that these programs continue and be integrated with the regional water quality management plan update recommendations regarding environmental corridors and conversion of cropland and pasture to wetland and prairie conditions.

Restricting Livestock Access to Streams

It is recommended that livestock access to streams be restricted through fencing or other means.

Management of Milking Center Wastewater

It is recommended that measures be taken to ensure proper handling and treatment of milking center wastewater.

Expanded Oversight and Maintenance of Private Onsite Wastewater Treatment Systems (POWTS)

The Technical Advisory Committee guiding the regional water quality management planning process identified improved oversight and maintenance of POWTS as a priority that should be addressed to improve groundwater and surface water quality. The rural nonpoint source sensitivity analysis described in Chapter IX indicated that

[22] *College of Agricultural & Life Sciences, University of Wisconsin-Madison,* The Wisconsin Buffer Initiative, *December 2005.*

such a program could be an effective component of the overall water quality plan. Therefore, it is recommended that, at a minimum, county-enforced inspection and maintenance programs be implemented for all new or replacement POWTS constructed after the date on which the counties adopted private sewage system programs. It is also recommended that voluntary county programs be instituted to inventory and inspect POWTS that were constructed prior to the dates on which the counties adopted private sewage system programs. Finally, it is recommended that the WDNR and the counties in the study area work together to strengthen oversight and enforcement of regulations for disposal of septage and to increase funding to adequately staff and implement such programs.

Recommended Urban Nonpoint Source Pollution Abatement Measures

The recommended best management practices to abate urban nonpoint source pollution were developed by the SEWRPC staff and the consultant team modeling staff[23] under the guidance of both the SEWRPC Technical Advisory Committee for the plan and the SEWRPC Modeling Subcommittee and in conjunction with the WDNR. Input was also solicited from the MMSD Technical Advisory Team, consisting of representatives of each of the 28 municipalities served by MMSD; the joint MMSD/SEWRPC Citizens Advisory Council; and the SEWRPC Watershed Officials Forum.

The recommended measures and their associated costs are set forth in Table 82 in Chapter X of this report. In some instances, the plan includes measures that go beyond what would be required to meet the performance standards of Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*. Descriptions of each of those recommended measures, including the recommended level of implementation and/or the anticipated level of reduction in nonpoint source pollution loads, are set forth below.

Implementation of the Nonagricultural (Urban) Performance Standards of Chapter NR 151

It is recommended that urban nonpoint source pollution controls be implemented that are consistent with the performance standards of Chapter NR 151. As noted in Chapters V through X in SEWRPC Technical Report No. 39, almost all of the municipalities in the study area are, or will be, required to meet NR 151 standards to the maximum extent practicable under the conditions of their WPDES municipal stormwater discharge permits issued pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*. By implementing controls to meet the standards of NR 151, municipalities will address the following:

- Control of construction site erosion;
- Control of stormwater pollution from areas of existing and planned urban development, redevelopment, and infill; and
- Infiltration of stormwater runoff from areas of new development.

Coordinated Programs to Detect and Eliminate Illicit Discharges to Storm Sewer Systems and to Control Urban-Sourced Pathogens that are Harmful to Human Health

The results of the analyses made by applying the calibrated water quality model as described in Chapters V and IX of this report indicated that urban impervious surfaces were significant contributors of fecal coliform bacteria to the streams of the study area. They also indicated that urban subsurface flows could be significant sources of fecal coliform bacteria. Some of these subsurface flows could be entering storm sewers through "illicit" connections from the sanitary sewer system such as infiltration from leaking sanitary sewers or cross connections between sanitary and storm sewers.

While mainly intended as an indicator of human sewage contamination, fecal coliform bacteria and *E. coli* also serve as indicators of the possible presence of a broader range of possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes. Because the presence of

[23]*Technical staff from HNTB, Tetra Tech, and StormTech.*

fecal coliform bacteria is not sufficient indication of a significant threat to human health, which would actually result from the presence of pathogens that are generally not directly measured, the recommended plan calls for a coordinated program to reduce pathogens in surface waters through better identification of the sources of fecal coliform bacteria and elimination or control of those sources that would potentially be most harmful to human health. While the program to control pathogens is intended to focus on pathogens from human sources, pathogens from domestic and/or wild animals and livestock could also pose threats to human health.

Although human-sourced pathogens in stormwater management systems might be found in stormwater runoff, it is more likely that they enter storm sewers through "illicit" connections from the sanitary sewer system. Thus, the main component of the recommended program to control pathogens from the urban environment is detection and elimination of illicit discharges from the sanitary sewerage system to the stormwater management system.

Based on review of recommended plan water quality model results for the streams of the study area and Lake Michigan, it was decided to recommend enhanced urban illicit discharge control and/or innovative methods to identify and control possible pathogen sources in stormwater runoff from all urban areas in the study area. To address the threats to human health and degradation of water quality resulting from human-specific pathogens and viruses entering stormwater systems, it is recommended that each municipality in the study area implement a program consisting of:

- Enhanced storm sewer outfall monitoring to test for fecal coliform bacteria in dry- and wet-weather discharges;

- Molecular tests for presence or absence of human-specific strains of *Bacteroides*, an indicator of human fecal contamination, at outfalls where high fecal coliform counts are found in the initial dry-weather screenings;

- Additional dry-weather screening upstream of outfalls where human-specific strains of *Bacteroides* are found to be present, with the goal of isolating the source of the illicit discharge;

- Elimination of illicit discharges that were detected through the program described in the preceding three steps; and

- It is anticipated that the program outlined above would also identify cases where illicit connections are not the primary source of bacteria, indicating that stormwater runoff is the main source. To adequately assess the appropriate way to deal with such bacteria sources (and the potentially associated pathogens), it is recommended that human health and ecological risk assessments be conducted to address pathogens in stormwater runoff.

Depending on the findings of the risk assessments, consideration should be given to pursuing innovative means of identifying and controlling possible pathogen sources in stormwater runoff.[24]

Chloride Reduction Programs

Water quality monitoring data set forth in SEWRPC Technical Report No. 39 indicated that chloride concentrations in the streams of the study area are increasing over time. While observed instream chloride concentrations are generally still less than the planning standard of 1,000 milligrams per liter (mg/l) that was adopted under the original regional water quality management plan, they more frequently exceed the 250 mg/l secondary drinking water standard. Instream concentrations generally do not exceed the chronic toxicity criterion of 395 mg/l or the acute toxicity criterion of 757 mg/l. Chloride concentrations are generally below 200 mg/l in

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[24]*It is not expected that municipalities would conduct individual risk assessments. It is envisioned that such assessments would be done at a watershed scale. Possible mechanisms for administering and funding such assessments are described in Chapter XI of this report.*

the outer harbor and the nearshore Lake Michigan area. In the lakes of the Milwaukee River watershed for which data are available, chloride concentrations are generally less than 50 mg/l, although concentrations appear to be increasing over time. Overall, the increasing trends in concentrations are a cause for concern.

Thus, it is recommended that the municipalities and counties in the study area continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose. It is also recommended that municipalities consider alternatives to current ice and snow control programs, such as applying a sand/salt mix to local roads with enhanced street sweeping in the spring to remove accumulated sand or using alternative materials for ice and snow control. It is recommended that education programs be implemented to provide information about 1) alternative ice and snow control measures in public and private parking lots and 2) optimal application rates in such areas.

Chlorides used in water softeners can increase instream chloride concentrations and they can also pose problems with elevated concentrations at wastewater treatment plants. It is recommended that education programs be implemented to provide information about alternative water softening media and the use of more-efficient water softeners which are regenerated based upon the amount of water used and the quality of the water.

Fertilizer Management

Because the washoff of fertilizer into inland lakes is a significant factor contributing to lake eutrophication, it is recommended that the use of low- or no-phosphorus fertilizers be encouraged in areas tributary to inland lakes and ponds and that consideration be given to adopting low- or no-phosphorus fertilizer ordinances in those areas.[25] Also, because of the general benefit in reducing phosphorus inputs to streams and to Lake Michigan, it is also recommended that information and education programs required under municipal WPDES stormwater discharge permits promote voluntary practices that optimize urban fertilizer application consistent with the requirements of WDNR Technical Standard No 1100, “Interim Turf Nutrient Management.”

Residential Roof Drain Disconnection from Sanitary and Combined Sewers and Infiltration of Roof Runoff

In an effort to reduce clearwater flows in the separate and combined sewer systems in the study area, it is recommended that programs be implemented to achieve a practical level of disconnection of the residential roof drains that are currently connected to sanitary and combined sewers. It is also recommended that roof drains that are not directly connected to sanitary or combined sewers, but which discharge to impervious areas, be redirected to pervious areas where feasible. Finally, it is recommended that consideration be given to directing those roof drains which are to be disconnected to rain barrels and/or rain gardens, with the runoff from those roofs ultimately being infiltrated.

Beach and Riparian Litter and Debris Control Programs

It is recommended that existing litter and debris control programs along Lake Michigan beaches, inland lake beaches, and along the urban streams of the study area be continued and that opportunities to expand such efforts be explored.

Pet Litter Management

It is recommended that all municipalities in the study area have pet litter control ordinance requirements and that those requirements be enforced.

Marina Waste Management Facilities

To avoid the direct discharge of sewage from holding tanks in recreational boats to the waters of Lake Michigan it is recommended that the Milwaukee County McKinley Marina, the Milwaukee Yacht Club, and the South Shore Yacht Club in the City of Milwaukee, and the Racine Reef Point Marina and other boating facility operators

[25]*It is appropriate for no-phosphorus ordinances to allow the use of compost-based fertilizers with relatively low phosphorus concentrations, such as Milorganite®.*

continue to maintain pump-out stations for disposal of those wastes through the public sanitary sewerage system and upgrade or expand those stations as necessary.

Research and Implementation Projects
It is recommended that MMSD and others continue to support targeted research on bacteria and pathogens and research and implementation of stormwater BMP techniques and programs. Because the monitoring of indicator organisms such as fecal coliform bacteria and *E. coli* constitute an indirect method of screening for the presence of pathogens, it is recommended that research to develop and apply more direct methods of identifying sources of pathogens important to human health also be supported.[26]

Instream Water Quality Measures Plan Subelement
The instream water quality management measures described in this report subsection are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Hydrologic and Hydraulic Management
Concrete Channel Renovation and Rehabilitation
The MMSD facilities plan recommends implementing projects to remove concrete linings from stream channels under MMSD jurisdiction and to rehabilitate those channels where such removal can be accomplished without creating flood or erosion hazards.

Renovation of the MMSD Kinnickinnic River Flushing Station
The Kinnickinnic River flushing station was constructed in the early 1900s to improve water quality in the lower reach of the Kinnickinnic River. The system pumps water from Lake Michigan into the River. MMSD operates the flushing station when dissolved oxygen concentrations in the River are less than 3.0 mg/L. A comparison of actual flushing tunnel flow data and observed downstream dissolved oxygen data verifies the usefulness of flushing tunnel operation in increasing dissolved oxygen levels in the Kinnickinnic River.

It is recommended that an engineering study be conducted to evaluate the condition of the tunnel and the pump station and that, depending on the findings of that study, consideration be given to renovating the flushing tunnel intake and outlet and the tunnel and pump station, if necessary and economically justifiable. Prior to implementing any major modifications to the flushing station, it is recommended that MMSD reevaluate dissolved oxygen levels in the estuary in light of possible future sediment removal projects that could improve dissolved oxygen conditions.

Dams
It is recommended that:

- Dam owners perform ongoing maintenance and repair of their dams. This is particularly important for high-hazard dams.

- Abandonment and associated riverine area restoration plans be prepared as part of the design of new, or reconstructed, dams and prior to abandonment of existing dams.

- Dam removals specifically include provisions to protect upstream reaches from erosion and downstream reaches from sedimentation by prohibiting excessive sediment transport from the impoundment during and after dam removal.

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[26]*As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, between 2006 and 2010 sampling will be conducted at three locations to determine the concentrations of five pathogenic human enteric viruses. In addition, as a part of Phase III, USGS and MMSD will conduct sampling for the protozoan parasites Cryptosporidium and Giardia in order to define relative loadings of these pathogens from different land uses and source areas.*

Culverts, Bridges, Drop Structures, and Channelized Stream Segments
It is recommended that, to the extent practicable, culverts, bridges, drop structures, and channelized stream segments, especially concrete lined segments, be limited. Where such crossings are required it is recommended that they be designed not only to pass water, but also allow the passage of aquatic organisms thus ensuring the continued connectivity of the ecosystem both upstream and downstream. Recommended design standards and criteria are included in Appendix P.

When opportunities arise, such as at the time of reconstruction of roadways and highways, it is recommended that "ecosystem-friendly" design standards be considered for implementation. In addition, it is recommended that, to the extent practicable, opportunities be considered for the removal of existing hydraulic structures, or for their replacement with "ecosystem-friendly" structures based on the design standards and criteria set forth in Appendix P.

Restoration and Remediation Programs
Restoration and remediation programs include a variety of activities focusing on the remediation of historically contaminated sites and the restoration of instream habitat, including restoration of riverine fisheries. As described and characterized in Chapter VII, "Surface Water Quality Conditions and Sources of Pollution in the Milwaukee River Watershed," of SEWRPC Technical Report No. 39, sites containing deposits of contaminated sediment have been identified in a five-mile segment of Cedar Creek in Cedarburg, Zeunert Pond in Cedarburg, Thiensville Millpond, Estabrook Impoundment, and the Milwaukee Harbor Estuary Area of Concern.

Management of contaminated sediment sites is recommended. As of 2006, remediation projects were ongoing for two sites: the Moss-American Superfund site along the Little Menomonee River and the Kinnickinnic River Environmental Restoration Project located in the Kinnickinnic River between S. Kinnickinnic Avenue and W. Becher Street. Management programs for remediation of contaminated sediment at Cedar Creek, Zeunert Pond, Thiensville Millpond, and Estabrook Impoundment should be reviewed and implemented. In support of this, it is recommended that consideration be given to extending the Milwaukee Estuary Area of Concern to include:

- The Little Menomonee River from W. Brown Deer Road (STH 100) to its confluence with the Menomonee River (Moss-American Superfund site),
- The Menomonee River from its confluence with the Little Menomonee River to N. 35th Street,
- Cedar Creek from Bridge Road to its confluence with the Milwaukee River,
- The Milwaukee River from its confluence with Cedar Creek to the site of the former North Avenue dam (includes the Estabrook Park dam and the associated impoundment), and
- Lincoln Creek.

It is recommended that monitoring of toxic substances, such as the program being conducted by the MMSD and USGS under Phase III of the MMSD Corridor Study, be continued and supported.

Dredging and Dredged Materials Disposal
A dredging and dredged material disposal plan was developed under the SEWRPC Milwaukee Harbor estuary study.[27] The regional water quality management plan update revises the recommendations from that study, taking into account the current status of navigational dredging programs and the implementation status of remedial action plans in the Milwaukee Estuary Area of Concern, which is one of 43 sites in the Great Lakes area targeted

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[27]*SEWRPC Planning Report No. 37,* A Water Resources Management Plan for the Milwaukee Harbor Estuary, *Volume Two,* Alternative and Recommended Plans, *December 1987.*

for priority attention under the U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) due to impairment of beneficial use of the area's ability to support aquatic life.

The need for dredging in the Milwaukee Harbor estuary is determined primarily by the need to maintain commercial navigation. That need may, however, also be determined by the need for the construction of new or updated port facilities; port safety, the need to provide for water quality improvement by reducing the impacts of polluted sediment on the water column and on the flora and fauna of the area; and the need to improve aquatic habitat. Each of these potential needs was carefully considered in the SEWRPC Milwaukee Harbor estuary study, and was reevaluated under the regional water quality management plan update.

CURRENT NAVIGATIONAL DREDGING ACTIVITIES IN THE LAKE MICHIGAN INNER AND OUTER HARBOR AREAS

Dredging and the disposal of the dredged materials is presently carried out within the Milwaukee Harbor estuary for maintenance of adequate water depths for commercial navigation. Dredged materials are disposed of at the Jones Island Confined Disposal Facility (CDF) constructed by the U.S. Army Corps of Engineers (USCOE) in 1975 along the shoreline of the southern portion of the outer harbor (see Map 79 in Chapter X of this report).

DREDGING NEEDS

Dredging for Navigation

The extent of the dredging recommended for navigation maintenance is shown on Map 79 in Chapter X, which also shows the depths to be maintained by dredging.

Dredging for Water Quality Improvement

Dredging for water quality improvement was not specifically recommended under the Milwaukee Harbor estuary study; however, the toxic substances management plan element did recommend that a second level, detailed study of the problems associated with toxic substances in the bottom sediments of the Milwaukee Harbor estuary be conducted. Since the Harbor estuary study was published, the need for dredging in the Kinnickinnic River in the reach from W. Becher Street downstream to S. Kinnickinnic Avenue has been identified under the RAP process for the Milwaukee Estuary Area of Concern. The Kinnickinnic River Environmental Restoration Project, which is scheduled for implementation during 2008 and 2009, calls for 1) dredging up to 170,000 cubic yards of sediments contaminated with polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), which will remove about 90 percent of the PCB mass in the project area, and 2) creating an 80-foot-wide, 20 to 24-foot-deep navigational channel. It is proposed to place the dredged material in the CDF, which would essentially exhaust the existing capacity of the CDF.

It is recommended that the Kinnickinnic River Environmental Restoration Project be implemented and that implementation of the Milwaukee Estuary Remedial Action Plan be continued and supported.

Dredging to Improve Aquatic Habitat

Another consideration regarding dredging is the need to improve aquatic habitat within the estuary. Review of the habitat conditions documented in the Harbor estuary study supplemented by information collected under the regional water quality management plan update effort, indicates that no widespread dredging should be undertaken to improve aquatic habitat. This conclusion was reached because the inventories found that there are adequate localized areas within the inner harbor that provide suitable feeding, cover, and spawning habitats for warmwater fish and aquatic life, even though habitat conditions for a desirable fishery throughout most of the inner harbor are generally poor. For example, in the reach of the Milwaukee River from the former North Avenue dam to N. Humboldt Avenue, there are numerous scoured areas with a substrate of rocks, sand, and hard clay. In addition, WDNR has implemented several restoration projects to enhance gamefish spawning habitat and nursery areas such as the North Avenue Dam walleye spawning shoal. Inventory data indicate that many warmwater fish species, including walleye, smallmouth and largemouth bass, northern pike, bullhead, catfish, suckers, carp, and sunfish, currently spawn in this reach. Similarly, there are localized shallow areas in the upper ends of the Menomonee and Kinnickinnic River estuaries, as well as in the upper ends of the Burnham and South Menomonee Canals, that support rooted aquatic vegetation that is used for spawning by northern pike, yellow perch, carp, and sunfish. Many of the fish that spawn in the inner harbor migrate in from Lake Michigan during spring and summer. As a result of pollution abatement actions including the MMSD Water Pollution Abatement

Program with its construction of the Inline Storage System, inputs of organic material and other pollutants into the estuary through combined sewer overflows and other sources of pollution have been reduced. These reductions coupled with decomposition and flushing of organic materials have resulted in riverbeds with cleaner sediments containing less organic matter. Thus, existing localized areas providing habitat have been improved for the maintenance of a limited, yet diverse, population of warmwater fish within the inner harbor.

Within the outer harbor, the existing bottom sediments, although in some locations classified as heavily polluted, are known to be conducive to the successful propagation of diverse populations of warmwater fish and aquatic life. The Milwaukee Harbor estuary study concluded that further site-specific analyses could indicate that it would be desirable to dredge or otherwise modify selected small areas within the estuary in order to improve habitat for aquatic life. However, it is recommended that such limited dredging be considered only if site-specific evaluation or findings support such a need.

Conclusion Regarding Dredging Needs

In view of the above, it is recommended that dredging be limited primarily to the areas and depths noted on Map 79 in Chapter X of this report.

DREDGED MATERIAL DISPOSAL

A dredged material management plan for the Milwaukee Harbor, which was completed by the USCOE Detroit District in November 2007, addresses future dredged material disposal needs from continued navigational dredging and from the USEPA/WDNR Kinnickinnic River Environmental Restoration Project. The study estimates that disposal of the approximately 176,000 cubic yards of dredged material from the Kinnickinnic River Project would use up the remaining capacity in the Jones Island CDF by about 2011. The dredged material management plan is designed to provide an additional 510,000 cubic yards of capacity, which is expected to meet dredged material disposal needs for 20 years beyond 2011. The USCOE study evaluated alternatives plans and selected a recommended plan that calls for constructing a raised perimeter dike that is offset from the existing CDF dikes. The regional water quality management plan update adopts that same recommendation.

Fisheries Protection and Enhancement

The maintenance and rehabilitation of the warmwater and coldwater sport fishery, key natural resources in the study area, are important components of this water quality management plan. The recommended fisheries management plan was developed to complement and to be consistent with the other plan recommendations regarding land use, point and nonpoint source pollution control, runoff management, and environmental monitoring. As recommended elsewhere in this report, to preserve and enhance the interconnection between the watershed's ecosystems, actions should focus on the restoration and management of declining habitats found not only within the stream, but also within the watershed as a whole.

Based upon an analysis and review of historic and recent fisheries surveys, fishery conditions in the greater Milwaukee watersheds study area range from very-poor to excellent. The streams and lakes of the study area are generally capable of supporting a quality warmwater sportfish community, with capabilities of supporting coldwater sportfish communities in some areas (see Chapters III through IX in SEWRPC Technical Report No. 39, the companion to this planning report).

Consistent with the actions recommended by WDNR for habitat improvement of stream systems, the following actions are recommended under this plan: 1) enhancement of streambank stability, 2) limitation of instream sediment deposition, 3) implementation of techniques to moderate the effects of channelization, and 4) restoration of instream and riparian habitat. Implementation of these actions will improve water quality, including water clarity and temperature regime, and improve the quality/quantity of food resources and habitat for fish and other aquatic species.

The following recommendations were formulated as an outgrowth of the assessment of fish and aquatic life resources set forth in Chapters V through IX of SEWRPC Technical Report No. 39. These recommendations are made to supplement or reinforce related recommendations set forth above to control point and nonpoint sources of pollution, to establish riparian buffers, and to restore and rehabilitate stream channels where feasible.

Implementation of the recommendations would help to protect and reestablish a high-quality native warmwater and/or coldwater fishery where appropriate.

1. To the extent practicable, protect remaining natural stream channels, including small tributaries and shoreland wetlands that provide habitat for the continued survival, growth, and reproduction of a sustainable fishery throughout the study area.

2. Restore wetlands, woodlands, and grasslands adjacent to the stream channel and establish minimum buffers 75 feet in width to reduce pollutant loads entering the stream and protect water quality.[28]

3. Restore, enhance, and/or rehabilitate stream channels to provide increased quality and quantity of available fisheries habitat—through improvement of water quality, shelter/cover, food production, and spawning opportunities—using management measures that include, but are not limited to:[29]

   - Minimize the number of stream crossings and other obstructions to limit fragmentation of stream reaches.

   - Stabilize stream banks to reduce erosion.

   - Limit instream sedimentation and selectively remove excessive silt accumulations.

   - Reestablish instream vegetation and bank cover to provide fish with shelter from predators, food, spawning areas, and protection from floods.

   - Realign channelized reaches of streams and remove concrete lining to provide heterogeneity in depth (e.g., alternating riffle and pool habitat), velocity or flow regime, and bottom substrate composition.

   - As opportunities arise when roadways crossing streams are replaced or reconstructed, remove or retrofit obstructions such as culverts, dams, and drop structures that limit the maintenance of healthy fish and macroinvertebrate populations.

4. Monitor fish and macroinvertebrate populations in order to evaluate the effectiveness of the water quality management program.[30]

5. Consider more intensive fisheries manipulation measures—in terms of removal of exotic carp species and/or stocking of gamefish or other native species—where warranted based upon specific goals and objectives established for each project site, reach, or subwatershed, based on detailed local level planning, throughout the study area.

It is recommended that the locations for carrying out the recommended stream restoration measures be developed with the guidance and direct involvement of the WDNR, based upon site-specific field evaluations.

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[28]*See the subsections of the nonpoint source pollution abatement plan subelement in Chapter X that are entitled "Riparian Buffers" and "Conversion of Cropland and Pasture to Wetlands and Prairies."*

[29]*See the "Watercourse-Related Plan Elements" subsection of the point source pollution abatement plan subelement in Chapter X.*

[30]*See the "Water Quality Monitoring" subsection of the auxiliary water quality management plan subelement.*

Inland Lake Water Quality Measures Plan Subelement
The inland lake water quality management measures described in Appendix Q are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Auxiliary Water Quality Management Plan Subelement
The auxiliary water quality management measures described in this report subsection are common to both the Regulatory Watershed-Based Approach and the Integrated Watershed-Based Approach.

Public Beaches
It is recommended that current public health monitoring programs at public beaches along Lake Michigan and inland waterbodies be maintained, and where possible, expanded to include public beaches that are not currently monitored. Monitoring agencies should continue to disseminate information regarding water quality at public beaches, including water quality advisories, both through postings at the beaches and through broadcast and internet media.

It is recommended that:

- Beaches with high frequencies of closings and water quality advisories due to high bacteria counts be evaluated for local sources of contamination, and that appropriate remedies be designed and implemented based on the findings of these evaluations.

- Sanitary surveys to identify sources of pollution be performed at beaches with high bacteria counts and that those surveys apply USEPA standards.

- Current programs of beach grooming be continued and expanded to beaches currently not groomed. The grooming methods used should be chosen to minimize persistence of water quality indicator organisms, such as *E. coli*, in beach sand.

Waterfowl Control
Waterfowl, especially gulls, can be a significant source of fecal coliform bacteria to the waters of the study area. It is recommended that programs be implemented to discourage unacceptably high numbers of waterfowl from congregating near beaches and other water features. These measures could include expanded use of informational signs regarding the negative aspects of feeding waterfowl, ordinances prohibiting the feeding of waterfowl, covering trash receptacles at beaches and water features, vegetative buffers along shorelines that discourage geese from congregating, and other, innovative measures such as trained dogs.

Coastal Zone Management
To coordinate management efforts for Lake Michigan among the many units of government, institutions, and organizations involved in management of the Lake, the U.S. Environmental Protection Agency has developed a Lakewide Management Plan. That plan contains recommendations regarding ballast water control, control of combined and separate sanitary sewer overflows, development of agricultural pollution prevention strategies, remediation of legacy contaminated sediment sites, protection of drinking source water, protection of wildlife habitat, stewardship actions, implementation of Great Lakes Areas of Concern Remedial Action Plans, fisheries management, and filling of gaps in data on the Lake. It is recommended that the Lake Michigan Lakewide Management Plan continue to be implemented and refined. To this end, it is also recommended that liaison and linkages be maintained with local, State, and Federal Great Lakes programs. It is recommended that the WDNR perform this role through their Office of the Great Lakes. In addition, shipping and harbor management programs and activities, including dredging and sediment remediation programs, ballast water management programs, and toxic contaminant management strategies, should be coordinated with environmental management programs and activities.

Water Pollution Control

Household Hazardous Waste Collection

The MMSD facilities plan recommends that MMSD continue its household hazardous waste collection program at the three permanent sites located in the Cities of Franklin and Milwaukee and the Village of Menomonee Falls and that MMSD continue providing waste collection at temporary collection sites between April and October each year. In addition, the regional water quality management plan update recommends that those communities in the study area that are not served by such programs consider developing and instituting them.

Emerging Issues

Recommendations are made regarding the following emerging issues.

Pharmaceuticals and Personal Care Products

It is recommended that assessments and evaluations be made of the significance for human health and for aquatic and terrestrial wildlife of the presence of pharmaceuticals and personal care products in surface waters. Ongoing research regarding the presence, effects, and fates of these compounds in the environment should continue to be monitored. As a part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, nine stream sites and three harbor sites will be sampled quarterly for two years for the presence of pharmaceuticals and personal care products in the water column, bed sediment, sediment pore water, and biota. It is recommended that this project be supported. It is also recommended that periodic collections of expired and unused medications be conducted.

Exotic Invasive Species

A number of programs have been developed to educate the public about exotic invasive species and to reduce the spread of exotic invasive species to inland waters, including the Watercraft Inspection Program and the Clean Boats, Clean Waters Program, both sponsored by the WDNR; aquatic invasive species educational materials, workshops, and outreach programs, all sponsored by the University of Wisconsin-Sea Grant Institute, University of Wisconsin-Extension, and the Wisconsin Association of Lakes. It is recommended that programs to reduce the spread of exotic invasive species be continued and supported and that the occurrence and spread of exotic and invasive species be monitored and documented. It is also recommended that programs to educate the public about exotic invasive species be continued and supported.

Water Temperature and Thermal Discharges

Because thermal discharges can act to alter the suitability of a waterbody as habitat, it is recommended that the WDNR develop a policy regarding water temperatures and thermal discharges into waterbodies.

Global Climate Change

Recent projections from global climate models suggest that patterns and frequency of precipitation in the Great Lakes area may change over the course of the next century. Should such changes occur, it is possible that they will cause alterations in stream hydrology and potentially affect sewerage systems and the capacities needed for wastewater treatment. It is recommended that future updates of this plan consider precipitation patterns and frequency and streamflow data and compare those data to the historical record.

Water Quality Monitoring

Recommendations Regarding Monitoring and Data Collection

It is recommended that the surface water quality monitoring programs currently being conducted by the WDNR, the USGS, and the MMSD be supported and continued. In addition, the USGS stream gauging program should be maintained as a minimum and expanded when possible It is also recommended that these agencies and other agencies conducting monitoring review and evaluate their monitoring programs in order to refine their monitoring strategies to address some of the data gaps identified in Chapter X. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, there will be continuous streamflow gauging along Honey Creek, Lincoln Creek, the Little Menomonee River, the Root River, and the Milwaukee River at Jones Island through 2010. It is recommended that this sampling be continued and supported.

Similarly, on those streams where data are being collected from multiple sampling stations in support of short-term projects, it may be desirable to continue sampling at some stations to provide long-term data. Candidate streams for monitoring within the areas served by MMSD include Mitchell Field Drainage Ditch, Wilson Park Creek, and the Little Menomonee River. Outside the area served by MMSD, there are numerous streams that are candidates for monitoring.

It is recommended that long-term water quality monitoring programs be extended to areas outside of the MMSD service area. At a minimum, water quality and quantity stream gauging monitoring programs should be continued at the USGS sampling stations established or reinstated for this update of the regional water quality management plan.

Some refinements should be made in the choice of which water quality parameters are sampled. It is important to recognize that the numerical values of some water quality criteria are dependent on the values of other parameters. Without information on the value of these other parameters, compliance with the criteria cannot be determined. Because of this, it is recommended that data be collected on temperature and pH whenever ammonia is sampled. Similarly, it is recommended that samples assessed for concentrations of cadmium, chromium, copper, lead, nickel, or zinc also be examined for hardness. In addition, it is recommended that those water quality parameters that can be assessed at relatively low cost and effort always be examined in any sampling. Examples of these parameters include those that can be examined through the use of electronic meters such as dissolved oxygen, pH, specific conductance, and temperature as well as those that can be examined through the use of relatively inexpensive equipment, such as Secchi depth.

It is recommended that long-term fisheries monitoring stations be established and maintained and that fisheries surveys be conducted periodically at these stations to assess species composition and toxicant loads. It is also recommended that long-term macroinvertebrate monitoring stations be established and maintained and that sampling be conducted periodically at these stations to assess species composition of invertebrates.

It is recommended that a more rational biological sampling strategy be adopted. In this regard it is recommended that at a minimum fish community and, where possible, macroinvertebrate assessments be conducted at least every two years at the long-term water quality monitoring sites established by MMSD, USGS, and WDNR.

It is recommended that long-term habitat monitoring stations be established and maintained and that surveys be conducted periodically at these stations to assess habitat quality and streambed and streambank stability. In addition, aquatic plant habitat assessments within lakes should be supported and better integrated with fishery survey assessments.

Given that it is desirable to be able to consolidate data from various monitoring programs to facilitate evaluation of temporal and spatial variation and trends in water quality, it is recommended that agencies and organizations conducting monitoring adopt common quality assurance and quality control procedures. In addition, it is recommended that, to the extent possible, sampling protocols and analysis protocols be standardized across monitoring programs, including both agency programs and citizen-based programs. In order to facilitate the coordination of sampling and the dissemination of water quality data, it is also recommended that current data management systems be maintained and upgraded. As part of Phase III of the MMSD Corridor Study conducted by MMSD and USGS, USGS intends to continue to maintain and enhance the MMSD Corridor Study Database through 2010. It is recommended that this action be supported.

It is recommended that citizen-based monitoring efforts such as the WDNR’s Wisconsin Citizen Lake Monitoring Network, the UW-Extension’s Water Action Volunteers Program, Riveredge Nature Center’s Testing the Waters Program, and the Friends of Milwaukee’s Rivers program be continued and supported. The methods and protocols used by these programs should be reviewed and upgraded to promote integration of the data they generate with data from agency-based programs. It is recommended that, as these programs develop new sampling sites, they target streams and lakes not currently being monitored.

Appendix Q, which sets forth recommendations regarding inland lake management, includes a recommendation that long-term trend lake monitoring programs be established or continued.

Maintenance of the Regional Water Quality Management Plan Update/MMSD 2020 Facilities Plan Modeling System

It is recommended that the water quality models developed under the regional water quality management plan update and the MMSD 2020 facilities planning program be maintained and updated at least every 10 years. The MMSD and SEWRPC would have responsibility for maintaining those models as described in Chapter X.

Ability of the Recommended Water Quality Management Plan to Meet Adopted Objectives and Standards

Evaluation of Water Quality Modeling Analysis Results Relative to the Adopted Water Use Objectives and Water Quality Standards

Water quality summary statistics for 106 water quality assessment points distributed along streams throughout the 1,127-square mile study area and in the nearshore area of Lake Michigan are set forth by watershed in Tables P-1 through P-6 in Appendix P of this report. Mean and median concentrations are set forth for the 10-year simulation period. For pollutants that have regulatory or planning standards, the percent of time is indicated that a given stream or Lake assessment point is in compliance with the applicable standard. Geometric means are presented for fecal coliform bacteria for comparison with regulatory standards.

The following general conclusions can be drawn from review of the data presented in Tables P-1 through P-6 in Appendix P of this report:

- **Fecal Coliform Bacteria**
    - Marked reductions in concentration may be achieved under recommended plan conditions.
    - Improvements in compliance with the applicable standards are not as pronounced because of the existing high concentrations.
- **Dissolved Oxygen**
    - Compliance with the applicable standards is generally good under existing conditions.
    - Little change is projected to occur under the other conditions analyzed.
- **Total Phosphorus**
    - The most significant reductions in concentration generally occur under revised 2020 baseline conditions relative to existing conditions.
    - These reductions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and construction of MMSD committed projects.
    - Increases in concentrations are projected to occur at some locations in the Milwaukee River watershed under revised 2020 baseline conditions.
    - The recommended plan is projected to produce marked reductions in concentrations relative to revised 2020 baseline conditions in the Lake Michigan inner and outer harbor areas.
    - Under the extreme measures condition marked reductions in concentrations relative to recommended plan conditions could occur in the Lake Michigan inner and outer harbor areas and at some locations in the Menomonee River watershed.

- **Total Nitrogen**
    - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
    - In the Milwaukee and Root River watersheds, the most significant reductions in concentrations occur under recommended plan conditions relative to the revised 2020 baseline conditions.
    - In the Lake Michigan inner and outer harbor, significant reductions in concentrations occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.
    - In the nearshore Lake Michigan area little change in concentrations would be expected among the five conditions considered.
- **Total Suspended Solids**
    - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
    - These reductions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and completion of MMSD committed projects.
    - In the Milwaukee River watershed, the greatest reductions in concentrations occur under recommended plan conditions relative to revised 2020 baseline conditions.
    - In the urban areas of the Root River watershed in Milwaukee County, significant reductions in concentrations are anticipated under revised 2020 baseline conditions relative to existing conditions.
    - In the remainder of the Root River watershed and in the Lake Michigan inner and outer harbor areas, reductions in concentrations would be anticipated to occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.
- **Copper**
    - In the Kinnickinnic River, Menomonee River, Oak Creek, and Root River watersheds and in the Lake Michigan inner and outer harbor areas, the most significant reductions in concentrations generally occur under the revised 2020 baseline conditions relative to existing conditions.
    - In most locations in the Milwaukee River watershed and the nearshore Lake Michigan area no significant changes in concentrations would be expected among the five conditions considered.

Compliance with Adopted Water Quality Standards
For purposes of assessing compliance with water quality standards under this regional water quality management plan update, it was assumed that a stream reach would meet the water quality standard and attain its designated use objective if the modeled water quality results indicate compliance with the standard at least 85 percent of the time.

The data on compliance with standards as set forth in Tables P-1 through P-6 in Appendix P of this report are summarized in Figures 57 through 68 in Chapter X of this report.

Evaluation of Water Quality Modeling Analysis Results Relative to the "Auxiliary Uses" with More-Stringent Water Quality Standards

The water use objectives for streams in the study area are set forth in detail in Table 70 in Chapter VII of this report. Those objectives include both the codified objectives and auxiliary uses to be considered for planning purposes. Those auxiliary uses were generally established by the WDNR in "State of the Basin" reports. For those waters assigned an auxiliary use objective the potential for achieving a higher objective or classification than currently codified was evaluated under the regional water quality management plan update. Stream reaches to be evaluated were identified in the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds, including within the Kinnickinnic, Menomonee, and Milwaukee River portions of the Milwaukee Harbor estuary.

A detailed evaluation of compliance with the water quality standards associated with the auxiliary use objectives under recommended plan conditions is presented in Chapter X. That evaluation included consideration of whether, for a given stream or stream reach, a recommendation could be made to 1) upgrade the existing regulatory water use objective or 2) propose a planned water use objective that might be achieved under recommended plan conditions. The evaluation of upgrading the existing regulatory water use objective was based on consideration of observed water quality data for the baseline period and the evaluation of possible planned water use objectives considered both observed and estimated future modeled water quality conditions.

In general, even though anticipated water quality conditions at some locations assessed fall short of the compliance criterion, implementation of the recommended plan would result in significant improvement in fecal coliform concentrations.

Based upon the results described in Chapter X, it is recommended that the WDNR consider pursuing changes to the existing regulatory water use objectives as set forth in Table 105. That table also indicates recommended planned water use objectives that are considered to be achievable under recommended plan conditions.

GROUNDWATER MANAGEMENT PLAN ELEMENT

As noted in Chapter III of this report, "Existing and Historical Surface Water and Groundwater Conditions," and in Chapter XI, "Groundwater Quality Conditions and Sources of Pollution in the Study Area," of SEWRPC Technical Report No. 39, this regional water quality management plan update was conducted concurrently with the regional water supply study documented in SEWRPC Planning Report No. 52, *A Regional Water Supply Plan for Southeastern Wisconsin*. In general, the recommendations of the regional water supply plan related to protection of groundwater quality are adopted by reference in the plan described herein.

Plan Recommendations Related to Groundwater

Specific recommendations related to groundwater recharge areas, groundwater sustainability, mapping of groundwater contamination potential, stormwater management measures affecting groundwater quality, issues related to the effects of emergency and unregulated contaminants on groundwater quality, and water conservation are summarized below.

Groundwater Recharge Areas

The most important groundwater recharge areas in that portion of the study area within the Region were identified and mapped under the SEWRPC regional water supply plan. Such recharge areas should be considered for preservation or for the use of development and stormwater management practices which are directed toward maintaining the natural hydrology as one measure to maintain the quality and quantity of groundwater in the shallow aquifer, which has a direct bearing on the quality of surface water resources. Maintenance of cold or cool baseflow from the shallow aquifer to streams or lakes helps to maintain desirable water temperatures in streams and lakes. Maintenance of high-quality baseflow is a significant factor in establishing good water quality over

Table 105

RECOMMENDATIONS REGARDING WATER USE OBJECTIVES

Assessment Point	Regulatory Water Use Objective Evaluated in Tables M-1 through M-6[a]	Auxiliary Use Objective(s) Proposed by WDNR and Evaluated in Table X-7	Recommended Existing Water Use Objective[b]	Recommended Planned Water Use Objective[b,c]
KK-10 Kinnickinnic River	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[d]
MN-14 Underwood Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[e]
MN-16 Honey Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
MN-17 and MN-18 Menomonee River from N. 70th Street to the Upstream End of the Milwaukee Harbor Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**
ML-22 Stony Creek	Fish and Aquatic Life	Coldwater	**Coldwater[f]**	**Coldwater[f]**
ML-31 Indian Creek Downstream of N. Manor Lane	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**	**Special Variance (Fish and Aquatic Life with Limited Recreational Use Standards)**
Indian Creek Upstream of N. Manor Lane	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
ML-32 Lincoln Creek	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[g]
RT-5 Whitnall Park Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
RT-6 Tess Corners Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
RT-19 Ives Grove Ditch	Limited Aquatic Life	Limited Forage Fish	Limited Aquatic Life	**Limited Forage Fish**
RT-20 Hoods Creek	Limited Forage Fish	Fish and Aquatic Life	Limited Forage Fish	**Fish and Aquatic Life**
LM-1. LM-4, and LM-6 Entire Milwaukee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Fish and Aquatic Life and Full Recreational Use**	**Fish and Aquatic Life and Full Recreational Use**
LM-2 and LM-3 Entire Menomonee River Estuary	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance
LM-5 Kinnickinnic River Estuary from Union Pacific Railroad Swing Bridge to Confluence with the Milwaukee River	Special Variance	Fish and Aquatic Life and Full Recreational Use	**Fish and Aquatic Life and Limited Recreational Use**	**Fish and Aquatic Life and Full Recreational Use**
Kinnickinnic River Estuary Upstream from Union Pacific Railroad Swing Bridge	Special Variance	Fish and Aquatic Life and Full Recreational Use	Special Variance	Special Variance[h]

[a]*Special variance use objectives include a bacteria standard that reflects a limited recreational use objective. Waters not under special variance are considered to have full recreational use objectives.*

[b]*Bold text indicates a change from the current regulatory water use objective.*

[c]*Anticipated to be achieved under recommended plan conditions.*

[d]*Subject to re-evaluation if concrete lining were removed from the stream channel.*

[e]*Subject to re-evaluation following removal of the concrete channel lining in the reach from N. Mayfair Road (STH 100) to the confluence with the Menomonee River.*

[f]*Subject to more extensive collection of temperature data.*

[g]*Re-evaluate when more dissolved oxygen data are available.*

[h]*Re-evaluate when contaminated sediment in the upper reach of the Kinnickinnic River portion of the estuary is remediated under the WDNR Kinnickinnic River Environmental Restoration Project.*

Source: Tetra Tech, Inc.; HydroQual, Inc.; and SEWRPC.

much of each year when streamflow is dominated by baseflow. Finally, the maintenance of an adequate volume of baseflow is essential to providing adequate instream habitat, to maintaining the hydroperiod of wetlands, and to maintaining lake levels.

It is recommended that the groundwater recharge area mapping be extended to those portions of the regional water quality management plan update study area outside of the Southeastern Wisconsin Region (i.e., those portions of Dodge, Fond du Lac, and Sheboygan Counties in the Milwaukee River watershed) and that consideration be given to following the recommendations of the regional water supply plan regarding maintenance of groundwater recharge areas in the entire regional water quality management plan update study area.

Groundwater Sustainability

Under the regional water supply planning process, groundwater sustainability analyses were made for six selected demonstration areas, each selected to represent a range of hydrogeologic conditions. It is recommended that the groundwater sustainability guidance results be considered by municipalities in the regional water quality plan update study area in evaluating the sustainability of proposed developments and in conducting local land use planning.

Mapping Groundwater Contamination Potential

As shown on Map 42 in Chapter IV of this report, the groundwater contamination potential of shallow aquifers in the Southeastern Wisconsin Region was mapped under the SEWRPC regional groundwater program. That mapping does not extend to that portion of the regional water quality management plan update study area in Dodge, Fond du Lac, and Sheboygan Counties. It is recommended that the groundwater contamination potential of the shallow aquifers in those counties be mapped.

Stormwater Management Measures Affecting Groundwater Quality

It is recommended that the design of stormwater management facilities that directly or indirectly involve infiltration of stormwater consider the potential impacts on groundwater quality. In this respect, the applicable WDNR post-construction stormwater management technical standards for site evaluation for stormwater infiltration, infiltration basins, bioretention facilities, and wet detention basins should be applied in the design of such management facilities.

Chlorides that are applied for snow and ice control on roads are conservative constituents that are often dissolved in stormwater runoff and are not treated and removed by stormwater infiltration practices. The previously-stated nonpoint source pollution abatement recommendation regarding implementing programs to reduce the use of road salt would have a positive effect on groundwater quality as well as surface water quality.

Groundwater Quality Issues Related to Disposal of Emergency and Unregulated Contaminants

The disposal of contaminants, such as pharmaceuticals, personal care products, and endocrine disruptor pharmaceutical products in onsite waste disposal systems or other systems which discharge to the groundwater system (e.g., septic systems, mound systems) can degrade the quality of the receiving groundwater. The water quality management plan subelement subsection of this report includes a recommendation regarding maintaining and expanding collection programs to properly dispose of household products. Implementation of that recommendation would serve to help protect groundwater quality as well as surface water quality.

Water Conservation

Detailed information on regional water conservation issues is set forth in Chapter VII, “Water Conservation,” of SEWRPC Technical Report No. 43, *State-of-the-Art of Water Supply Practices*, which is a companion report to SEWRPC Planning Report No. 52. Consistent with the regional water supply plan, this water quality management plan update recommends that utility- or community-specific water conservation programs be developed and implemented based upon a number of factors, including the composition of the community water users, the operational characteristics of the utility, the level of efficiency already being achieved, the water supply infrastructure in place, that needed to meet future demands, and the sustainability of the water supply.

COST ANALYSIS

In order to assist public officials in evaluating the recommended regional water quality management plan update for the greater Milwaukee watersheds, estimates were prepared of capital costs and attendant annual operation and maintenance costs. The overall recommended plan costs are summarized in Table 82 in Chapter X of this report.

The capital cost of implementing the recommended plan for the greater Milwaukee watersheds is estimated at $1.492 billion and annual operation and maintenance costs are estimated to be $28.4 million. With the exception of an estimated $50,000 for additional studies recommended under the groundwater management plan element, that entire capital cost is for surface water quality measures.

As set forth in Table 87 in Chapter X of this report, an additional $1.228 billion is for 1) existing programs that are to continue, 2) plan elements that have been committed under other planning efforts, and 3) programs that are to be implemented to meet regulatory requirements. The estimated annual operation and maintenance costs for those programs is $33.0 million. These costs were not assigned to the recommended regional water quality management plan update.

The capital costs for the continuing-program, previously-committed, or regulatory measures include:

- About $197 million for implementation of the nonagricultural (urban) performance standards of Chapter NR 151 of the *Wisconsin Administrative Code*, as mandated under the Wisconsin Pollutant Discharge Elimination System municipal stormwater discharge permits issued pursuant to Chapter NR 216 of the *Administrative Code*,

- About $1.026 billion for existing and committed MMSD facilities, programs, operations, and policies (see Table 84 in Chapter X of this report),

- About $1.0 million for skimmer boat operation in the Milwaukee Harbor estuary, and

- About $3.6 million for research and implementation projects related to urban nonpoint source pollution control measures.

Cost assignments to public and private sector entities are set forth in Table 100 in Chapter XI of this report. Detailed cost apportionment among municipalities, State and Federal agencies, and special units of government are set forth in Appendix R.

PLAN IMPLEMENTATION

While the recommended regional water quality management plan update is designed to attain, to the extent practicable, the agreed upon water quality and related objectives, the plan is not complete in a practical sense until the steps required to implement the plan—that is, to convert the plan into action policies and programs—are specified. The implementation plan outlines the actions which must be taken by the various levels and agencies of government in concert with private sector organizations if the recommended water quality plan is to be fully carried out by the design year 2020. Those units and agencies of government which have plan adoption and plan implementation powers applicable to the plan are identified; necessary or desirable formal plan adoption actions are specified; and specific implementation actions are recommended for each of the units and agencies of government with respect to the land use, surface water quality management, and groundwater elements of the plan. Also, the coordinated roles of the public and private sectors are described, and financial and technical assistance programs available to implement the water quality management plan are summarized.

Tables 93 through 99 in Chapter XI of this report indicate the designated management agencies for the following recommended plan elements or subelements :

- Point source pollution abatement (62 agencies),
- Rural nonpoint source pollution abatement (61 agencies and four private land trusts),
- Urban nonpoint source pollution abatement (121 agencies and two nongovernmental organizations),
- Instream water quality measures (104 agencies),
- Inland lake water quality management (35 agencies),
- Auxiliary water quality management (49 agencies and two nongovernmental organizations), and
- Groundwater quality management (95 agencies).

All but 35 of the designated management agencies currently exist. Depending on how many counties in the study area have adequate existing programs to provide the additional oversight of private onsite wastewater treatment systems (POWTS) that is recommended to be performed by existing or new town utility districts, up to 28 new utility districts could be established to provide additional oversight of POWTS. In addition, seven of the proposed new agencies would be lake protection and rehabilitation districts.

The plan implementation recommendations contained in this chapter are, to the maximum extent possible, based upon and related to year 2007 government programs and private sector initiatives and are predicated upon existing enabling legislation. Because of the possibility of unforeseen changes in economic conditions, State and Federal legislation, case law decisions, governmental organization, and tax and fiscal policies, it is not possible to determine exactly how a process as complex as watershed-based water quality plan implementation should be administered and financed. In the continuing regional planning program for southeastern Wisconsin, it will, therefore, be necessary to periodically update not only the water quality management plan elements and the data and forecasts on which these plan elements are based, but the recommendations contained herein for plan implementation. That approach is consistent with the “adaptive management” approach adopted by the Milwaukee Metropolitan Sewerage District (MMSD) for implementation of the MMSD 2020 wastewater treatment facilities plan component. In addition to consideration of the possible changed conditions listed above, such updates should consider future changes to planned sewer service areas, the effects of those changes on hydrologic and hydraulic conditions, and the consequences for water quality management in the study area.

The ongoing comprehensive planning program being conducted pursuant to legislation enacted by the Wisconsin Legislature in 1999 and set forth in Section 66.1001 of the *Wisconsin Statutes* (often referred to as the State’s "Smart Growth" law), provides a new framework for the development, adoption, and implementation of comprehensive plans by regional planning commissions and by county, city, village, and town units of government. Those plans contain elements related to land use; utilities and community facilities; and agricultural, natural, and cultural resources which are also components of the regional water quality management plan update. Thus, there is a relationship between the comprehensive plans and the regional water quality management plan update and the implementation of the plans may be complementary.

Chapter XI provides detailed information on grant and loan funding programs that may be possible sources of funding for the implementation of specific plan recommendations. Appendix R provides an apportionment by designated management agency of the costs of implementing recommended plan activities.

PUBLIC REACTION TO THE RECOMMENDED PLAN AND SUBSEQUENT ACTION OF THE TECHNICAL ADVISORY COMMITTEE

Introduction

Appendix A documents the extensive public informational activities conducted during the regional water quality management plan update process. Those educational activities, included, but were not limited to:

- Four "Clean Rivers, Clean Lakes" water quality conferences that were conducted in conjunction with MMSD in 2004, 2005, 2006, and 2007, each of which was attended by several hundred people,

- Inclusion of descriptive material and preliminary draft chapters from this report, SEWRPC Planning Report No. 50, *A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds,* and its companion report, SEWRPC Technical Report No. 39, *Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds*, on the SEWRPC website (www.sewrpc.org), along with contact information to provide comments on the preliminary draft chapters to SEWRPC staff,

- Numerous presentations to the Citizens Advisory Council that was specifically established under the joint SEWRPC regional water quality management plan update and MMSD 2020 facilities planning process,

- Several presentations to local elected officials in the study area,

- Numerous presentations to the MMSD Technical Advisory Team, consisting of engineers and public works directors from the 28 MMSD member or contract communities,

- Detailed review of the plan by the SEWRPC Technical Advisory Committee for the Regional Water Quality Management Plan for the Greater Milwaukee Watersheds,

- Distribution of the notice of public informational meetings and hearings (included in Appendix A) to all chief elected officials and clerks in the nine counties and 88 cities, villages, and towns in the study area; the Wisconsin Farm Bureau Federation office in each county in the study area, the members of the Milwaukee River Basin Partnership and the Root-Pike Watershed Initiative Network; the MMSD Technical Advisory Team; the MMSD/SEWRPC Citizens Advisory Council; and the SEWRPC Technical Advisory Committee and Modeling Subcommittee, and

- Publication of a notice of public informational meetings and hearings (included in Appendix W) in El Conquistador (Milwaukee area), The Reporter (Fond du Lac), The Insider News (Racine area), the Milwaukee Courier, the Milwaukee Journal Sentinel, the News Graphic (Ozaukee County), The Journal Times (Racine), The Sheboygan Press, The Freeman (Waukesha), and the Daily News (West Bend).

The following public information meetings/public hearings were conducted within the study area:

- October 15, 2007, at the Gateway Technical College in the City of Racine in Racine County,

- October 16, 2007, at the Milwaukee Downtown Transit Center in the City of Milwaukee in Milwaukee County,

- October 23, 2007, at the Riveredge Nature Center, near the Village of Newburg at the boundary between Ozaukee and Washington Counties.

The purpose of these informational meetings was to: 1) provide a briefing on the preliminary water quality management plan update recommendations; 2) answer any questions that interested citizens and local public officials may have had on the plan; and 3) solicit constructive comments and criticism on the preliminary plan. Each meeting consisted of an open house from 4:30 to 5:30 p.m. at which the public had the opportunity to meet with the SEWRPC staff to receive information, ask questions, and provide comment. Each open house was followed by a SEWRPC staff presentation summarizing the planning process and the recommended plan from 5:30 to 6:00 p.m. A copy of this presentation is included in Appendix X. Each presentation was followed by a public hearing during which public comments were made. Mr. Daniel Schmidt, a SEWRPC Commissioner and

Chair of the Technical Advisory Committee on the Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, presided at each public hearing.

Summary of Public Comment

Comments at the October 15, 2007, Racine Public Hearing

This public information meeting/public hearing was attended by five members of the public. During the public hearing, which is documented in the transcript included in Appendix W, there were no specific comments made regarding the regional water quality management plan update. Mr. Walter R. Madsen of Nielsen, Madsen & Barber consulting engineers, inquired regarding the use in the plan of water quality sampling data from storm sewer outfalls. He noted that his firm in cooperation with the City of Racine was sampling stormwater outfalls in the Village of Wind Point for fecal coliform bacteria and phosphorus. Mr. Madsen, the SEWRPC staff, and a representative of the consultant team for the plan discussed issues related to stormwater monitoring data.

There were no written comments received from those in attendance at this meeting.

Comments at the October 16, 2007, Milwaukee Public Hearing

This public information meeting/public hearing was attended by 12 members of the public. During the public hearing, which is documented in the transcript included in Appendix W, verbal public comment was provided by:

- Ms. Cheryl Nenn of Friends of Milwaukee's Rivers, who is a member of the Technical Advisory Committee for the regional water quality management plan update, and

- Ms. Vivian Corres, a resident of the City of Milwaukee.

In addition written comments were provided by

- Mr. Gregory F. Bird, a resident of the City of Milwaukee;

- Mr. Curt Bolton, the Greenfield City Engineer;

- Ms. Corres;

- Joint comments from Friends of Milwaukee's Rivers, the Sierra Club Great Waters Group, the Milwaukee County Conservation Coalition, and the Natural Resources Defense Council; and

- The League of Women Voters of Milwaukee County, as represented by Dr. Jennifer A. Runquist, a member of the Citizens Advisory Council for the SEWRPC regional water quality management plan update and the MMSD 2020 facilities plan.

The comments of each of those who spoke or wrote are documented in the attached transcript and the written comment forms, both of which are included in Appendix W. The comments are summarized below, along with responses from the SEWRPC staff.

Friends of Milwaukee's Rivers, Sierra Club Great Waters Group, Milwaukee County Conservation Coalition, and Natural Resources Defense Council

Ms. Nenn provided verbal comments stating that, in general, Friends of Milwaukee's Rivers was "very supportive of the plan, with a couple of major concerns." The areas of support noted by Ms. Nenn included recommendations related to 1) protection of primary environmental corridors, 2) instream measures, and 3) all of the recommended nonpoint source pollution control measures, including those to improve fertilizer management, detect and eliminate illicit discharges, and possibly form town utility districts to expand oversight of private onsite wastewater treatment systems. Areas of concern related to 1) the five-year level of protection against sanitary sewer overflows, 2) only "holding the line" on infiltration and inflow, and 3) the possibility of blending at the South Shore wastewater treatment plant. Ms. Nenn's comments were consistent with the written comments, thus, the responses to the following comments, which are taken directly from the comment letter, relate to Ms. Nenn's verbal comments at the hearing as well.

1. **Comment**: "The proposed 5-year Level of Protection for Sanitary Sewer Overflows (SSOs) is illegal under Federal and State law. MMSD (and other treatment plants) must eliminate SSOs and address both point and non-point sources of pollution affecting our waterways."

   Response: It is noted in Chapter IV, "Legal Structures Affecting the Regional Water Quality Management Plan Update," and Chapter IX, "Development of Alternative Plans: Description and Evaluation," that sanitary sewer overflows are prohibited under the Clean Water Act (CWA) and under the WPDES discharge permits for MMSD facilities and the other wastewater treatment facilities in the study area. However, current Federal and State regulations acknowledge that it is not feasible to prevent SSOs at all times and under all circumstances. Therefore, those regulations allow regulators to include "exceptional circumstances" language in permits. While all SSOs are prohibited under current Federal and State rules, the WDNR may exercise enforcement discretion for certain SSO events such as 1) those that are unavoidable to prevent loss of life, personal injury, or severe property damage; 2) those for which there are no feasible alternatives; and 3) those associated with wet weather conditions where the bypass or overflow of excessive storm drainage or runoff results from a precipitation event having a probable frequency of once in five years or less. To meet regulatory requirements, the 2020 MMSD facilities plan proposes to provide a five-year level of control of SSOs.

   The five-year level of protection was selected for system design purposes under the MMSD facilities plan after considerable discussion with the WDNR and USEPA in several meetings specifically held to address that issue as well as during the Oversight Committee meetings that were held throughout the planning process.[31] The five-year LOP would be an improvement over the current estimating operating condition of a two-year LOP, which was determined through water quality modeling. Comparison of water quality conditions for the revised 2020 baseline condition and the revised 2020 baseline with a five-year level of protection (LOP) against SSOs at those locations that could be affected by SSOs from the MMSD system indicates no significant difference in water quality under the two conditions. That conclusion supports the observation that has been stated previously in this report that further reductions in such point sources of pollution would be expected to have no significant effects on water quality. In addition, under the MMSD facilities planning process, modeling analyses were also performed for a 10-year LOP, relative instream and inlake water quality conditions and costs were compared, and it was concluded that, while substantial additional costs would be incurred to attain a 10-year LOP, it would result in no significant improvement in water quality. The WDNR review of the draft facilities plan, which is currently underway, will include consideration of the LOP against sanitary sewer overflows.

2. **Comment:** "Cost effectiveness can be used to prioritize future actions but not to justify continuing pollution of our waterways."

   Response: The plan does not use cost effectiveness to justify continuing pollution of waterways. The plan uses cost effectiveness to identify those actions that can most readily be implemented to achieve the greatest water quality improvement.

3. **Comment:** "We encourage SEWRPC to set more concrete water quality goals, which allow agencies and organizations to focus time and attention on addressing specific problems, as well as ensure that we all remember the ultimate goal of improving water quality."

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[31]*The Oversight Committee consists of staff members from the MMSD, WDNR, SEWRPC, and the project consultant team.*

Response: Chapter X, “Recommended Water Quality Management Plan,” and Chapter XI, “Plan Implementation,” clearly identify those specific areas on which efforts to improve water quality conditions should be focused. Chapter X includes detailed information and recommendations regarding stream reaches where existing water use objectives could be upgraded, and implementation priorities for the components of the plan are set forth in Tables 93 through 99 in Chapter XI. Chapter XII, “Summary,” provides a more succinct statement of plan recommendations and implementation functions. It is anticipated that further emphasis on addressing specific problems in the context of the overall plan will be accomplished at the watershed and subwatershed level during the implementation phase.

4. **Comment:** “The SEWRPC Regional Water Quality Plan (208 Plan), must comply with Clean Water Act fishable and swimmable goals, and address antidegradation requirements regardless of cost effectiveness.” The explanatory text regarding this comment mentions that “we cannot practice an ‘either/or’ approach to pollution (e.g. spend all our money on non-point pollution to get more ‘bang for our buck”) and expect to meet fishable/swimmable standards throughout both our rural and urban waterways.” The explanatory text also asks that “SEWRPC analyze existing models in use throughout the country and make some solid recommendations of crucial policy and technical components that should be part of” watershed permitting, watershed trading, and other such mechanisms.

   Response: The plan clearly recognizes the goals of the Clean Water Act and it provides a detailed, framework of recommendations to improve, not degrade, the water quality of the lakes and streams in the study area and to advance toward the fishable and swimmable goals of the Act. As noted under the response to the previous comment, Chapter X includes detailed information and recommendations regarding stream reaches where existing water use objectives could be upgraded.

   Regarding the “either/or” comment, it is noted that about 75 percent of the total $2.7 billion cost of the plan is for point source components.

   Regarding recommendations for watershed permitting and other related concepts, those issues would be best addressed during the upcoming implementation phase when it is anticipated that implementation mechanisms will be evaluated and initiated on a trial basis by watershed. Given the many stakeholders who will need to participate in the implementation process in order to ensure its success and the wide range of issues to be addressed, some of which are unique to individual watersheds, it would be premature to impose specific recommendations in this case.

5. **Comment:** “Holding the line on infiltration and inflow (I/I) is not enough. We must go after I/I more aggressively and achieve reductions.”

   Response: Experience shows that, in many situations, achieving reductions in infiltration and inflow can be very challenging. Given the potential growth in development under planned year 2020 conditions and the potential for I/I to increase as sewerage systems age, a recommendation to maintain I/I at current levels is considered to be an aggressive one. The SEWRPC regional water quality management plan and the MMSD 2020 facilities plan call for watercourse projects directed toward reducing I/I through reducing overland flooding in developed areas. Also, the MMSD in cooperation with the technical advisory team (TAT) which is comprised of members from all communities served by the District, is drafting a Wet Weather Peak Flow Management Plan (WWPFMP) which will establish peak wet weather flow standards for each municipality served by MMSD and incorporate activities that will serve to keep I/I from growing beyond current levels. The WWPFMP is to be coordinated with MMSD’s Capacity, Management, Operations, and Maintenance (CMOM) program.

6. **Comment:** "While we support increasing secondary capacity at South Shore Treatment Plant, sewage blending is unacceptable."[32] The written comments and Ms. Nenn's comments at the public hearing noted that, while the blending currently permitted at the MMSD Jones Island wastewater treatment plant is accomplished in compliance with the conditions of MMSD's discharge permit, the permit does not have standards for parasites and viruses that could be a threat to human health.

   Response: The recommendations for addressing capacity issues at the South Shore plant, as described in detail in Chapter X of this report, call for a multi-step approach with blending being the last option if other approaches are not found to be feasible. The flow that would infrequently bypass secondary treatment under the blending process would be treated with ultraviolet disinfection, which is generally considered to result in an enhanced level of pathogen control relative to chlorination.

   The recommended plan calls for consideration of additional study of blending at the South Shore plant. Such study could include evaluation of the effects of ultraviolet disinfection on reducing pathogens, including parasites, viruses, and certain bacteria.

7. **Comment:** "We do not support the efforts of MMSD and customer communities to obtain regulatory recognition of the integrated nature of the MMSD system."

   Response: The regulatory requirement that a distinction be drawn between SSOs and CSOs from the MMSD system creates a situation under which the capacity of the ISS may be underutilized despite MMSD's best efforts to apply a variable VRSSI operating strategy to avoid overflows. Therefore, the regional water quality management plan recommends that MMSD and its customer communities work with the WDNR and USEPA to obtain formal regulatory recognition of the integrated nature of the MMSD system, perhaps extending to elimination of the present distinction between ISS-related SSOs and CSOs. The final decision on this matter rests with the WDNR and USEPA.

8. **Comment:** "We support watercourse improvements to improve physical-chemical water quality as well as fishable/swimmable goals."

   Response: This statement of support for the instream measures subelement of the plan is appreciated.

9. **Comment:** "We support collaborative efforts to implement solutions to non-point runoff and other sources of pollution as identified in SEWRPC's Regional Water Quality Management Plan." (The explanatory text regarding this comment refers to public and peer review of the models that will be used for the total maximum daily load development (TMDL) process being undertaken by MMSD.)

   Response: No response required other than to clarify that the TMDL process is under the control of MMSD.

10. **Comment:** "We encourage SEWRPC to come up with more concrete recommendations on how to aggressively deal with illicit discharges in our waterways, as well as how to deal with problem outfalls discharging into our waterways where illicit discharges can not be detected. These may include end of the pipe treatment systems and other emerging technologies."

    Response: It is because of the potentially variable nature of sources of illicit discharges from sanitary sewerage systems to stormwater management systems that the recommendations are kept somewhat

[32]*Blending is the practice of diverting diluted wastewater flows that exceed the wet weather capacity of the wastewater treatment plant around secondary treatment during peak wet weather events in an effort to avoid significant damage to biological treatment units and loss of treatment capability. The diverted flows are then normally recombined with flows from the fully utilized secondary treatment units for further treatment, including disinfection, prior to discharge.*

general to allow flexibility in the means by which illicit discharges are detected and eliminated. It is also recommended that human health and ecological risk assessments be conducted to address pathogens in stormwater runoff, and that, depending on the findings of the risk assessments, consideration be given to pursuing innovative means of identifying and controlling possible pathogen sources in stormwater runoff. That recommendation is also flexible enough to include some end-of-pipe treatment where appropriate.

11. **Comment:** "SEWRPC has provided solid evidence that orthophosphate, which was added to the water treatment systems of many area communities in the late 90s as an anti-corrosion inhibitor for drinking water pipes, is causing demonstrable spikes in phosphorus in many of our area rivers. We stand by SEWRPC's recommendation that municipalities using this inhibitor look for alternatives to orthophosphate that still protect our drinking water supply as well as minimize nutrient pollution of our rivers and lakes."

    Response: This statement of support for the plan recommendation is appreciated.

12. **Comment:** "We support the proposed protection of both Primary Environmental Corridors and Agricultural Buffers as proposed in the land use element of the Plan. The explanatory text for this comment states: "We would encourage SEWRPC to prioritize where buffers should be created, if possible, based on information from our models and taking in consideration of erodibility of area soils, slope of riparian areas, land use, etc."

    Response: This statement of support for the plan recommendation is appreciated. Maps 74, 75, and 76 in Chapter X of this report identify candidate areas in the Menomonee, Milwaukee, and Root River watersheds for possible buffer creation or expansion based on the existing buffer inventory conducted under the plan and applying the criterion of locating buffers on agricultural land. Application of the other criterion could be made during the plan implementation phase as specific sites are considered.

13. **Comment:** "We support SEWRPC recommendations to create town utility districts to deal with inspection, and possibly repair, of private onsite treatment systems or septic systems."

    Response: This statement of support for the plan recommendation is appreciated.

14. **Comment:** "We urge SEWRPC to recommend state regulations and local ordinances to more effectively deal with both urban and rural non-point pollution." The explanatory text for this comment supports the plan recommendations directed toward reducing fertilizer application, chloride application on roads, promotion of best management practices to abate nonpoint source pollution, fuller implementation of the Chapter NR 151 standards, manure and nutrient management, controls on barnyard runoff, management of milking center wastewater, and restricting livestock access to streams. The explanatory text asks that the plan recommend that all municipalities consider banning phosphorus from fertilizers.

    Response: This statement of support for the plan recommendations is appreciated.

    Review of the water quality modeling analysis results set forth in Appendix N indicates that in many cases, significant reductions in year 2020 instream phosphorus concentrations relative to existing year 2000 conditions may be achieved through programs to meet the nonpoint source pollution control standards of Chapter NR 151 of the *Wisconsin Administrative Code* along with the construction of committed MMSD projects. Because of the estimated relatively high degree of compliance with the phosphorus planning standard in the streams of the study area and Lake Michigan under planned conditions, no recommendation for an overall ban on the use of phosphorus fertilizers was warranted. However, because of the general benefit in reducing phosphorus inputs to streams and to Lake Michigan, it is also recommended that information and education programs required under municipal

WPDES stormwater discharge permits promote voluntary practices that optimize urban fertilizer application

15. **Comment:** "SEWRPC should propose more specific management measures and monitoring to deal with emerging pollutants of pharmaceuticals and personal care products if possible." The explanatory text for this comment specifically requests additional recommendations regarding more effective removal of these pollutants by wastewater treatment plants and onsite treatment systems, while recognizing that there is currently little information available on this issue. The text also promotes increased monitoring in surface waters, at treatment plant outfalls, and water supply facility intakes.

    Response: Available information on the efficiency with which wastewater treatment plants remove certain pharmaceutical and personal care compounds is set forth in Chapter II of SEWRPC Technical Report No. 39, the companion to this report which addresses water quality conditions and sources of pollution. Because there are thousands of compounds of interest and there is a lack of information regarding the processes required to treat such compounds, the SEWRPC staff cannot make an informed recommendation on this issue at this time.

    This is an important issue that should receive further attention as more information becomes available. It is not considered equitable to place the burden for further research in this area solely on the wastewater treatment plant operators of the study area. The number of compounds involved is in the thousands and each of those compounds may have different effects on the environment, thus, further research would be needed to identify the compounds of most concern prior to establishing either instream or outfall monitoring programs. Monitoring for pharmaceuticals and personal care products at wastewater treatment plant outfalls would most appropriately be addressed at the Federal level by the U.S. Environmental Protection Agency.

16. **Comment:** "We support SEWRPC recommendations to more aggressively identify and address local sources of beach contamination."

    Response: This statement of support for the plan recommendation is appreciated.

17. **Comment:** "Upgrade citizen based monitoring programs and continue to support existing monitoring and expand monitoring efforts into local tributaries." The explanatory text goes on to express support for the plan's recommendations that call for the actions listed in the comment.

    Response: This statement of support for the plan recommendations is appreciated.

Ms. Vivian Corres-Resident of the City of Milwaukee

Comment: Ms. Corres' verbal and written comments supported the position of Friends of Milwaukee's Rivers as stated by Ms. Nenn in her verbal comments. She also praised the monitoring training provided by Friends of Milwaukee's Rivers and she encouraged public officials to listen to public citizen volunteer groups.

Response: The SEWRPC staff has solicited input from citizen volunteer groups throughout the planning process, as evidenced by the presence of a representative from Friends of Milwaukee's Rivers on the Technical Advisory Committee and by establishment with MMSD of the Citizens Advisory Council. Also, the plan recognizes and supports the continuation of the water quality training and testing program being conducted by Friends of Milwaukee's Rivers.

Mr. Gregory F. Bird-Resident of the City of Milwaukee

Mr. Bird's written comments addressed the following issues:

1. **Comment**: The proposed expansion of the boundary of the Area of Concern (AOC) for remedial action planning should be extended even further to include the entire watershed. Mr. Bird made this

suggestion as a way of addressing what he termed "poorly regulated farm practices upstream, loss of riparian/undeveloped lands to housing & other paving development as West Bend, Saukville, Kewaskum, etc. grow and create runoff."

Response: Mr. Bird expresses valid concerns that are recognized in the plan and for which pollution abatement measures are recommended. The expansion of the AOC would require establishing direct connections between certain pollution sources and instream beneficial use impairments. That may not be possible for areas outside of the recommended expansion of the AOC. Also, it is not clear that, given the extensive point and nonpoint source control recommendations for parts of the study area outside the AOC, that expansion is necessary.

2. **Comment**: "Include Milwaukee River Environmental Corridor between N. Ave. dam site to Silver Spring to support efforts to establish 'Central Park' in area."

Response: Portions of the proposed "Central Park" are included in the primary environmental corridor along this reach of the River, and the Central Park concept is consistent with the plan recommendations related to preservation of primary environmental corridors. The SEWRPC staff is assisting the Milwaukee River Work Group[33] through the provision of data and attendance at planning charrettes organized by the Group.

3. **Comment:** "Require best practices WWTP at all facilities."

Response: The requirements for Wisconsin Pollutant Discharge Elimination System (WPDES) permits for wastewater treatment plants are determined by the WDNR, which is the permitting authority. Those requirements are established on a case-specific basis that considers the nature of the receiving waters and they are intended to enable attainment of the water quality standards associated with the water use assigned to the receiving waters. In general, the plan calls for continued compliance with the conditions of the WPDES permits for wastewater treatment facilities and for those facilities to implement necessary future upgrades through the facilities planning process which involves WDNR and SEWRPC.

4. **Comment:** "Begin to separate sanitary sewage from surface runoff by sealing leaking lateral sewers with fabric resin liners. Finance above by changing financial responsibility from homeowner responsible to main to homeowner responsible to curb-municipality/sewer district from curb to main-begin mandatory lateral lining. "

Response: The regional water quality management plan update calls for measures to limit infiltration and inflow to current levels even after accounting for growth through the year 2020. Thus, the general concept expressed by Mr. Bird is included in the plan recommendations. Policies regarding responsibility for laterals and approaches to sealing laterals from infiltration are considered to be local decisions that would be addressed by each community based on their specific circumstances as they implement a program to limit infiltration and inflow.

5. **Comment:** "Phase out snow-melt chemicals in favor of sand & pavement heaters & snow tires."

Response: The regional water quality management plan update includes recommendations related to the issue raised. The plan calls for municipalities and counties in the study area to continue to evaluate their practices regarding the application of chlorides for ice and snow control and strive to obtain optimal application rates to ensure public safety without applying more chlorides than necessary for that purpose. It is also recommended that municipalities consider alternatives to current ice and snow control programs, such as applying a sand/salt mix to local roads with enhanced street

[33]*Friends of Milwaukee's Rivers, the River Revitalization Foundation, and the Urban Ecology Center.*

sweeping in the spring of the year to remove accumulated sand. It is recommended that education programs be implemented to provide information about 1) alternative ice and snow control measures in public and private parking lots and 2) optimal application rates in such areas.

Mr. Curt Bolton, Greenfield City Engineer

Comment: "The deep tunnel should be considered to be … a regional stormwater quality facility. Then for NR 216 permits, the benefits in reduction of TSS discharged to Lake Michigan should be distributed among the communities that paid for the facility."

Response: Based on conversation between the SEWRPC staff and Mr. Bolton, this comment is related to his concern that it may be difficult for municipalities with WPDES stormwater discharge permits issued under Chapter NR 216 "Storm Water Discharge Permits," of the *Wisconsin Administrative Code* to meet the standards set forth in Chapter NR 151, "Runoff Management." Chapter NR 151 calls for areas of existing development to achieve, to the maximum extent practicable, a 20 percent reduction in total suspended solids (TSS) in 2008 and a 40 percent reduction in 2013. Mr. Bolton's comment relates to his contention that the ability for a municipality to claim some credit for the level of control of TSS in stormwater captured by the Inline Storage System (deep tunnel) would assist municipalities in meeting the 20 and 40 percent levels of control.

The analyses conducted under the regional water quality management plan update incorporate a level of TSS control from areas of existing development that is consistent with the standards of Chapter NR 151. Those analyses also reflect the pollution reduction effects of the ISS. Under planned conditions, significant reductions in TSS could be achieved through implementation of the recommended plan, and those reductions can largely be attributed to reductions from controls on agricultural and urban nonpoint sources. Those TSS reductions would improve water quality in stream reaches within, and downstream of, the areas where the controls are applied, rather than only in the far downstream portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers and Lake Michigan where the effects of the ISS are felt.

One possible source of relief for municipalities that have difficulty achieving the NR 151 TSS reductions is the "maximum extent practicable" concept. It is suggested that communities that are unable to practically achieve the 20 and/or 40 percent TSS reductions pursue the possibility of WDNR approval of their nonpoint source pollution control efforts based on a demonstration that the municipality has achieved control, to the "maximum extent practicable."

Ultimately, the issue raised by Mr. Bolton is one to be decided by WDNR, as the WPDES permitting authority.

The League of Women Voters of Milwaukee County

The written comments submitted by Dr. Runquist on behalf of the League of Women voters characterize the regional water quality management plan update as "a good structure for coordinating community efforts towards improving water quality using the Watershed Approach." The comments also support the plan recommendations regarding illicit discharges. The comments support the plan recommendation regarding increased State of Wisconsin funding for nonpoint source pollution control, noting that, in 2003, the League of Women Voters of Wisconsin proposed that "new or reallocated funds should be combined with General Purpose Revenues to meet (Wisconsin's) need for management of its water resources." The comments from the League of Women Voters requiring a response addressed the following issues (the complete text of the comments is provided in Appendix W):

1. **Comment:** "It is unfortunate to allow CSOs or SSOs into our drinking water and recreational waters."

   Response: This issue is largely addressed under the response to Comment 1 from Friends of Milwaukee's Rivers (FMR), the Sierra Club Great Waters Group (SCGWP), the Milwaukee County

Conservation Coalition (MCCC), and the Natural Resources Defense Council (NRDC). In addition it is important to reiterate that, under recommended plan conditions, the level of protection against SSOs from the MMSD system would increase from about two years under current conditions to five years. Also, the MMSD system currently meets its permit requirement regarding no more than an average of four CSOs a year and a maximum of six CSOs a year. On average, more than 50 CSOs occurred annually prior to construction of the ISS (deep tunnel). The SEWRPC regional water quality management plan update and the MMSD 2020 facilities plan document the relatively insignificant changes in water quality conditions resulting from increased controls on point sources such as CSOs and SSOs and the very large costs associated with achieving those controls. That is one reason why the regional plan recommends focusing on nonpoint source controls.

2. **Comment:** "We think that I/I should be aggressively reduced. Let's not just 'hold the line' on I/I but reduce it."

   Response: See the response to Comment 5 from FMR, SCGWP, MCCC, and NRDC.

3. **Comment:** "Monitoring for viruses and parasites in stream and lakes should be required, not just for *E. coli*, oxygen, phosphorus, etc., although these parameters are also important indicators of water quality."

   Response: The recommendation regarding illicit discharges to the stormwater management system as set forth in Chapter X of this report calls for monitoring of stormwater outfalls and risk assessments of stormwater runoff in an effort to identify possible threats to human health, including pathogens associated with both human sewage and domestic and wild animal wastes.

   The issue of mandatory monitoring as described in the comment would have to be addressed by the WDNR, as the water quality regulatory authority.

4. **Comment:** "We have concerns about sewage blending…"

   Response: See the response to Comment 6 from FMR, SCGWP, MCCC, and NRDC. It is important to reiterate that, if blending were to be used at the MMSD South Shore wastewater treatment plant, disinfection of the partially treated sewage flow bypassing secondary treatment would be accomplished through ultraviolet light, rather than chlorination.

Comments at the October 23, 2007, Newburg Public Hearing

This public information meeting/public hearing was attended by 13 members of the public. During the public hearing, which is documented in the transcript included in Appendix W, verbal public comment was provided by:

- Ms. Rose Hass Leider, Ozaukee County Supervisor for District No. 2,
- Ms. Marilyn John, representing Watershed Watchers, Inc., and
- Mr. Timothy John.

The comments are summarized below, along with responses from Mr. Schmidt and the SEWRPC staff.

Ms. Rose Hass Leider, Ozaukee County Supervisor

Comment: Ms. Hass Leider commented on the need to protect the Great Lakes as a source of water from a quantity and quality perspective. She expressed concerns regarding "raw sewage going into Lake Michigan," particularly from the MMSD sewerage system, and she indicated that something needs to be done to address that. She also noted that she is a farm owner and she praised Mr. Andrew Holschbach, Ozaukee County Director of the Ozaukee County Planning, Resources, and Land Management Department and a member of the Technical Advisory Committee for the SEWRPC water quality plan, and his staff for their work promoting adequate manure storage, adequate handling of milk house waste, and land conservation.

Response: In response, Mr. Hahn replied that the plan under consideration at the hearing addresses water quality as it relates to the nearshore Lake Michigan area. He mentioned that there is a separate, ongoing SEWRPC planning effort directed toward water supply issues.[34]

Regarding the issue of raw sewage going into Lake Michigan, it is noted that the MMSD system currently meets its permit requirement regarding no more than an average of four combined sewer overflows (CSOs) a year and a maximum of six CSOs a year. On average, more than 50 CSOs occurred annually prior to construction of the Inline Storage System (deep tunnel). Also, the plan calls for measures to provide a greater level of protection against sanitary sewer overflows. The plan has identified urban and rural nonpoint source pollution as the major sources of pollutant loads to the streams and lakes of the study area and recommends implementation of measures to abate pollution from nonpoint sources.

Consistent with Ms. Hass Leider's comments, the plan recommends adequate manure storage, adequate handling of milk house waste, and land conservation measures.

Ms. Marilyn John, Watershed Watchers, Inc.

Comment: Ms. John asked 1) what the plan is to correct contamination of water and loss of wetlands and 2) whether the plan would be implemented to take care of the problems.

Response: Mr. Schmidt noted that the support of the 88 municipalities and nine counties in the study area would be important to successful plan implementation, and he said that securing adequate funding would be another factor. He noted that the plan includes an extensive list of available grant programs. Mr. Hahn said that 1) the plan addresses the kinds of problems that Ms. John mentioned, 2) considerable improvements in water quality were achieved through implementation of the initial 1979 regional water quality management plan, and 3) obtaining adequate funding to implement the plan would be a challenge.

Details on plan recommendations to address contaminants in water can be found in Chapter X, "Recommended Water Quality Management Plan," Chapter XI, "Plan Implementation," and Chapter XII, "Summary." Regarding the loss of wetlands, the plan assumes continued application by the WDNR of the wetland water quality standards set forth in Chapter NR 103 of the *Wisconsin Administrative Code* and it calls for the conversion of 5 percent of the marginal cropland in the study area to wetlands, along with an additional 5 percent conversion of cropland to prairie conditions.

Mr. Timothy John

Comment: Mr. John asked whether any work had been done to determine what a pre-settlement river looked like.

Response: Mr. Hahn replied that was also raised by the Advisory Committee. He said it would be an interesting exercise, but it was not a part of the study. He said that it would be difficult to reliably predict such a condition, but that it would be instructive to know what background conditions were.

Action of the Technical Advisory Committee

The Technical Advisory Committee considered the public comments and the Commission staff responses as set forth above at its meeting on October 31, 2007. The Committee voted to approve this chapter at that meeting, including relatively minor revisions to the public comment subsection that are reflected in the preceding subsections and documented in the minutes of the meeting.

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[34]*SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin, *in progress.*

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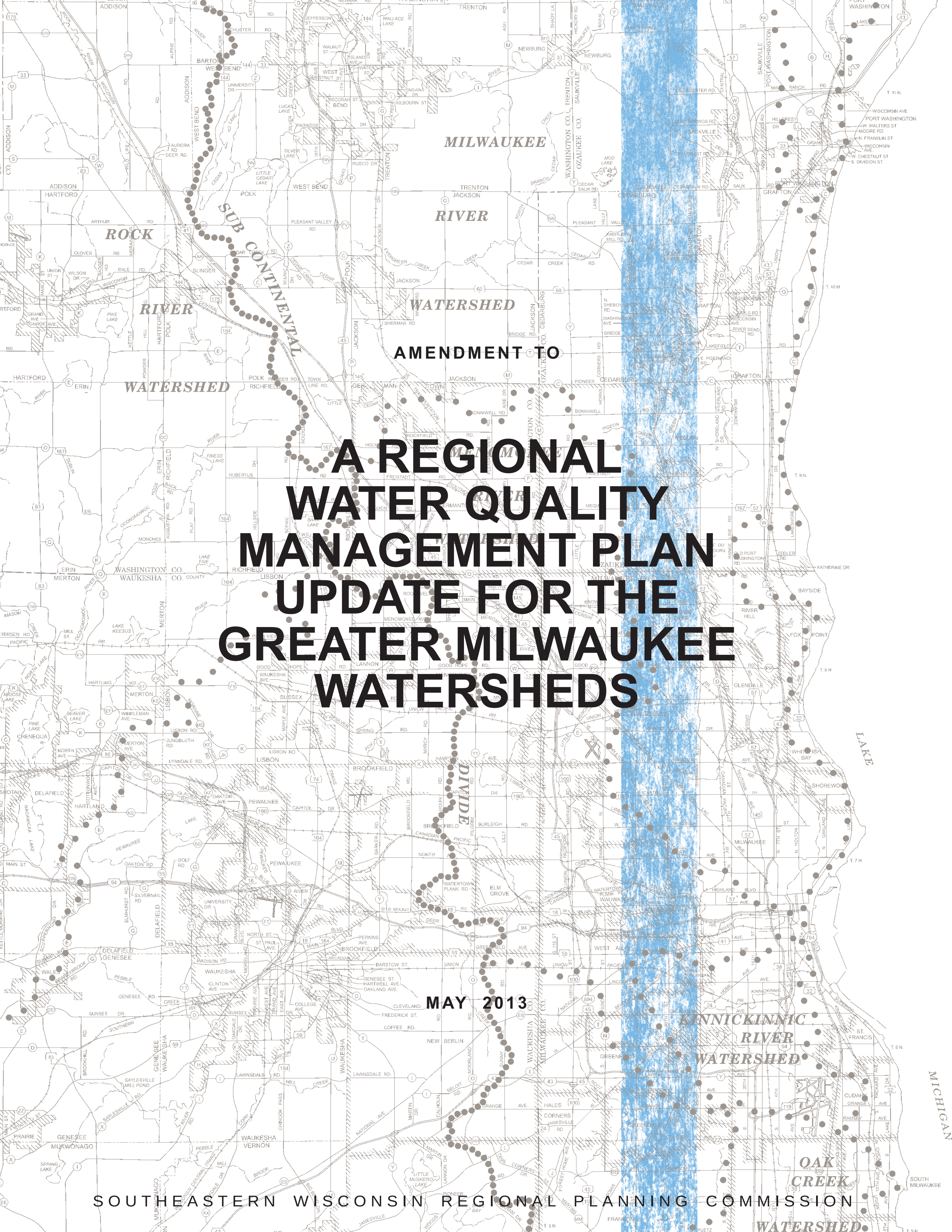
AMENDMENT TO

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS



MAY 2013

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SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Shawn L. Wesener .... Assistant Planning Director, Planning and Resources Department, Sheboygan County
Thomas A. Wiza .... Director of Engineering and Public Works, City of Cedarburg

AMENDMENT TO PLANNING REPORT NUMBER 50

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

Prepared by the

Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin 53187-1607
www.sewrpc.org

May 2013

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Amendment to SEWRPC Planning Report No. 50

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

May 2013

BACKGROUND ON THIS PLAN AMENDMENT

This amendment presents revisions to SEWRPC Planning Report No. 50 (PR No. 50)[1] based on changes to the watershed water quality models necessitated by findings during additional modeling efforts conducted after the plan report was issued. Those modeling efforts were conducted under a separate study directed toward evaluating the possible effects of climate change on water quality in the streams of the study area.

In this plan amendment document:

- New text providing background and explanations of the reasons why this plan amendment report was prepared and notes in the text indicating the location of revised sections of PR No. 50 are indicated with yellow highlighting,

- Revisions to text originally presented in PR No. 50 and subsequently revised for the reasons described below are indicated with blue highlighting, and

- Original text from PR No. 50 that is unchanged, but is provided in this plan amendment report to provide context for associated report changes, is unhighlighted.

REASONS FOR THIS PLAN AMENDMENT

In 2011, the Southeastern Wisconsin Regional Planning Commission staff, with funding from the National Oceanic and Atmospheric Administration (NOAA) Sectoral Applications Research Program (SARP), and working collaboratively with the University of Wisconsin-Milwaukee (UW-M) School of Freshwater Sciences Great Lakes WATER Institute, the UW-M Department of Civil Engineering and Mechanics, the University of Wisconsin-Madison Nelson Institute for Environmental Studies Center for Climatic Research (CCR), and Tetra Tech, Inc., began a study to evaluate the possible effects of climate change on water quality in the greater Milwaukee watersheds. That study was designed to apply statistically downscaled meteorological data representing best and worst case climate change conditions as determined from general circulation models developed by several climatology laboratories using a standard set of greenhouse gas emission scenarios developed by the Intergovernmental Panel on Climate Change. Time series reflecting climate change were developed by the Nelson Institute CCR for precipitation and air temperature, and potential evapotranspiration time series were recomputed using the parameters described in Chapter V, "Water Resource Simulation Models and Analytic Methods," of SEWRPC PR No. 50. The precipitation, air temperature, and potential evapotranspiration time series reflecting best and worst case climate change conditions were input to the calibrated and validated U.S. Environmental Protection Agency HSPF continuous simulation water quality models of the Kinnickinnic, Menomonee, Milwaukee, and Root River watersheds, and the Oak Creek watershed that were developed in conjunction with the planning effort documented in SEWRPC PR No. 50.

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[1]*SEWRPC Planning Report No. 50,* A Regional Water Quality Management Plan Update for the Greater Milwaukee Watersheds, *Parts 1 and 2, December 2007.*

Tetra Tech performed the watershed water quality modeling under the regional water quality management plan update for the greater Milwaukee watersheds documented in PR No. 50, and they also did the modeling for the NOAA SARP study. In the course of doing the NOAA SARP modeling, Tetra Tech discovered an error in the HSPF input files that affected the summation and reporting of total nitrogen (TN) and total phosphorus (TP) at some water quality assessment locations in the Kinnickinnic, Menomonee, and Root River watersheds and the Oak Creek watershed (see Attachment A).[2,3] The Tetra Tech memorandum notes that "[t]he error was a result of an improper conversion factor applied to the inorganic fraction of N and P when calculating sums of TN and TP." The Milwaukee River LSPC watershed continuous simulation model and the Lake Michigan Direct Drainage area model, and the water quality results from those models, were not affected by the error.

It is important to note that the error did not represent a fundamental problem with the watershed water quality models in that it only affected how total nitrogen and total phosphorus concentrations were summarized at certain instream locations, and it did not affect:

- Model calibration/validation[4]
- Any load predictions
- Boundary conditions to the estuary model
- Internal calculations, and any reported results for nutrient species
- Instream statistical measures for:
  - Fecal coliform bacteria
  - Dissolved oxygen (DO)
  - Biochemical oxygen demand (BOD)
  - Copper
  - Total suspended sediment (TSS)

Tetra Tech revised the continuous simulation models for the Kinnickinnic, Menomonee, and Root River watersheds and the Oak Creek watershed.[5]

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[2]*Tetra Tech Memorandum,* Nutrient Output for Milwaukee HSPF Models (Revised), *March 13, 2012.*

[3]*Specifically, only mean and median TN and TP concentrations and the percent of time that TP exceeds the 0.1 mg/L planning standard applied under the RWQMPU were affected at assessment locations other than those locations where water quality monitoring data were available.*

[4]*Instream concentrations of TN and TP computed at the assessment points representing calibration/validation monitoring stations were not affected by the error.*

[5]*That revision also corrected a relatively minor error that affected total nitrogen concentrations at some instream assessment points. When calibrating and validating the models, nitrite was not modeled because the total nitrogen concentrations reported at instream water quality monitoring stations did not include nitrite. However, when subsequent model analyses were made for existing year 2000 conditions, original and revised 2020 baseline conditions, scenarios, alternatives, the recommended plan, and the extreme measures condition, the modelers did not include nitrite in the calculation of total nitrogen. In general, the inclusion of nitrite in the computation of mean and median total nitrogen concentrations resulted in relatively small (3 percent or less) increases in total nitrogen concentrations. The exception was at assessment point OK-10 in the lower Oak Creek watershed where concentration increases were 9 percent or less.*

The parts of SEWRPC PR No. 50 that were affected by the revisions include:[6]

- The “Comparison of Alternative Plans” subsection on pages 482 through 484 of the report,

- Figures 67 and 68, each entitled “Achievement of Recommended Total Phosphorus Planning Standard,” on pages 615 and 616,

- The portion of the “Evaluation of Water Quality Modeling Analysis Results Relative to the Adopted Water Use Objectives and Water Quality Standards/Criteria,” subsection related to total phosphorus on pages 617, 621, and 622 of the report,

- Appendix J, “Comparison of Water Quality Summary Statistics for Alternative Water Quality Management Plans,”

- Appendix K, “ Water Quality Standard Compliance Summary Statistics for Alternative Water Quality Management Plans,” and

- Appendix N, “Water Quality Summary Statistics for the Recommended Plan.”

The revised sections and subsections, or portions thereof, of SEWRPC PR No. 50, Part 1, including text, tables, and figures, and the revised Appendices J, K, and N from SEWRPC PR No. 50, Part 2 are presented below. Within a report section or subsection, the revised text and figures are excerpted and some preceding and following text is included to provide proper context for the changed portions. For the three appendices, the entire revised appendix is presented.[7]

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[6]*As noted above, the NOAA SARP study utilized the RWQMPU continuous simulation watershed water quality models. The model error described previously was discovered during conduct of that study, was corrected, and did not adversely affect the results of that study. In addition, MMSD was conducting a third-party total maximum daily load study of the Kinnickinnic, Menomonee, and Milwaukee River watersheds at the time that the error was discovered. That study also applied the RWQMPU water quality models. The error was discovered prior to execution of those models under the TMDL study, and appropriate model revisions were made to ensure that the TMDL study results were correct.*

[7]*The regional water quality management plan update for the greater Milwaukee watersheds (PR No. 50, RWQMPU) was published prior to revisions to Wisconsin’s water quality standards for total phosphorus becoming effective on December 1, 2010. In the absence of a State water quality criterion for total phosphorus at the time of publication, a planning standard of 0.1 mg/l was adopted for the RWQMPU. For consistency with the RWQMPU approach, this amendment document also applies a total phosphorus planning standard of 0.1 mg/l to all streams and rivers evaluated. The revisions to the State phosphorus water quality standards are reflected in Chapters NR 102, “Water Quality Standards for Wisconsin Surface Waters,” and NR 217 “Effluent Standards and Limitations for Phosphorus,” of the* Wisconsin Administrative Code. *Section NR 102.06(3)(a) establishes a total phosphorus water quality criterion of 0.100 mg/l for designated rivers, Section NR 102.06(3)(b) calls for most other “surface waters generally exhibiting unidirectional flow” to meet a total phosphorus criterion of 0.075 mg/l, and Section NR 102.06(5)(b) calls for the nearshore waters of Lake Michigan to meet a total phosphorus criterion of 0.007 mg/l. Within the greater Milwaukee watersheds, the river reaches that are assigned a total phosphorus criterion of 0.100 mg/l are the Kinnickinnic River from its confluence with Wilson Park Creek to the Milwaukee River, the Menomonee River from its confluence with the Little Menomonee River to the Milwaukee River, and the Milwaukee River from its confluence with Cedar Creek downstream through the Milwaukee Harbor estuary and the outer harbor. Thus, in those three river reaches, the planning standard applied under the RWQMPU and herein are equivalent. In other stream reaches evaluated herein, the planning standard of 0.1 mg/l is one-third greater than the current State criterion of 0.075 mg/l.*

[NOTE: The following section is a revised version of the text on pages 480 to 484 in Chapter IX, “Development of Alternative Plans: Description and Evaluation,” of PR No. 50.]

COMPARATIVE EVALUATION OF WATER QUALITY MANAGEMENT ALTERNATIVE PLANS

The preceding section of this chapter describes water quality management plan alternatives for the greater Milwaukee watersheds. This section compares the major features of those alternative plans, including economic considerations and water quality benefits. The following evaluation and comparison serves as the basis for the development of the preliminary recommended water quality management plan.

Pollutant Loading Analysis

Tabular comparisons of the various point and nonpoint source pollutant loadings for the alternative water quality management plans are presented in Appendix B. Also shown for comparative purposes are loads based on existing land use with current wastewater conveyance, storage, and treatment systems in place.

The information presented in Appendix B shows that the expected pollutant loadings under Alternative A, the future year 2020 baseline condition, are generally similar to existing conditions. The largest loading differences are in fecal coliform bacteria, which are anticipated to drop by about 21 percent relative to existing conditions, and total suspended solids, which are anticipated to increase by about 10 percent relative to existing conditions. The other indicator pollutants listed show modest differences of ±3 percent relative to existing conditions. Although there is more development under the future condition, and thus more potential for pollutant loads, this is offset by construction of the additional committed MMSD and community facilities and implementation of the Chapter NR 151 nonpoint source pollution control rules, all of which are assumed under the future condition.

Among the remaining water quality management plan alternatives, Alternatives B1 and B2 provide similar results to one another. The major difference is in the allocation of fecal coliform point source loadings between SSOs and CSOs. Alternative B2, which calls for a change in operating procedure for the ISS, shows a lower loading from CSOs than Alternative B1, but a higher loading from SSOs. Overall, the total combined CSO and SSO fecal coliform bacteria load is higher under Alternative B2 than for Alternative B1. For the other pollutants listed, the difference between these two alternatives is negligible.

In terms of overall pollutant load reduction, Alternative C1 provides results that are similar to Alternatives B1 and B2. Alternative C2, which includes the highest level of nonpoint source controls, provides the highest overall level of pollutant load reduction among the alternative plans. For all of the alternative plans, the highest percent reductions occur for total suspended solids and fecal coliform bacteria, while the lowest percent reductions occur for total nitrogen and copper.

Water Quality Conditions and Ability to Meet Water Use Objectives

The water quality benefits of the alternative plans were evaluated by comparing the effects of the plan alternatives, as predicted using the mathematical simulation modeling techniques described in Chapter V of this report, upon a number of water quality indicators. Tabular comparisons of water quality conditions among alternative plans are presented in Appendix J (revised). In general, the anticipated differences in water quality conditions among alternatives are small.

Methodology for Comparing Alternative Plans

The effects of the alternative plans on water quality indicators were compared at 64 water quality assessment points. The locations of these assessment points are shown on Maps 57 through 62. Many of the assessment points also correspond with the location of MMSD water quality sampling sites. A cross-reference between the assessment point designations shown on the maps and the MMSD sampling site designations is provided in Table 75. A series of comparisons were made at each site using 20 indicators related to concentrations of the following six water quality parameters: fecal coliform bacteria, dissolved oxygen, total phosphorus, total nitrogen, total suspended solids, and copper. These indicators are listed in Table 77. A variety of indicators were compared for these parameters. For all six parameters, comparisons were made among the arithmetic mean concentrations predicted for each alternative plan. Similarly, comparisons were made among the median concentrations predicted for each alternative plan for all parameters except fecal coliform bacteria, where the geometric mean

Table 77

WATER QUALITY INDICATORS USED TO COMPARE ALTERNATIVE PLANS

Parameter	Indicator
Fecal Coliform Bacteria over Entire Year	Arithmetic mean concentration of fecal coliform bacteria
	Proportion of time fecal coliform bacteria concentration is equal to or below single sample standard
	Geometric mean concentration of fecal coliform bacteria
	Days per year geometric mean of fecal coliform bacteria is equal to or below geometric mean standard
Fecal Coliform Bacteria from May to September	Arithmetic mean concentration of fecal coliform bacteria
	Proportion of time fecal coliform bacteria concentration is equal to or below single sample standard
	Geometric mean concentration of fecal coliform bacteria
	Days per year geometric mean of fecal coliform bacteria is equal to or below geometric mean standard
Dissolved Oxygen	Mean concentration of dissolved oxygen
	Median concentration of dissolved oxygen
	Proportion of time dissolved oxygen concentration is equal to or above applicable standard
Total Phosphorus	Mean concentration of total phosphorus
	Median concentration of total phosphorus
	Proportion of time total phosphorus concentration is equal to or below the recommended planning standard
Total Nitrogen	Mean concentration of total nitrogen
	Median concentration of total nitrogen
Total Suspended Solids	Mean concentration of total suspended solids
	Median concentration of total suspended solids
Copper	Mean concentration of copper
	Median concentration of copper

Source: SEWRPC.

concentrations were applied. For those water quality parameters for which there are regulatory or planning water quality criteria and standards (see Chapter VII of this report), comparisons were also made of the proportion of time that the parameter would be in compliance with the criteria and standards.[14] Where special use or variance waters were identified, the applicable standards were used. All comparisons involving fecal coliform bacteria were performed both on a full-year basis and for the May to September period when the potential for body contact would be greater.

For each indicator at each assessment point, the four alternative plans other than the future baseline condition (Alternative A) were compared to one another. Alternative A was not included in the comparison since it served as the basis of the remaining four alternatives, and, thus, should always reflect the worst water quality conditions

[14]*The proportion of time in compliance estimates are based on the results of the water quality model simulation that utilized a 10-year simulation period.*

among all of the alternative plans. The comparison among the remaining four alternatives was made by computing the relative deviation of the value of the indicator associated with that alternative plan from the mean value of the indicator for all four alternatives. This was computed by subtracting the mean value of the indicator for all alternatives at a given site from the value of the indicator for the alternative and dividing the result by the mean value that was subtracted. The sign of the relative deviation was adjusted for some indicators so that a positive relative deviation indicated better water quality and a negative relative deviation indicated poorer water quality.[15] For each water quality parameter, the relative deviations from all indicators were totaled. Subtotals were also computed for each watershed. An overall score was computed by totaling the scores from each water quality parameter. Prior to totaling, the scores were adjusted to give each water quality parameter equal weight in the overall total.[16]

It is worth commenting on two properties of this method. First, this method compares the effects of alternative plans relative to one another. A higher value in the final total for an alternative plan indicates better water quality relative to the other alternative plans. Similarly, a lower value in the final total for an alternative plan indicates poorer water quality relative to the other alternatives. It is important to note that because only the alternative plans were included in this analysis, a negative value in the final total does not indicate poorer water quality than existing or future baseline conditions. Second, because greater differences among alternative plans in the values of indicators result in larger relative deviations, greater differences in the final totals for alternative plans indicate greater differences in overall effects on water quality conditions. Conversely, similar final totals for two alternatives indicate that their overall effects on water quality conditions are not very different.

Comparison of Alternative Plans

Watershed totals and overall totals for relative deviations of water quality indicators from mean values are shown in Table 78. This analysis indicates that the greatest overall water quality benefit is provided by Alternative C2. This alternative is followed, in decreasing order of the benefit provided, by Alternative C1, Alternative B2, and Alternative B1. In most watersheds, the relative effects of the alternative plans follow this overall pattern.

There are four important exceptions to this generalization. First, the differences in total relative deviations between Alternative B1 and Alternative B2 in the Menomonee River, Milwaukee River, and Oak Creek watersheds are small, suggesting that there is little difference between the overall water quality resulting from these two alternatives in these watersheds. Second, there is no difference in the total relative deviations between Alternative C1 and C2 in the Kinnickinnic River watershed, suggesting that there is little difference in overall water quality resulting from these two alternatives in this watershed. Third, in the Kinnickinnic River watershed,

[15]*Because the methodology for assessing relative water quality conditions among alternatives was based on combining relative deviations computed for given indicators that are characteristic of given pollutants, it was necessary that the sign of the relative deviation relate to differences in water quality in a consistent manner. In cases where a lower concentration indicated better water quality, the sign of the relative deviation of a better than average alternative would be computed to be negative. In contrast, in cases where a higher concentration indicated better water quality the sign of the relative deviation of a better than average alternative would be computed to be positive. Therefore, to facilitate combining relative deviations in a manner that would properly represent relative water quality conditions, the sign of the relative deviation was reversed for those indicators for which a lower concentration indicated better water quality. This enabled the relative deviations from different indicators to be combined into a single index for which a larger positive value indicated better relative water quality.*

[16]*This unweighting was necessary because different numbers of indicators were used to characterize different water quality parameters. For example, eight indicators were used to characterize fecal coliform bacteria. By contrast, total phosphorus was characterized by three indicators, Thus, to ensure that each water quality parameter had equal influence when the relative deviations were totaled, the sum of the relative deviations for the eight fecal coliform indicators was divided by eight and the sum of the relative deviations for total phosphorus was divided by three.*

Table 78 (revised)

SUMMED RELATIVE DEVIATIONS OF WATER QUALITY INDICATORS FROM THE AVERAGE VALUE FOR ALTERNATIVE PLANS B1, B2, C1, AND C2

Plan Alternative	Watershed						Total
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan[a]	
B1	-0.367	-0.666	-0.131	-0.738	-0.721	-1.377	-4.001
B2	-0.400	-0.664	-0.131	-0.738	-1.156	-0.027	-3.116
C1	0.384	0.418	-0.597	0.727	-0.173	0.437	1.195
C2	0.384	0.913	0.859	0.750	2.050	0.967	5.922

[a]Lake Michigan assessment points include sites in the Milwaukee Harbor estuary, outer harbor, and nearshore Lake Michigan areas.

Source: SEWRPC.

Alternative B1 provides slightly greater water quality benefits than Alternative B2. This difference from the overall result is driven by lower arithmetic and geometric mean concentrations of fecal coliform bacteria and slightly lower mean concentrations of total nitrogen and mean and median concentrations of total phosphorus for Alternative B1 at some assessment points along the mainstem of the Kinnickinnic River. Fourth, in the Milwaukee River watershed, Alternatives B1 and B2 provide greater water quality benefit than Alternative C1. These differences from the overall result are driven by Alternatives B1 and B2 resulting in lower mean concentrations of total phosphorus and total nitrogen and higher percent of compliance with the standard for total phosphorus than Alternative C1 at some assessment points.

The compliance with applicable regulatory or planning water quality standards and criteria for fecal coliform bacteria, dissolved oxygen, and total phosphorus expected under the four alternative plans are summarized in Appendix K (revised). In general, only small differences in compliance with water quality standards were noted among the alternative plans.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that violations of the applicable regulatory standards for fecal coliform bacteria may be expected to occur in the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers and Oak Creek under each alternative plan. The frequency of these violations is expected to range from occasional to frequent, with chronic violations expected to occur at a few assessment points in upstream areas of the Milwaukee River. By contrast, substantial achievement of applicable standards for fecal coliform bacteria is expected under each alternative plan at most assessment points in the estuary, outer harbor, and nearshore Lake Michigan areas.[17] At most assessment points, the expected level of compliance with applicable standards for fecal coliform bacteria is slightly higher during the May to September swimming season than during the entire year. While differences in the expected levels of compliance among alternative plans are small, Alternative C2 provides the highest level of compliance with water quality standards for fecal coliform bacteria followed by Alternative C1, Alternative B2, and Alternative B1.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that each alternative would allow for substantial achievement of the applicable regulatory dissolved oxygen standards in the Kinnickinnic River, Menomonee River, Milwaukee River, Root River, estuary, outer harbor, and nearshore Lake Michigan areas. The analyses also indicate that each alternative would allow for substantial achievement of the dissolved oxygen standard for fish and aquatic life in the downstream reaches of Oak Creek. Violations of the dissolved oxygen standard for fish and aquatic life would be expected to occur occasionally to frequently in the upstream reaches of Oak Creek. The analyses indicated that there are few

[17]*In the outer harbor and nearshore Lake Michigan area, the full recreational use fecal coliform standards of a geometric mean concentration of 200 counts per 100 ml and a maximum single sample concentration of 400 counts per 100 ml were used to evaluate compliance.*

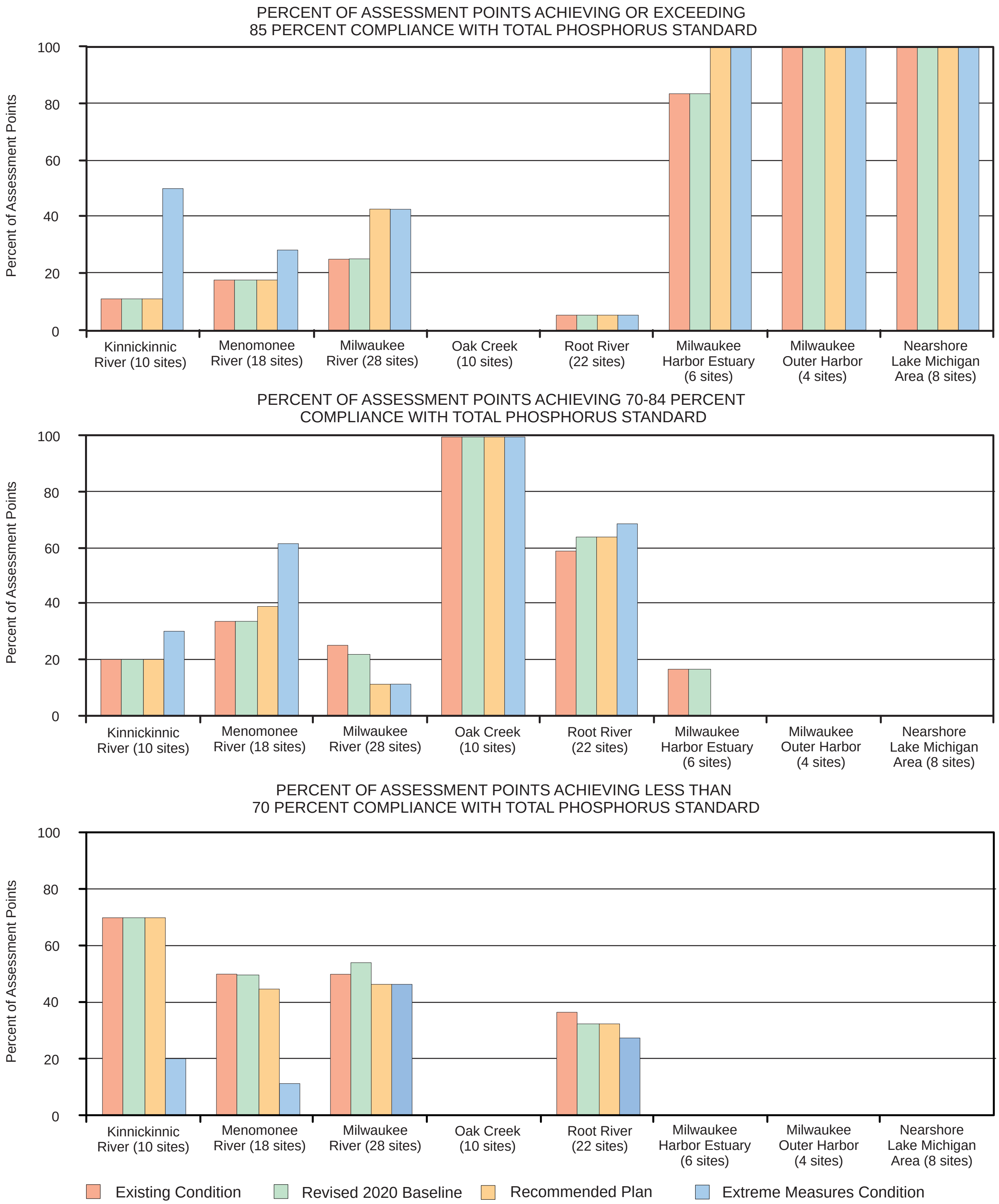
differences among alternatives in the expected level of compliance with applicable dissolved oxygen standards. At assessment points where differences are expected, these differences are small.

Quantitative analyses of the water quality conditions expected to be achieved under the four alternative plans indicated that violations of the recommended planning standard for total phosphorus may be expected to occur in the Kinnickinnic, Menomonee, Milwaukee, and Root Rivers; Oak Creek; and the estuary under each alternative plan. The frequency of these violations is expected to range from occasional to frequent, with total phosphorus exceeding the recommended concentration the majority of the time at all assessment points in the Kinnickinnic River watershed and most in the Milwaukee River watershed, but generally not exceeding the planning standard the majority of the time in the other watersheds. While differences in the expected levels of compliance among alternative plans are small, Alternative C1 provides the highest level of compliance with the recommended planning water quality standard for total phosphorus, followed by Alternative C2, and then by Alternatives B2, and B1, which would generally be expected to achieve the same level of compliance.

[NOTE: Figures 67 and 68 and the following text are revised versions of information set forth in Chapter X, “Recommended Water Quality Management Plan,” of PR No. 50 in the section titled “Ability of the Recommended Water Quality Management Plan to Meet Adopted Objectives and Standards.” The following figures and text revise information set forth on pages 615 to 622.]

Figure 67 (revised)

ACHIEVEMENT OF THE RECOMMENDED TOTAL PHOSPHORUS PLANNING STANDARD

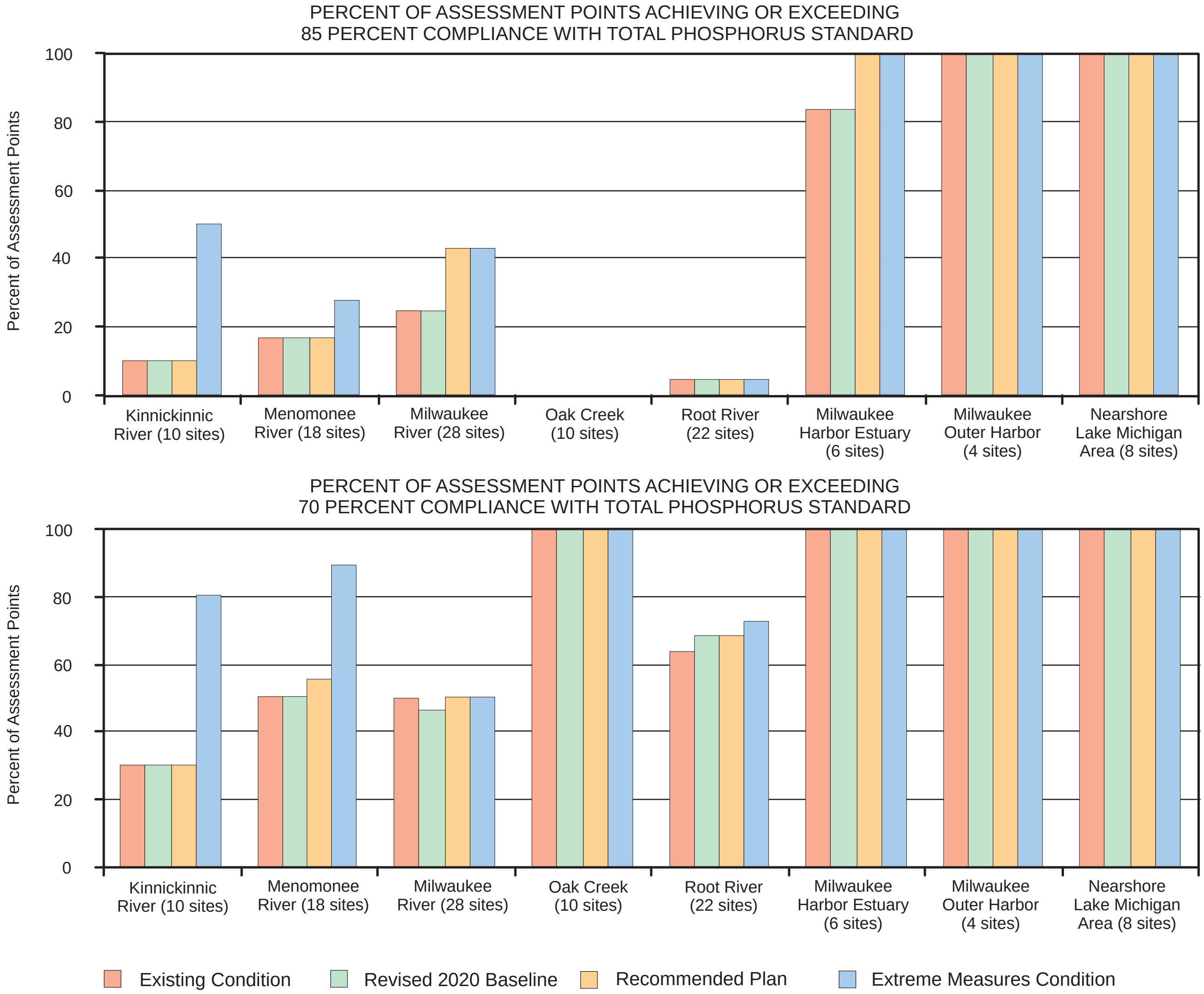


NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N (revised) of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Figure 68 (revised)

ACHIEVEMENT OF THE RECOMMENDED TOTAL PHOSPHORUS PLANNING STANDARD



NOTE: The numerical water quality standards that were applied to assess compliance are set forth in Tables N-1 through N-6 of Appendix N (revised) of this report.

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

- **Wetland/Prairie Restoration:** Increase conversion of cropland and pasture to prairie from the recommended 5 percent to 10 percent and increase conversion of cropland and pasture to wetland from the recommended 5 percent to 10 percent.

- **Septic System Management:** Increase reduction in fecal coliform bacteria from systems installed prior to 1980 from 10 percent under the recommended plan to 50 percent.

- **Fertilizer Management:** A 10 percent reduction in the phosphorus load from lawns was assumed under the recommended plan. The extreme measures condition applies targeted reductions of 50 percent from lawns in the Kinnickinnic, Menomonee, and Milwaukee River watersheds and 15 percent in the Oak Creek and Root River watersheds.

- **Phosphorus in Industrial Noncontact Cooling Water:** Assume that there is no significant phosphorus load to streams from noncontact cooling water discharges.

Evaluation of Water Quality Modeling Analysis Results Relative to the Adopted Water Use Objectives and Water Quality Standards/Criteria

Water quality summary statistics for 106 water quality assessment points distributed along streams throughout the 1,127-square mile study area and in the nearshore area of Lake Michigan are set forth by watershed in Tables N-1 through N-6. Mean and median concentrations are set forth for the 10-year simulation period. For pollutants that have regulatory or planning standards, the percent of time is indicated that a given stream or Lake assessment point is in compliance with the applicable standard. Geometric means are presented for fecal coliform bacteria for comparison with regulatory standards.

The following general conclusions can be drawn from review of the data presented in Tables N-1 through N-6:

- **Fecal Coliform Bacteria**
  - Marked reductions in concentration may be achieved under recommended plan conditions.
  - Improvements in compliance with the applicable standards are not as pronounced because of the existing high concentrations.
- **Dissolved Oxygen**
  - Compliance with the applicable standards is generally good under existing conditions.
  - Little change is projected to occur under the other conditions analyzed.
- **Total Phosphorus**
  - The most significant reductions in concentration generally occur under revised 2020 baseline conditions relative to existing conditions, except in stream reaches where discharges of noncontact cooling water are significant. In reaches where there are substantive noncontact cooling water discharges, the most significant total phosphorus reductions occur under the "extreme measures" condition.
  - The reductions under revised 2020 baseline conditions relative to existing conditions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and construction of MMSD committed projects.
  - Increases in concentrations are projected to occur at some locations in the upper Menomonee River watershed and the Milwaukee River watershed under revised 2020 baseline conditions. Relatively small increases in concentrations could occur at three locations in the Outer Harbor and two in the nearshore Lake Michigan area.
  - The recommended plan is projected to produce marked reductions in concentrations relative to revised 2020 baseline conditions in the Lake Michigan inner and outer harbor areas.
  - Under the extreme measures condition marked reductions in concentrations relative to recommended plan conditions could occur in the Lake Michigan inner and outer harbor areas and at some locations in the Kinnickinnic and Menomonee River watersheds, particularly in reaches with significant noncontact cooling water discharges.
- **Total Nitrogen**
  - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds and the upper portion of the Root River watershed where urban land use predominates, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
  - In the Milwaukee River watershed, the most significant reductions in concentrations occur under recommended plan conditions relative to the revised 2020 baseline conditions.
  - In the Root River Canal subwatershed and the lower Root River watershed downstream of the confluence with the Root River Canal, significant reductions in concentrations occur under both revised 2020 baseline conditions relative to existing conditions and recommended plan conditions relative to the revised 2020 baseline conditions.

- In the Lake Michigan inner and outer harbor, significant reductions in concentrations occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.
- In the nearshore Lake Michigan area little change in concentrations would be expected among the five conditions considered.

- **Total Suspended Solids**
  - In the Kinnickinnic River, Menomonee River, and Oak Creek watersheds, the most significant reductions in concentrations occur under revised 2020 baseline conditions relative to existing conditions.
  - These reductions may be attributable to the effects of implementation of NR 151 stormwater runoff controls and completion of MMSD committed projects.
  - In the Milwaukee River watershed, the greatest reductions in concentrations occur under recommended plan conditions relative to revised 2020 baseline conditions.
  - In the urban areas of the Root River watershed in Milwaukee County, significant reductions in concentrations are anticipated under revised 2020 baseline conditions relative to existing conditions.
  - In the remainder of the Root River watershed and in the Lake Michigan inner and outer harbor areas, reductions in concentrations would be anticipated to occur both under revised 2020 baseline conditions relative to existing conditions and under recommended plan conditions relative to revised 2020 baseline conditions.

- **Copper**
  - In the Kinnickinnic River, Menomonee River, Oak Creek, and Root River watersheds and in the Lake Michigan inner and outer harbor areas, the most significant reductions in concentrations generally occur under the revised 2020 baseline conditions relative to existing conditions.
  - In most locations in the Milwaukee River watershed and the nearshore Lake Michigan area no significant changes in concentrations would be expected among the five conditions considered.

Compliance with Adopted Water Quality Standards

For purposes of assessing compliance with water quality standards under this regional water quality management plan update, it was assumed that a stream reach would meet the water quality standard and attain its designated use objective if the modeled water quality results indicate compliance with the standard at least 85 percent of the time.

The data on compliance with standards as set forth in Tables N-1 through N-6 are summarized in Figures 57 through 68. For a given pollutant and standard, a pair of figures indicate the degree of compliance with applicable standards among the existing, revised 2020 baseline, recommended plan, and extreme measures conditions for each watershed in the study area, the Milwaukee harbor estuary, the outer harbor, and the nearshore Lake Michigan area. The first figure in each pair presents a set of three graphical comparisons. These comparisons consist of:

- The percentage of assessment points achieving or exceeding 85 percent compliance with the standard over the 10-year water quality simulation period,
- The percentage of assessment points achieving or exceeding 70 to 84 percent compliance with the standard over the 10-year simulation period, and
- The percentage of assessment points achieving less than 70 percent compliance with the standard over the 10-year simulation period.

Thus, for the four conditions represented, these graphs facilitate determination of the degree to which 1) a water quality standard is complied with in a given watershed (defined as compliance 85 percent of the time or greater), 2) a standard is close to being complied with (compliance 70 to 84 percent of the time), and 3) a standard is unlikely to be complied with (compliance less than 70 percent of the time). The second figure in each pair presents a pair of graphical comparisons of cumulative levels of compliance for each of the conditions indicated above. The two graphical comparisons consist of:

- The percentage of assessment points achieving or exceeding 85 percent compliance with the standard over the 10-year water quality simulation period.

- The percentage of assessment points achieving or exceeding 70 percent compliance with the standard over the 10-year water quality simulation period.

The assessments in Figures 57 through 68 are evaluated below.

- **Figures 57 and 58: Achievement of the Single Sample Fecal Coliform Bacteria Standard Assessed on an Annual Basis**
  Compliance with this standard 85 percent of the time would not be expected under existing, revised 2020 baseline, or recommended plan conditions at the assessment points in the Kinnickinnic River, Menomonee River, Oak Creek, or Root River watersheds. In the Kinnickinnic River watershed, 30 percent or less of the assessment points would be expected to achieve compliance 85 percent of the time under the extreme measures condition. In the Menomonee River, Oak Creek and Root River watersheds, none of the assessment points would be expected to achieve 85 percent compliance even under the extreme measures condition. In the Milwaukee River watershed less than 10 percent of the assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

  In the Milwaukee outer harbor and nearshore Lake Michigan area, compliance with standards was evaluated through comparison of modeled water quality results with the standards for the fish and aquatic life water use objective with full recreational use. In the Harbor estuary, compliance with the standard would be expected 85 percent of the time or more at more than 80 percent of the assessment points under the revised 2020 baseline, recommended plan, and extreme measures conditions. In the Outer harbor and nearshore Lake Michigan area 85 percent compliance with the standard would be expected at all locations.

  Substantial proportions of the total numbers of assessment points in the Kinnickinnic and Menomonee River watersheds, and to a lesser degree the Root River watershed, would be expected to achieve compliance in the 70 to 84 percent range. Large proportions of the total numbers of assessment points in the Milwaukee River, Oak Creek, and Root River watersheds, would be expected to achieve compliance less than 70 percent of the time.

  Overall, in all riverine reaches, a low degree of compliance with this standard would be expected under all conditions considered. However, a high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area.

- **Figures 59 and 60: Achievement of the Geometric Mean Fecal Coliform Bacteria Standard Assessed on an Annual Basis**
  Compliance with this standard 85 percent of the time would not be expected at a large number of assessment points in any of the watersheds under the four conditions analyzed, although, somewhat greater compliance would be expected under the extreme measures condition in the Kinnickinnic River watershed. That indicates that, if expenditures on additional point source controls could be foregone as might be possible under the recommended plan, additional resources directed toward control of nonpoint source pollution could achieve measurable improvements in water quality in that watershed.

In the Oak Creek and Root River watersheds, none of the assessment points would be expected to achieve compliance 85 percent of the time under any of the four conditions. With the exceptions of the Kinnickinnic River watershed under the extreme measures conditions only, compliance with this standard would be expected less than 70 percent of the time at a large proportion of the assessment points in all of the watersheds. In the estuary, the majority of assessment points would be expected to achieve 85 percent compliance, or better, under the revised 2020 baseline, recommended plan, and extreme measures conditions. All assessment points in the outer harbor and nearshore Lake Michigan area would be expected to achieve at least 85 percent compliance under all four conditions.

Overall, in all riverine reaches, a low degree of compliance with this standard would be expected under all conditions considered. However, a relatively high degree of compliance would be expected in the estuary and a high degree of compliance would be expected in the outer harbor, and nearshore Lake Michigan area.

- **Figures 61 and 62: Achievement of the Single Sample Fecal Coliform Bacteria Standard Assessed on a May to September Basis**
  In comparison to the previously-evaluated single sample standard assessed on an annual basis, much better compliance with this standard would be expected at assessment points in the Kinnickinnic and Menomonee River watersheds, and somewhat better compliance would be expected in the Milwaukee River watershed where implementation of the recommended plan would be expected to achieve a significant improvement relative to the revised 2020 baseline condition. For all four cases in the Root River watershed, 10 percent or fewer of the assessment points would be expected to achieve compliance 85 percent, or more, of the time. In the Oak Creek watershed, none of the assessment points would be expected to achieve compliance 85 percent of the time under any conditions except the extreme measures case, when about 10 percent of the assessment points would achieve 85 percent compliance. In the estuary, all assessment points would be expected to achieve 85 percent compliance, or better, under the revised 2020 baseline, recommended plan, and extreme measures conditions. In the outer harbor, and nearshore Lake Michigan area, all assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

  Overall, a relatively high degree of compliance with this standard would be expected in the Kinnickinnic and Menomonee River watersheds under the recommended plan and extreme measures conditions. In comparison to the single sample standard assessed on an annual basis that was evaluated above, assessment points in the Milwaukee and Root River watersheds would achieve higher levels of compliance with the standard under the recommended plan and extreme measures conditions, although those levels fall well short of what would be considered substantial compliance. Once again, the Oak Creek watershed would not be expected to achieve compliance 85 percent of the time under any conditions analyzed, except at 10 percent of the sites under the extreme measures condition. A high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area under all conditions considered.

- **Figures 63 and 64: Achievement of the Geometric Mean Fecal Coliform Bacteria Standard Assessed on a May to September Basis**
  In comparison to the previously-evaluated geometric mean standard assessed on an annual basis, much better compliance with this standard would be expected in the Kinnickinnic and Menomonee River watersheds, and somewhat better compliance would be expected in the Milwaukee River watershed. In the Menomonee and Milwaukee River watersheds, implementation of the recommended plan would be expected to result in improved water quality relative to the revised 2020 baseline condition. While not quite as pronounced as for the geometric mean standard assessed on an annual basis, for this condition there are still large percentages of assessment points in the Kinnickinnic River, Menomonee River, Milwaukee River, Root River, and Oak Creek watersheds that would be expected to achieve less than 70 percent compliance with the standard under recommended plan conditions. In the estuary, outer harbor, and nearshore Lake Michigan area, all assessment points would be expected to achieve 85 percent compliance, or better, under all four conditions.

Overall, a relatively high degree of compliance with this standard would be expected at assessment points in the Kinnickinnic River watershed under the extreme measures condition and in the Menomonee River watershed under the recommended plan and extreme measures conditions. In comparison to the geometric mean standard assessed on an annual basis that was evaluated above, assessment points in the Milwaukee and Root River watersheds would be expected to achieve higher levels of compliance with the standard under the recommended plan and extreme measures conditions, although those levels fall well short of what would be considered substantial compliance. No assessment points in the Oak Creek watershed achieve compliance 85 percent of the time except under the extreme measures condition where 30 percent of the points would be expected to achieve compliance. A high degree of compliance would be expected in the estuary, outer harbor, and nearshore Lake Michigan area under all conditions considered.

- **Figures 65 and 66: Achievement of the Dissolved Oxygen Standard**
  In general, 85 percent compliance with this standard, or better, would be expected under existing, revised 2020 baseline, recommended plan, and extreme measures conditions at the assessment points in the Menomonee, Milwaukee, and Root River watersheds, as well as the estuary, outer harbor, and nearshore Lake Michigan area. A somewhat lesser, but relatively high, degree of compliance would be expected in the Kinnickinnic River watershed, and a lower level of compliance would be anticipated in the Oak Creek watershed. However, at the assessment points in the Kinnickinnic River and Oak Creek watersheds, general compliance with the standard would be expected 70 percent or more of the time. Many of the assessment points in the Oak Creek watershed that are in the 70 to 84 percent of time compliance range fall in the higher end of that range.

  Overall, a high degree of compliance with this standard would be expected under all conditions considered. As noted above, compliance within the Oak Creek watershed is somewhat better than indicated by Figure 65, because, although significant percentages of the Oak Creek watershed assessment points fall in the 70 to 84 percent of time compliance range, many of the points fall in the higher end of that range.

- **Figures 67 and 68: Achievement of the Recommended Total Phosphorus Planning Standard**

  Compliance with the planning standard would be expected eighty-five percent of the time or more at:

  - About 10 percent of the assessment points in the Kinnickinnic River watershed for the existing, revised 2020 baseline, and recommended plan conditions, and about 50 percent of the points under the extreme measures condition;

  - Fifteen to 20 percent of the assessment points in the Menomonee River watershed for the existing, revised 2020 baseline, and recommended plan conditions, and about 25 percent of the points under the extreme measures condition;

  - Twenty-five percent of the assessment points in the Milwaukee River for the existing and revised 2020 baseline conditions, and at about 40 percent of the points under the recommended plan and extreme measures conditions;

  - No assessment points in the Oak Creek watershed. (However, the Oak Creek watershed is the only one where all of the assessment points would be expected to meet the planning standard 70 percent, or more, of the time.); and

  - Five percent of the assessment points in the Root River watershed under all four conditions.

  In the estuary, over 80 percent of the assessment points would be expected to achieve compliance with the planning standard 85 percent of the time or more under existing and revised 2020 baseline conditions. All assessment points would be expected to achieve 85 percent compliance, or better, under the recommended plan and extreme measures conditions. All assessment points in the outer harbor and nearshore Lake Michigan area would be expected to achieve at least 85 percent compliance under all four conditions.

Overall, with respect to the 85 percent of time bench mark, a relatively low degree of compliance with this standard would be expected in all of the watersheds under all four conditions. The assessment points in the Oak Creek watershed would be expected to achieve compliance with the planning standard more than 70 percent of the time for all four conditions. About half of the points in the Milwaukee River watershed and 60 to 70 percent of those in the Root River watershed would be expected to comply with the planning standard 70 percent or more of the time under all four conditions. About 30 percent of the assessment points in the Kinnickinnic River watershed would be expected to comply with the planning standard 70 percent or more of the time under the existing, revised 2020 baseline, and recommended plan conditions, and 80 percent of the points would comply 70 percent or more of the time under the extreme measures condition. About 50 to 55 percent of the assessment points in the Menomonee River watershed would be expected to comply with the planning standard 70 percent or more of the time under the existing, revised 2020 baseline, and recommended plan conditions, and about 90 percent of the points would comply 70 percent or more of the time under the extreme measures condition. A high degree of compliance with the planning standard would be expected in the estuary, outer harbor, and nearshore Lake Michigan area.

Comparison of Water Quality Conditions: Revised 2020 Baseline vs. Revised 2020 Baseline with Five-Year Level of Protection Against SSOs from MMSD System

The water quality assessment points in, or downstream from, the MMSD planning area that are indicated on Maps N-1 through N-6 are the only assessment points that could be affected by SSOs from the MMSD system. Outside of those locations, there is no difference in the water quality statistics between the revised 2020 baseline condition and the revised 2020 baseline with a five-year level of protection (LOP) against SSOs from the MMSD system. Comparison of the water quality conditions tabulated in Appendix N (revised) with and without the five-year LOP (at those locations where there could be SSOs from the MMSD system) indicates no significant difference in water quality under the two conditions. That conclusion supports the observation that has been stated previously in this report that further reductions in point sources of pollution would be expected to have no significant effects on water quality.

Appendix J (revised)

COMPARISON OF WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

[NOTE: These page numbers match those in PR No. 50.]

Table J-1

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: KINNICKINNIC RIVER WATERSHED

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
KK-3 Kinnickinnic River Upstream of Confluence with Wilson Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,373	4,533	4,522	4,522	3,960	3,960
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	79	80	80	80	80	80
		Geometric mean (cells per 100 ml)	371	318	318	318	282	282
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	305	317	317	317	322	322
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,747	2,375	2,348	2,348	1,831	1,831
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	89	89	89	89	90	90
		Geometric mean (cells per 100 ml)	260	228	227	227	196	196
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	152	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	9.4	9.4	9.4	9.4	9.4	9.4
		Median (mg/l)	8.8	8.8	8.8	8.8	8.8	8.8
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.222	0.214	0.214	0.214	0.211	0.211
		Median (mg/l)	0.206	0.199	0.199	0.199	0.197	0.197
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	13	14	14	14	14	14
	Total Nitrogen	Mean (mg/l)	1.39	1.30	1.30	1.30	1.29	1.29
		Median (mg/l)	1.36	1.28	1.28	1.28	1.27	1.27
	Total Suspended Solids	Mean (mg/l)	10.6	8.5	8.5	8.5	8.5	8.5
		Median (mg/l)	4.2	3.5	3.5	3.5	3.5	3.5
	Copper	Mean (mg/l)	0.0037	0.0030	0.0030	0.0030	0.0030	0.0030
		Median (mg/l)	0.0010	0.0008	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table J-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
KK-4 Wilson Creek Upstream of Holmes Avenue Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,897	3,244	3,240	3,240	2,812	2,812
		Percent compliance with single sample standard (<400 cells per 100 ml)	52	52	52	52	56	56
		Geometric mean (cells per 100 ml)	609	520	520	520	422	422
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	54	72	72	72	101	101
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,179	1,764	1,755	1,755	1,329	1,329
		Percent compliance with single sample standard (<400 cells per 100 ml)	67	68	68	68	76	76
		Geometric mean (cells per 100 ml)	313	257	257	257	181	181
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	36	47	47	47	69	69
	Dissolved Oxygen	Mean (mg/l)	7.5	7.6	7.6	7.6	7.6	7.6
		Median (mg/l)	7.3	7.3	7.3	7.3	7.3	7.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.222	0.220	0.220	0.220	0.217	0.217
		Median (mg/l)	0.123	0.122	0.122	0.122	0.121	0.121
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	35	33	33	33	34	34
	Total Nitrogen	Mean (mg/l)	1.65	1.57	1.57	1.57	1.56	1.56
		Median (mg/l)	0.99	0.89	0.89	0.89	0.88	0.88
	Total Suspended Solids	Mean (mg/l)	20.1	15.2	15.2	15.2	15.2	15.2
		Median (mg/l)	6.5	5.4	5.4	5.4	5.4	5.4
	Copper	Mean (mg/l)	0.0041	0.0036	0.0036	0.0036	0.0036	0.0036
		Median (mg/l)	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019

Indicates Revision

Table J-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
KK-8 Wilson Park Creek, USGS Gauge	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,124	4,244	4,243	4,243	3,679	3,679
		Percent compliance with single sample standard (<400 cells per 100 ml)	56	57	57	57	60	60
		Geometric mean (cells per 100 ml)	697	598	598	598	497	497
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	35	49	49	49	69	69
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,552	2,119	2,118	2,118	1,571	1,571
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	73	73	73	78	78
		Geometric mean (cells per 100 ml)	357	304	304	304	226	226
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	26	34	34	34	48	48
	Dissolved Oxygen	Mean (mg/l)	10.9	10.9	10.9	10.9	10.9	10.9
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.200	0.194	0.194	0.194	0.191	0.191
		Median (mg/l)	0.142	0.139	0.139	0.139	0.137	0.137
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	33	33	33	33	33	33
	Total Nitrogen	Mean (mg/l)	1.48	1.38	1.38	1.38	1.37	1.37
		Median (mg/l)	1.16	1.06	1.06	1.06	1.05	1.05
	Total Suspended Solids	Mean (mg/l)	14.1	10.9	10.9	10.9	10.9	10.9
		Median (mg/l)	4.8	3.7	3.7	3.7	3.7	3.7
	Copper	Mean (mg/l)	0.0044	0.0038	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0018	0.0016	0.0016	0.0016	0.0016	0.0016

Indicates Revision

Table J-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
KK-9 Kinnickinnic River Downstream of Wilson Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,785	4,899	4,517	4,616	4,362	4,362
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	74	75	75	75	76	76
		Geometric mean (cells per 100 ml)	654	563	558	561	473	473
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	254	265	265	265	274	274
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,360	3,004	2,394	2,579	2,625	2,625
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	87	86	86	86	88	88
		Geometric mean (cells per 100 ml)	343	295	291	294	227	227
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	146	148	148	148	151	151
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.206	0.199	0.197	0.197	0.196	0.196
		Median (mg/l)	0.171	0.164	0.164	0.164	0.161	0.161
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	24	24	24	24	25	25
	Total Nitrogen	Mean (mg/l)	1.40	1.30	1.30	1.30	1.29	1.29
		Median (mg/l)	1.22	1.13	1.13	1.13	1.12	1.12
	Total Suspended Solids	Mean (mg/l)	14.5	11.5	11.4	11.4	11.5	11.5
		Median (mg/l)	4.8	3.8	3.8	3.8	3.8	3.8
	Copper	Mean (mg/l)	0.0047	0.0041	0.0041	0.0041	0.0041	0.0041
		Median (mg/l)	0.0019	0.0018	0.0018	0.0018	0.0018	0.0018

Indicates Revision

Table J-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
KK-10 Kinnickinnic River near Upstream Limit of Estuary	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,859	4,909	4,541	4,625	4,293	4,293
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	74	75	75	75	76	76
		Geometric mean (cells per 100 ml)	842	703	684	689	590	590
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	229	250	256	254	262	262
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,401	3,000	2,406	2,564	2,444	2,444
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	86	86	86	86	88	88
		Geometric mean (cells per 100 ml)	498	415	395	401	317	317
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	131	140	145	144	146	146
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>2 mg/l)[a]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.196	0.189	0.187	0.188	0.186	0.186
		Median (mg/l)	0.165	0.158	0.157	0.158	0.155	0.155
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	27	27	27	27	28	28
	Total Nitrogen	Mean (mg/l)	1.36	1.27	1.27	1.27	1.26	1.26
		Median (mg/l)	1.22	1.12	1.12	1.12	1.12	1.12
	Total Suspended Solids	Mean (mg/l)	13.2	10.5	10.4	10.4	10.5	10.5
		Median (mg/l)	4.7	3.8	3.8	3.8	3.8	3.8
	Copper	Mean (mg/l)	0.0048	0.0041	0.0041	0.0041	0.0041	0.0041
		Median (mg/l)	0.0019	0.0017	0.0017	0.0017	0.0017	0.0017

Indicates Revision

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

[b]*Variance Standard in Chapter NR 104 of the* Wisconsin Administrative Code.

Source: Tetra Tech, Inc., and SEWRPC.

Table J-2

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: MENOMONEE RIVER WATERSHED

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
MN-2 Upper Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	797	983	975	975	824	834
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	71	72	72	73	73
		Geometric mean (cells per 100 ml)	124	150	131	131	114	117
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	262	240	249	249	262	260
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	602	698	692	692	588	598
		Percent compliance with single sample standard (<400 cells per 100 ml)	86	83	83	83	83	83
		Geometric mean (cells per 100 ml)	79	92	77	77	68	69
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	144	137	140	140	143	143
	Dissolved Oxygen	Mean (mg/l)	9.3	9.4	9.4	9.4	9.4	9.4
		Median (mg/l)	9.1	9.2	9.2	9.2	9.2	9.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	96	100
	Total Phosphorus	Mean (mg/l)	0.143	0.146	0.145	0.145	0.143	0.145
		Median (mg/l)	0.111	0.112	0.112	0.112	0.110	0.112
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	46	45	46	46	46	46
	Total Nitrogen	Mean (mg/l)	1.47	1.36	1.35	1.35	1.34	1.24
		Median (mg/l)	1.35	1.26	1.26	1.26	1.25	1.17
	Total Suspended Solids	Mean (mg/l)	7.9	7.9	7.8	7.8	7.5	7.4
		Median (mg/l)	5.7	5.7	5.6	5.6	5.5	5.4
	Copper	Mean (mg/l)	0.0024	0.0026	0.0026	0.0026	0.0024	0.0023
		Median (mg/l)	0.0012	0.0011	0.0011	0.0011	0.0011	0.0010

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
MN-5 Menomonee River at Washington-Waukesha County Line	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,417	1,605	1,601	1,601	1,354	1,361
		Percent compliance with single sample standard (<400 cells per 100 ml)	68	65	65	65	66	66
		Geometric mean (cells per 100 ml)	205	234	220	220	187	190
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	202	184	190	190	210	209
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	890	982	979	979	831	837
		Percent compliance with single sample standard (<400 cells per 100 ml)	82	79	79	79	80	80
		Geometric mean (cells per 100 ml)	105	118	109	109	93	94
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	125	114	118	118	129	129
	Dissolved Oxygen	Mean (mg/l)	10.5	10.5	10.5	10.5	10.5	10.5
		Median (mg/l)	10.7	10.7	10.7	10.7	10.7	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.097	0.105	0.105	0.105	0.100	0.101
		Median (mg/l)	0.063	0.066	0.066	0.066	0.064	0.065
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	70	68	68	68	69	69
	Total Nitrogen	Mean (mg/l)	1.23	1.09	1.09	1.09	1.06	1.00
		Median (mg/l)	1.11	0.99	0.99	0.99	0.96	0.91
	Total Suspended Solids	Mean (mg/l)	10.2	10.2	10.1	10.1	9.4	9.4
		Median (mg/l)	6.0	5.8	5.8	5.8	5.5	5.5
	Copper	Mean (mg/l)	0.0041	0.0047	0.0047	0.0047	0.0043	0.0043
		Median (mg/l)	0.0016	0.0017	0.0017	0.0017	0.0016	0.0015

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
MN-9 Menomonee River Downstream of Butler Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,828	2,728	2,726	2,726	2,387	2,374
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	56	56	56	57	57
		Geometric mean (cells per 100 ml)	489	489	482	482	420	421
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	72	78	81	81	105	104
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,571	1,438	1,437	1,437	1,265	1,232
		Percent compliance with single sample standard (<400 cells per 100 ml)	76	74	74	74	75	75
		Geometric mean (cells per 100 ml)	229	216	212	212	186	186
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	51	57	59	59	77	77
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	11.0	11.0	11.0	11.0	11.0	11.0
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.101	0.102	0.102	0.102	0.097	0.098
		Median (mg/l)	0.061	0.065	0.065	0.065	0.063	0.064
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	69	66	66	66	68	68
	Total Nitrogen	Mean (mg/l)	1.10	0.94	0.93	0.93	0.91	0.88
		Median (mg/l)	1.01	0.87	0.87	0.87	0.85	0.82
	Total Suspended Solids	Mean (mg/l)	15.7	13.3	13.3	13.3	12.8	12.8
		Median (mg/l)	6.0	5.2	5.2	5.2	5.0	4.9
	Copper	Mean (mg/l)	0.0052	0.0052	0.0052	0.0052	0.0050	0.0050
		Median (mg/l)	0.0019	0.0020	0.0020	0.0020	0.0018	0.0018

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
MN-11 Little Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,777	6,389	6,390	6,390	5,750	5,777
		Percent compliance with single sample standard (<400 cells per 100 ml)	53	53	53	53	54	54
		Geometric mean (cells per 100 ml)	700	589	559	559	509	512
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	68	84	88	88	97	96
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,477	3,591	3,589	3,589	3,232	3,254
		Percent compliance with single sample standard (<400 cells per 100 ml)	70	70	70	70	71	71
		Geometric mean (cells per 100 ml)	261	213	197	197	180	181
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	48	60	63	63	69	69
	Dissolved Oxygen	Mean (mg/l)	10.4	10.4	10.4	10.4	10.4	10.3
		Median (mg/l)	10.5	10.5	10.5	10.5	10.5	10.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.111	0.105	0.105	0.105	0.102	0.103
		Median (mg/l)	0.072	0.070	0.070	0.070	0.069	0.070
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	68	69	69	69	70	69
	Total Nitrogen	Mean (mg/l)	1.24	1.01	1.01	1.01	1.00	0.97
		Median (mg/l)	1.15	0.93	0.93	0.93	0.92	0.90
	Total Suspended Solids	Mean (mg/l)	13.2	9.8	9.7	9.7	9.8	9.7
		Median (mg/l)	4.6	3.4	3.4	3.4	3.4	3.4
	Copper	Mean (mg/l)	0.0050	0.0042	0.0042	0.0042	0.0042	0.0042
		Median (mg/l)	0.0017	0.0015	0.0015	0.0015	0.0015	0.0014

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
MN-12 Menomonee River Downstream of Little Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,366	3,913	3,912	3,913	3,476	3,481
		Percent compliance with single sample standard (<400 cells per 100 ml)	50	49	49	49	50	50
		Geometric mean (cells per 100 ml)	795	746	737	737	651	654
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	31	38	39	39	49	49
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,175	1,895	1,894	1,896	1,689	1,682
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	68	68	68	69	69
		Geometric mean (cells per 100 ml)	348	314	309	309	274	275
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	21	26	27	27	34	34
	Dissolved Oxygen	Mean (mg/l)	10.7	10.7	10.7	10.7	10.7	10.7
		Median (mg/l)	10.9	10.9	10.9	10.9	10.9	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.100	0.100	0.100	0.100	0.095	0.096
		Median (mg/l)	0.061	0.064	0.064	0.064	0.062	0.063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	69	68	68	68	69	69
	Total Nitrogen	Mean (mg/l)	1.09	0.91	0.91	0.91	0.89	0.87
		Median (mg/l)	1.02	0.87	0.87	0.87	0.85	0.82
	Total Suspended Solids	Mean (mg/l)	13.4	11.2	11.1	11.1	10.8	10.8
		Median (mg/l)	5.2	4.4	4.3	4.3	4.2	4.2
	Copper	Mean (mg/l)	0.0054	0.0052	0.0052	0.0052	0.0050	0.0050
		Median (mg/l)	0.0021	0.0021	0.0021	0.0021	0.0021	0.0020

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
MN-14 Underwood Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	8,133	6,589	6,589	6,589	5,823	5,793
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	71	71	71	71	72	72
		Geometric mean (cells per 100 ml)	691	552	552	552	493	494
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	247	261	261	261	267	267
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,964	2,459	2,459	2,459	1,956	1,956
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	86	86	86	86	87	87
		Geometric mean (cells per 100 ml)	351	278	278	278	246	246
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	147	151	151	151	152	152
	Dissolved Oxygen	Mean (mg/l)	11.0	11.1	11.1	11.1	11.1	11.1
		Median (mg/l)	11.1	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.096	0.084	0.084	0.084	0.080	0.080
		Median (mg/l)	0.061	0.055	0.055	0.055	0.054	0.054
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	77	80	80	80	81	81
	Total Nitrogen	Mean (mg/l)	1.17	1.00	1.00	1.00	0.99	0.99
		Median (mg/l)	1.11	0.95	0.95	0.95	0.94	0.94
	Total Suspended Solids	Mean (mg/l)	16.8	12.4	12.4	12.4	12.4	12.4
		Median (mg/l)	7.9	5.7	5.7	5.7	5.7	5.7
	Copper	Mean (mg/l)	0.0048	0.0037	0.0037	0.0037	0.0037	0.0037
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
MN-16 Honey Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9,286	7,750	7,750	7,750	6,730	6,609
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	72	73	73	73	74	74
		Geometric mean (cells per 100 ml)	612	511	511	511	449	446
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	259	270	270	270	277	278
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,073	3,404	3,404	3,404	2,478	2,478
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	86	86	86	86	88	88
		Geometric mean (cells per 100 ml)	325	272	272	272	230	230
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	148	152	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0	11.0
		Median (mg/l)	10.7	10.6	10.6	10.6	10.6	10.6
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	97	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.118	0.110	0.110	0.110	0.107	0.107
		Median (mg/l)	0.084	0.080	0.080	0.080	0.079	0.079
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	64	67	67	67	68	68
	Total Nitrogen	Mean (mg/l)	1.28	1.17	1.17	1.17	1.16	1.16
		Median (mg/l)	1.22	1.12	1.12	1.12	1.10	1.10
	Total Suspended Solids	Mean (mg/l)	14.4	11.1	11.1	11.1	11.1	11.1
		Median (mg/l)	7.2	5.6	5.6	5.6	5.6	5.6
	Copper	Mean (mg/l)	0.0046	0.0038	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0016	0.0014	0.0014	0.0014	0.0014	0.0014

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
MN-17 Menomonee River Downstream of Honey Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,926	5,878	5,810	5,804	5,109	5,071
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	63	63	63	63	64	64
		Geometric mean (cells per 100 ml)	1,124	1,000	989	989	867	867
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	196	205	206	206	217	217
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,622	3,051	2,920	2,908	2,366	2,367
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	81	81	81	81	82	82
		Geometric mean (cells per 100 ml)	496	423	416	417	358	360
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	130	137	138	138	142	142
	Dissolved Oxygen	Mean (mg/l)	11.1	10.9	10.9	10.9	10.9	10.9
		Median (mg/l)	11.1	11.0	11.0	11.0	11.0	11.0
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.111	0.108	0.107	0.107	0.103	0.104
		Median (mg/l)	0.074	0.077	0.077	0.077	0.075	0.075
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	66	65	65	65	67	66
	Total Nitrogen	Mean (mg/l)	1.14	0.98	0.98	0.98	0.96	0.95
		Median (mg/l)	1.08	0.94	0.94	0.94	0.92	0.91
	Total Suspended Solids	Mean (mg/l)	16.3	13.3	13.3	13.3	13.1	13.0
		Median (mg/l)	6.0	4.9	4.9	4.9	4.8	4.8
	Copper	Mean (mg/l)	0.0057	0.0052	0.0052	0.0052	0.0051	0.0051
		Median (mg/l)	0.0024	0.0024	0.0024	0.0024	0.0023	0.0023

Indicates Revision

Table J-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
MN-18 Menomonee River near Upstream Limit of Estuary	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,889	5,922	5,858	5,849	5,128	5,089
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	64	63	63	63	64	65
		Geometric mean (cells per 100 ml)	1,081	972	961	961	842	841
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	200	207	208	208	218	218
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,557	3,062	2,939	2,924	2,322	2,323
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	81	81	81	81	82	82
		Geometric mean (cells per 100 ml)	468	407	400	401	343	344
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	133	137	138	138	141	141
	Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.9	10.9
		Median (mg/l)	11.0	10.9	10.9	10.9	10.9	10.9
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.133	0.130	0.130	0.130	0.126	0.126
		Median (mg/l)	0.104	0.106	0.105	0.105	0.103	0.104
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	52	50	51	51	52	51
	Total Nitrogen	Mean (mg/l)	1.26	1.11	1.11	1.11	1.09	1.08
		Median (mg/l)	1.20	1.07	1.07	1.07	1.05	1.04
	Total Suspended Solids	Mean (mg/l)	16.0	13.3	13.2	13.3	13.0	13.0
		Median (mg/l)	5.5	4.8	4.8	4.8	4.7	4.7
	Copper	Mean (mg/l)	0.0056	0.0051	0.0051	0.0051	0.0050	0.0050
		Median (mg/l)	0.0023	0.0023	0.0023	0.0023	0.0022	0.0022

Indicates Revision

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

[b]*Variance Standard in Chapter NR 104 of the* Wisconsin Administrative Code.

Source: Tetra Tech, Inc., and SEWRPC.

Table J-3

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: MILWAUKEE RIVER WATERSHED

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-4 West Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,808	3,201	3,201	3,201	2,971	2,883
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	1	1	1	1	2
		Geometric mean (cells per 100 ml)	1,770	1,942	1,942	1,942	1,867	1,697
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	0	0	0
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,003	2,362	2,362	2,362	2,215	2,140
		Percent compliance with single sample standard (<400 cells per 100 ml)	3	3	3	3	3	4
		Geometric mean (cells per 100 ml)	1,302	1,444	1,444	1,444	1,404	1,266
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	0	0	0
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.060	0.058	0.053	0.053	0.055	0.055
		Median (mg/l)	0.024	0.023	0.022	0.022	0.022	0.023
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	82	84	84	83	83
	Total Nitrogen	Mean (mg/l)	2.59	2.57	2.54	2.54	2.56	2.27
		Median (mg/l)	2.53	2.52	2.51	2.51	2.52	2.24
	Total Suspended Solids	Mean (mg/l)	17.70	17.33	15.11	15.11	16.01	15.58
		Median (mg/l)	8.40	8.30	7.95	7.95	8.12	7.91
	Copper	Mean (mg/l)	0.0030	0.0030	0.0030	0.0030	0.0030	0.0031
		Median (mg/l)	0.0020	0.0020	0.0020	0.0020	0.0020	0.002

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
ML-5 Kewaskum, USGS Sampling Location (4086149)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,761	1,875	1,875	1,875	1,738	1,674
		Percent compliance with single sample standard (<400 cells per 100 ml)	11	10	10	10	10	15
		Geometric mean (cells per 100 ml)	1,116	1,182	1,182	1,182	1,128	1,029
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	3	3	3
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,088	1,192	1,192	1,192	1,117	1,067
		Percent compliance with single sample standard (<400 cells per 100 ml)	24	21	21	21	22	29
		Geometric mean (cells per 100 ml)	702	759	759	759	734	658
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	3	3	3
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.068	0.068	0.061	0.061	0.065	0.064
		Median (mg/l)	0.047	0.047	0.044	0.044	0.045	0.046
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	84	84	87	87	86	86
	Total Nitrogen	Mean (mg/l)	2.33	2.31	2.28	2.28	2.30	2.02
		Median (mg/l)	2.29	2.27	2.25	2.25	2.27	2.00
	Total Suspended Solids	Mean (mg/l)	14.10	13.96	12.13	12.13	12.90	12.76
		Median (mg/l)	8.50	8.50	7.76	7.76	8.05	8.03
	Copper	Mean (mg/l)	0.0032	0.0032	0.0032	0.0032	0.0032	0.0033
		Median (mg/l)	0.0027	0.0028	0.0028	0.0028	0.0028	0.0028

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-10 East Branch Milwaukee River, USGS Sampling Location (4086200)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	948	1,025	1,025	1,025	932	934
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	47	47	47	50	52
		Geometric mean (cells per 100 ml)	472	488	488	488	454	435
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	45	43	43	43	47	55
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	667	769	769	769	703	708
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	79	79	79	81	82
		Geometric mean (cells per 100 ml)	268	278	278	278	264	246
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	41	39	39	39	43	50
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.084	0.083	0.076	0.076	0.080	0.080
		Median (mg/l)	0.079	0.078	0.071	0.071	0.075	0.075
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	83	88	88	86	86
	Total Nitrogen	Mean (mg/l)	1.37	1.35	1.30	1.30	1.32	1.17
		Median (mg/l)	1.36	1.35	1.29	1.29	1.32	1.16
	Total Suspended Solids	Mean (mg/l)	3.5	3.4	3.0	3.0	3.2	3.2
		Median (mg/l)	2.2	2.1	1.9	1.9	2.0	2.0
	Copper	Mean (mg/l)	0.0032	0.0032	0.0032	0.0032	0.0032	0.0033
		Median (mg/l)	0.0030	0.0030	0.0030	0.0030	0.0030	0.0031

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
ML-13 Newburg, USGS Sampling Location (4086265)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,822	915	915	915	839	813
		Percent compliance with single sample standard (<400 cells per 100 ml)	40	43	44	44	44	46
		Geometric mean (cells per 100 ml)	659	452	452	452	425	395
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	68	95	95	95	99	108
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	808	383	383	383	351	341
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	76	76	76	77	78
		Geometric mean (cells per 100 ml)	257	184	184	184	176	159
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	62	84	84	84	87	94
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.118	0.129	0.123	0.123	0.126	0.129
		Median (mg/l)	0.103	0.115	0.111	0.111	0.113	0.116
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	51	45	49	49	47	45
	Total Nitrogen	Mean (mg/l)	1.70	1.60	1.57	1.57	1.59	1.39
		Median (mg/l)	1.64	1.55	1.52	1.52	1.54	1.34
	Total Suspended Solids	Mean (mg/l)	9.3	9.1	8.0	8.0	8.4	8.5
		Median (mg/l)	5.2	5.2	4.7	4.7	4.8	4.8
	Copper	Mean (mg/l)	0.0056	0.0061	0.0061	0.0061	0.0061	0.0063
		Median (mg/l)	0.0053	0.0058	0.0058	0.0058	0.0058	0.0060

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
ML-23 North Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,707	2,848	2,847	2,847	2,634	2,567
		Percent compliance with single sample standard (<400 cells per 100 ml)	7	7	7	7	7	10
		Geometric mean (cells per 100 ml)	1,447	1,476	1,476	1,476	1,421	1,296
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	3	3	4
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,718	1,877	1,877	1,877	1,743	1,695
		Percent compliance with single sample standard (<400 cells per 100 ml)	16	16	16	16	16	22
		Geometric mean (cells per 100 ml)	892	914	914	914	886	795
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	3	3	4
	Dissolved Oxygen	Mean (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.206	0.212	0.207	0.207	0.209	0.221
		Median (mg/l)	0.185	0.190	0.187	0.187	0.188	0.201
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	40	39	40	40	39	37
	Total Nitrogen	Mean (mg/l)	1.77	1.76	1.73	1.73	1.75	1.54
		Median (mg/l)	1.73	1.72	1.71	1.71	1.72	1.51
	Total Suspended Solids	Mean (mg/l)	7.9	7.9	7.1	7.1	7.4	7.4
		Median (mg/l)	4.6	4.6	4.5	4.5	4.5	4.5
	Copper	Mean (mg/l)	0.0036	0.0035	0.0035	0.0035	0.0035	0.0036
		Median (mg/l)	0.0027	0.0026	0.0026	0.0026	0.0026	0.0026

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-24 Fredonia, USGS Sampling Location (4086360)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,678	1,394	1,394	1,394	1,302	1,262
		Percent compliance with single sample standard (<400 cells per 100 ml)	32	33	33	33	33	36
		Geometric mean (cells per 100 ml)	777	682	682	682	660	605
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	52	54	54	54	55	62
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	673	637	637	637	590	565
		Percent compliance with single sample standard (<400 cells per 100 ml)	63	64	64	64	65	70
		Geometric mean (cells per 100 ml)	311	289	289	289	278	246
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	49	51	51	51	52	58
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.129	0.136	0.130	0.130	0.132	0.138
		Median (mg/l)	0.112	0.121	0.116	0.116	0.118	0.124
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	49	45	48	48	47	45
	Total Nitrogen	Mean (mg/l)	1.73	1.67	1.64	1.64	1.66	1.45
		Median (mg/l)	1.67	1.62	1.60	1.60	1.61	1.41
	Total Suspended Solids	Mean (mg/l)	11.9	11.7	10.4	10.4	10.9	11.0
		Median (mg/l)	7.5	7.4	6.8	6.8	7.0	7.1
	Copper	Mean (mg/l)	0.0048	0.0051	0.0051	0.0051	0.0051	0.0053
		Median (mg/l)	0.0045	0.0048	0.0048	0.0048	0.0048	0.0050

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
ML-28 Lower Cedar Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,093	460	460	460	421	406
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	61	61	61	63	64
		Geometric mean (cells per 100 ml)	268	144	144	144	136	127
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	149	181	181	181	183	187
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	381	381	138	138	126	121
		Percent compliance with single sample standard (<400 cells per 100 ml)	78	89	89	89	90	91
		Geometric mean (cells per 100 ml)	63	37	37	37	35	32
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	118	129	129	129	131	132
	Dissolved Oxygen	Mean (mg/l)	10.6	10.6	10.6	10.6	10.6	10.5
		Median (mg/l)	10.7	10.6	10.7	10.7	10.7	10.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	95	96	96	96	94
	Total Phosphorus	Mean (mg/l)	0.131	0.141	0.133	0.133	0.137	0.140
		Median (mg/l)	0.119	0.131	0.124	0.124	0.127	0.131
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	42	36	39	39	38	36
	Total Nitrogen	Mean (mg/l)	1.53	1.43	1.39	1.39	1.42	1.25
		Median (mg/l)	1.45	1.36	1.33	1.33	1.35	1.19
	Total Suspended Solids	Mean (mg/l)	19.4	19.0	16.9	16.9	17.8	17.9
		Median (mg/l)	16.8	16.5	14.8	14.8	15.5	15.6
	Copper	Mean (mg/l)	0.0051	0.0055	0.0055	0.0055	0.0055	0.0056
		Median (mg/l)	0.0051	0.0054	0.0054	0.0054	0.0054	0.0055

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
ML-29 Milwaukee River at the Milwaukee-Ozaukee County Line	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,107	618	618	618	573	549
		Percent compliance with single sample standard (<400 cells per 100 ml)	42	54	54	54	55	57
		Geometric mean (cells per 100 ml)	385	222	222	222	212	195
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	127	155	155	155	157	161
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	358	157	157	157	145	136
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	90	90	90	91	91
		Geometric mean (cells per 100 ml)	112	63	63	63	60	54
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	103	117	117	117	118	120
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0	10.9
		Median (mg/l)	11.1	11.1	11.1	11.1	11.1	11.0
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.132	0.142	0.135	0.135	0.139	0.143
		Median (mg/l)	0.119	0.131	0.125	0.125	0.128	0.133
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	41	35	37	37	36	34
	Total Nitrogen	Mean (mg/l)	1.69	1.62	1.58	1.58	1.61	1.42
		Median (mg/l)	1.62	1.56	1.53	1.53	1.55	1.37
	Total Suspended Solids	Mean (mg/l)	17.8	17.5	15.6	15.6	16.3	16.6
		Median (mg/l)	13.9	13.7	12.4	12.4	12.8	13.1
	Copper	Mean (mg/l)	0.0049	0.0053	0.0053	0.0053	0.0053	0.0054
		Median (mg/l)	0.0048	0.0052	0.0052	0.0052	0.0052	0.0053

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-30 Milwaukee River Downstream of Beaver Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,359	1,022	1,021	1,022	917	903
		Percent compliance with single sample standard (<400 cells per 100 ml)	42	47	47	47	48	49
		Geometric mean (cells per 100 ml)	442	321	313	321	298	281
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	120	145	145	145	149	154
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	543	460	460	460	408	405
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	77	77	77	78	79
		Geometric mean (cells per 100 ml)	143	106	100	106	99	92
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	94	110	110	110	113	116
	Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.9	10.9
		Median (mg/l)	11.0	11.0	11.0	11.0	11.0	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	99	99	99	99	98
	Total Phosphorus	Mean (mg/l)	0.134	0.143	0.135	0.135	0.138	0.142
		Median (mg/l)	0.122	0.132	0.126	0.126	0.128	0.133
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	39	34	36	36	35	33
	Total Nitrogen	Mean (mg/l)	1.67	1.58	1.54	1.54	1.57	1.39
		Median (mg/l)	1.60	1.52	1.50	1.50	1.51	1.34
	Total Suspended Solids	Mean (mg/l)	20.7	19.9	17.7	17.7	18.5	18.8
		Median (mg/l)	16.1	15.7	14.1	14.1	14.6	14.8
	Copper	Mean (mg/l)	0.0049	0.0052	0.0052	0.0052	0.0052	0.0053
		Median (mg/l)	0.0048	0.0051	0.0051	0.0051	0.0051	0.0052

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-33 Milwaukee River at Lincoln/ Estabrook Parks	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,559	1,328	1,316	1,329	1,191	1,182
		Percent compliance with single sample standard (<400 cells per 100 ml)	43	46	46	46	47	48
		Geometric mean (cells per 100 ml)	354	273	264	272	249	236
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	140	152	153	152	154	157
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	596	598	579	604	548	547
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	76	76	76	77	77
		Geometric mean (cells per 100 ml)	84	64	60	64	59	54
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	107	114	115	114	116	117
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	10.9	10.9	10.9	10.9	10.9	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.139	0.145	0.137	0.137	0.141	0.144
		Median (mg/l)	0.128	0.135	0.129	0.129	0.131	0.136
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	35	32	34	34	33	31
	Total Nitrogen	Mean (mg/l)	1.63	1.54	1.51	1.51	1.53	1.36
		Median (mg/l)	1.57	1.49	1.46	1.46	1.48	1.32
	Total Suspended Solids	Mean (mg/l)	24.2	22.4	19.9	19.9	20.8	21.1
		Median (mg/l)	18.7	17.7	15.9	15.9	16.4	16.7
	Copper	Mean (mg/l)	0.0052	0.0053	0.0053	0.0053	0.0053	0.0054
		Median (mg/l)	0.0051	0.0053	0.0053	0.0053	0.0053	0.0054

Table J-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
ML-34 Milwaukee River at the Former North Avenue Dam	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,380	1,155	1,126	1,128	1,024	1,015
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	79	79	79	82	82
		Geometric mean (cells per 100 ml)	311	244	201	243	222	214
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	236	255	256	256	266	269
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	515	502	454	455	439	438
		Percent compliance with single sample standard (<400 cells per 100 ml)	92	93	93	93	94	94
		Geometric mean (cells per 100 ml)	73	58	39	57	53	50
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	145	149	149	149	150	151
	Dissolved Oxygen	Mean (mg/l)	10.6	10.6	10.6	10.6	10.6	10.5
		Median (mg/l)	10.6	10.6	10.7	10.7	10.7	10.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.169	0.174	0.165	0.165	0.169	0.173
		Median (mg/l)	0.160	0.166	0.159	0.159	0.161	0.167
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	24	22	24	24	24	21
	Total Nitrogen	Mean (mg/l)	1.60	1.52	1.48	1.48	1.50	1.34
		Median (mg/l)	1.53	1.46	1.43	1.43	1.45	1.30
	Total Suspended Solids	Mean (mg/l)	24.8	22.6	20.0	20.0	20.9	21.2
		Median (mg/l)	19.3	17.8	16.0	16.0	16.6	16.9
	Copper	Mean (mg/l)	0.0051	0.0052	0.0052	0.0052	0.0052	0.0052
		Median (mg/l)	0.0050	0.0051	0.0051	0.0051	0.0051	0.0052

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

Source: Tetra Tech, Inc., and SEWRPC.

Table J-4

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: OAK CREEK WATERSHED

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
OK-1 Upper Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,905	3,928	3,928	3,928	3,491	3,487
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	64	64	64	65	65
		Geometric mean (cells per 100 ml)	541	504	503	503	452	453
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	65	67	67	67	81	81
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,012	1,666	1,666	1,666	1,393	1,394
		Percent compliance with single sample standard (<400 cells per 100 ml)	84	82	82	82	83	82
		Geometric mean (cells per 100 ml)	256	260	259	259	231	232
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	47	47	47	47	56	56
	Dissolved Oxygen	Mean (mg/l)	8.4	8.2	8.2	8.2	8.2	8.2
		Median (mg/l)	8.7	8.6	8.6	8.6	8.6	8.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	77	72	72	72	72	72
	Total Phosphorus	Mean (mg/l)	0.075	0.066	0.066	0.066	0.063	0.063
		Median (mg/l)	0.031	0.025	0.025	0.025	0.025	0.025
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	83	82	82	82	83	83
	Total Nitrogen	Mean (mg/l)	1.52	0.89	0.89	0.89	0.88	0.88
		Median (mg/l)	1.38	0.84	0.84	0.84	0.84	0.83
	Total Suspended Solids	Mean (mg/l)	13.7	7.2	7.2	7.2	7.2	7.2
		Median (mg/l)	7.8	4.4	4.4	4.4	4.4	4.4
	Copper	Mean (mg/l)	0.0038	0.0031	0.0031	0.0031	0.0031	0.0031
		Median (mg/l)	0.0012	0.0007	0.0007	0.0007	0.0007	0.0007

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
OK-2 North Branch of Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,987	4,136	4,136	4,136	3,643	3,640
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	56	56	56	57	57
		Geometric mean (cells per 100 ml)	611	563	562	562	505	505
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	60	64	64	64	74	74
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,561	2,054	2,054	2,054	1,657	1,658
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	73	73	73	74	74
		Geometric mean (cells per 100 ml)	289	277	276	276	245	246
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	44	45	45	45	52	51
	Dissolved Oxygen	Mean (mg/l)	8.8	8.5	8.5	8.5	8.5	8.5
		Median (mg/l)	8.6	8.3	8.3	8.3	8.3	8.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	82	80	80	80	80	80
	Total Phosphorus	Mean (mg/l)	0.084	0.074	0.074	0.074	0.071	0.071
		Median (mg/l)	0.032	0.030	0.030	0.030	0.030	0.030
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	79	79	79	80	80
	Total Nitrogen	Mean (mg/l)	1.32	0.91	0.91	0.91	0.89	0.89
		Median (mg/l)	1.18	0.81	0.81	0.81	0.81	0.80
	Total Suspended Solids	Mean (mg/l)	22.9	14.9	14.9	14.9	14.9	14.9
		Median (mg/l)	9.0	6.2	6.2	6.2	6.2	6.2
	Copper	Mean (mg/l)	0.0052	0.0040	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
OK-3 Oak Creek Downstream of North Branch of Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	10,233	8,236	8,236	8,236	7,299	7,276
		Percent compliance with single sample standard (<400 cells per 100 ml)	55	55	55	55	55	55
		Geometric mean (cells per 100 ml)	1,191	1,060	1,058	1,058	953	952
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	20	20	20	23	23
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,750	3,735	3,735	3,735	3,089	3,064
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	72	72	72	73	73
		Geometric mean (cells per 100 ml)	555	508	507	507	454	452
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	15	17	17	17	19	19
	Dissolved Oxygen	Mean (mg/l)	10.0	9.7	9.7	9.7	9.7	9.7
		Median (mg/l)	10.5	10.3	10.3	10.3	10.3	10.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	83	80	80	80	80	80
	Total Phosphorus	Mean (mg/l)	0.086	0.076	0.076	0.076	0.073	0.073
		Median (mg/l)	0.032	0.029	0.029	0.029	0.029	0.029
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	79	79	79	80	80
	Total Nitrogen	Mean (mg/l)	1.37	0.89	0.89	0.89	0.88	0.87
		Median (mg/l)	1.24	0.81	0.81	0.81	0.80	0.80
	Total Suspended Solids	Mean (mg/l)	20.9	12.9	12.9	12.9	12.9	12.9
		Median (mg/l)	8.5	5.7	5.7	5.7	5.7	5.7
	Copper	Mean (mg/l)	0.0049	0.0038	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
OK-4 Middle Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,953	6,806	6,806	6,806	6,055	6,044
		Percent compliance with single sample standard (<400 cells per 100 ml)	51	52	52	52	53	53
		Geometric mean (cells per 100 ml)	1,041	946	945	945	851	850
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	20	22	22	22	26	26
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,103	2,731	2,730	2,730	2,289	2,274
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	70	70	70	72	71
		Geometric mean (cells per 100 ml)	463	445	444	444	397	396
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	18	18	18	22	22
	Dissolved Oxygen	Mean (mg/l)	9.4	9.2	9.2	9.2	9.2	9.2
		Median (mg/l)	9.6	9.4	9.4	9.4	9.4	9.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	85	82	82	82	82	82
	Total Phosphorus	Mean (mg/l)	0.081	0.073	0.073	0.073	0.070	0.070
		Median (mg/l)	0.032	0.030	0.030	0.030	0.029	0.029
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	80	80	80	81	81
	Total Nitrogen	Mean (mg/l)	1.34	0.87	0.87	0.87	0.85	0.85
		Median (mg/l)	1.17	0.76	0.76	0.76	0.76	0.76
	Total Suspended Solids	Mean (mg/l)	14.9	9.4	9.4	9.4	9.4	9.4
		Median (mg/l)	7.9	5.2	5.2	5.2	5.2	5.2
	Copper	Mean (mg/l)	0.0049	0.0039	0.0039	0.0039	0.0039	0.0039
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
OK-6 Mitchell Field Drainage Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,917	6,358	6,349	6,349	5,616	5,556
		Percent compliance with single sample standard (<400 cells per 100 ml)	31	57	57	57	58	58
		Geometric mean (cells per 100 ml)	1,442	1,182	1,145	1,145	1,039	1,038
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	2	2	2	3	3
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,906	2,788	2,771	2,771	2,256	2,260
		Percent compliance with single sample standard (<400 cells per 100 ml)	27	75	75	75	76	76
		Geometric mean (cells per 100 ml)	806	641	605	605	547	548
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	0	0	0
	Dissolved Oxygen	Mean (mg/l)	9.0	8.9	8.9	8.9	8.9	8.9
		Median (mg/l)	8.7	8.5	8.5	8.5	8.5	8.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	81	79	79	79	79	79
	Total Phosphorus	Mean (mg/l)	0.076	0.073	0.073	0.073	0.070	0.071
		Median (mg/l)	0.046	0.048	0.048	0.048	0.046	0.047
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	84	80	80	80	81	81
	Total Nitrogen	Mean (mg/l)	1.57	1.08	1.08	1.08	1.06	1.05
		Median (mg/l)	1.41	1.01	1.01	1.01	0.99	0.98
	Total Suspended Solids	Mean (mg/l)	11.0	6.8	6.8	6.8	6.8	6.8
		Median (mg/l)	7.0	4.2	4.2	4.2	4.2	4.1
	Copper	Mean (mg/l)	0.0041	0.0032	0.0032	0.0032	0.0032	0.0032
		Median (mg/l)	0.0012	0.0008	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
OK-7 Oak Creek Downstream of Mitchell Field Drainage Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,729	6,753	6,752	6,752	5,986	5,965
		Percent compliance with single sample standard (<400 cells per 100 ml)	49	51	51	51	53	53
		Geometric mean (cells per 100 ml)	1,190	1,035	1,030	1,030	926	924
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	18	19	19	21	21
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,136	2,788	2,787	2,787	2,290	2,279
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	69	69	69	71	71
		Geometric mean (cells per 100 ml)	543	476	472	472	420	419
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	11	16	16	16	18	18
	Dissolved Oxygen	Mean (mg/l)	9.3	9.1	9.1	9.1	9.1	9.1
		Median (mg/l)	9.2	9.3	9.3	9.3	9.3	9.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	81	79	79	79	80	80
	Total Phosphorus	Mean (mg/l)	0.091	0.091	0.091	0.091	0.087	0.087
		Median (mg/l)	0.056	0.060	0.060	0.060	0.058	0.058
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	76	73	73	73	75	75
	Total Nitrogen	Mean (mg/l)	1.38	1.00	1.00	1.00	0.98	0.98
		Median (mg/l)	1.25	0.93	0.93	0.93	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	14.9	9.5	9.5	9.5	9.5	9.5
		Median (mg/l)	7.3	4.6	4.6	4.6	4.6	4.6
	Copper	Mean (mg/l)	0.0051	0.0040	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
OK-8 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	15,506	13,474	13,473	13,473	11,978	11,949
		Percent compliance with single sample standard (<400 cells per 100 ml)	17	23	24	24	28	28
		Geometric mean (cells per 100 ml)	2,700	2,360	2,353	2,353	2,105	2,101
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	11	11	11	12	12
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6,370	5,564	5,563	5,563	4,650	4,631
		Percent compliance with single sample standard (<400 cells per 100 ml)	31	41	41	41	47	46
		Geometric mean (cells per 100 ml)	1,079	909	904	904	799	796
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	11	11	11	11	11
	Dissolved Oxygen	Mean (mg/l)	10.2	10.1	10.1	10.1	10.2	10.2
		Median (mg/l)	10.0	10.1	10.1	10.1	10.2	10.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	93	92	92	92	92	92
	Total Phosphorus	Mean (mg/l)	0.091	0.091	0.091	0.091	0.087	0.087
		Median (mg/l)	0.058	0.063	0.063	0.063	0.060	0.060
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	76	73	73	73	75	75
	Total Nitrogen	Mean (mg/l)	1.30	0.97	0.97	0.97	0.95	0.95
		Median (mg/l)	1.18	0.90	0.90	0.90	0.89	0.89
	Total Suspended Solids	Mean (mg/l)	15.9	10.2	10.2	10.2	10.2	10.2
		Median (mg/l)	7.3	4.6	4.6	4.6	4.6	4.6
	Copper	Mean (mg/l)	0.0052	0.0041	0.0041	0.0041	0.0041	0.0041
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
OK-9 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,401	6,376	6,376	6,376	5,596	5,569
		Percent compliance with single sample standard (<400 cells per 100 ml)	51	54	54	54	55	54
		Geometric mean (cells per 100 ml)	993	783	781	781	694	692
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	26	40	41	41	46	46
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,061	2,633	2,633	2,633	2,027	2,020
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	73	73	73	74	74
		Geometric mean (cells per 100 ml)	388	283	281	281	244	243
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	21	32	32	32	35	36
	Dissolved Oxygen	Mean (mg/l)	10.5	10.5	10.5	10.5	10.6	10.6
		Median (mg/l)	10.3	10.3	10.3	10.3	10.4	10.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.092	0.087	0.087	0.087	0.084	0.084
		Median (mg/l)	0.062	0.065	0.065	0.065	0.063	0.063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	75	74	74	74	76	76
	Total Nitrogen	Mean (mg/l)	1.26	0.96	0.96	0.96	0.94	0.94
		Median (mg/l)	1.14	0.93	0.93	0.93	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	16.0	10.3	10.3	10.3	10.3	10.3
		Median (mg/l)	6.7	4.3	4.3	4.3	4.3	4.2
	Copper	Mean (mg/l)	0.0052	0.0041	0.0041	0.0041	0.0041	0.0041
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
OK-10 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,643	5,738	5,738	5,738	5,070	5,061
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	48	49	49	49	49
		Geometric mean (cells per 100 ml)	752	604	603	603	538	537
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	70	86	87	87	97	97
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,504	2,171	2,171	2,171	1,730	1,726
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	71	71	71	72	71
		Geometric mean (cells per 100 ml)	179	132	132	132	115	115
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	59	70	70	70	79	79
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.078	0.072	0.072	0.072	0.069	0.069
		Median (mg/l)	0.046	0.045	0.045	0.045	0.043	0.043
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	79	79	79	80	80
	Total Nitrogen	Mean (mg/l)	1.07	0.81	0.81	0.81	0.80	0.80
		Median (mg/l)	0.98	0.71	0.71	0.71	0.70	0.70
	Total Suspended Solids	Mean (mg/l)	19.6	12.5	12.5	12.5	12.5	12.5
		Median (mg/l)	7.4	5.0	5.0	5.0	5.0	5.0
	Copper	Mean (mg/l)	0.006	0.0048	0.0048	0.0048	0.0048	0.0048
		Median (mg/l)	0.0025	0.0022	0.0022	0.0022	0.0022	0.0022

Indicates Revision

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

Source: Tetra Tech, Inc., and SEWRPC.

Table J-5

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: ROOT RIVER WATERSHED

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-1 Root River Upstream of Hale Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,644	4,648	4,647	4,647	4,184	4,184
		Percent compliance with single sample standard (<400 cells per 100 ml)	70	71	71	71	71	71
		Geometric mean (cells per 100 ml)	525	409	405	405	369	369
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	33	61	62	62	74	74
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,385	2,781	2,780	2,780	2,503	2,503
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	81	81	81	82	82
		Geometric mean (cells per 100 ml)	393	303	301	301	274	274
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	27	28	28	34	34
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	10.8	10.8	10.8	10.8	10.8	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.062	0.053	0.053	0.053	0.051	0.051
		Median (mg/l)	0.025	0.021	0.021	0.021	0.021	0.021
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	87	88	88	88	88	88
	Total Nitrogen	Mean (mg/l)	0.98	0.85	0.85	0.85	0.84	0.84
		Median (mg/l)	1.01	0.87	0.87	0.87	0.86	0.86
	Total Suspended Solids	Mean (mg/l)	6.9	5.0	5.0	5.0	5.0	5.0
		Median (mg/l)	4.8	3.3	3.3	3.3	3.3	3.3
	Copper	Mean (mg/l)	0.0033	0.0026	0.0026	0.0026	0.0026	0.0026
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-2 Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,040	5,869	5,868	5,868	4,879	4,877
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	66	66	66	68	68
		Geometric mean (cells per 100 ml)	630	501	497	497	424	424
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	27	46	47	47	63	63
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,968	3,412	3,411	3,411	2,108	2,108
		Percent compliance with single sample standard (<400 cells per 100 ml)	77	76	76	76	80	80
		Geometric mean (cells per 100 ml)	464	371	369	369	287	287
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	10	18	19	19	29	29
	Dissolved Oxygen	Mean (mg/l)	8.4	8.4	8.4	8.4	8.4	8.4
		Median (mg/l)	8.4	8.4	8.4	8.4	8.4	8.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.079	0.067	0.067	0.067	0.064	0.064
		Median (mg/l)	0.025	0.020	0.020	0.020	0.020	0.020
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	83	83	83	84	84
	Total Nitrogen	Mean (mg/l)	1.13	0.97	0.97	0.97	0.96	0.96
		Median (mg/l)	1.07	0.91	0.91	0.91	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	6.3	4.6	4.6	4.6	4.6	4.6
		Median (mg/l)	4.9	3.3	3.3	3.3	3.3	3.3
	Copper	Mean (mg/l)	0.0047	0.0036	0.0036	0.0036	0.0036	0.0036
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-3 Root River at Wildcat Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,328	6,066	6,068	6,064	5,305	5,309
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	64	64	64	65	65
		Geometric mean (cells per 100 ml)	645	518	513	513	456	457
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	27	43	44	44	55	55
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,228	3,537	3,543	3,534	2,812	2,812
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	74	74	74	76	76
		Geometric mean (cells per 100 ml)	477	383	381	381	327	327
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	10	17	17	17	24	24
	Dissolved Oxygen	Mean (mg/l)	8.9	8.9	8.9	8.9	8.9	8.9
		Median (mg/l)	8.7	8.7	8.7	8.7	8.7	8.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	87	88	88	88	88	88
	Total Phosphorus	Mean (mg/l)	0.078	0.066	0.066	0.066	0.063	0.063
		Median (mg/l)	0.022	0.018	0.018	0.018	0.018	0.018
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	81	82	82	82	83	83
	Total Nitrogen	Mean (mg/l)	1.08	0.92	0.92	0.92	0.91	0.91
		Median (mg/l)	0.98	0.83	0.83	0.83	0.83	0.83
	Total Suspended Solids	Mean (mg/l)	9.2	6.7	6.7	6.7	6.7	6.7
		Median (mg/l)	4.8	3.3	3.3	3.3	3.2	3.2
	Copper	Mean (mg/l)	0.0049	0.0038	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-4 Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,101	5,914	5,914	5,913	5,182	5,168
		Percent compliance with single sample standard (<400 cells per 100 ml)	56	58	58	58	59	59
		Geometric mean (cells per 100 ml)	865	697	691	691	616	616
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	19	29	30	30	37	37
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,018	3,370	3,372	3,368	2,696	2,696
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	68	68	68	69	69
		Geometric mean (cells per 100 ml)	603	491	489	488	421	421
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	7	11	11	11	16	16
	Dissolved Oxygen	Mean (mg/l)	9.6	9.5	9.5	9.5	9.5	9.5
		Median (mg/l)	9.4	9.3	9.3	9.3	9.3	9.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	95	95	95	95	95	95
	Total Phosphorus	Mean (mg/l)	0.080	0.068	0.068	0.068	0.065	0.065
		Median (mg/l)	0.022	0.019	0.019	0.019	0.018	0.018
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	80	80	80	81	81
	Total Nitrogen	Mean (mg/l)	1.12	0.89	0.89	0.89	0.88	0.88
		Median (mg/l)	1.00	0.77	0.77	0.77	0.76	0.76
	Total Suspended Solids	Mean (mg/l)	10.3	7.2	7.2	7.2	7.2	7.2
		Median (mg/l)	4.7	3.2	3.2	3.2	3.2	3.2
	Copper	Mean (mg/l)	0.0054	0.0043	0.0043	0.0043	0.0043	0.0043
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
RT-10 Root River Upstream of Ryan Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,995	5,966	5,965	5,964	5,294	5,289
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	51	51	51	52	52
		Geometric mean (cells per 100 ml)	1,189	985	979	979	874	874
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	9	18	18	18	22	22
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,768	3,213	3,214	3,212	2,711	2,711
		Percent compliance with single sample standard (<400 cells per 100 ml)	59	62	62	62	64	64
		Geometric mean (cells per 100 ml)	717	593	590	589	514	514
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	4	9	10	10	13	13
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.087	0.077	0.077	0.077	0.073	0.073
		Median (mg/l)	0.057	0.052	0.052	0.052	0.050	0.050
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	73	76	76	76	77	77
	Total Nitrogen	Mean (mg/l)	1.15	0.90	0.90	0.90	0.89	0.89
		Median (mg/l)	1.13	0.88	0.88	0.88	0.87	0.87
	Total Suspended Solids	Mean (mg/l)	12.9	8.6	8.6	8.6	8.6	8.6
		Median (mg/l)	4.8	3.2	3.2	3.2	3.2	3.2
	Copper	Mean (mg/l)	0.0020	0.0017	0.0017	0.0017	0.0017	0.0017
		Median (mg/l)	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
RT-13 West Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,372	2,234	2,266	2,266	1,944	1,958
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	65	65	65	67	68
		Geometric mean (cells per 100 ml)	412	396	390	390	319	318
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	59	61	64	64	93	93
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,099	1,968	1,981	1,981	1,714	1,697
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	74	74	74	74	77
		Geometric mean (cells per 100 ml)	256	252	248	248	203	204
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	41	42	44	44	61	61
	Dissolved Oxygen	Mean (mg/l)	11.8	11.8	11.8	11.8	11.8	11.8
		Median (mg/l)	12.3	12.2	12.2	12.2	12.2	12.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.164	0.151	0.151	0.151	0.147	0.141
		Median (mg/l)	0.076	0.069	0.070	0.070	0.068	0.068
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	63	66	65	65	66	67
	Total Nitrogen	Mean (mg/l)	2.75	2.61	2.59	2.59	2.58	2.30
		Median (mg/l)	2.00	1.95	1.94	1.94	1.94	1.67
	Total Suspended Solids	Mean (mg/l)	28.1	25.3	21.1	21.1	23.2	19.6
		Median (mg/l)	4.0	4.0	4.0	4.0	3.9	3.9
	Copper	Mean (mg/l)	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005
		Median (mg/l)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
RT-15 East Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,272	3,025	3,022	3,022	2,546	2,525
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	71	71	71	72	72
		Geometric mean (cells per 100 ml)	288	280	276	276	208	214
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	121	127	131	131	192	186
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,853	2,572	2,568	2,568	2,172	2,145
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	80	80	80	81	81
		Geometric mean (cells per 100 ml)	213	207	205	205	155	160
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	64	67	69	69	102	99
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>3 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.143	0.141	0.140	0.140	0.135	0.129
		Median (mg/l)	0.065	0.066	0.067	0.067	0.064	0.063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	72	71	71	71	72	73
	Total Nitrogen	Mean (mg/l)	2.64	2.58	2.56	2.56	2.54	2.23
		Median (mg/l)	2.05	2.02	2.02	2.02	2.00	1.74
	Total Suspended Solids	Mean (mg/l)	57.2	50.2	41.5	41.5	45.6	38.1
		Median (mg/l)	5.0	4.9	4.9	4.9	4.8	4.8
	Copper	Mean (mg/l)	0.0034	0.0034	0.0034	0.0034	0.0032	0.0030
		Median (mg/l)	0.0014	0.0014	0.0014	0.0014	0.0013	0.0012

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-17 Root River at Upstream Crossing of Milwaukee-Racine County Line and Downstream of Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,656	4,048	4,067	4,066	3,571	3,585
		Percent compliance with single sample standard (<400 cells per 100 ml)	43	45	46	46	48	48
		Geometric mean (cells per 100 ml)	1,123	1,012	1,001	1,001	872	869
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	7	9	9	9	11	11
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,994	2,536	2,542	2,541	2,164	2,164
		Percent compliance with single sample standard (<400 cells per 100 ml)	55	57	57	57	60	60
		Geometric mean (cells per 100 ml)	720	642	635	635	549	547
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	4	4	5	5	6	6
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.104	0.094	0.095	0.095	0.091	0.089
		Median (mg/l)	0.071	0.067	0.068	0.068	0.065	0.065
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	71	73	73	73	75	75
	Total Nitrogen	Mean (mg/l)	1.68	1.48	1.47	1.47	1.46	1.33
		Median (mg/l)	1.39	1.22	1.22	1.22	1.20	1.13
	Total Suspended Solids	Mean (mg/l)	20.6	16.2	14.1	14.1	15.2	13.5
		Median (mg/l)	4.6	3.8	3.7	3.7	3.8	3.7
	Copper	Mean (mg/l)	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
		Median (mg/l)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
RT-18 Root River Upstream of Hoods Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,253	3,654	3,669	3,669	3,230	3,243
		Percent compliance with single sample standard (<400 cells per 100 ml)	46	47	48	48	49	49
		Geometric mean (cells per 100 ml)	983	865	855	855	744	743
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	11	16	17	17	23	23
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,687	2,232	2,235	2,235	1,928	1,930
		Percent compliance with single sample standard (<400 cells per 100 ml)	60	61	61	61	62	62
		Geometric mean (cells per 100 ml)	556	484	479	479	413	413
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	9	12	13	13	18	18
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.6	11.7	11.7	11.7	11.6	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.102	0.094	0.093	0.093	0.090	0.088
		Median (mg/l)	0.068	0.065	0.066	0.066	0.063	0.064
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	73	75	74	74	77	76
	Total Nitrogen	Mean (mg/l)	1.64	1.45	1.42	1.42	1.42	1.29
		Median (mg/l)	1.32	1.16	1.16	1.16	1.15	1.07
	Total Suspended Solids	Mean (mg/l)	31	23.7	18.7	18.7	22.0	19.2
		Median (mg/l)	5.2	4.4	4.2	4.3	4.3	4.2
	Copper	Mean (mg/l)	0.0013	0.0012	0.0012	0.0012	0.0012	0.0012
		Median (mg/l)	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
RT-20 Hoods Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,039	3,218	3,211	3,211	2,879	2,890
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	68	68	68	69	69
		Geometric mean (cells per 100 ml)	286	277	275	275	209	213
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	148	149	151	151	194	190
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,354	2,601	2,597	2,597	2,329	2,359
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	79	79	79	79	79
		Geometric mean (cells per 100 ml)	158	161	160	160	113	115
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	84	83	84	84	109	106
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0	11.0
		Median (mg/l)	11.7	11.8	11.8	11.8	11.8	11.8
		Percent compliance with dissolved oxygen standard (>3 mg/l)[b]	98	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.381	0.337	0.334	0.334	0.334	0.355
		Median (mg/l)	0.131	0.113	0.112	0.112	0.110	0.112
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	43	49	49	49	50	49
	Total Nitrogen	Mean (mg/l)	3.20	2.84	2.81	2.81	2.83	2.73
		Median (mg/l)	2.39	2.05	2.03	2.03	2.04	1.89
	Total Suspended Solids	Mean (mg/l)	33.5	23.4	16.8	16.8	21.8	18.8
		Median (mg/l)	4.9	4.5	4.5	4.5	4.5	4.4
	Copper	Mean (mg/l)	0.0048	0.0040	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0022	0.0020	0.0020	0.0020	0.0019	0.0019

Indicates Revision

Table J-5 (continued)

					Alternative[a]			
Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	B1	B2	C1	C2
RT-21 Root River at the City of Racine, USGS Sampling Location (4087240)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,547	3,908	3,921	3,921	3,465	3,477
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	49	49	49	50	50
		Geometric mean (cells per 100 ml)	853	761	754	754	657	658
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	23	24	24	34	34
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,041	2,552	2,554	2,554	2,211	2,216
		Percent compliance with single sample standard (<400 cells per 100 ml)	62	63	63	63	64	64
		Geometric mean (cells per 100 ml)	479	422	418	418	361	362
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	18	18	18	26	26
	Dissolved Oxygen	Mean (mg/l)	11	11.1	11.1	11.1	11.1	11.1
		Median (mg/l)	11.3	11.4	11.4	11.4	11.3	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.109	0.099	0.098	0.098	0.095	0.093
		Median (mg/l)	0.075	0.071	0.072	0.072	0.068	0.069
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	67	71	70	70	73	72
	Total Nitrogen	Mean (mg/l)	1.58	1.38	1.35	1.35	1.36	1.23
		Median (mg/l)	1.24	1.09	1.09	1.09	1.08	1.01
	Total Suspended Solids	Mean (mg/l)	35.9	26.5	21.1	21.1	24.7	21.8
		Median (mg/l)	7.0	5.8	5.3	5.3	5.6	5.3
	Copper	Mean (mg/l)	0.0008	0.0006	0.0006	0.0006	0.0006	0.0006
		Median (mg/l)	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001

Indicates Revision

Table J-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
RT-22 Mouth of Root River at Lake Michigan	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,924	4,132	4,144	4,143	3,679	3,690
		Percent compliance with single sample standard (<400 cells per 100 ml)	47	48	48	48	49	49
		Geometric mean (cells per 100 ml)	869	763	755	755	661	661
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	28	34	35	35	45	45
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,327	2,710	2,712	2,711	2,377	2,382
		Percent compliance with single sample standard (<400 cells per 100 ml)	62	62	62	62	64	64
		Geometric mean (cells per 100 ml)	440	383	379	379	329	330
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	22	28	28	28	36	36
	Dissolved Oxygen	Mean (mg/l)	11.1	11.1	11.1	11.1	11.1	11.2
		Median (mg/l)	11.3	11.3	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.115	0.104	0.103	0.103	0.099	0.098
		Median (mg/l)	0.079	0.074	0.075	0.075	0.072	0.072
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	65	68	67	67	70	70
	Total Nitrogen	Mean (mg/l)	1.56	1.36	1.33	1.33	1.33	1.22
		Median (mg/l)	1.23	1.08	1.09	1.09	1.07	1.00
	Total Suspended Solids	Mean (mg/l)	38.5	28.8	23.7	23.7	27.1	24.3
		Median (mg/l)	4.4	8.0	7.4	7.4	7.7	7.4
	Copper	Mean (mg/l)	0.0015	0.0011	0.0011	0.0011	0.0011	0.0011
		Median (mg/l)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002

Indicates Revision

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

[b]*Under Chapter NR 104 of the* Wisconsin Administrative Code, *this assessment point is in a stream reach classified as capable of supporting limited forage fish.*

Source: Tetra Tech, Inc., and SEWRPC.

Table J-6

WATER QUALITY SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: NEARSHORE LAKE MICHIGAN AREA

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-1 Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,101	788	674	646	691	682
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	79	87	91	91	91	91
		Geometric mean (cells per 100 ml)	175	123	89	106	109	105
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	254	291	304	304	303	306
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	457	332	254	196	277	273
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	95	97	99	99	98	98
		Geometric mean (cells per 100 ml)	26	17	10	14	15	14
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	147	152	152	152	152	152
	Dissolved Oxygen	Mean (mg/l)	10.0	9.9	10.0	10.0	10.0	9.9
		Median (mg/l)	10.8	10.8	10.9	10.9	10.9	10.8
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	99	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.066	0.065	0.064	0.064	0.064	0.062
		Median (mg/l)	0.055	0.055	0.054	0.054	0.054	0.053
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	79	79	79	79	81
	Total Nitrogen	Mean (mg/l)	1.69	1.62	1.61	1.61	1.61	1.46
		Median (mg/l)	1.48	1.43	1.42	1.42	1.42	1.30
	Total Suspended Solids	Mean (mg/l)	22.5	20.7	19.3	19.3	19.3	19.6
		Median (mg/l)	13.1	12.4	11.8	11.8	11.8	11.9
	Copper	Mean (mg/l)	0.0045	0.0046	0.0046	0.0046	0.0046	0.0047
		Median (mg/l)	0.0044	0.0045	0.0045	0.0045	0.0045	0.0045

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-2 Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,466	3,187	2,182	2,152	1,976	1,975
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	58	59	67	67	70	70
		Geometric mean (cells per 100 ml)	595	538	294	292	261	260
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	208	212	239	239	242	242
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,250	1,119	793	743	687	688
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	84	85	89	89	92	92
		Geometric mean (cells per 100 ml)	135	118	60	59	50	50
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	139	142	150	150	151	151
	Dissolved Oxygen	Mean (mg/l)	9.3	9.4	9.5	9.5	9.5	9.5
		Median (mg/l)	9.7	9.9	10.0	10.0	10.0	9.9
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.070	0.070	0.069	0.069	0.068	0.067
		Median (mg/l)	0.065	0.066	0.066	0.065	0.064	0.064
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	86	88	88	89	90	90
	Total Nitrogen	Mean (mg/l)	1.53	1.33	1.31	1.30	1.29	1.24
		Median (mg/l)	1.51	1.31	1.29	1.28	1.27	1.23
	Total Suspended Solids	Mean (mg/l)	20.1	18.1	17.7	17.7	17.6	17.7
		Median (mg/l)	11.6	11.3	10.9	10.9	10.8	10.9
	Copper	Mean (mg/l)	0.0187	0.0187	0.0187	0.0187	0.0185	0.0187
		Median (mg/l)	0.0141	0.0137	0.0137	0.0137	0.0136	0.0136

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-3 Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	931	813	592	582	564	562
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	86	88	92	92	93	93
		Geometric mean (cells per 100 ml)	141	120	83	83	77	76
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	308	324	347	346	351	351
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	494	446	317	301	299	298
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	94	94	96	96	97	97
		Geometric mean (cells per 100 ml)	40	33	21	21	19	18
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	150	151	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	9.1	9.3	9.3	9.3	9.3	9.3
		Median (mg/l)	9.7	9.9	10.0	10.0	10.0	9.9
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.062	0.062	0.061	0.061	0.060	0.059
		Median (mg/l)	0.059	0.060	0.059	0.059	0.058	0.057
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	93	94	94	94	95	95
	Total Nitrogen	Mean (mg/l)	1.53	1.40	1.37	1.37	1.36	1.28
		Median (mg/l)	1.44	1.31	1.28	1.28	1.27	1.21
	Total Suspended Solids	Mean (mg/l)	19.0	17.6	16.9	16.9	16.8	17.0
		Median (mg/l)	12.2	11.7	11.3	11.2	11.2	11.3
	Copper	Mean (mg/l)	0.0056	0.0054	0.0054	0.0054	0.0054	0.0054
		Median (mg/l)	0.0051	0.0049	0.0049	0.0049	0.0048	0.0049

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-4 Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	850	693	546	540	539	534
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	85	90	94	94	95	95
		Geometric mean (cells per 100 ml)	147	121	92	93	89	87
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	298	316	336	336	339	341
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	399	341	247	239	245	243
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	95	96	98	98	98	98
		Geometric mean (cells per 100 ml)	37	29	20	21	19	18
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	150	152	153	153	152	153
	Dissolved Oxygen	Mean (mg/l)	9.5	9.6	9.7	9.7	9.7	9.6
		Median (mg/l)	10.1	10.3	10.4	10.4	10.4	10.3
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.059	0.060	0.058	0.058	0.058	0.057
		Median (mg/l)	0.055	0.055	0.053	0.053	0.053	0.052
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	92	91	92	92	92	93
	Total Nitrogen	Mean (mg/l)	1.58	1.49	1.46	1.46	1.45	1.34
		Median (mg/l)	1.42	1.34	1.30	1.30	1.29	1.22
	Total Suspended Solids	Mean (mg/l)	19.0	17.9	17.0	17.0	16.9	17.1
		Median (mg/l)	12.1	11.8	11.2	11.2	11.2	11.2
	Copper	Mean (mg/l)	0.0054	0.0053	0.0053	0.0053	0.0053	0.0053
		Median (mg/l)	0.0051	0.0050	0.0050	0.0050	0.0050	0.0051

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-5 Kinnickinnic River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	352	368	221	243	340	339
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	98	98	99	99	99	99
		Geometric mean (cells per 100 ml)	52	46	40	40	37	37
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	363	363	364	364	363	363
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	255	320	143	176	290	289
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	98	99	99	99	99	99
		Geometric mean (cells per 100 ml)	17	15	12	12	11	11
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	152	152	153	153	152	152
	Dissolved Oxygen	Mean (mg/l)	8.1	8.2	8.4	8.4	8.3	8.3
		Median (mg/l)	8.6	8.7	8.9	8.8	8.8	8.8
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.049	0.048	0.045	0.046	0.046	0.046
		Median (mg/l)	0.044	0.043	0.041	0.041	0.041	0.040
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	97	97	98	98	98	98
	Total Nitrogen	Mean (mg/l)	1.39	1.32	1.21	1.21	1.21	1.14
		Median (mg/l)	1.30	1.24	1.14	1.14	1.13	1.07
	Total Suspended Solids	Mean (mg/l)	12.2	11.3	10.7	10.7	10.8	10.9
		Median (mg/l)	7.8	7.5	7.1	7.1	7.1	7.1
	Copper	Mean (mg/l)	0.0069	0.0066	0.0066	0.0066	0.0066	0.0067
		Median (mg/l)	0.0070	0.0066	0.0066	0.0066	0.0066	0.0067

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-6 Mouth of Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	445	379	297	296	306	302
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	95	97	98	98	98	98
		Geometric mean (cells per 100 ml)	78	69	57	57	55	54
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	352	360	364	364	363	363
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	229	202	143	144	158	156
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[b]	98	98	99	99	99	99
		Geometric mean (cells per 100 ml)	26	22	18	18	17	16
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[b]	152	152	153	153	152	152
	Dissolved Oxygen	Mean (mg/l)	9.5	9.5	9.7	9.7	9.6	9.6
		Median (mg/l)	10.0	10.1	10.2	10.2	10.2	10.2
		Percent compliance with dissolved oxygen standard (>2 mg/l)[b]	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.047	0.048	0.045	0.045	0.045	0.044
		Median (mg/l)	0.042	0.043	0.040	0.040	0.040	0.039
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	97	97	97	97	97	98
	Total Nitrogen	Mean (mg/l)	1.51	1.45	1.23	1.23	1.23	1.15
		Median (mg/l)	1.44	1.39	1.14	1.14	1.13	1.07
	Total Suspended Solids	Mean (mg/l)	13.3	12.7	12.0	12.0	12.0	12.1
		Median (mg/l)	8.5	8.3	8.0	8.0	8.0	7.9
	Copper	Mean (mg/l)	0.0072	0.0070	0.0070	0.0070	0.0070	0.0070
		Median (mg/l)	0.0073	0.0070	0.0070	0.0070	0.0070	0.0070

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-7 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	91	82	63	64	70	69
		Percent compliance with single sample standard (<400 cells per 100 ml)	96	97	98	98	98	98
		Geometric mean (cells per 100 ml)	21	20	17	17	17	17
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	360	362	365	364	363	364
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	81	74	54	56	63	62
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	98	98	98
		Geometric mean (cells per 100 ml)	13	12	11	11	10	10
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	153	152	152	152
	Dissolved Oxygen	Mean (mg/l)	10.3	10.4	10.5	10.5	10.5	10.5
		Median (mg/l)	10.7	10.7	10.9	10.9	10.9	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.027	0.028	0.025	0.025	0.025	0.025
		Median (mg/l)	0.024	0.025	0.022	0.022	0.022	0.021
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	99	99	99	99	99
	Total Nitrogen	Mean (mg/l)	1.15	1.13	0.82	0.82	0.82	0.80
		Median (mg/l)	1.09	1.08	0.76	0.76	0.76	0.74
	Total Suspended Solids	Mean (mg/l)	6.4	6.2	5.9	5.9	5.9	6.0
		Median (mg/l)	4.0	4.1	3.9	3.9	3.9	3.9
	Copper	Mean (mg/l)	0.0094	0.0093	0.0093	0.0093	0.0093	0.0093
		Median (mg/l)	0.0096	0.0095	0.0095	0.0095	0.0095	0.0095

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-8 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	66	60	44	46	52	52
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	99	98	98
		Geometric mean (cells per 100 ml)	15	14	13	13	12	12
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	363	363	365	363	363	363
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	65	59	43	45	50	50
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	98	99	99	98	98
		Geometric mean (cells per 100 ml)	11	10	9	9	9	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	153	152	152	152
	Dissolved Oxygen	Mean (mg/l)	10.5	10.5	10.6	10.6	10.6	10.6
		Median (mg/l)	10.8	10.8	11.0	11.0	11.0	11.0
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.024	0.024	0.022	0.022	0.022	0.021
		Median (mg/l)	0.020	0.020	0.018	0.018	0.018	0.018
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	99	100	100	100	100
	Total Nitrogen	Mean (mg/l)	1.04	1.02	0.78	0.78	0.78	0.76
		Median (mg/l)	0.98	0.97	0.71	0.71	0.71	0.70
	Total Suspended Solids	Mean (mg/l)	5.7	5.6	5.3	5.3	5.3	5.4
		Median (mg/l)	3.5	3.6	3.4	3.4	3.4	3.4
	Copper	Mean (mg/l)	0.0095	0.0094	0.0094	0.0094	0.0094	0.0094
		Median (mg/l)	0.0097	0.0096	0.0096	0.0096	0.0096	0.0096

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-9 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	47	42	33	34	35	35
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	99	99	99	99	99
		Geometric mean (cells per 100 ml)	11	10	9	9	9	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	26	24	18	19	21	21
		Percent compliance with single sample standard (<400 cells per 100 ml)	99	99	100	99	99	99
		Geometric mean (cells per 100 ml)	6	6	5	5	5	5
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	10.7	10.7	10.8	10.8	10.8	10.8
		Median (mg/l)	10.9	11.0	11.1	11.1	11.1	11.1
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.021	0.021	0.019	0.019	0.019	0.018
		Median (mg/l)	0.018	0.018	0.016	0.016	0.016	0.016
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.95	0.94	0.70	0.70	0.70	0.68
		Median (mg/l)	0.84	0.83	0.64	0.64	0.64	0.63
	Total Suspended Solids	Mean (mg/l)	4.6	4.5	4.3	4.3	4.3	4.4
		Median (mg/l)	3.2	3.2	3.1	3.1	3.1	3.1
	Copper	Mean (mg/l)	0.0097	0.0096	0.0096	0.0096	0.0096	0.0096
		Median (mg/l)	0.0099	0.0098	0.0098	0.0098	0.0098	0.0098

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-10 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	66	59	46	47	52	52
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	99	99	99	99
		Geometric mean (cells per 100 ml)	17	16	14	14	14	14
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	362	363	363	363	363	363
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	50	46	34	35	39	38
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	98	99	99	99	99
		Geometric mean (cells per 100 ml)	11	10	9	9	9	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	152	152	152	152
	Dissolved Oxygen	Mean (mg/l)	10.4	10.4	10.5	10.5	10.5	10.5
		Median (mg/l)	10.7	10.8	10.9	10.9	10.9	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.026	0.026	0.023	0.023	0.023	0.023
		Median (mg/l)	0.023	0.024	0.020	0.020	0.020	0.020
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	1.14	1.13	0.81	0.81	0.81	0.79
		Median (mg/l)	1.08	1.07	0.75	0.75	0.75	0.74
	Total Suspended Solids	Mean (mg/l)	5.6	5.5	5.2	5.2	5.2	5.2
		Median (mg/l)	3.7	3.7	3.6	3.6	3.6	3.6
	Copper	Mean (mg/l)	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096
		Median (mg/l)	0.0097	0.0096	0.0096	0.0096	0.0096	0.0096

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-11 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	11	10	9	9	9	9
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	4	4	4	4
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6	5	5	5	5	5
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.010	0.010	0.009	0.009	0.009	0.009
		Median (mg/l)	0.008	0.008	0.007	0.007	0.007	0.007
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.62	0.62	0.55	0.55	0.55	0.54
		Median (mg/l)	0.55	0.55	0.52	0.52	0.52	0.52
	Total Suspended Solids	Mean (mg/l)	2.6	2.6	2.6	2.6	2.6	2.6
		Median (mg/l)	2.3	2.3	2.3	2.3	2.3	2.3
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-12 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	12	11	10	10	10	10
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	5	5	5
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6	6	5	5	5	5
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	4	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.010	0.010	0.009	0.009	0.009	0.009
		Median (mg/l)	0.008	0.008	0.008	0.008	0.008	0.008
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.63	0.63	0.55	0.55	0.55	0.55
		Median (mg/l)	0.56	0.56	0.53	0.53	0.53	0.53
	Total Suspended Solids	Mean (mg/l)	2.7	2.7	2.6	2.6	2.6	2.6
		Median (mg/l)	2.4	2.4	2.4	2.4	2.4	2.4
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-13 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	69	59	55	54	53	53
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	99	99	99	99
		Geometric mean (cells per 100 ml)	16	15	14	14	13	13
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	363	364	365	365	364	364
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	58	49	46	44	44	44
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	99	99	99	99
		Geometric mean (cells per 100 ml)	10	9	9	9	8	8
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	10.9	10.9	11.0	11.0	11.0	11.0
		Median (mg/l)	11.1	11.2	11.3	11.3	11.3	11.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.020	0.020	0.018	0.018	0.018	0.018
		Median (mg/l)	0.016	0.016	0.015	0.015	0.015	0.015
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.86	0.85	0.68	0.68	0.68	0.67
		Median (mg/l)	0.78	0.77	0.63	0.63	0.63	0.62
	Total Suspended Solids	Mean (mg/l)	4.2	4.0	3.9	3.9	3.9	3.9
		Median (mg/l)	2.8	2.8	2.8	2.8	2.8	2.8
	Copper	Mean (mg/l)	0.0098	0.0100	0.0100	0.0100	0.0099	0.0099
		Median (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-14 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3	3	3	3	3	3
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2	2	2	2	2	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.6	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.007	0.007	0.007	0.007	0.007	0.007
		Median (mg/l)	0.005	0.005	0.005	0.005	0.005	0.005
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.54	0.54	0.53	0.53	0.53	0.52
		Median (mg/l)	0.53	0.53	0.52	0.52	0.52	0.51
	Total Suspended Solids	Mean (mg/l)	2.4	2.4	2.4	2.4	2.4	2.4
		Median (mg/l)	2.3	2.3	2.3	2.3	2.3	2.3
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-15 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5	5	4	4	4	4
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	8	7	5	6	6	6
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.009	0.009	0.008	0.008	0.008	0.008
		Median (mg/l)	0.006	0.007	0.006	0.006	0.006	0.006
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.58	0.57	0.55	0.55	0.55	0.55
		Median (mg/l)	0.55	0.55	0.53	0.53	0.53	0.53
	Total Suspended Solids	Mean (mg/l)	2.7	2.6	2.6	2.6	2.6	2.6
		Median (mg/l)	2.3	2.3	2.3	2.3	2.3	2.3
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-16 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9	9	8	8	8	8
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	4	4	4	4
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	5	4	4	4	4	4
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.012	0.012	0.012	0.012	0.012	0.012
		Median (mg/l)	0.010	0.010	0.010	0.010	0.010	0.010
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.65	0.65	0.60	0.60	0.60	0.60
		Median (mg/l)	0.62	0.62	0.57	0.57	0.57	0.57
	Total Suspended Solids	Mean (mg/l)	2.6	2.5	2.5	2.5	2.5	2.5
		Median (mg/l)	2.3	2.3	2.3	2.3	2.3	2.3
	Copper	Mean (mg/l)	0.0099	0.0100	0.0100	0.0100	0.0100	0.0100
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a]			
					B1	B2	C1	C2
LM-17 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	21	20	20	20	19	19
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	8	7	7	7	7	7
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	364	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	9	9	9	9	8	8
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	5	5	5
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.3	11.3	11.3	11.3
		Median (mg/l)	11.4	11.4	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.020	0.019	0.023	0.023	0.023	0.023
		Median (mg/l)	0.016	0.016	0.019	0.019	0.019	0.019
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.97	0.96	0.94	0.94	0.94	0.94
		Median (mg/l)	0.88	0.88	0.85	0.85	0.85	0.85
	Total Suspended Solids	Mean (mg/l)	2.5	2.5	2.4	2.4	2.4	2.4
		Median (mg/l)	2.3	2.3	2.2	2.2	2.2	2.2
	Copper	Mean (mg/l)	0.0102	0.0101	0.0101	0.0101	0.0101	0.0102
		Median (mg/l)	0.0101	0.0100	0.0100	0.0100	0.0100	0.0100

Table J-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Existing	Original 2020 Baseline	Alternative[a] B1	B2	C1	C2
LM-18 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3	3	3	3	3	3
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2	2	2	2	2	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.008	0.008	0.008	0.008	0.008	0.008
		Median (mg/l)	0.006	0.006	0.006	0.006	0.006	0.006
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.57	0.57	0.56	0.56	0.56	0.55
		Median (mg/l)	0.56	0.56	0.55	0.55	0.55	0.55
	Total Suspended Solids	Mean (mg/l)	2.2	2.2	2.2	2.2	2.2	2.2
		Median (mg/l)	2.2	2.2	2.2	2.2	2.2	2.2
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100

[a]*Alternatives B1 and B2 assume full implementation of measures aimed at addressing agricultural runoff as set forth in* Wisconsin Administrative Code *Chapter NR 151. Alternatives C1 and C2 only assume a level of control that would be expected based on current levels of cost-share funding for such measures. As a result, nonpoint source loads under Alternatives C1 and C2 may, in some cases, be higher than under Alternatives B1 and B2.*

Source: HydroQual, Inc., and SEWRPC.

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Appendix K (revised)

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS

[NOTE: These page numbers match those in PR No. 50.]

Table K-1

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: KINNICKINNIC RIVER WATERSHED

			Alternative				
Water Quality Parameter	Water Quality Indicator	Statistic[a]	A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	68	68	68	70	70
		Median	75	75	75	76	76
		Minimum	52	52	52	56	56
		Maximum	80	80	80	80	80
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	191	192	191	206	206
		Median	250	256	254	262	262
		Minimum	49	49	49	69	69
		Maximum	317	317	317	322	322
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	80	80	80	84	84
		Median	86	86	86	88	88
		Minimum	68	68	68	76	76
		Maximum	89	89	89	90	90
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	104	105	105	113	113
		Median	140	145	144	146	146
		Minimum	34	34	34	48	48
		Maximum	153	153	153	153	153
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	100	100	100	100	100
		Median	100	100	100	100	100
		Minimum	100	100	100	100	100
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	26	26	26	27	27
		Median	24	24	24	28	28
		Minimum	14	14	14	14	14
		Maximum	33	33	33	34	34

Indicates Revision

[a]*Based on estimates of compliance at five individual assessment points as presented in Appendix J (revised).*

Source: Tetra Tech, Inc., and SEWRPC.

Table K-2

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: MENOMONEE RIVER WATERSHED

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	63	63	63	64	64
		Median	63	63	63	64	65
		Minimum	49	49	49	50	50
		Maximum	73	73	73	74	74
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	174	177	177	189	189
		Median	205	206	206	217	217
		Minimum	38	39	39	49	49
		Maximum	270	270	270	277	278
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	79	79	79	80	80
		Median	81	81	81	82	82
		Minimum	68	68	68	69	69
		Maximum	86	86	86	88	88
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	108	110	110	116	116
		Median	137	138	138	141	141
		Minimum	26	27	27	34	34
		Maximum	152	152	152	153	153
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	99	99	99	99	99
		Median	99	99	99	99	99
		Minimum	98	98	98	96	98
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	64	64	64	66	65
		Median	67	67	67	68	68
		Minimum	45	46	46	46	46
		Maximum	80	80	80	81	81

Indicates Revision

[a]*Based upon estimates of compliance at nine individual assessment points as presented in Appendix J (revised).*

Source: Tetra Tech, Inc., and SEWRPC.

Table K-3

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: MILWAUKEE RIVER WATERSHED

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	39	39	39	40	42
		Median	46	46	46	47	48
		Minimum	1	1	1	1	2
		Maximum	79	79	79	82	82
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	99	99	99	101	105
		Median	95	95	95	99	108
		Minimum	0	0	0	0	0
		Maximum	255	256	256	266	269
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	62	62	62	63	65
		Median	76	76	76	77	78
		Minimum	3	3	3	3	4
		Maximum	93	93	93	94	94
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	73	73	73	74	77
		Median	84	84	84	87	94
		Minimum	0	0	0	0	0
		Maximum	149	149	149	150	151
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	99	99	99	99	99
		Median	100	100	100	100	100
		Minimum	95	96	96	96	94
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	49	51	51	50	49
		Median	39	40	40	39	37
		Minimum	22	24	24	24	21
		Maximum	84	88	88	86	86

[a]*Based on estimates of compliance at 11 individual assessment points as presented in Appendix J (revised).*

Source: Tetra Tech, Inc., and SEWRPC.

Table K-4

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: OAK CREEK WATERSHED

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	51	51	51	53	52
		Median	54	54	54	55	54
		Minimum	23	24	24	28	28
		Maximum	64	64	64	65	65
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	37	37	37	43	43
		Median	22	22	22	26	26
		Minimum	2	2	2	3	3
		Maximum	86	87	87	97	97
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	70	70	70	71	71
		Median	72	72	72	73	73
		Minimum	41	41	41	47	46
		Maximum	82	82	82	83	82
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	28	28	28	32	32
		Median	18	18	18	22	22
		Minimum	0	0	0	0	0
		Maximum	70	70	70	79	79
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	84	84	84	85	85
		Median	80	80	80	80	80
		Minimum	72	72	72	72	72
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	78	78	78	79	79
		Median	79	79	79	80	80
		Minimum	73	73	73	75	75
		Maximum	82	82	82	83	83

Indicates Revision

[a]*Based on estimates of compliance at nine individual assessment points as presented in Appendix J (revised).*

Source: Tetra Tech, Inc. and SEWRPC.

Table K-5

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: ROOT RIVER WATERSHED

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	59	59	59	60	60
		Median	61	61	61	62	62
		Minimum	45	46	46	48	48
		Maximum	71	71	71	72	72
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	51	53	53	70	69
		Median	39	40	40	50	50
		Minimum	9	9	9	11	11
		Maximum	149	151	151	194	190
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	70	70	70	71	72
		Median	71	71	71	72	73
		Minimum	57	57	57	60	60
		Maximum	81	81	81	82	82
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	28	29	29	40	40
		Median	18	19	19	28	28
		Minimum	4	5	5	6	6
		Maximum	83	84	84	109	106
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	97	97	97	97	97
		Median	99	99	99	99	99
		Minimum	88	88	88	88	88
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	74	73	73	75	75
		Median	72	74	74	76	76
		Minimum	49	49	49	50	49
		Maximum	88	88	88	88	88

Indicates Revision

[a]*Based on estimates of compliance at 12 different assessment points as presented in Appendix J (revised).*

Source: Tetra Tech, Inc. and SEWRPC.

Table K-6

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: NEARSHORE LAKE MICHIGAN AREA

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	95	96	96	97	97
		Median	98	99	99	99	99
		Minimum	59	67	67	70	70
		Maximum	100	100	100	100	100
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	347	352	352	352	352
		Median	364	365	365	364	364
		Minimum	212	239	239	242	242
		Maximum	365	365	365	365	365
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	98	99	99	99	99
		Median	99	99	99	99	99
		Minimum	85	89	89	92	92
		Maximum	100	100	100	100	100
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	152	153	153	153	153
		Median	153	153	153	153	153
		Minimum	142	150	150	151	151
		Maximum	153	153	153	153	153
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	100	100	100	100	100
		Median	100	100	100	100	100
		Minimum	99	99	99	99	99
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	97	97	97	97	97
		Median	100	100	100	100	100
		Minimum	79	79	79	79	81
		Maximum	100	100	100	100	100

[a]*Based on estimates of compliance at 18 individual assessment points as presented in Appendix J (revised).*

Source: Brown and Caldwell, Inc.; HydroQual, Inc.; and SEWRPC.

Table K-7

WATER QUALITY STANDARD COMPLIANCE SUMMARY STATISTICS FOR ALTERNATIVE WATER QUALITY MANAGEMENT PLANS: OVERALL

Water Quality Parameter	Water Quality Indicator	Statistic[a]	Alternative				
			A Original 2020 Baseline	B1	B2	C1	C2
Fecal Coliform Bacteria (annual)	Percent compliance with applicable single sample standard	Mean	66	66	66	67	67
		Median	64	64	64	65	65
		Minimum	1	1	1	1	2
		Maximum	100	100	100	100	100
	Days of compliance with applicable geometric mean standard (365 maximum)	Mean	169	171	171	178	179
		Median	147	148	148	156	159
		Minimum	0	0	0	0	0
		Maximum	365	365	365	365	365
Fecal Coliform Bacteria (May-September: 153 days total)	Percent compliance with applicable single sample standard	Mean	78	79	79	80	80
		Median	80	80	80	81	82
		Minimum	3	3	3	3	4
		Maximum	100	100	100	100	100
	Days of compliance with applicable geometric mean standard (153 maximum)	Mean	88	89	88	93	93
		Median	97	97	97	111	111
		Minimum	0	0	0	0	0
		Maximum	153	153	153	153	153
Dissolved Oxygen	Percent compliance with applicable dissolved oxygen standard	Mean	97	97	97	97	97
		Median	100	100	100	100	100
		Minimum	72	72	72	72	72
		Maximum	100	100	100	100	100
Total Phosphorus	Percent compliance with recommended phosphorus standard	Mean	71	727	72	72	72
		Median	78	78	78	8378	78
		Minimum	14	14	14	2414	14
		Maximum	100	100	100	100	100

Indicates Revision

[a]*Based upon estimates of compliance at 64 individual assessment points as presented in Appendix J (revised).*

Source: Brown and Caldwell; HydroQual, Inc.; Tetra Tech, Inc.; and SEWRPC.

Appendix N (revised)

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN

[NOTE: These page numbers match those in PR No. 50.]

Table N-1

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: KINNICKINNIC RIVER WATERSHED[a]

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan[c]	Condition: "Extreme Measures" Condition[c]
KK-1 Lyons Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,659	4,770	4,770	3,184	1,632
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	80	81	81	82	85
		Geometric mean (cells per 100 ml)	492	416	416	278	143
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	296	309	309	331	353
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,660	2,255	2,255	1,522	807
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	90	90	90	92	93
		Geometric mean (cells per 100 ml)	361	308	308	205	106
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	150	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	6.6	6.7	6.7	6.6	6.6
		Median (mg/l)	6.3	6.3	6.3	6.3	6.3
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.075	0.068	0.068	0.067	0.064
		Median (mg/l)	0.036	0.034	0.034	0.034	0.033
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	85	86	86	86	87
	Total Nitrogen	Mean (mg/l)	1.14	1.03	1.03	1.03	1.03
		Median (mg/l)	1.17	1.06	1.06	1.06	1.06
	Total Suspended Solids	Mean (mg/l)	8.5	6.8	6.8	6.8	6.8
		Median (mg/l)	5.0	3.9	3.9	4.0	4.0
	Copper	Mean (mg/l)	0.0036	0.0030	0.0030	0.0030	0.0030
		Median (mg/l)	0.0013	0.0011	0.0011	0.0011	0.0011

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-2 S. 43rd Street Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,080	3,402	3,402	2,280	1,177
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	82	81	81	84	87
		Geometric mean (cells per 100 ml)	227	197	197	132	68
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	325	334	334	347	359
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,047	1,770	1,770	1,201	650
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	91	90	90	92	94
		Geometric mean (cells per 100 ml)	153	138	138	92	47
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	9.5	9.6	9.6	9.6	9.2
		Median (mg/l)	9.4	9.4	9.4	9.4	8.8
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.347	0.338	0.338	0.338	0.083
		Median (mg/l)	0.346	0.337	0.337	0.336	0.060
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	2	2	2	2	85
	Total Nitrogen	Mean (mg/l)	1.63	1.56	1.56	1.56	1.55
		Median (mg/l)	1.61	1.54	1.54	1.54	1.53
	Total Suspended Solids	Mean (mg/l)	9.2	7.5	7.5	8.0	8.0
		Median (mg/l)	3.8	3.4	3.4	3.4	3.4
	Copper	Mean (mg/l)	0.0033	0.0026	0.0026	0.0026	0.0026
		Median (mg/l)	0.0007	0.0006	0.0006	0.0006	0.0006

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-3 Kinnickinnic River Upstream of Confluence with Wilson Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,373	4,514	4,510	3,011	1,542
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	79	80	80	82	85
		Geometric mean (cells per 100 ml)	371	318	318	214	110
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	305	317	317	335	355
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,747	2,356	2,347	1,578	830
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	89	89	89	91	93
		Geometric mean (cells per 100 ml)	260	228	228	152	79
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	152	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	9.4	9.4	9.4	9.4	9.3
		Median (mg/l)	8.8	8.8	8.8	8.8	8.5
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.222	0.213	0.213	0.212	0.076
		Median (mg/l)	0.206	0.199	0.199	0.198	0.048
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	13	14	14	15	85
	Total Nitrogen	Mean (mg/l)	1.39	1.30	1.30	1.30	1.30
		Median (mg/l)	1.36	1.27	1.27	1.27	1.29
	Total Suspended Solids	Mean (mg/l)	10.6	8.5	8.5	8.7	8.7
		Median (mg/l)	4.2	3.5	3.5	3.5	3.5
	Copper	Mean (mg/l)	0.0037	0.0030	0.0030	0.0030	0.0030
		Median (mg/l)	0.001	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-4 Wilson Creek Upstream of Holmes Avenue Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,897	3,249	3,247	2,091	1,063
		Percent compliance with single sample standard (<400 cells per 100 ml)	52	53	53	58	66
		Geometric mean (cells per 100 ml)	609	517	517	330	169
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	54	72	72	126	219
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,179	1,781	1,775	1,024	523
		Percent compliance with single sample standard (<400 cells per 100 ml)	67	68	68	75	81
		Geometric mean (cells per 100 ml)	313	259	258	155	79
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	36	46	46	80	133
	Dissolved Oxygen	Mean (mg/l)	7.5	7.6	7.6	7.6	7.6
		Median (mg/l)	7.3	7.3	7.3	7.3	7.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.222	0.218	0.218	0.216	0.154
		Median (mg/l)	0.123	0.121	0.121	0.120	0.042
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	35	34	34	35	79
	Total Nitrogen	Mean (mg/l)	1.65	1.56	1.56	1.56	1.56
		Median (mg/l)	0.99	0.89	0.89	0.89	0.89
	Total Suspended Solids	Mean (mg/l)	20.1	15.1	15.1	15.1	15.8
		Median (mg/l)	6.5	5.4	5.4	5.4	5.5
	Copper	Mean (mg/l)	0.0041	0.0035	0.0035	0.0035	0.0035
		Median (mg/l)	0.0019	0.0018	0.0018	0.0017	0.0017

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-5 Holmes Avenue Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,178	4,228	4,228	2,824	1,433
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	71	71	73	77
		Geometric mean (cells per 100 ml)	385	317	317	213	110
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	106	133	133	199	276
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,162	1,790	1,790	1,192	605
		Percent compliance with single sample standard (<400 cells per 100 ml)	86	84	84	85	88
		Geometric mean (cells per 100 ml)	213	179	179	120	62
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	58	73	73	111	150
	Dissolved Oxygen	Mean (mg/l)	9.9	9.9	9.9	9.9	9.9
		Median (mg/l)	9.8	9.8	9.8	9.8	9.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	92	92	92	92	93
	Total Phosphorus	Mean (mg/l)	0.450	0.442	0.442	0.441	0.333
		Median (mg/l)	0.400	0.391	0.391	0.389	0.287
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	2	2	2	2	9
	Total Nitrogen	Mean (mg/l)	2.35	2.26	2.26	2.26	2.25
		Median (mg/l)	2.03	1.93	1.93	1.93	1.93
	Total Suspended Solids	Mean (mg/l)	9.7	7.5	7.5	7.8	7.8
		Median (mg/l)	3.8	3.0	3.0	3.1	3.1
	Copper	Mean (mg/l)	0.0040	0.0033	0.0033	0.0033	0.0033
		Median (mg/l)	0.0009	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-6 Villa Mann Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,565	4,563	4,563	3,041	1,544
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	71	71	73	76
		Geometric mean (cells per 100 ml)	557	462	462	309	158
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	38	59	59	122	258
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,339	1,952	1,952	1,294	657
		Percent compliance with single sample standard (<400 cells per 100 ml)	87	84	84	85	88
		Geometric mean (cells per 100 ml)	346	293	293	196	101
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	19	33	33	68	143
	Dissolved Oxygen	Mean (mg/l)	7.4	7.4	7.4	7.4	7.4
		Median (mg/l)	6.6	6.7	6.7	6.7	6.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	70	71	71	71	71
	Total Phosphorus	Mean (mg/l)	0.085	0.076	0.076	0.075	0.071
		Median (mg/l)	0.041	0.037	0.037	0.037	0.037
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	82	82	83	83
	Total Nitrogen	Mean (mg/l)	1.18	1.05	1.05	1.05	1.05
		Median (mg/l)	1.20	1.07	1.07	1.07	1.07
	Total Suspended Solids	Mean (mg/l)	8.9	6.9	6.9	7.3	7.3
		Median (mg/l)	5.0	3.7	3.7	3.7	3.7
	Copper	Mean (mg/l)	0.0041	0.0034	0.0034	0.0033	0.0033
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-7 Cherokee Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,715	3,950	3,950	2,632	1,337
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	74	74	75	78
		Geometric mean (cells per 100 ml)	453	393	393	265	139
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	47	64	64	137	267
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,187	1,905	1,905	1,260	641
		Percent compliance with single sample standard (<400 cells per 100 ml)	87	84	84	85	87
		Geometric mean (cells per 100 ml)	337	301	301	203	107
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	19	28	28	66	140
	Dissolved Oxygen	Mean (mg/l)	7.3	7.3	7.3	7.3	7.3
		Median (mg/l)	6.5	6.7	6.7	6.7	6.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	71	71	71	71	71
	Total Phosphorus	Mean (mg/l)	0.076	0.069	0.069	0.068	0.065
		Median (mg/l)	0.039	0.036	0.036	0.036	0.036
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	84	84	84	84	85
	Total Nitrogen	Mean (mg/l)	1.12	1.02	1.02	1.02	1.02
		Median (mg/l)	1.01	0.94	0.94	0.93	0.93
	Total Suspended Solids	Mean (mg/l)	7.7	6.3	6.3	6.7	6.7
		Median (mg/l)	5.0	4.0	4.0	4.0	4.0
	Copper	Mean (mg/l)	0.0036	0.0030	0.0030	0.0030	0.0030
		Median (mg/l)	0.0012	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-8 Wilson Park Creek, USGS Gauge	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,124	4,259	4,259	2,794	1,419
		Percent compliance with single sample standard (<400 cells per 100 ml)	56	57	57	63	70
		Geometric mean (cells per 100 ml)	697	596	596	386	198
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	35	49	49	99	214
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,552	2,133	2,132	1,315	669
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	73	73	79	83
		Geometric mean (cells per 100 ml)	357	304	304	189	97
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	26	34	34	63	131
	Dissolved Oxygen	Mean (mg/l)	10.9	10.9	10.9	10.9	10.8
		Median (mg/l)	11.2	11.2	11.2	11.2	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.200	0.193	0.193	0.192	0.141
		Median (mg/l)	0.142	0.138	0.138	0.137	0.079
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	33	33	33	33	66
	Total Nitrogen	Mean (mg/l)	1.48	1.38	1.38	1.38	1.38
		Median (mg/l)	1.16	1.07	1.07	1.06	1.07
	Total Suspended Solids	Mean (mg/l)	14.1	10.8	10.8	11.3	11.3
		Median (mg/l)	4.8	3.7	3.7	3.7	3.7
	Copper	Mean (mg/l)	0.0044	0.0037	0.0037	0.0037	0.0037
		Median (mg/l)	0.0018	0.0016	0.0016	0.0015	0.0015

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-9 Kinnickinnic River Downstream of Wilson Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,785	4,885	4,553	3,028	1,569
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	74	75	75	78	82
		Geometric mean (cells per 100 ml)	654	560	556	363	186
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	254	266	266	297	334
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,360	2,978	2,421	1,579	851
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	87	86	86	89	92
		Geometric mean (cells per 100 ml)	343	295	292	184	95
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	146	148	148	153	153
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.2
		Median (mg/l)	11.4	11.4	11.4	11.4	11.3
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.206	0.198	0.196	0.195	0.112
		Median (mg/l)	0.171	0.164	0.164	0.162	0.066
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	24	25	25	25	74
	Total Nitrogen	Mean (mg/l)	1.40	1.30	1.30	1.30	1.31
		Median (mg/l)	1.22	1.13	1.13	1.13	1.15
	Total Suspended Solids	Mean (mg/l)	14.5	11.4	11.3	11.7	11.7
		Median (mg/l)	4.8	3.8	3.8	3.8	3.8
	Copper	Mean (mg/l)	0.0047	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0019	0.0017	0.0017	0.0017	0.0017

Indicates Revision

Table N-1 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
KK-10 Kinnickinnic River near Upstream Limit of Estuary	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,859	4,942	4,633	3,091	1,613
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	74	75	75	78	82
		Geometric mean (cells per 100 ml)	842	702	686	449	230
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	229	250	256	292	332
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,401	2,999	2,470	1,634	904
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	86	86	86	89	92
		Geometric mean (cells per 100 ml)	498	416	398	253	130
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	131	140	145	152	153
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.3
		Median (mg/l)	11.5	11.5	11.5	11.5	11.4
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.196	0.188	0.187	0.185	0.108
		Median (mg/l)	0.165	0.157	0.157	0.155	0.064
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	27	27	28	28	74
	Total Nitrogen	Mean (mg/l)	1.36	1.27	1.26	1.26	1.27
		Median (mg/l)	1.22	1.12	1.12	1.12	1.14
	Total Suspended Solids	Mean (mg/l)	13.2	10.4	10.4	10.7	10.7
		Median (mg/l)	4.7	3.8	3.8	3.9	3.9
	Copper	Mean (mg/l)	0.0048	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0019	0.0017	0.0017	0.0017	0.0017

Indicates Revision

Table N-1 Footnotes

[a]*In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b]*Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[d]*Variance Standard in Chapter NR 104 of the* Wisconsin Administrative Code.

Source: Tetra Tech, Inc., and SEWRPC.

Table N-2

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: MENOMONEE RIVER WATERSHED[a]

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-1 North Branch Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	701	955	955	726	692
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	78	78	80	80
		Geometric mean (cells per 100 ml)	116	138	138	68	69
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	287	263	263	309	311
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	672	906	906	700	670
		Percent compliance with single sample standard (<400 cells per 100 ml)	89	86	86	87	88
		Geometric mean (cells per 100 ml)	90	104	104	44	44
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	147	138	138	152	152
	Dissolved Oxygen	Mean (mg/l)	9.6	9.6	9.6	9.5	9.5
		Median (mg/l)	9.5	9.5	9.5	9.5	9.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	90	90	90	90	90
	Total Phosphorus	Mean (mg/l)	0.061	0.061	0.061	0.059	0.058
		Median (mg/l)	0.046	0.046	0.046	0.045	0.045
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	92	91	91	92	92
	Total Nitrogen	Mean (mg/l)	2.10	1.96	1.96	1.57	1.48
		Median (mg/l)	1.87	1.75	1.75	1.42	1.34
	Total Suspended Solids	Mean (mg/l)	8.2	7.9	7.9	7.1	7.1
		Median (mg/l)	6.9	6.7	6.7	5.8	5.9
	Copper	Mean (mg/l)	0.0023	0.0022	0.0022	0.0022	0.0022
		Median (mg/l)	0.0013	0.0013	0.0013	0.0012	0.0012

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	“Extreme Measures” Condition[c]
MN-2 Upper Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	797	1,031	1,031	832	787
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	71	71	73	74
		Geometric mean (cells per 100 ml)	124	152	152	100	96
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	262	238	238	269	271
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	602	741	741	502	477
		Percent compliance with single sample standard (<400 cells per 100 ml)	86	82	82	85	85
		Geometric mean (cells per 100 ml)	79	93	93	53	51
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	144	137	137	147	148
	Dissolved Oxygen	Mean (mg/l)	9.3	9.4	9.4	9.3	9.2
		Median (mg/l)	9.1	9.1	9.1	9.1	9.0
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	99
	Total Phosphorus	Mean (mg/l)	0.143	0.147	0.147	0.146	0.058
		Median (mg/l)	0.111	0.113	0.113	0.111	0.046
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	46	45	45	46	91
	Total Nitrogen	Mean (mg/l)	1.47	1.36	1.36	1.16	1.11
		Median (mg/l)	1.35	1.27	1.27	1.10	1.06
	Total Suspended Solids	Mean (mg/l)	7.9	7.8	7.8	7.4	7.4
		Median (mg/l)	5.7	5.6	5.6	5.1	5.1
	Copper	Mean (mg/l)	0.0024	0.0024	0.0024	0.0024	0.0024
		Median (mg/l)	0.0012	0.0011	0.0011	0.0011	0.0011

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-3 West Branch Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,167	1,526	1,526	1,161	1,096
		Percent compliance with single sample standard (<400 cells per 100 ml)	77	74	74	76	76
		Geometric mean (cells per 100 ml)	159	185	185	127	119
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	250	231	231	262	266
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	712	1,021	1,021	612	580
		Percent compliance with single sample standard (<400 cells per 100 ml)	90	86	86	87	87
		Geometric mean (cells per 100 ml)	101	117	117	70	66
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	144	133	133	147	148
	Dissolved Oxygen	Mean (mg/l)	9.4	9.4	9.4	9.4	9.4
		Median (mg/l)	9.5	9.4	9.4	9.4	9.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	91	91	91	91	91
	Total Phosphorus	Mean (mg/l)	0.073	0.075	0.075	0.072	0.070
		Median (mg/l)	0.048	0.048	0.048	0.047	0.046
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	87	86	86	87	87
	Total Nitrogen	Mean (mg/l)	1.77	1.51	1.51	1.29	1.20
		Median (mg/l)	1.59	1.36	1.36	1.17	1.09
	Total Suspended Solids	Mean (mg/l)	10.6	10.0	10.0	10.0	10.0
		Median (mg/l)	8.1	7.8	7.8	7.2	7.2
	Copper	Mean (mg/l)	0.0035	0.0036	0.0036	0.0036	0.0036
		Median (mg/l)	0.0013	0.0012	0.0012	0.0012	0.0012

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-4 Willow Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,244	1,415	1,415	1,196	1,180
		Percent compliance with single sample standard (<400 cells per 100 ml)	76	74	74	75	75
		Geometric mean (cells per 100 ml)	183	200	200	161	160
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	218	206	206	233	234
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	794	872	872	607	601
		Percent compliance with single sample standard (<400 cells per 100 ml)	87	86	86	86	86
		Geometric mean (cells per 100 ml)	125	134	134	99	98
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	125	121	121	136	136
	Dissolved Oxygen	Mean (mg/l)	8.9	8.9	8.9	8.9	8.9
		Median (mg/l)	9.1	9.1	9.1	9.1	9.1
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	94	94	94	94
	Total Phosphorus	Mean (mg/l)	0.052	0.056	0.056	0.055	0.054
		Median (mg/l)	0.032	0.032	0.032	0.032	0.031
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	90	88	88	88	89
	Total Nitrogen	Mean (mg/l)	1.30	1.12	1.12	1.02	0.99
		Median (mg/l)	1.18	1.03	1.03	0.92	0.90
	Total Suspended Solids	Mean (mg/l)	9.1	8.7	8.7	8.8	8.8
		Median (mg/l)	7.3	7.0	7.0	6.7	6.7
	Copper	Mean (mg/l)	0.0030	0.0030	0.0030	0.0030	0.0030
		Median (mg/l)	0.0012	0.0012	0.0012	0.0012	0.0012

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-5 Menomonee River at Washington-Waukesha County Line	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,417	1,649	1,649	1,362	1,314
		Percent compliance with single sample standard (<400 cells per 100 ml)	68	65	65	67	67
		Geometric mean (cells per 100 ml)	205	234	234	180	174
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	202	185	185	214	217
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	890	995	995	657	635
		Percent compliance with single sample standard (<400 cells per 100 ml)	82	79	79	81	82
		Geometric mean (cells per 100 ml)	105	117	117	79	77
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	125	116	116	134	135
	Dissolved Oxygen	Mean (mg/l)	10.5	10.5	10.5	10.5	10.4
		Median (mg/l)	10.7	10.7	10.7	10.7	10.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.097	0.105	0.105	0.102	0.064
		Median (mg/l)	0.063	0.066	0.066	0.065	0.033
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	70	68	68	69	84
	Total Nitrogen	Mean (mg/l)	1.23	1.09	1.09	0.97	0.96
		Median (mg/l)	1.11	0.98	0.98	0.87	0.87
	Total Suspended Solids	Mean (mg/l)	10.2	9.9	9.9	9.7	9.7
		Median (mg/l)	6	5.8	5.8	5.5	5.5
	Copper	Mean (mg/l)	0.0041	0.0043	0.0043	0.0042	0.0042
		Median (mg/l)	0.0016	0.0016	0.0016	0.0016	0.0016

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-6 Nor-X-Way Channel	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,261	3,510	3,510	2,124	1,075
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	70	70	72	75
		Geometric mean (cells per 100 ml)	208	187	187	118	69
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	200	212	212	250	284
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,962	1,893	1,893	875	444
		Percent compliance with single sample standard (<400 cells per 100 ml)	83	81	81	83	86
		Geometric mean (cells per 100 ml)	113	92	92	54	32
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	114	122	122	141	149
	Dissolved Oxygen	Mean (mg/l)	10.0	9.9	9.9	9.9	9.7
		Median (mg/l)	9.9	9.7	9.7	9.7	9.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.172	0.190	0.190	0.188	0.071
		Median (mg/l)	0.125	0.136	0.136	0.134	0.037
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	43	38	38	39	84
	Total Nitrogen	Mean (mg/l)	1.34	0.91	0.91	0.88	0.88
		Median (mg/l)	1.17	0.77	0.77	0.74	0.75
	Total Suspended Solids	Mean (mg/l)	16.0	10.8	10.8	10.6	10.6
		Median (mg/l)	4.3	3.2	3.2	3.1	3.1
	Copper	Mean (mg/l)	0.0037	0.0036	0.0036	0.0035	0.0035
		Median (mg/l)	0.0011	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-7 Lilly Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,427	2,045	2,045	1,211	617
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	69	69	72	76
		Geometric mean (cells per 100 ml)	359	290	290	190	103
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	89	122	122	210	285
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,416	1,179	1,179	547	282
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	80	80	84	87
		Geometric mean (cells per 100 ml)	265	212	212	132	72
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	38	53	53	115	151
	Dissolved Oxygen	Mean (mg/l)	9.3	9.2	9.2	9.2	9.2
		Median (mg/l)	9.3	9.2	9.2	9.2	9.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	92	92	92	92	92
	Total Phosphorus	Mean (mg/l)	0.092	0.080	0.080	0.079	0.078
		Median (mg/l)	0.048	0.043	0.043	0.043	0.043
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	80	81	81	81	82
	Total Nitrogen	Mean (mg/l)	1.34	0.97	0.97	0.97	0.97
		Median (mg/l)	1.20	0.86	0.86	0.86	0.86
	Total Suspended Solids	Mean (mg/l)	19.0	12.7	12.7	12.9	12.9
		Median (mg/l)	7.9	5.1	5.1	5.2	5.2
	Copper	Mean (mg/l)	0.0051	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-8 Butler Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,425	2,022	2,022	1,297	677
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	65	65	68	74
		Geometric mean (cells per 100 ml)	424	345	345	228	119
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	82	109	109	178	269
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,325	1,126	1,126	700	390
		Percent compliance with single sample standard (<400 cells per 100 ml)	79	79	79	82	86
		Geometric mean (cells per 100 ml)	286	233	233	152	80
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	31	46	46	98	150
	Dissolved Oxygen	Mean (mg/l)	9.6	9.6	9.6	9.6	9.6
		Median (mg/l)	9.3	9.3	9.3	9.3	9.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	93	93	93	93	93
	Total Phosphorus	Mean (mg/l)	0.094	0.081	0.081	0.080	0.077
		Median (mg/l)	0.051	0.045	0.045	0.046	0.045
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	81	81	81	82
	Total Nitrogen	Mean (mg/l)	1.18	1.01	1.01	1.02	1.02
		Median (mg/l)	1.10	0.95	0.95	0.96	0.96
	Total Suspended Solids	Mean (mg/l)	17.5	12.3	12.3	12.6	12.6
		Median (mg/l)	7.9	5.5	5.5	5.6	5.6
	Copper	Mean (mg/l)	0.0046	0.0035	0.0035	0.0035	0.0035
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-9 Menomonee River Down-stream of Butler Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,828	2,739	2,739	1,865	1,262
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	56	56	59	62
		Geometric mean (cells per 100 ml)	489	477	477	329	231
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	72	83	83	149	191
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,571	1,451	1,451	783	497
		Percent compliance with single sample standard (<400 cells per 100 ml)	76	74	74	78	80
		Geometric mean (cells per 100 ml)	229	212	212	131	88
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	51	61	61	113	136
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	11	11.0	11.0	11.0	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.101	0.101	0.101	0.098	0.067
		Median (mg/l)	0.061	0.064	0.064	0.063	0.029
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	69	67	67	68	80
	Total Nitrogen	Mean (mg/l)	1.10	0.93	0.93	0.86	0.88
		Median (mg/l)	1.01	0.87	0.87	0.80	0.82
	Total Suspended Solids	Mean (mg/l)	15.7	12.9	12.9	12.9	12.9
		Median (mg/l)	6	5.1	5.1	5.0	5.0
	Copper	Mean (mg/l)	0.0052	0.0048	0.0048	0.0047	0.0047
		Median (mg/l)	0.0019	0.0019	0.0019	0.0019	0.0019

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-10 Little Menomonee Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,970	4,101	4,101	4,075	4,091
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	58	58	59	59
		Geometric mean (cells per 100 ml)	438	379	379	278	287
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	91	117	117	163	158
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,710	3,000	3,000	2,998	3,022
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	74	74	74	74
		Geometric mean (cells per 100 ml)	201	173	173	110	115
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	62	80	80	108	106
	Dissolved Oxygen	Mean (mg/l)	9.2	9.2	9.2	9.2	9.2
		Median (mg/l)	9.2	9.2	9.2	9.2	9.2
		Percent compliance with recommended dissolved oxygen standard (>5 mg/l)	97	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.082	0.075	0.075	0.072	0.071
		Median (mg/l)	0.055	0.053	0.053	0.052	0.051
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	81	84	84	84	85
	Total Nitrogen	Mean (mg/l)	1.79	1.56	1.56	1.32	1.28
		Median (mg/l)	1.59	1.39	1.39	1.19	1.15
	Total Suspended Solids	Mean (mg/l)	24.6	19.6	19.6	18.1	17.8
		Median (mg/l)	10.8	9.9	9.9	9.0	9.0
	Copper	Mean (mg/l)	0.0031	0.0026	0.0026	0.0026	0.0025
		Median (mg/l)	0.0014	0.0012	0.0012	0.0012	0.0012

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-11 Little Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,777	6,485	6,485	6,053	6,045
		Percent compliance with single sample standard (<400 cells per 100 ml)	53	54	54	54	54
		Geometric mean (cells per 100 ml)	700	591	591	520	521
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	68	83	83	96	96
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,477	3,677	3,677	2,704	2,705
		Percent compliance with single sample standard (<400 cells per 100 ml)	70	70	70	71	71
		Geometric mean (cells per 100 ml)	261	216	216	171	172
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	48	60	60	69	69
	Dissolved Oxygen	Mean (mg/l)	10.4	10.4	10.4	10.4	10.3
		Median (mg/l)	10.5	10.6	10.6	10.6	10.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	97
	Total Phosphorus	Mean (mg/l)	0.111	0.104	0.104	0.103	0.072
		Median (mg/l)	0.072	0.069	0.069	0.068	0.045
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	68	70	70	70	80
	Total Nitrogen	Mean (mg/l)	1.24	1.01	1.01	0.95	0.99
		Median (mg/l)	1.15	0.93	0.93	0.88	0.91
	Total Suspended Solids	Mean (mg/l)	13.2	9.8	9.8	9.7	9.7
		Median (mg/l)	4.6	3.4	3.4	3.3	3.4
	Copper	Mean (mg/l)	0.005	0.0041	0.0041	0.0040	0.0040
		Median (mg/l)	0.0017	0.0014	0.0014	0.0014	0.0014

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-12 Menomonee River Down-stream of Little Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,366	3,947	3,947	3,237	2,836
		Percent compliance with single sample standard (<400 cells per 100 ml)	50	50	50	52	53
		Geometric mean (cells per 100 ml)	795	731	731	554	448
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	31	39	39	80	115
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,175	1,928	1,928	1,220	1,052
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	69	69	72	73
		Geometric mean (cells per 100 ml)	348	308	308	205	157
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	21	27	27	60	88
	Dissolved Oxygen	Mean (mg/l)	10.7	10.7	10.7	10.7	10.6
		Median (mg/l)	10.9	10.9	10.9	10.9	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.1	0.098	0.098	0.096	0.067
		Median (mg/l)	0.061	0.063	0.063	0.062	0.034
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	69	69	69	69	80
	Total Nitrogen	Mean (mg/l)	1.09	0.91	0.91	0.85	0.88
		Median (mg/l)	1.02	0.86	0.86	0.80	0.83
	Total Suspended Solids	Mean (mg/l)	13.4	10.9	10.9	10.8	10.8
		Median (mg/l)	5.2	4.4	4.4	4.2	4.3
	Copper	Mean (mg/l)	0.0054	0.0048	0.0048	0.0048	0.0048
		Median (mg/l)	0.0021	0.0020	0.0020	0.0020	0.0020

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-13 Underwood Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9,075	7,347	7,347	4,845	2,467
		Percent compliance with single sample standard (<400 cells per 100 ml)	61	62	62	64	67
		Geometric mean (cells per 100 ml)	789	627	627	422	225
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	44	69	69	119	194
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,377	3,545	3,545	2,210	1,134
		Percent compliance with single sample standard (<400 cells per 100 ml)	77	78	78	80	83
		Geometric mean (cells per 100 ml)	404	322	322	212	114
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	30	30	66	116
	Dissolved Oxygen	Mean (mg/l)	10.1	10.1	10.1	10.1	10.0
		Median (mg/l)	9.8	9.8	9.8	9.8	9.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.095	0.083	0.083	0.082	0.079
		Median (mg/l)	0.063	0.056	0.056	0.056	0.054
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	75	79	79	79	81
	Total Nitrogen	Mean (mg/l)	1.19	1.02	1.02	1.02	1.02
		Median (mg/l)	1.14	0.97	0.97	0.97	0.97
	Total Suspended Solids	Mean (mg/l)	17.2	12.6	12.6	12.8	12.8
		Median (mg/l)	7.6	5.5	5.5	5.6	5.6
	Copper	Mean (mg/l)	0.0048	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-14 Underwood Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	8,133	6,588	6,588	4,250	2,166
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	71	71	71	74	79
		Geometric mean (cells per 100 ml)	691	552	552	369	195
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	247	261	261	282	309
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,964	2,460	2,460	1,332	692
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	86	86	86	89	92
		Geometric mean (cells per 100 ml)	351	279	279	180	96
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	147	151	151	153	153
	Dissolved Oxygen	Mean (mg/l)	11.0	11.1	11.1	11.1	11.1
		Median (mg/l)	11.1	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.096	0.083	0.083	0.082	0.076
		Median (mg/l)	0.061	0.055	0.055	0.055	0.050
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	77	80	80	80	82
	Total Nitrogen	Mean (mg/l)	1.17	1.00	1.00	1.00	1.00
		Median (mg/l)	1.11	0.95	0.95	0.95	0.95
	Total Suspended Solids	Mean (mg/l)	16.8	12.4	12.4	12.7	12.7
		Median (mg/l)	7.9	5.8	5.8	5.8	5.8
	Copper	Mean (mg/l)	0.0048	0.0037	0.0037	0.0037	0.0037
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-15 Menomonee Mainstem	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,137	5,198	5,198	3,820	2,583
		Percent compliance with single sample standard (<400 cells per 100 ml)	47	47	47	50	52
		Geometric mean (cells per 100 ml)	1,063	930	930	677	469
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	12	21	21	53	107
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,064	2,531	2,531	1,538	946
		Percent compliance with single sample standard (<400 cells per 100 ml)	67	67	67	70	73
		Geometric mean (cells per 100 ml)	476	399	399	263	172
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	12	12	36	80
	Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.8
		Median (mg/l)	11.1	11.0	11.0	11.0	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.102	0.098	0.098	0.096	0.077
		Median (mg/l)	0.063	0.065	0.065	0.064	0.042
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	69	69	69	70	78
	Total Nitrogen	Mean (mg/l)	1.12	0.95	0.95	0.91	0.93
		Median (mg/l)	1.06	0.90	0.90	0.86	0.87
	Total Suspended Solids	Mean (mg/l)	15.6	12.5	12.5	12.5	12.5
		Median (mg/l)	5.6	4.7	4.7	4.6	4.6
	Copper	Mean (mg/l)	0.0057	0.0050	0.0050	0.0049	0.0049
		Median (mg/l)	0.0023	0.0022	0.0022	0.0022	0.0022

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-16 Honey Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9,286	7,761	7,761	4,864	2,156
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	72	73	73	75	81
		Geometric mean (cells per 100 ml)	612	512	512	338	162
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	259	270	270	294	325
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,073	3,413	3,413	1,882	801
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	86	87	87	88	92
		Geometric mean (cells per 100 ml)	325	273	273	178	86
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	148	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0
		Median (mg/l)	10.7	10.6	10.6	10.6	10.6
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	97	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.118	0.110	0.110	0.109	0.106
		Median (mg/l)	0.084	0.080	0.080	0.080	0.079
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	64	67	67	67	68
	Total Nitrogen	Mean (mg/l)	1.28	1.17	1.17	1.18	1.18
		Median (mg/l)	1.22	1.11	1.11	1.12	1.12
	Total Suspended Solids	Mean (mg/l)	14.4	11.2	11.2	11.5	11.5
		Median (mg/l)	7.2	5.7	5.7	5.7	5.7
	Copper	Mean (mg/l)	0.0046	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0016	0.0014	0.0014	0.0014	0.0014

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-17 Menomonee River Down-stream of Honey Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,926	5,903	5,863	4,198	2,657
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	63	63	63	66	70
		Geometric mean (cells per 100 ml)	1,124	981	978	704	471
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	196	207	207	230	252
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,622	3,064	2,985	1,833	1,100
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	81	81	81	84	87
		Geometric mean (cells per 100 ml)	496	415	412	271	173
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	130	138	138	147	151
	Dissolved Oxygen	Mean (mg/l)	11.1	10.9	10.9	10.9	10.9
		Median (mg/l)	11.1	11.0	11.0	11.0	10.9
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.111	0.107	0.106	0.105	0.082
		Median (mg/l)	0.074	0.076	0.076	0.075	0.048
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	66	66	66	67	77
	Total Nitrogen	Mean (mg/l)	1.14	0.98	0.98	0.94	0.96
		Median (mg/l)	1.08	0.93	0.93	0.90	0.91
	Total Suspended Solids	Mean (mg/l)	16.3	13.2	13.2	13.2	13.2
		Median (mg/l)	6.0	4.9	4.9	4.9	4.9
	Copper	Mean (mg/l)	0.0057	0.0050	0.0050	0.0049	0.0049
		Median (mg/l)	0.0024	0.0022	0.0022	0.0022	0.0022

Indicates Revision

Table N-2 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
MN-18 Menomonee River near Upstream Limit of Estuary	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,889	5,945	5,907	4,214	2,552
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	64	63	63	66	70
		Geometric mean (cells per 100 ml)	1,081	955	952	685	449
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	200	209	209	232	254
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,557	3,073	2,998	1,861	1,052
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	81	81	81	85	88
		Geometric mean (cells per 100 ml)	468	399	396	261	163
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	133	138	138	147	151
	Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.9
		Median (mg/l)	11.0	10.9	11.0	10.9	10.9
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.133	0.129	0.129	0.127	0.102
		Median (mg/l)	0.104	0.105	0.105	0.103	0.076
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	52	51	51	52	68
	Total Nitrogen	Mean (mg/l)	1.26	1.11	1.11	1.07	1.09
		Median (mg/l)	1.20	1.07	1.07	1.03	1.04
	Total Suspended Solids	Mean (mg/l)	16	13.1	13.1	13.1	13.1
		Median (mg/l)	5.5	4.8	4.8	4.7	4.7
	Copper	Mean (mg/l)	0.0056	0.0049	0.0049	0.0048	0.0048
		Median (mg/l)	0.0023	0.0022	0.0022	0.0022	0.0022

Indicates Revision

Table N-2 Footnotes

[a]*In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b]*Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[d]*Variance Standard in Chapter NR 104 of the* Wisconsin Administrative Code.

Source: Tetra Tech, Inc., and SEWRPC.

Table N-3

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: MILWAUKEE RIVER WATERSHED[a]

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-1 Kettle Moraine Lake	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,342	1,521	1,521	1,110	1,103
		Percent compliance with single sample standard (<400 cells per 100 ml)	22	21	21	68	68
		Geometric mean (cells per 100 ml)	742	781	781	164	159
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	5	4	4	206	207
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,036	1,231	1,231	787	785
		Percent compliance with single sample standard (<400 cells per 100 ml)	30	28	28	86	86
		Geometric mean (cells per 100 ml)	578	614	614	65	62
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	5	4	4	138	138
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.4	11.4	11.4	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.082	0.080	0.080	0.059	0.059
		Median (mg/l)	0.068	0.066	0.066	0.049	0.050
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	83	84	84	91	91
	Total Nitrogen	Mean (mg/l)	2.11	2.09	2.09	0.80	0.76
		Median (mg/l)	2.07	2.06	2.06	0.76	0.73
	Total Suspended Solids	Mean (mg/l)	9.1	8.9	8.9	6.3	6.4
		Median (mg/l)	4.3	4.2	4.2	2.7	2.8
	Copper	Mean (mg/l)	0.0034	0.0034	0.0034	0.0027	0.0028
		Median (mg/l)	0.0031	0.0031	0.0031	0.0024	0.0024

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-2 Auburn Lake Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,963	4,558	4,558	3,855	3,811
		Percent compliance with single sample standard (<400 cells per 100 ml)	6	5	5	58	59
		Geometric mean (cells per 100 ml)	1,676	1,811	1,811	472	457
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	78	86
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,026	3,704	3,704	2,822	2,798
		Percent compliance with single sample standard (<400 cells per 100 ml)	4	3	3	74	74
		Geometric mean (cells per 100 ml)	1,428	1,582	1,582	286	276
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	42	48
	Dissolved Oxygen	Mean (mg/l)	10.9	10.9	10.9	10.9	11.0
		Median (mg/l)	11.0	11.0	11.0	11.0	11.0
		Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.046	0.045	0.045	0.044	0.043
		Median (mg/l)	0.015	0.015	0.015	0.014	0.014
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	87	87	87	87	87
	Total Nitrogen	Mean (mg/l)	1.08	1.08	1.08	0.81	0.78
		Median (mg/l)	1.04	1.04	1.04	0.76	0.73
	Total Suspended Solids	Mean (mg/l)	12.2	12.1	12.1	11.2	11.1
		Median (mg/l)	5.4	5.4	5.4	4.6	4.6
	Copper	Mean (mg/l)	0.0028	0.0028	0.0028	0.0026	0.0027
		Median (mg/l)	0.0016	0.0016	0.0016	0.0014	0.0014

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-3 Lake Fifteen Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,334	2,367	2,367	1,932	1,902
		Percent compliance with single sample standard (<400 cells per 100 ml)	14	14	14	65	65
		Geometric mean (cells per 100 ml)	1,021	1,035	1,035	326	316
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	1	1	1	136	143
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,887	1,924	1,924	1,407	1,390
		Percent compliance with single sample standard (<400 cells per 100 ml)	15	14	14	80	80
		Geometric mean (cells per 100 ml)	840	859	859	184	176
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	1	1	1	97	102
	Dissolved Oxygen	Mean (mg/l)	11.1	11.2	11.2	11.2	11.2
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.075	0.075	0.075	0.071	0.070
		Median (mg/l)	0.057	0.057	0.057	0.053	0.053
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	86	87	87	88	88
	Total Nitrogen	Mean (mg/l)	1.40	1.38	1.38	1.09	1.03
		Median (mg/l)	1.38	1.36	1.36	1.06	1.00
	Total Suspended Solids	Mean (mg/l)	6.2	6.2	6.2	5.8	5.8
		Median (mg/l)	2.6	2.6	2.6	2.4	2.3
	Copper	Mean (mg/l)	0.0036	0.0036	0.0036	0.0035	0.0036
		Median (mg/l)	0.0027	0.0027	0.0027	0.0026	0.0026

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-4 West Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,808	3,375	3,375	2,128	2,095
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	1	1	54	54
		Geometric mean (cells per 100 ml)	1,770	1,997	1,997	582	562
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	28	33
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,003	2,500	2,500	1,488	1,468
		Percent compliance with single sample standard (<400 cells per 100 ml)	3	3	3	72	72
		Geometric mean (cells per 100 ml)	1,302	1,492	1,492	332	319
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	24	28
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.060	0.058	0.058	0.054	0.052
		Median (mg/l)	0.024	0.023	0.023	0.022	0.021
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	82	82	84	84
	Total Nitrogen	Mean (mg/l)	2.59	2.57	2.57	2.30	2.15
		Median (mg/l)	2.53	2.52	2.52	2.26	2.11
	Total Suspended Solids	Mean (mg/l)	17.7	17.3	17.3	16.3	16.0
		Median (mg/l)	8.4	8.3	8.3	7.7	7.6
	Copper	Mean (mg/l)	0.0030	0.0030	0.0030	0.0029	0.0030
		Median (mg/l)	0.0020	0.0020	0.0020	0.0019	0.0019

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-5 Kewaskum, USGS Sampling Location (4086149)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,761	2,051	2,051	1,245	1,215
		Percent compliance with single sample standard (<400 cells per 100 ml)	11	10	10	52	52
		Geometric mean (cells per 100 ml)	1,116	1,225	1,225	409	393
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	102	108
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,088	1,341	1,341	744	728
		Percent compliance with single sample standard (<400 cells per 100 ml)	24	22	22	74	74
		Geometric mean (cells per 100 ml)	702	783	783	189	180
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	90	94
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.068	0.068	0.068	0.058	0.057
		Median (mg/l)	0.047	0.047	0.047	0.041	0.041
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	84	84	84	88	88
	Total Nitrogen	Mean (mg/l)	2.33	2.31	2.31	1.67	1.56
		Median (mg/l)	2.29	2.27	2.27	1.64	1.54
	Total Suspended Solids	Mean (mg/l)	14.1	13.9	13.9	14.6	14.5
		Median (mg/l)	8.5	8.5	8.5	9.7	9.7
	Copper	Mean (mg/l)	0.0032	0.0032	0.0032	0.0029	0.0030
		Median (mg/l)	0.0027	0.0027	0.0027	0.0025	0.0025

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-7 Upper Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,950	2,046	2,046	1,030	1,003
		Percent compliance with single sample standard (<400 cells per 100 ml)	19	19	19	52	53
		Geometric mean (cells per 100 ml)	1,069	1,092	1,092	377	361
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	7	7	109	115
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,128	1,222	1,222	564	548
		Percent compliance with single sample standard (<400 cells per 100 ml)	39	39	39	74	74
		Geometric mean (cells per 100 ml)	600	617	617	171	162
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	7	7	96	99
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.3	11.4	11.4	11.3	11.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.080	0.085	0.085	0.077	0.076
		Median (mg/l)	0.061	0.066	0.066	0.061	0.061
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	75	75	80	80
	Total Nitrogen	Mean (mg/l)	2.20	2.15	2.15	1.60	1.49
		Median (mg/l)	2.15	2.11	2.11	1.57	1.47
	Total Suspended Solids	Mean (mg/l)	10.8	10.6	10.6	9.8	9.7
		Median (mg/l)	5.7	5.6	5.6	5.0	5.0
	Copper	Mean (mg/l)	0.0035	0.0037	0.0037	0.0034	0.0035
		Median (mg/l)	0.0031	0.0032	0.0032	0.0030	0.0030

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-8 Watercress Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,280	3,733	3,733	2,627	2,613
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	57	58
		Geometric mean (cells per 100 ml)	1,860	1,985	1,985	500	491
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	38	40
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,908	3,459	3,459	1,998	1,998
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	70	70
		Geometric mean (cells per 100 ml)	1,827	1,988	1,988	344	338
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	24	25
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0
		Median (mg/l)	11.0	11.0	11.0	11.0	11.0
		Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.032	0.032	0.032	0.028	0.028
		Median (mg/l)	0.012	0.012	0.012	0.009	0.009
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	92	93	93	93	93
	Total Nitrogen	Mean (mg/l)	1.49	1.48	1.48	0.90	0.87
		Median (mg/l)	1.53	1.43	1.43	0.84	0.80
	Total Suspended Solids	Mean (mg/l)	10.8	10.6	10.6	8.3	8.3
		Median (mg/l)	5.6	5.6	5.6	4.0	4.0
	Copper	Mean (mg/l)	0.0022	0.0022	0.0022	0.0019	0.0020
		Median (mg/l)	0.0014	0.0014	0.0014	0.0011	0.0011

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-9 Watercress Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	301	313	313	265	263
		Percent compliance with single sample standard (<400 cells per 100 ml)	90	90	90	91	91
		Geometric mean (cells per 100 ml)	76	77	77	27	26
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	311	311	311	363	364
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	232	255	255	231	231
		Percent compliance with single sample standard (<400 cells per 100 ml)	95	95	95	95	95
		Geometric mean (cells per 100 ml)	44	44	44	11	11
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	150	150	150	153	153
	Dissolved Oxygen	Mean (mg/l)	11.6	11.6	11.6	11.6	11.6
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.118	0.114	0.114	0.081	0.079
		Median (mg/l)	0.117	0.114	0.114	0.080	0.079
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	38	43	43	89	92
	Total Nitrogen	Mean (mg/l)	1.66	1.64	1.64	0.79	0.75
		Median (mg/l)	1.67	1.64	1.64	0.78	0.75
	Total Suspended Solids	Mean (mg/l)	3.4	3.4	3.4	3.0	3.0
		Median (mg/l)	3.0	3.0	3.0	2.5	2.6
	Copper	Mean (mg/l)	0.0034	0.0034	0.0034	0.0026	0.0027
		Median (mg/l)	0.0033	0.0033	0.0033	0.0025	0.0026

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-10 East Branch Milwaukee River, USGS Sampling Location (4086200)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	948	991	991	884	871
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	48	48	57	58
		Geometric mean (cells per 100 ml)	472	478	478	310	304
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	45	44	44	119	121
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	667	736	736	631	626
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	80	80	85	85
		Geometric mean (cells per 100 ml)	268	274	274	134	131
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	41	40	40	104	105
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.084	0.083	0.083	0.067	0.066
		Median (mg/l)	0.079	0.078	0.078	0.062	0.061
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	83	83	94	94
	Total Nitrogen	Mean (mg/l)	1.37	1.35	1.35	0.75	0.71
		Median (mg/l)	1.36	1.35	1.35	0.73	0.70
	Total Suspended Solids	Mean (mg/l)	3.5	3.4	3.4	3.2	3.2
		Median (mg/l)	2.2	2.1	2.1	2.0	2.0
	Copper	Mean (mg/l)	0.0032	0.0032	0.0032	0.0028	0.0028
		Median (mg/l)	0.0030	0.0030	0.0030	0.0026	0.0026

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-11 East Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,030	1,087	1,087	707	695
		Percent compliance with single sample standard (<400 cells per 100 ml)	51	51	51	60	60
		Geometric mean (cells per 100 ml)	452	452	452	246	241
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	62	64	64	148	149
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	680	729	729	393	388
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	81	81	84	85
		Geometric mean (cells per 100 ml)	231	228	228	91	89
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	57	59	59	126	127
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.080	0.079	0.079	0.065	0.064
		Median (mg/l)	0.073	0.072	0.072	0.057	0.057
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	83	84	84	92	93
	Total Nitrogen	Mean (mg/l)	1.32	1.31	1.31	0.76	0.72
		Median (mg/l)	1.31	1.30	1.30	0.74	0.70
	Total Suspended Solids	Mean (mg/l)	2.7	2.7	2.7	2.6	2.6
		Median (mg/l)	1.8	1.8	1.8	1.6	1.6
	Copper	Mean (mg/l)	0.0032	0.0032	0.0032	0.0028	0.0029
		Median (mg/l)	0.0029	0.0029	0.0029	0.0025	0.0025

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-14 Middle Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,493	1,123	1,123	647	603
		Percent compliance with single sample standard (<400 cells per 100 ml)	39	40	40	52	53
		Geometric mean (cells per 100 ml)	601	510	510	212	194
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	80	85	85	153	157
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	533	458	458	318	298
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	74	74	79	80
		Geometric mean (cells per 100 ml)	207	187	187	58	52
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	72	76	76	128	130
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.4	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	100	100
	Total Phosphorus	Mean (mg/l)	0.110	0.120	0.120	0.113	0.112
		Median (mg/l)	0.095	0.107	0.107	0.102	0.102
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	55	48	48	53	53
	Total Nitrogen	Mean (mg/l)	1.71	1.62	1.62	1.20	1.12
		Median (mg/l)	1.64	1.56	1.56	1.15	1.08
	Total Suspended Solids	Mean (mg/l)	11.8	11.6	11.6	10.9	10.8
		Median (mg/l)	7.4	7.3	7.3	6.9	6.8
	Copper	Mean (mg/l)	0.0054	0.0059	0.0059	0.0056	0.0057
		Median (mg/l)	0.0052	0.0057	0.0057	0.0054	0.0055

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan[c]	Condition: "Extreme Measures" Condition[c]
ML-15 North Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,252	4,260	4,260	3,213	3,167
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	50	50
		Geometric mean (cells per 100 ml)	2,313	2,325	2,325	626	616
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	60	64
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,530	3,501	3,501	2,249	2,224
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	1	1	81	81
		Geometric mean (cells per 100 ml)	1,867	1,845	1,845	253	247
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	55	58
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	10.9	10.9	10.9	10.9	10.9
		Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.785	0.881	0.881	0.898	0.921
		Median (mg/l)	0.748	0.844	0.844	0.862	0.887
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	2	1	1	1	1
	Total Nitrogen	Mean (mg/l)	2.27	2.30	2.30	1.34	1.29
		Median (mg/l)	2.24	2.27	2.27	1.29	1.24
	Total Suspended Solids	Mean (mg/l)	7.1	7.0	7.0	5.7	5.7
		Median (mg/l)	4.4	4.4	4.4	3.4	3.4
	Copper	Mean (mg/l)	0.0037	0.0038	0.0038	0.0035	0.0036
		Median (mg/l)	0.0025	0.0026	0.0026	0.0023	0.0023

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-16 Chambers Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,613	4,229	4,229	2,664	2,625
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	75	75
		Geometric mean (cells per 100 ml)	2,095	2,277	2,277	285	272
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	127	141
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,982	4,863	4,863	2,694	2,677
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	85	85
		Geometric mean (cells per 100 ml)	2,418	2,684	2,684	250	240
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	62	71
	Dissolved Oxygen	Mean (mg/l)	10.7	10.7	10.7	10.7	10.6
		Median (mg/l)	10.7	10.7	10.7	10.7	10.7
		Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[d]	86	86	86	85	85
	Total Phosphorus	Mean (mg/l)	0.038	0.037	0.037	0.031	0.031
		Median (mg/l)	0.012	0.012	0.012	0.009	0.009
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	92	92	92	93	93
	Total Nitrogen	Mean (mg/l)	2.36	2.35	2.35	1.43	1.35
		Median (mg/l)	2.29	2.29	2.29	1.37	1.29
	Total Suspended Solids	Mean (mg/l)	19.7	19.5	19.5	15.5	15.3
		Median (mg/l)	14.9	14.9	14.9	12.0	12.0
	Copper	Mean (mg/l)	0.0023	0.0023	0.0023	0.0020	0.0020
		Median (mg/l)	0.0013	0.0013	0.0013	0.0010	0.0010

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-17 Melius Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,637	4,129	4,129	2,798	2,749
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	75	75
		Geometric mean (cells per 100 ml)	1,937	2,063	2,063	260	248
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	157	169
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,328	4,021	4,021	2,248	2,219
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	1	1	87	87
		Geometric mean (cells per 100 ml)	1,985	2,170	2,170	190	180
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	89	97
	Dissolved Oxygen	Mean (mg/l)	11.1	11.1	11.1	11.1	11.1
		Median (mg/l)	11.1	11.1	11.1	11.1	11.1
		Percent compliance with dissolved oxygen standard (>6 mg/l, >7 mg/l October-December)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.037	0.037	0.037	0.032	0.032
		Median (mg/l)	0.011	0.011	0.011	0.009	0.009
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	91	91	91	92	92
	Total Nitrogen	Mean (mg/l)	1.97	1.97	1.97	1.17	1.12
		Median (mg/l)	1.93	1.93	1.93	1.12	1.06
	Total Suspended Solids	Mean (mg/l)	10.8	10.7	10.7	8.3	8.2
		Median (mg/l)	6.4	6.4	6.4	4.6	4.7
	Copper	Mean (mg/l)	0.0025	0.0025	0.0025	0.0022	0.0023
		Median (mg/l)	0.0014	0.0014	0.0014	0.0010	0.0011

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-18 Batavia Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,460	4,105	4,105	2,649	2,611
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	0	0	71	72
		Geometric mean (cells per 100 ml)	2,091	2,296	2,296	302	289
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	121	135
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,302	4,133	4,133	2,336	2,314
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	1	1	85	85
		Geometric mean (cells per 100 ml)	2,037	2,294	2,294	215	205
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	67	79
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	11.0	11.0
		Median (mg/l)	11.0	11.0	11.0	11.0	11.1
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.040	0.040	0.040	0.034	0.034
		Median (mg/l)	0.012	0.012	0.012	0.009	0.009
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	90	90	90	91	92
	Total Nitrogen	Mean (mg/l)	2.31	2.30	2.30	1.37	1.29
		Median (mg/l)	2.27	2.26	2.26	1.31	1.24
	Total Suspended Solids	Mean (mg/l)	13.4	13.2	13.2	9.9	9.9
		Median (mg/l)	7.4	7.4	7.4	5.2	5.3
	Copper	Mean (mg/l)	0.0025	0.0025	0.0025	0.0021	0.0021
		Median (mg/l)	0.0014	0.0014	0.0014	0.0010	0.0010

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-20 Silver Creek (Sheboygan County)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,944	3,369	3,369	1,487	1,450
		Percent compliance with single sample standard (<400 cells per 100 ml)	3	3	3	73	73
		Geometric mean (cells per 100 ml)	1,341	1,347	1,347	348	330
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	44	60
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,287	2,744	2,744	1,113	1,086
		Percent compliance with single sample standard (<400 cells per 100 ml)	6	7	7	87	87
		Geometric mean (cells per 100 ml)	1,125	1,149	1,149	278	264
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	15	25
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.4	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>3 mg/l)[e]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.111	0.120	0.120	0.116	0.116
		Median (mg/l)	0.091	0.102	0.102	0.099	0.099
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	64	57	57	59	59
	Total Nitrogen	Mean (mg/l)	1.50	1.43	1.43	1.31	1.21
		Median (mg/l)	1.46	1.39	1.39	1.27	1.17
	Total Suspended Solids	Mean (mg/l)	8.8	8.9	8.9	8.7	8.4
		Median (mg/l)	4.3	4.5	4.5	4.4	4.3
	Copper	Mean (mg/l)	0.0056	0.0060	0.0060	0.0056	0.0057
		Median (mg/l)	0.0047	0.0052	0.0052	0.0048	0.0049

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-21 Silver Creek (Sheboygan County)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,909	3,321	3,321	1,622	1,585
		Percent compliance with single sample standard (<400 cells per 100 ml)	3	3	3	70	70
		Geometric mean (cells per 100 ml)	1,439	1,466	1,466	369	351
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	54	68
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,277	2,667	2,667	1,190	1,165
		Percent compliance with single sample standard (<400 cells per 100 ml)	6	7	7	84	84
		Geometric mean (cells per 100 ml)	1,169	1,195	1,195	265	252
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	30	37
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.4	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.101	0.109	0.109	0.106	0.106
		Median (mg/l)	0.078	0.087	0.087	0.085	0.086
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	70	65	65	66	66
	Total Nitrogen	Mean (mg/l)	1.66	1.59	1.59	1.46	1.35
		Median (mg/l)	1.61	1.55	1.55	1.42	1.31
	Total Suspended Solids	Mean (mg/l)	8.8	8.5	8.5	8.4	8.1
		Median (mg/l)	4.3	4.3	4.3	4.2	4.1
	Copper	Mean (mg/l)	0.0053	0.0057	0.0057	0.0053	0.0054
		Median (mg/l)	0.0043	0.0047	0.0047	0.0044	0.0045

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-22 Stony Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,751	4,536	4,536	3,458	3,407
		Percent compliance with single sample standard (<400 cells per 100 ml)	0	0	0	43	43
		Geometric mean (cells per 100 ml)	2,124	2,392	2,392	805	788
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	10	11
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,240	4,241	4,241	2,964	2,936
		Percent compliance with single sample standard (<400 cells per 100 ml)	1	1	1	53	53
		Geometric mean (cells per 100 ml)	1,856	2,163	2,163	554	545
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	4	5
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.044	0.044	0.044	0.041	0.040
		Median (mg/l)	0.015	0.015	0.015	0.013	0.013
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	88	89	89	89	90
	Total Nitrogen	Mean (mg/l)	2.02	2.02	2.02	1.50	1.41
		Median (mg/l)	2.00	1.99	1.99	1.46	1.37
	Total Suspended Solids	Mean (mg/l)	16.1	16.0	16.0	13.9	13.7
		Median (mg/l)	10.0	10.0	10.0	8.4	8.3
	Copper	Mean (mg/l)	0.0028	0.0028	0.0028	0.0026	0.0027
		Median (mg/l)	0.0016	0.0016	0.0016	0.0014	0.0014

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-23 North Branch of the Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,707	2,773	2,773	1,886	1,858
		Percent compliance with single sample standard (<400 cells per 100 ml)	7	7	7	53	54
		Geometric mean (cells per 100 ml)	1,447	1,469	1,469	508	494
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	73	79
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,718	1,756	1,756	1,070	1,057
		Percent compliance with single sample standard (<400 cells per 100 ml)	16	15	15	74	74
		Geometric mean (cells per 100 ml)	892	904	904	235	227
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	3	3	66	72
	Dissolved Oxygen	Mean (mg/l)	11.6	11.6	11.6	11.6	11.6
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.206	0.212	0.212	0.217	0.222
		Median (mg/l)	0.185	0.190	0.190	0.197	0.202
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	40	39	39	38	37
	Total Nitrogen	Mean (mg/l)	1.77	1.76	1.76	1.36	1.27
		Median (mg/l)	1.73	1.72	1.72	1.32	1.23
	Total Suspended Solids	Mean (mg/l)	7.9	7.9	7.9	7.3	7.2
		Median (mg/l)	4.6	4.6	4.6	4.2	4.1
	Copper	Mean (mg/l)	0.0036	0.0035	0.0035	0.0033	0.0034
		Median (mg/l)	0.0027	0.0026	0.0026	0.0024	0.0024

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-24 Fredonia, USGS Sampling Location (4086360)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,678	1,497	1,497	964	926
		Percent compliance with single sample standard (<400 cells per 100 ml)	32	32	32	51	52
		Geometric mean (cells per 100 ml)	777	722	722	290	274
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	52	52	52	141	145
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	673	664	664	433	417
		Percent compliance with single sample standard (<400 cells per 100 ml)	63	64	64	77	77
		Geometric mean (cells per 100 ml)	311	305	305	90	84
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	49	49	49	118	121
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.6	11.6	11.6	11.6	11.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.129	0.136	0.136	0.132	0.133
		Median (mg/l)	0.112	0.121	0.121	0.120	0.121
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	49	45	45	48	48
	Total Nitrogen	Mean (mg/l)	1.73	1.67	1.67	1.25	1.17
		Median (mg/l)	1.67	1.62	1.62	1.21	1.13
	Total Suspended Solids	Mean (mg/l)	11.9	11.7	11.7	11.1	10.9
		Median (mg/l)	7.5	7.4	7.4	7.0	6.9
	Copper	Mean (mg/l)	0.0048	0.0051	0.0051	0.0048	0.0049
		Median (mg/l)	0.0045	0.0048	0.0048	0.0046	0.0046

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-25 Upper Lower Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,154	1,066	1,066	512	486
		Percent compliance with single sample standard (<400 cells per 100 ml)	42	42	42	60	61
		Geometric mean (cells per 100 ml)	382	364	364	138	129
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	128	130	130	180	183
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	370	360	360	204	193
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	75	75	83	84
		Geometric mean (cells per 100 ml)	107	105	105	38	35
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	102	102	102	128	130
	Dissolved Oxygen	Mean (mg/l)	11.1	11.0	11.0	10.9	10.9
		Median (mg/l)	11.1	11.1	11.1	10.9	10.9
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.134	0.145	0.145	0.141	0.141
		Median (mg/l)	0.120	0.132	0.132	0.131	0.133
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	43	38	38	39	39
	Total Nitrogen	Mean (mg/l)	1.74	1.67	1.67	1.29	1.20
		Median (mg/l)	1.67	1.61	1.61	1.24	1.16
	Total Suspended Solids	Mean (mg/l)	16.7	16.5	16.5	15.7	15.5
		Median (mg/l)	12.4	12.3	12.3	11.7	11.6
	Copper	Mean (mg/l)	0.0049	0.0053	0.0053	0.0049	0.0050
		Median (mg/l)	0.0048	0.0051	0.0051	0.0048	0.0049

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-27 Cedar Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,887	1,793	1,793	771	744
		Percent compliance with single sample standard (<400 cells per 100 ml)	17	19	19	67	68
		Geometric mean (cells per 100 ml)	938	909	909	226	214
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	1	2	2	176	183
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,143	1,090	1,090	458	443
		Percent compliance with single sample standard (<400 cells per 100 ml)	31	32	32	83	83
		Geometric mean (cells per 100 ml)	626	612	612	119	112
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	1	1	1	127	129
	Dissolved Oxygen	Mean (mg/l)	10.7	10.8	10.8	10.8	10.8
		Median (mg/l)	10.8	10.8	10.8	10.8	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.149	0.160	0.160	0.143	0.140
		Median (mg/l)	0.129	0.142	0.142	0.130	0.128
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	35	29	29	37	38
	Total Nitrogen	Mean (mg/l)	1.74	1.68	1.68	1.01	0.94
		Median (mg/l)	1.66	1.60	1.60	0.96	0.89
	Total Suspended Solids	Mean (mg/l)	11.7	11.4	11.4	9.9	9.7
		Median (mg/l)	9.1	8.9	8.9	7.8	7.6
	Copper	Mean (mg/l)	0.0043	0.0046	0.0046	0.0040	0.0040
		Median (mg/l)	0.0037	0.0040	0.0040	0.0035	0.0035

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-29 Milwaukee River at the Milwaukee-Ozaukee County Line	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,107	964	964	448	415
		Percent compliance with single sample standard (<400 cells per 100 ml)	42	43	43	62	64
		Geometric mean (cells per 100 ml)	385	339	339	129	117
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	127	136	136	184	194
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	358	319	319	178	163
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	76	76	84	85
		Geometric mean (cells per 100 ml)	112	99	99	36	33
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	103	106	106	131	134
	Dissolved Oxygen	Mean (mg/l)	11.0	11.0	11.0	10.9	10.8
		Median (mg/l)	11.1	11.0	11.0	10.9	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.132	0.142	0.142	0.136	0.136
		Median (mg/l)	0.119	0.131	0.131	0.128	0.129
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	41	34	34	37	38
	Total Nitrogen	Mean (mg/l)	1.69	1.62	1.62	1.19	1.11
		Median (mg/l)	1.62	1.56	1.56	1.15	1.07
	Total Suspended Solids	Mean (mg/l)	17.8	17.5	17.5	16.4	16.2
		Median (mg/l)	13.9	13.6	13.6	12.9	12.8
	Copper	Mean (mg/l)	0.0049	0.0053	0.0053	0.0049	0.0050
		Median (mg/l)	0.0048	0.0052	0.0052	0.0048	0.0049

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-30 Milwaukee River Downstream of Beaver Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,359	1,211	1,211	647	532
		Percent compliance with single sample standard (<400 cells per 100 ml)	42	43	43	54	56
		Geometric mean (cells per 100 ml)	442	393	393	167	133
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	120	130	130	177	188
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	543	532	532	423	354
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	73	73	78	79
		Geometric mean (cells per 100 ml)	143	130	130	54	40
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	94	99	99	128	131
	Dissolved Oxygen	Mean (mg/l)	11.0	10.9	10.9	10.9	10.8
		Median (mg/l)	11.0	11.0	11.0	10.8	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	99	99	98	98
	Total Phosphorus	Mean (mg/l)	0.134	0.143	0.143	0.134	0.133
		Median (mg/l)	0.122	0.132	0.132	0.126	0.126
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	39	34	34	37	38
	Total Nitrogen	Mean (mg/l)	1.67	1.58	1.58	1.16	1.09
		Median (mg/l)	1.60	1.52	1.52	1.12	1.05
	Total Suspended Solids	Mean (mg/l)	20.7	19.9	19.9	18.9	18.6
		Median (mg/l)	16.1	15.6	15.6	14.9	14.6
	Copper	Mean (mg/l)	0.0049	0.0052	0.0052	0.0047	0.0048
		Median (mg/l)	0.0048	0.0051	0.0051	0.0046	0.0047

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-31 Indian Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,135	6,898	6,898	2,956	1,814
		Percent compliance with single sample standard (<2000 cells per 100 ml)[f]	57	56	56	65	73
		Geometric mean (cells per 100 ml)	614	649	649	307	180
		Days of compliance with geometric mean standard (<1000 cells per 100 ml)[b]	214	215	215	267	315
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,587	3,275	3,275	2,615	2,071
		Percent compliance with single sample standard (<2000 cells per 100 ml)[f]	78	75	75	77	79
		Geometric mean (cells per 100 ml)	130	159	159	103	70
		Days of compliance with geometric mean standard (<1000 cells per 100 ml)[f]	138	137	137	146	150
	Dissolved Oxygen	Mean (mg/l)	8.0	8.1	8.1	7.8	7.7
		Median (mg/l)	7.8	8.0	8.0	7.7	7.6
		Percent compliance with dissolved oxygen standard (>2 mg/l)[f]	95	95	95	95	95
	Total Phosphorus	Mean (mg/l)	0.128	0.106	0.106	0.075	0.071
		Median (mg/l)	0.092	0.075	0.075	0.051	0.048
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	55	60	60	73	75
	Total Nitrogen	Mean (mg/l)	1.07	0.99	0.99	0.85	0.86
		Median (mg/l)	0.98	0.93	0.93	0.82	0.83
	Total Suspended Solids	Mean (mg/l)	41.5	34.0	34.0	37.1	37.1
		Median (mg/l)	32.2	28.0	28.0	29.1	29.1
	Copper	Mean (mg/l)	0.0073	0.0057	0.0057	0.0041	0.0041
		Median (mg/l)	0.0056	0.0045	0.0045	0.0031	0.0031

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-32 Lincoln Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,770	4,405	4,400	1,913	1,168
		Percent compliance with single sample standard (<2000 cells per 100 ml)[f]	55	51	51	65	80
		Geometric mean (cells per 100 ml)	561	742	741	403	206
		Days of compliance with geometric mean standard (<1000 cells per 100 ml)[f]	200	184	184	225	297
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,223	1,866	1,860	1,505	1,213
		Percent compliance with single sample standard (<2000 cells per 100 ml)[f]	82	77	77	79	82
		Geometric mean (cells per 100 ml)	106	162	162	130	69
		Days of compliance with geometric mean standard (<1000 cells per 100 ml)[f]	135	129	129	138	150
	Dissolved Oxygen	Mean (mg/l)	6.4	7.1	7.1	6.5	6.5
		Median (mg/l)	6.3	7.0	7.0	6.5	6.5
		Percent compliance with dissolved oxygen standard (>2 mg/l)[f]	90	95	95	93	93
	Total Phosphorus	Mean (mg/l)	0.260	0.231	0.231	0.191	0.185
		Median (mg/l)	0.256	0.228	0.228	0.188	0.183
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	5	7	7	9	11
	Total Nitrogen	Mean (mg/l)	1.10	0.98	0.98	0.82	0.82
		Median (mg/l)	1.09	0.98	0.98	0.81	0.81
	Total Suspended Solids	Mean (mg/l)	55.2	44.1	44.1	48.7	48.7
		Median (mg/l)	49.8	39.9	39.9	44.3	44.3
	Copper	Mean (mg/l)	0.0093	0.0075	0.0075	0.0054	0.0054
		Median (mg/l)	0.0091	0.0074	0.0074	0.0053	0.0053

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-33 Milwaukee River at Lincoln/ Estabrook Parks	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,559	1,483	1,472	736	553
		Percent compliance with single sample standard (<400 cells per 100 ml)	43	43	43	53	56
		Geometric mean (cells per 100 ml)	354	333	333	185	141
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	140	143	143	173	187
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	596	674	653	515	417
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	72	72	76	78
		Geometric mean (cells per 100 ml)	84	83	83	61	45
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	107	107	108	125	130
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.7	10.7
		Median (mg/l)	10.9	10.9	10.9	10.8	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.139	0.145	0.145	0.134	0.132
		Median (mg/l)	0.128	0.135	0.135	0.127	0.126
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	35	32	32	35	37
	Total Nitrogen	Mean (mg/l)	1.63	1.54	1.54	1.14	1.07
		Median (mg/l)	1.57	1.49	1.49	1.10	1.04
	Total Suspended Solids	Mean (mg/l)	24.2	22.4	22.4	21.9	21.7
		Median (mg/l)	18.7	17.6	17.6	17.1	16.9
	Copper	Mean (mg/l)	0.0052	0.0053	0.0053	0.0047	0.0048
		Median (mg/l)	0.0051	0.0052	0.0052	0.0047	0.0047

Table N-3 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
ML-34 Milwaukee River at the Former North Avenue Dam	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,380	1,275	1,263	628	471
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	76	76	94	98
		Geometric mean (cells per 100 ml)	311	293	292	155	103
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	236	242	242	342	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	515	557	533	426	353
		Percent compliance with single sample standard (<400 cells per 100 ml)	92	92	92	94	96
		Geometric mean (cells per 100 ml)	73	73	73	48	28
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	145	147	147	153	153
	Dissolved Oxygen	Mean (mg/l)	10.6	10.6	10.6	10.4	10.4
		Median (mg/l)	10.6	10.6	10.6	10.5	10.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.169	0.173	0.173	0.163	0.161
		Median (mg/l)	0.160	0.165	0.165	0.158	0.157
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	24	22	22	22	22
	Total Nitrogen	Mean (mg/l)	1.60	1.52	1.52	1.13	1.06
		Median (mg/l)	1.53	1.46	1.46	1.09	1.03
	Total Suspended Solids	Mean (mg/l)	24.8	22.6	22.6	22.2	22.0
		Median (mg/l)	19.3	17.8	17.8	17.4	17.3
	Copper	Mean (mg/l)	0.0051	0.0051	0.0051	0.0046	0.0046
		Median (mg/l)	0.0052	0.0053	0.0053	0.0045	0.0046

Table N-3 Footnotes

[a]*In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b]*Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[d]*Under Chapter NR 102 of the* Wisconsin Administrative Code *and* Wisconsin Trout Streams (1980)*, this assessment point is in a stream reach classified as capable of supporting a coldwater biological community.*

[e]*Under Chapter NR 104 of the* Wisconsin Administrative Code*, this assessment point is in a stream reach classified as capable of supporting limited forage fish.*

[f]*Variance Standard in Chapter NR 104 of the* Wisconsin Administrative Code*.*

Source: Tetra Tech, Inc., and SEWRPC.

Table N-4

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: OAK CREEK WATERSHED[a]

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-1 Upper Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,905	3,983	3,983	2,603	1,321
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	64	64	67	72
		Geometric mean (cells per 100 ml)	541	508	508	346	192
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	65	65	65	123	231
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,012	1,713	1,713	1,079	552
		Percent compliance with single sample standard (<400 cells per 100 ml)	84	82	82	84	87
		Geometric mean (cells per 100 ml)	256	264	264	181	103
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	47	46	46	82	141
	Dissolved Oxygen	Mean (mg/l)	8.4	8.2	8.2	8.2	8.2
		Median (mg/l)	8.7	8.6	8.6	8.6	8.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	77	73	73	73	73
	Total Phosphorus	Mean (mg/l)	0.075	0.066	0.066	0.064	0.063
		Median (mg/l)	0.031	0.025	0.025	0.025	0.025
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	83	83	83	83	84
	Total Nitrogen	Mean (mg/l)	1.52	0.89	0.89	0.88	0.87
		Median (mg/l)	1.38	0.84	0.84	0.82	0.82
	Total Suspended Solids	Mean (mg/l)	13.7	7.4	7.4	7.9	7.9
		Median (mg/l)	7.8	4.6	4.6	4.6	4.6
	Copper	Mean (mg/l)	0.0038	0.0030	0.0030	0.0030	0.0029
		Median (mg/l)	0.0012	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-2 North Branch of Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,987	4,199	4,199	2,722	1,385
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	56	56	60	65
		Geometric mean (cells per 100 ml)	611	568	568	385	213
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	60	63	63	108	210
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,561	2,113	2,113	1,289	658
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	73	73	76	80
		Geometric mean (cells per 100 ml)	289	281	281	192	109
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	44	45	45	71	131
	Dissolved Oxygen	Mean (mg/l)	8.8	8.6	8.6	8.6	8.6
		Median (mg/l)	8.6	8.3	8.3	8.3	8.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	82	80	80	80	80
	Total Phosphorus	Mean (mg/l)	0.084	0.074	0.074	0.072	0.071
		Median (mg/l)	0.032	0.030	0.030	0.030	0.030
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	79	79	80	80
	Total Nitrogen	Mean (mg/l)	1.32	0.91	0.91	0.91	0.90
		Median (mg/l)	1.18	0.81	0.81	0.80	0.80
	Total Suspended Solids	Mean (mg/l)	22.9	15.1	15.1	15.7	15.7
		Median (mg/l)	9	6.4	6.4	6.4	6.4
	Copper	Mean (mg/l)	0.0052	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-3 Oak Creek Downstream of North Branch of Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	10,233	8,341	8,341	5,436	2,760
		Percent compliance with single sample standard (<400 cells per 100 ml)	55	55	55	58	63
		Geometric mean (cells per 100 ml)	1,191	1,070	1,070	729	402
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	19	19	36	99
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,750	3,834	3,834	2,382	1,216
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	72	72	76	80
		Geometric mean (cells per 100 ml)	555	518	518	355	203
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	15	16	16	30	69
	Dissolved Oxygen	Mean (mg/l)	10	9.7	9.7	9.7	9.7
		Median (mg/l)	10.5	10.4	10.4	10.4	10.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	83	81	81	81	81
	Total Phosphorus	Mean (mg/l)	0.086	0.076	0.076	0.074	0.073
		Median (mg/l)	0.032	0.029	0.029	0.029	0.029
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	79	79	80	80
	Total Nitrogen	Mean (mg/l)	1.37	0.89	0.89	0.88	0.88
		Median (mg/l)	1.24	0.81	0.81	0.80	0.80
	Total Suspended Solids	Mean (mg/l)	20.9	13.2	13.2	13.7	13.7
		Median (mg/l)	8.5	5.9	5.9	5.9	5.9
	Copper	Mean (mg/l)	0.0049	0.0038	0.0038	0.0037	0.0037
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan[c]	Condition: "Extreme Measures" Condition[c]
OK-4 Middle Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,953	6,856	6,856	4,447	2,259
		Percent compliance with single sample standard (<400 cells per 100 ml)	51	52	52	56	62
		Geometric mean (cells per 100 ml)	1,041	956	956	648	357
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	20	21	21	46	125
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,103	2,780	2,780	1,672	855
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	70	70	75	79
		Geometric mean (cells per 100 ml)	463	453	453	308	175
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	17	17	35	87
	Dissolved Oxygen	Mean (mg/l)	9.4	9.2	9.2	9.2	9.2
		Median (mg/l)	9.6	9.5	9.5	9.5	9.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	85	82	82	82	82
	Total Phosphorus	Mean (mg/l)	0.081	0.073	0.073	0.071	0.071
		Median (mg/l)	0.032	0.030	0.030	0.029	0.029
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	80	80	81	81
	Total Nitrogen	Mean (mg/l)	1.34	0.87	0.87	0.86	0.86
		Median (mg/l)	1.17	0.76	0.76	0.76	0.76
	Total Suspended Solids	Mean (mg/l)	14.9	9.6	9.6	9.9	9.9
		Median (mg/l)	7.9	5.3	5.3	5.3	5.3
	Copper	Mean (mg/l)	0.0049	0.0039	0.0039	0.0038	0.0038
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Condition: Revised 2020 Baseline	Condition: Revised 2020 Baseline with Five-Year LOP[b]	Condition: Recommended Plan[c]	Condition: "Extreme Measures" Condition[c]
OK-5 Middle Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,666	6,634	6,634	4,289	2,178
		Percent compliance with single sample standard (<400 cells per 100 ml)	49	50	50	55	62
		Geometric mean (cells per 100 ml)	1,105	995	995	664	360
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	18	20	20	40	115
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,019	2,700	2,700	1,595	814
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	67	67	73	79
		Geometric mean (cells per 100 ml)	497	466	466	309	172
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	15	17	17	32	81
	Dissolved Oxygen	Mean (mg/l)	9.5	9.3	9.3	9.3	9.3
		Median (mg/l)	9.6	9.7	9.7	9.7	9.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	93	90	90	90	90
	Total Phosphorus	Mean (mg/l)	0.083	0.078	0.078	0.076	0.075
		Median (mg/l)	0.033	0.032	0.032	0.032	0.032
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	79	78	78	78	78
	Total Nitrogen	Mean (mg/l)	1.32	0.89	0.89	0.89	0.88
		Median (mg/l)	1.15	0.78	0.78	0.78	0.77
	Total Suspended Solids	Mean (mg/l)	14.1	9.1	9.1	9.4	9.4
		Median (mg/l)	7.2	4.6	4.6	4.7	4.7
	Copper	Mean (mg/l)	0.0051	0.0040	0.0040	0.0039	0.0039
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-6 Mitchell Field Drainage Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,917	6,257	6,257	3,966	2,035
		Percent compliance with single sample standard (<400 cells per 100 ml)	31	56	56	62	68
		Geometric mean (cells per 100 ml)	1,442	1,179	1,179	775	457
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	2	2	13	66
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,906	2,761	2,761	1,590	836
		Percent compliance with single sample standard (<400 cells per 100 ml)	27	75	75	80	84
		Geometric mean (cells per 100 ml)	806	644	644	411	256
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	0	0	0	5	33
	Dissolved Oxygen	Mean (mg/l)	9	8.9	8.9	8.8	8.9
		Median (mg/l)	8.7	8.5	8.5	8.4	8.5
		Percent compliance with dissolved oxygen standard (>5 mg/l)	81	79	79	78	79
	Total Phosphorus	Mean (mg/l)	0.076	0.073	0.073	0.070	0.070
		Median (mg/l)	0.046	0.048	0.048	0.046	0.046
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	84	81	81	82	82
	Total Nitrogen	Mean (mg/l)	1.57	1.08	1.08	1.00	1.00
		Median (mg/l)	1.41	1.00	1.00	0.94	0.94
	Total Suspended Solids	Mean (mg/l)	11	6.9	6.9	7.1	7.1
		Median (mg/l)	7	4.2	4.2	4.2	4.2
	Copper	Mean (mg/l)	0.0041	0.0032	0.0032	0.0031	0.0031
		Median (mg/l)	0.0012	0.0008	0.0008	0.0008	0.0008

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-7 Oak Creek Downstream of Mitchell Field Drainage Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,729	6,765	6,765	4,358	2,216
		Percent compliance with single sample standard (<400 cells per 100 ml)	49	51	51	56	62
		Geometric mean (cells per 100 ml)	1,190	1,039	1,039	696	384
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	18	18	35	101
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,136	2,818	2,818	1,657	848
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	69	69	74	79
		Geometric mean (cells per 100 ml)	543	481	481	320	183
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	11	16	16	28	70
	Dissolved Oxygen	Mean (mg/l)	9.3	9.1	9.1	9.1	9.1
		Median (mg/l)	9.2	9.3	9.3	9.3	9.3
		Percent compliance with dissolved oxygen standard (>5 mg/l)	81	79	79	80	80
	Total Phosphorus	Mean (mg/l)	0.091	0.090	0.090	0.088	0.087
		Median (mg/l)	0.056	0.060	0.060	0.058	0.058
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	76	74	74	75	75
	Total Nitrogen	Mean (mg/l)	1.38	1.00	1.00	0.98	0.98
		Median (mg/l)	1.25	0.93	0.93	0.92	0.91
	Total Suspended Solids	Mean (mg/l)	14.9	9.6	9.6	9.9	9.9
		Median (mg/l)	7.3	4.7	4.7	4.8	4.8
	Copper	Mean (mg/l)	0.0051	0.0040	0.0040	0.0039	0.0039
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-8 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	15,506	13,491	13,491	8,662	4,405
		Percent compliance with single sample standard (<400 cells per 100 ml)	17	23	23	39	53
		Geometric mean (cells per 100 ml)	2,700	2,363	2,363	1,550	834
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	11	11	13	27
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6,370	5,619	5,619	3,218	1,649
		Percent compliance with single sample standard (<400 cells per 100 ml)	31	40	40	61	74
		Geometric mean (cells per 100 ml)	1,079	919	919	593	331
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	11	11	12	22
	Dissolved Oxygen	Mean (mg/l)	10.2	10.2	10.2	10.2	10.2
		Median (mg/l)	10	10.1	10.1	10.2	10.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	93	92	92	92	92
	Total Phosphorus	Mean (mg/l)	0.091	0.091	0.091	0.088	0.087
		Median (mg/l)	0.058	0.062	0.062	0.060	0.059
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	76	73	73	74	75
	Total Nitrogen	Mean (mg/l)	1.30	0.97	0.97	0.96	0.95
		Median (mg/l)	1.18	0.91	0.91	0.90	0.89
	Total Suspended Solids	Mean (mg/l)	15.9	10.4	10.4	10.7	10.7
		Median (mg/l)	7.3	4.7	4.7	4.8	4.8
	Copper	Mean (mg/l)	0.0052	0.0041	0.0041	0.0040	0.0040
		Median (mg/l)	0.0014	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-9 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,401	6,384	6,384	4,091	2,079
		Percent compliance with single sample standard (<400 cells per 100 ml)	51	54	54	57	62
		Geometric mean (cells per 100 ml)	993	790	790	526	289
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	26	40	40	68	150
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,061	2,661	2,661	1,502	768
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	73	73	76	80
		Geometric mean (cells per 100 ml)	388	288	288	189	107
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	21	31	31	50	104
	Dissolved Oxygen	Mean (mg/l)	10.5	10.5	10.5	10.5	10.5
		Median (mg/l)	10.3	10.3	10.3	10.3	10.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.092	0.087	0.087	0.085	0.084
		Median (mg/l)	0.062	0.065	0.065	0.063	0.063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	75	75	75	76	76
	Total Nitrogen	Mean (mg/l)	1.26	0.96	0.96	0.95	0.95
		Median (mg/l)	1.14	0.92	0.92	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	16	10.4	10.4	10.4	10.4
		Median (mg/l)	6.7	4.3	4.3	4.3	4.3
	Copper	Mean (mg/l)	0.0052	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0013	0.0010	0.0010	0.0010	0.0010

Indicates Revision

Table N-4 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
OK-10 Lower Oak Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,643	5,733	5,733	3,696	1,878
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	49	49	52	58
		Geometric mean (cells per 100 ml)	752	607	607	404	220
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	70	86	86	118	178
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,504	2,189	2,189	1,262	644
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	71	71	74	78
		Geometric mean (cells per 100 ml)	179	134	134	89	51
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	59	70	70	93	131
	Dissolved Oxygen	Mean (mg/l)	11.2	11.2	11.2	11.2	11.2
		Median (mg/l)	11.2	11.2	11.2	11.2	11.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.078	0.071	0.071	0.070	0.069
		Median (mg/l)	0.046	0.045	0.045	0.044	0.043
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	80	80	80	80
	Total Nitrogen	Mean (mg/l)	1.07	0.82	0.82	0.81	0.81
		Median (mg/l)	0.98	0.71	0.71	0.71	0.70
	Total Suspended Solids	Mean (mg/l)	19.6	12.8	12.8	13.2	13.2
		Median (mg/l)	7.4	5.1	5.1	5.1	5.1
	Copper	Mean (mg/l)	0.006	0.0047	0.0047	0.0047	0.0047
		Median (mg/l)	0.0025	0.0021	0.0021	0.0021	0.0021

Indicates Revision

Table N-4 Footnotes

[a]*In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b]*Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

Source: Tetra Tech, Inc., and SEWRPC.

Table N-5

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: ROOT RIVER WATERSHED[a]

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-1 Root River Upstream of Hale Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,644	4,728	4,728	2,979	1,545
		Percent compliance with single sample standard (<400 cells per 100 ml)	70	71	71	73	77
		Geometric mean (cells per 100 ml)	525	413	413	272	141
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	33	60	60	136	260
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,385	2,929	2,929	1,572	868
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	81	81	84	87
		Geometric mean (cells per 100 ml)	393	308	308	195	101
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	27	27	71	139
	Dissolved Oxygen	Mean (mg/l)	10.8	10.8	10.8	10.8	10.8
		Median (mg/l)	10.8	10.8	10.8	10.8	10.8
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.062	0.053	0.053	0.053	0.053
		Median (mg/l)	0.025	0.022	0.022	0.022	0.022
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	87	88	88	88	88
	Total Nitrogen	Mean (mg/l)	0.98	0.85	0.85	0.85	0.85
		Median (mg/l)	1.01	0.87	0.87	0.87	0.87
	Total Suspended Solids	Mean (mg/l)	6.9	5.0	5.0	5.1	5.1
		Median (mg/l)	4.8	3.3	3.3	3.4	3.4
	Copper	Mean (mg/l)	0.0033	0.0026	0.0026	0.0026	0.0026
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-2 Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,040	5,898	5,898	3,765	1,929
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	66	66	69	72
		Geometric mean (cells per 100 ml)	630	504	504	333	172
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	27	45	45	98	228
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,968	3,478	3,478	1,927	1,019
		Percent compliance with single sample standard (<400 cells per 100 ml)	77	76	76	79	82
		Geometric mean (cells per 100 ml)	464	374	374	240	124
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	10	17	17	46	121
	Dissolved Oxygen	Mean (mg/l)	8.4	8.4	8.4	8.4	8.4
		Median (mg/l)	8.4	8.4	8.4	8.4	8.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	96	96	96	96	96
	Total Phosphorus	Mean (mg/l)	0.079	0.067	0.067	0.067	0.066
		Median (mg/l)	0.025	0.02	0.02	0.020	0.020
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	83	83	84	84
	Total Nitrogen	Mean (mg/l)	1.13	0.97	0.97	0.97	0.97
		Median (mg/l)	1.07	0.91	0.91	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	6.3	4.6	4.6	4.9	4.9
		Median (mg/l)	4.9	3.4	3.4	3.4	3.4
	Copper	Mean (mg/l)	0.0047	0.0036	0.0036	0.0036	0.0036
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-3 Root River at Wildcat Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,328	6,087	6,087	3,800	1,933
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	64	64	66	70
		Geometric mean (cells per 100 ml)	645	521	521	342	177
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	27	42	42	96	222
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,228	3,563	3,563	1,799	926
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	74	74	76	80
		Geometric mean (cells per 100 ml)	477	386	386	244	126
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	10	16	16	46	117
	Dissolved Oxygen	Mean (mg/l)	8.9	8.9	8.9	8.9	8.9
		Median (mg/l)	8.7	8.7	8.7	8.7	8.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	87	88	88	88	88
	Total Phosphorus	Mean (mg/l)	0.078	0.066	0.066	0.066	0.066
		Median (mg/l)	0.022	0.018	0.018	0.018	0.018
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	81	82	82	82	82
	Total Nitrogen	Mean (mg/l)	1.08	0.93	0.93	0.93	0.93
		Median (mg/l)	0.98	0.83	0.83	0.84	0.83
	Total Suspended Solids	Mean (mg/l)	9.2	6.8	6.8	6.9	6.9
		Median (mg/l)	4.8	3.3	3.3	3.3	3.3
	Copper	Mean (mg/l)	0.0049	0.0038	0.0038	0.0038	0.0038
		Median (mg/l)	0.0013	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-4 Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	7,101	5,944	5,944	3,707	1,883
		Percent compliance with single sample standard (<400 cells per 100 ml)	56	58	58	61	66
		Geometric mean (cells per 100 ml)	865	701	701	450	234
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	19	28	28	64	167
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,018	3,393	3,393	1,681	859
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	68	68	71	76
		Geometric mean (cells per 100 ml)	603	495	495	297	154
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	7	11	11	33	88
	Dissolved Oxygen	Mean (mg/l)	9.6	9.6	9.6	9.6	9.6
		Median (mg/l)	9.4	9.4	9.4	9.4	9.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	95	95	95	95	95
	Total Phosphorus	Mean (mg/l)	0.08	0.068	0.068	0.068	0.067
		Median (mg/l)	0.022	0.019	0.019	0.019	0.019
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	80	80	80	80
	Total Nitrogen	Mean (mg/l)	1.12	0.89	0.89	0.90	0.89
		Median (mg/l)	1.00	0.77	0.77	0.77	0.77
	Total Suspended Solids	Mean (mg/l)	10.3	7.2	7.2	7.3	7.3
		Median (mg/l)	4.7	3.2	3.2	3.3	3.3
	Copper	Mean (mg/l)	0.0054	0.0042	0.0042	0.0042	0.0042
		Median (mg/l)	0.0014	0.0011	0.0011	0.0011	0.0011

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-5 Whitnall Park Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	8,198	6,734	6,734	4,213	2,139
		Percent compliance with single sample standard (<400 cells per 100 ml)	55	57	57	59	63
		Geometric mean (cells per 100 ml)	896	715	715	461	239
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	18	28	28	66	165
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	5,142	4,201	4,201	2,141	1,091
		Percent compliance with single sample standard (<400 cells per 100 ml)	66	67	67	70	74
		Geometric mean (cells per 100 ml)	628	497	497	301	156
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	7	13	13	34	90
	Dissolved Oxygen	Mean (mg/l)	8.5	8.5	8.5	8.5	8.5
		Median (mg/l)	8.4	8.4	8.4	8.4	8.4
		Percent compliance with dissolved oxygen standard (>3 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.089	0.076	0.076	0.076	0.075
		Median (mg/l)	0.027	0.024	0.024	0.023	0.023
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	76	78	78	78	78
	Total Nitrogen	Mean (mg/l)	1.12	0.96	0.96	0.97	0.97
		Median (mg/l)	0.98	0.83	0.83	0.84	0.83
	Total Suspended Solids	Mean (mg/l)	15.3	11.3	11.3	11.5	11.5
		Median (mg/l)	5.0	3.5	3.5	3.5	3.5
	Copper	Mean (mg/l)	0.0056	0.0044	0.0044	0.0045	0.0045
		Median (mg/l)	0.0016	0.0012	0.0012	0.0012	0.0012

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-6 Tess Corners Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5,811	5,007	5,007	3,094	1,574
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	64	64	66	69
		Geometric mean (cells per 100 ml)	502	477	477	314	167
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	43	48	48	105	230
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,814	3,218	3,218	1,592	816
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	73	73	76	79
		Geometric mean (cells per 100 ml)	368	356	356	223	117
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	19	20	20	54	123
	Dissolved Oxygen	Mean (mg/l)	10.3	10.3	10.3	10.3	10.3
		Median (mg/l)	10.4	10.4	10.4	10.4	10.4
		Percent compliance with dissolved oxygen standard (>3 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.068	0.060	0.060	0.059	0.059
		Median (mg/l)	0.021	0.018	0.018	0.018	0.018
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	83	83	83	83	83
	Total Nitrogen	Mean (mg/l)	1.28	0.81	0.81	0.82	0.81
		Median (mg/l)	1.17	0.72	0.72	0.72	0.72
	Total Suspended Solids	Mean (mg/l)	16.4	9.4	9.4	9.9	9.9
		Median (mg/l)	5.0	3.5	3.5	3.5	3.5
	Copper	Mean (mg/l)	0.0042	0.0033	0.0033	0.0033	0.0033
		Median (mg/l)	0.0012	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-7 Whitnall Park Creek Down-stream of Tess Corners Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,947	5,721	5,721	3,573	1,815
		Percent compliance with single sample standard (<400 cells per 100 ml)	57	58	58	61	65
		Geometric mean (cells per 100 ml)	725	617	617	401	211
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	25	35	35	77	187
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	4,307	3,536	3,536	1,787	913
		Percent compliance with single sample standard (<400 cells per 100 ml)	68	68	68	71	75
		Geometric mean (cells per 100 ml)	496	428	428	263	138
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	12	16	16	41	103
	Dissolved Oxygen	Mean (mg/l)	10.1	10.1	10.1	10.1	10.1
		Median (mg/l)	10.0	9.9	9.9	9.9	9.9
		Percent compliance with dissolved oxygen standard (>3 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.078	0.067	0.067	0.066	0.065
		Median (mg/l)	0.023	0.020	0.020	0.020	0.020
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	80	80	80	80
	Total Nitrogen	Mean (mg/l)	1.17	0.86	0.86	0.87	0.87
		Median (mg/l)	1.09	0.74	0.74	0.74	0.74
	Total Suspended Solids	Mean (mg/l)	14.9	9.8	9.8	10.1	10.1
		Median (mg/l)	5.0	3.4	3.4	3.5	3.5
	Copper	Mean (mg/l)	0.0051	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0015	0.0011	0.0011	0.0011	0.0011

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-8 Middle Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,584	5,569	5,569	3,674	2,134
		Percent compliance with single sample standard (<400 cells per 100 ml)	46	48	48	52	56
		Geometric mean (cells per 100 ml)	1,262	1,069	1,069	714	418
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	6	10	10	27	79
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,951	3,257	3,257	1,788	1,090
		Percent compliance with single sample standard (<400 cells per 100 ml)	58	60	60	65	70
		Geometric mean (cells per 100 ml)	770	643	643	394	226
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	3	5	5	18	53
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.092	0.082	0.082	0.080	0.078
		Median (mg/l)	0.061	0.058	0.058	0.056	0.055
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	73	76	76	76	77
	Total Nitrogen	Mean (mg/l)	1.27	0.99	0.99	0.96	0.94
		Median (mg/l)	1.22	0.97	0.97	0.95	0.93
	Total Suspended Solids	Mean (mg/l)	19.4	11.6	11.6	11.3	11.1
		Median (mg/l)	5.1	3.5	3.5	3.5	3.5
	Copper	Mean (mg/l)	0.0007	0.0007	0.0007	0.0007	0.0007
		Median (mg/l)	0.0002	0.0002	0.0002	0.0002	0.0002

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-9 East Branch Root River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,332	5,369	5,369	3,443	1,746
		Percent compliance with single sample standard (<400 cells per 100 ml)	65	64	64	67	70
		Geometric mean (cells per 100 ml)	594	523	523	349	183
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	35	49	49	104	226
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,348	2,866	2,866	1,590	807
		Percent compliance with single sample standard (<400 cells per 100 ml)	79	77	77	79	83
		Geometric mean (cells per 100 ml)	365	326	326	213	111
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	21	27	27	59	130
	Dissolved Oxygen	Mean (mg/l)	8.2	8.2	8.2	8.2	8.2
		Median (mg/l)	7.8	7.8	7.8	7.8	7.8
		Percent compliance with dissolved oxygen standard (>1 mg/l)[e]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.072	0.063	0.063	0.063	0.062
		Median (mg/l)	0.029	0.024	0.024	0.024	0.024
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	82	83	83	83	83
	Total Nitrogen	Mean (mg/l)	1.27	0.91	0.91	0.91	0.91
		Median (mg/l)	1.22	0.89	0.89	0.89	0.89
	Total Suspended Solids	Mean (mg/l)	10.8	6.6	6.6	6.9	6.9
		Median (mg/l)	5.0	3.3	3.3	3.3	3.3
	Copper	Mean (mg/l)	0.0042	0.0033	0.0033	0.0033	0.0033
		Median (mg/l)	0.0012	0.0009	0.0009	0.0009	0.0009

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-10 Root River Upstream of Ryan Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	6,995	5,982	5,982	3,770	1,913
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	51	51	55	61
		Geometric mean (cells per 100 ml)	1,189	985	985	628	324
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	9	17	17	39	116
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,768	3,229	3,229	1,655	842
		Percent compliance with single sample standard (<400 cells per 100 ml)	59	62	62	68	74
		Geometric mean (cells per 100 ml)	717	594	594	353	182
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	4	9	9	26	71
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.087	0.076	0.076	0.075	0.075
		Median (mg/l)	0.057	0.052	0.052	0.051	0.051
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	73	76	76	76	77
	Total Nitrogen	Mean (mg/l)	1.15	0.91	0.91	0.90	0.90
		Median (mg/l)	1.13	0.88	0.88	0.88	0.87
	Total Suspended Solids	Mean (mg/l)	12.9	8.7	8.7	8.8	8.8
		Median (mg/l)	4.8	3.3	3.3	3.3	3.3
	Copper	Mean (mg/l)	0.002	0.0017	0.0017	0.0017	0.0017
		Median (mg/l)	0.0006	0.0005	0.0005	0.0005	0.0005

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-11 West Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,428	2,336	2,336	2,152	2,059
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	71	71	71	72
		Geometric mean (cells per 100 ml)	262	267	267	209	199
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	129	125	125	172	180
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,995	1,877	1,877	1,579	1,500
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	79	79	80	80
		Geometric mean (cells per 100 ml)	164	174	174	137	129
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	67	64	64	85	89
	Dissolved Oxygen	Mean (mg/l)	12.2	12.6	12.6	12.6	12.6
		Median (mg/l)	12.9	13.3	13.3	13.3	13.3
		Percent compliance with dissolved oxygen standard (>1 mg/l)[e]	92	95	95	95	95
	Total Phosphorus	Mean (mg/l)	0.266	0.239	0.239	0.231	0.226
		Median (mg/l)	0.179	0.150	0.150	0.147	0.146
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	32	40	40	41	42
	Total Nitrogen	Mean (mg/l)	3.72	3.43	3.43	3.06	2.94
		Median (mg/l)	3.12	2.79	2.79	2.41	2.29
	Total Suspended Solids	Mean (mg/l)	31.2	26.7	26.7	20.6	18.9
		Median (mg/l)	3.6	3.7	3.7	3.4	3.4
	Copper	Mean (mg/l)	0.0062	0.0055	0.0055	0.0054	0.0054
		Median (mg/l)	0.0046	0.0040	0.0040	0.0039	0.0039

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-12 West Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,573	2,429	2,429	2,240	2,139
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	70	70	71	72
		Geometric mean (cells per 100 ml)	250	254	254	190	183
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	139	133	133	187	195
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,270	2,104	2,104	1,830	1,736
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	79	79	80	80
		Geometric mean (cells per 100 ml)	160	170	170	129	123
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	70	66	66	92	98
	Dissolved Oxygen	Mean (mg/l)	12.2	12.4	12.4	12.3	12.3
		Median (mg/l)	12.7	12.8	12.8	12.7	12.7
		Percent compliance with dissolved oxygen standard (>3 mg/l)[e]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.242	0.217	0.217	0.208	0.203
		Median (mg/l)	0.135	0.117	0.117	0.114	0.112
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	40	46	46	47	47
	Total Nitrogen	Mean (mg/l)	3.57	3.32	3.32	2.91	2.77
		Median (mg/l)	2.84	2.63	2.63	2.21	2.09
	Total Suspended Solids	Mean (mg/l)	39.1	34.2	34.2	26.1	23.8
		Median (mg/l)	4.1	4.1	4.1	3.7	3.8
	Copper	Mean (mg/l)	0.0057	0.0050	0.0050	0.0050	0.0049
		Median (mg/l)	0.0039	0.0034	0.0034	0.0033	0.0032

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-13 West Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,372	2,234	2,234	2,105	2,015
		Percent compliance with single sample standard (<400 cells per 100 ml)	64	65	65	68	68
		Geometric mean (cells per 100 ml)	412	396	396	313	297
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	59	61	61	101	110
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,099	1,968	1,968	1,801	1,710
		Percent compliance with single sample standard (<400 cells per 100 ml)	74	74	74	77	77
		Geometric mean (cells per 100 ml)	256	252	252	198	188
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	41	42	42	62	66
	Dissolved Oxygen	Mean (mg/l)	11.8	11.8	11.8	11.7	11.7
		Median (mg/l)	12.3	12.2	12.2	12.2	12.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.164	0.151	0.151	0.143	0.138
		Median (mg/l)	0.076	0.069	0.069	0.067	0.066
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	63	66	66	67	67
	Total Nitrogen	Mean (mg/l)	2.75	2.61	2.61	2.21	2.08
		Median (mg/l)	2.00	1.95	1.95	1.58	1.47
	Total Suspended Solids	Mean (mg/l)	28.1	25.3	25.3	19.5	17.9
		Median (mg/l)	4.0	4.0	4.0	3.6	3.7
	Copper	Mean (mg/l)	0.0006	0.0006	0.0006	0.0006	0.0006
		Median (mg/l)	0.0002	0.0002	0.0002	0.0002	0.0002

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-14 East Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,582	2,417	2,417	2,234	2,124
		Percent compliance with single sample standard (<400 cells per 100 ml)	75	75	75	76	76
		Geometric mean (cells per 100 ml)	227	221	221	136	136
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	160	168	168	258	260
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,456	2,275	2,275	2,133	2,023
		Percent compliance with single sample standard (<400 cells per 100 ml)	83	83	83	84	84
		Geometric mean (cells per 100 ml)	178	172	172	112	110
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	82	86	86	126	127
	Dissolved Oxygen	Mean (mg/l)	12.1	12.1	12.1	12.0	12.0
		Median (mg/l)	12.3	12.3	12.3	12.3	12.3
		Percent compliance with dissolved oxygen standard (>1 mg/l)[e]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.183	0.181	0.181	0.168	0.162
		Median (mg/l)	0.074	0.074	0.074	0.070	0.068
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	65	65	65	67	68
	Total Nitrogen	Mean (mg/l)	3.14	3.10	3.10	2.55	2.37
		Median (mg/l)	2.43	2.40	2.40	1.92	1.76
	Total Suspended Solids	Mean (mg/l)	59.6	53.7	53.7	40.4	36.6
		Median (mg/l)	5.0	4.9	4.9	4.3	4.4
	Copper	Mean (mg/l)	0.0028	0.0028	0.0028	0.0027	0.0026
		Median (mg/l)	0.0014	0.0014	0.0014	0.0013	0.0013

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-15 East Branch Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,272	3,025	3,025	2,698	2,570
		Percent compliance with single sample standard (<400 cells per 100 ml)	71	71	71	72	72
		Geometric mean (cells per 100 ml)	288	280	280	189	185
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	121	127	127	209	213
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,853	2,572	2,572	2,109	2,003
		Percent compliance with single sample standard (<400 cells per 100 ml)	80	80	80	80	81
		Geometric mean (cells per 100 ml)	213	207	207	142	137
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	64	67	67	109	112
	Dissolved Oxygen	Mean (mg/l)	11.3	11.3	11.3	11.3	11.3
		Median (mg/l)	11.5	11.5	11.5	11.5	11.5
		Percent compliance with dissolved oxygen standard (>3 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.143	0.141	0.141	0.131	0.126
		Median (mg/l)	0.065	0.066	0.066	0.063	0.062
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	72	71	71	73	74
	Total Nitrogen	Mean (mg/l)	2.64	2.58	2.58	2.11	1.96
		Median (mg/l)	2.05	2.02	2.02	1.64	1.52
	Total Suspended Solids	Mean (mg/l)	57.2	50.2	50.2	38.4	35.1
		Median (mg/l)	5	4.9	4.9	4.3	4.4
	Copper	Mean (mg/l)	0.0034	0.0034	0.0034	0.0033	0.0032
		Median (mg/l)	0.0014	0.0014	0.0014	0.0013	0.0012

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-16 Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	2,401	2,304	2,304	2,161	2,069
		Percent compliance with single sample standard (<400 cells per 100 ml)	62	62	62	65	66
		Geometric mean (cells per 100 ml)	423	415	415	332	315
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	62	64	64	95	105
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,066	1,968	1,968	1,772	1,682
		Percent compliance with single sample standard (<400 cells per 100 ml)	72	72	72	75	75
		Geometric mean (cells per 100 ml)	255	254	254	202	191
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	47	49	49	66	70
	Dissolved Oxygen	Mean (mg/l)	11.7	11.8	11.8	11.8	11.7
		Median (mg/l)	12.1	12.2	12.2	12.2	12.2
		Percent compliance with dissolved oxygen standard (>5 mg/l)	97	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.129	0.122	0.122	0.114	0.110
		Median (mg/l)	0.069	0.065	0.065	0.063	0.062
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	71	73	73	74	74
	Total Nitrogen	Mean (mg/l)	2.31	2.23	2.23	1.85	1.73
		Median (mg/l)	1.79	1.73	1.73	1.43	1.33
	Total Suspended Solids	Mean (mg/l)	27.4	24.6	24.6	19.3	17.8
		Median (mg/l)	4.5	4.5	4.5	4.1	4.1
	Copper	Mean (mg/l)	0.0019	0.0019	0.0019	0.0018	0.0018
		Median (mg/l)	0.0006	0.0006	0.0006	0.0006	0.0006

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-17 Root River at Upstream Crossing of Milwaukee-Racine County Line and Down-stream of Root River Canal	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,656	4,077	4,077	2,909	1,982
		Percent compliance with single sample standard (<400 cells per 100 ml)	43	45	45	51	55
		Geometric mean (cells per 100 ml)	1,123	1,008	1,008	713	503
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	7	9	9	18	45
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,994	2,570	2,570	1,594	1,145
		Percent compliance with single sample standard (<400 cells per 100 ml)	55	57	57	63	68
		Geometric mean (cells per 100 ml)	720	641	641	422	291
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	4	4	4	12	33
	Dissolved Oxygen	Mean (mg/l)	11.5	11.5	11.5	11.5	11.5
		Median (mg/l)	11.7	11.7	11.7	11.7	11.7
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.104	0.096	0.096	0.091	0.088
		Median (mg/l)	0.071	0.067	0.067	0.065	0.064
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	71	73	73	74	75
	Total Nitrogen	Mean (mg/l)	1.68	1.48	1.48	1.29	1.23
		Median (mg/l)	1.39	1.21	1.21	1.11	1.07
	Total Suspended Solids	Mean (mg/l)	20.6	16.3	16.3	13.8	13.0
		Median (mg/l)	4.6	3.8	3.8	3.6	3.6
	Copper	Mean (mg/l)	0.0006	0.0005	0.0005	0.0005	0.0005
		Median (mg/l)	0.0001	0.0001	0.0001	0.0001	0.0001

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-18 Root River Upstream of Hoods Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,253	3,675	3,675	2,801	2,096
		Percent compliance with single sample standard (<400 cells per 100 ml)	46	48	48	51	54
		Geometric mean (cells per 100 ml)	983	865	865	629	466
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	11	16	16	37	69
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,687	2,255	2,255	1,589	1,290
		Percent compliance with single sample standard (<400 cells per 100 ml)	60	61	61	65	68
		Geometric mean (cells per 100 ml)	556	485	485	330	241
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	9	12	12	29	54
	Dissolved Oxygen	Mean (mg/l)	11.4	11.4	11.4	11.4	11.4
		Median (mg/l)	11.6	11.6	11.6	11.6	11.6
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	100	100
	Total Phosphorus	Mean (mg/l)	0.102	0.094	0.094	0.089	0.085
		Median (mg/l)	0.068	0.065	0.065	0.064	0.063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	73	75	75	76	76
	Total Nitrogen	Mean (mg/l)	1.64	1.45	1.45	1.26	1.19
		Median (mg/l)	1.32	1.16	1.16	1.04	1.00
	Total Suspended Solids	Mean (mg/l)	31	23.8	23.8	20.0	18.7
		Median (mg/l)	5.2	4.4	4.4	4.1	4.1
	Copper	Mean (mg/l)	0.0013	0.0012	0.0012	0.0012	0.0012
		Median (mg/l)	0.0004	0.0003	0.0003	0.0003	0.0003

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-19 Ives Grove Ditch	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,398	2,730	2,730	1,649	841
		Percent compliance with single sample standard (<400 cells per 100 ml)	73	74	74	77	80
		Geometric mean (cells per 100 ml)	219	204	204	78	53
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	183	194	194	270	303
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2,457	2,013	2,013	991	509
		Percent compliance with single sample standard (<400 cells per 100 ml)	85	84	84	86	89
		Geometric mean (cells per 100 ml)	103	104	104	29	21
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	105	109	109	147	151
	Dissolved Oxygen	Mean (mg/l)	10.1	9.9	9.9	9.9	9.9
		Median (mg/l)	8.8	8.8	8.8	8.7	8.7
		Percent compliance with dissolved oxygen standard (>1 mg/l)	96	97	97	97	97
	Total Phosphorus	Mean (mg/l)	0.771	0.659	0.659	0.673	0.690
		Median (mg/l)	0.343	0.263	0.263	0.265	0.268
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	21	25	25	25	25
	Total Nitrogen	Mean (mg/l)	4.67	4.27	4.27	4.07	4.04
		Median (mg/l)	3.47	3.15	3.15	2.87	2.75
	Total Suspended Solids	Mean (mg/l)	20.5	18.0	18.0	15.5	14.4
		Median (mg/l)	4.8	4.6	4.6	4.2	4.2
	Copper	Mean (mg/l)	0.0056	0.0048	0.0048	0.0048	0.0048
		Median (mg/l)	0.0035	0.0029	0.0029	0.0029	0.0029

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-20 Hoods Creek	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,039	3,218	3,218	1,975	1,006
		Percent compliance with single sample standard (<400 cells per 100 ml)	69	68	68	71	75
		Geometric mean (cells per 100 ml)	286	277	277	121	76
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	148	149	149	248	287
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,354	2,602	2,602	1,393	714
		Percent compliance with single sample standard (<400 cells per 100 ml)	81	79	79	80	83
		Geometric mean (cells per 100 ml)	158	161	161	55	37
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	84	83	83	138	149
	Dissolved Oxygen	Mean (mg/l)	11	11.0	11.0	11.0	11.0
		Median (mg/l)	11.7	11.8	11.8	11.8	11.8
		Percent compliance with dissolved oxygen standard (>3 mg/l)[d]	98	98	98	98	98
	Total Phosphorus	Mean (mg/l)	0.381	0.337	0.337	0.345	0.355
		Median (mg/l)	0.131	0.113	0.113	0.113	0.112
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	43	49	49	49	49
	Total Nitrogen	Mean (mg/l)	3.20	2.84	2.84	2.67	2.63
		Median (mg/l)	2.39	2.05	2.05	1.86	1.79
	Total Suspended Solids	Mean (mg/l)	33.5	23.4	23.4	20.5	19.0
		Median (mg/l)	4.9	4.5	4.5	4.2	4.1
	Copper	Mean (mg/l)	0.0048	0.0040	0.0040	0.0040	0.0040
		Median (mg/l)	0.0022	0.0020	0.0020	0.0020	0.0020

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-21 Root River at the City of Racine, USGS Sampling Location (4087240)	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,547	3,910	3,910	2,672	1,677
		Percent compliance with single sample standard (<400 cells per 100 ml)	48	49	49	53	56
		Geometric mean (cells per 100 ml)	853	759	759	522	352
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	17	23	23	57	105
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,041	2,555	2,555	1,489	943
		Percent compliance with single sample standard (<400 cells per 100 ml)	62	63	63	67	71
		Geometric mean (cells per 100 ml)	479	421	421	268	178
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	13	18	18	43	79
	Dissolved Oxygen	Mean (mg/l)	11	11.1	11.1	11.1	11.1
		Median (mg/l)	11.3	11.4	11.4	11.4	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.109	0.099	0.099	0.094	0.091
		Median (mg/l)	0.075	0.071	0.071	0.070	0.069
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	67	71	71	71	72
	Total Nitrogen	Mean (mg/l)	1.58	1.38	1.38	1.20	1.14
		Median (mg/l)	1.24	1.09	1.09	0.99	0.95
	Total Suspended Solids	Mean (mg/l)	35.9	25.6	26.6	22.8	21.4
		Median (mg/l)	7	5.8	5.8	5.2	5.1
	Copper	Mean (mg/l)	0.0008	0.0006	0.0006	0.0006	0.0006
		Median (mg/l)	0.0002	0.0001	0.0001	0.0001	0.0001

Indicates Revision

Table N-5 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
RT-22 Mouth of Root River at Lake Michigan	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	4,924	4,135	4,135	2,762	1,165
		Percent compliance with single sample standard (<400 cells per 100 ml)	47	48	48	51	55
		Geometric mean (cells per 100 ml)	869	761	761	516	339
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	28	34	34	68	114
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	3,327	2,714	2,714	1,508	903
		Percent compliance with single sample standard (<400 cells per 100 ml)	62	62	62	67	70
		Geometric mean (cells per 100 ml)	440	382	382	240	155
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	22	27	27	54	87
	Dissolved Oxygen	Mean (mg/l)	11.1	11.1	11.1	11.1	11.1
		Median (mg/l)	11.3	11.3	11.3	11.4	11.4
		Percent compliance with dissolved oxygen standard (>5 mg/l)	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.115	0.104	0.104	0.099	0.096
		Median (mg/l)	0.079	0.074	0.074	0.073	0.072
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	65	68	68	69	70
	Total Nitrogen	Mean (mg/l)	1.56	1.36	1.36	1.20	1.13
		Median (mg/l)	1.23	1.08	1.08	0.98	0.94
	Total Suspended Solids	Mean (mg/l)	38.5	28.9	28.9	25.3	23.9
		Median (mg/l)	9.4	8.0	8.0	7.3	7.2
	Copper	Mean (mg/l)	0.0015	0.0011	0.0011	0.0011	0.0011
		Median (mg/l)	0.0002	0.0002	0.0002	0.0002	0.0002

Indicates Revision

Table N-5 Footnotes

[a] *In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b] *Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

[c] *Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[d] *Under Chapter NR 104 of the Wisconsin Administrative Code, this assessment point is in a stream reach classified as capable of supporting limited forage fish.*

[e] *Under Chapter NR 104 of the Wisconsin Administrative Code, this assessment point is in a stream reach classified as capable of supporting limited aquatic life.*

Source: Tetra Tech, Inc., and SEWRPC.

Table N-6

WATER QUALITY SUMMARY STATISTICS FOR THE RECOMMENDED PLAN: MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN AREA[a]

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-1 Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	1,101	863	850	428	331
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	79	85	85	99	99
		Geometric mean (cells per 100 ml)	175	145	144	79	50
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	254	277	277	364	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	457	353	328	272	241
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	95	97	97	98	98
		Geometric mean (cells per 100 ml)	26	22	21	16	9
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	147	150	150	153	153
	Dissolved Oxygen	Mean (mg/l)	9.96	9.94	9.94	9.89	9.87
		Median (mg/l)	10.85	10.85	10.85	10.75	10.73
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	99	99	99	99	99
	Total Phosphorus	Mean (mg/l)	0.0657	0.0653	0.0652	0.0536	0.0512
		Median (mg/l)	0.0550	0.0554	0.0555	0.0447	0.0426
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	78	79	79	87	89
	Total Nitrogen	Mean (mg/l)	1.69	1.63	1.63	1.24	1.18
		Median (mg/l)	1.48	1.43	1.43	1.11	1.05
	Total Suspended Solids	Mean (mg/l)	22.46	20.69	20.68	20.28	20.14
		Median (mg/l)	13.09	12.38	12.38	11.47	11.38
	Copper	Mean (mg/l)	0.0045	0.0046	0.0046	0.0040	0.0041
		Median (mg/l)	0.0044	0.0044	0.0044	0.0039	0.0039

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-2 Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3,466	3,208	3,169	2,245	1,280
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	58	59	59	67	78
		Geometric mean (cells per 100 ml)	595	546	542	376	233
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	208	211	212	229	253
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	1,250	1,111	1,040	709	418
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	84	85	86	91	96
		Geometric mean (cells per 100 ml)	135	119	117	79	49
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	139	142	142	148	152
	Dissolved Oxygen	Mean (mg/l)	9.26	9.45	9.46	9.49	9.51
		Median (mg/l)	9.71	9.96	9.96	9.95	9.93
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0704	0.0698	0.0696	0.0651	0.0611
		Median (mg/l)	0.0645	0.0659	0.0659	0.0609	0.0574
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	86	88	88	90	93
	Total Nitrogen	Mean (mg/l)	1.53	1.33	1.33	1.19	1.17
		Median (mg/l)	1.51	1.31	1.31	1.19	1.17
	Total Suspended Solids	Mean (mg/l)	20.09	18.00	17.99	17.96	17.92
		Median (mg/l)	11.64	11.20	11.20	10.88	10.83
	Copper	Mean (mg/l)	0.0187	0.0183	0.0182	0.0173	0.0174
		Median (mg/l)	0.0141	0.0134	0.0134	0.0130	0.0130

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-3 Menomonee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	931	828	808	533	320
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	86	87	88	93	98
		Geometric mean (cells per 100 ml)	141	127	126	80	53
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	308	320	320	353	364
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	494	442	406	286	180
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	94	94	95	97	99
		Geometric mean (cells per 100 ml)	40	35	34	24	16
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	150	151	151	153	153
	Dissolved Oxygen	Mean (mg/l)	9.12	9.28	9.28	9.32	9.34
		Median (mg/l)	9.74	9.95	9.96	9.93	9.90
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0620	0.0619	0.0618	0.0553	0.0522
		Median (mg/l)	0.0589	0.0600	0.0600	0.0533	0.0508
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	93	94	94	96	98
	Total Nitrogen	Mean (mg/l)	1.53	1.40	1.40	1.18	1.15
		Median (mg/l)	1.44	1.31	1.31	1.13	1.10
	Total Suspended Solids	Mean (mg/l)	19.00	17.49	17.49	17.19	17.12
		Median (mg/l)	12.24	11.66	11.65	11.11	11.06
	Copper	Mean (mg/l)	0.0056	0.0053	0.0053	0.0050	0.0050
		Median (mg/l)	0.0051	0.0048	0.0048	0.0045	0.0045

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-4 Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	850	731	716	416	278
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	85	89	89	97	99
		Geometric mean (cells per 100 ml)	147	132	131	78	54
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	298	310	310	360	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	399	345	319	235	167
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	95	96	96	98	99
		Geometric mean (cells per 100 ml)	37	31	31	22	15
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	150	151	151	153	153
	Dissolved Oxygen	Mean (mg/l)	9.51	9.62	9.63	9.63	9.64
		Median (mg/l)	10.13	10.33	10.34	10.28	10.25
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0591	0.0595	0.0594	0.0512	0.0486
		Median (mg/l)	0.0545	0.0549	0.0550	0.0467	0.0448
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	92	91	91	96	97
	Total Nitrogen	Mean (mg/l)	1.58	1.49	1.49	1.20	1.15
		Median (mg/l)	1.42	1.33	1.33	1.10	1.06
	Total Suspended Solids	Mean (mg/l)	19.03	17.84	17.84	17.34	17.24
		Median (mg/l)	12.06	11.75	11.75	10.94	10.84
	Copper	Mean (mg/l)	0.0054	0.0052	0.0052	0.0048	0.0048
		Median (mg/l)	0.0051	0.0049	0.0049	0.0045	0.0045

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-5 Kinnickinnic River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	352	358	265	184	129
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	98	98	99	99	99
		Geometric mean (cells per 100 ml)	52	48	47	31	21
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	363	363	363	364	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	255	298	166	140	118
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	98	99	99	99	99
		Geometric mean (cells per 100 ml)	17	15	15	11	9
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	152	152	153	153	153
	Dissolved Oxygen	Mean (mg/l)	8.09	8.24	8.26	8.37	8.42
		Median (mg/l)	8.58	8.74	8.76	8.91	8.95
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0490	0.0480	0.0471	0.0423	0.0398
		Median (mg/l)	0.0436	0.0429	0.0429	0.0384	0.0365
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	97	97	98	99	99
	Total Nitrogen	Mean (mg/l)	1.39	1.32	1.31	1.13	1.10
		Median (mg/l)	1.30	1.24	1.23	1.07	1.05
	Total Suspended Solids	Mean (mg/l)	12.16	11.26	11.20	10.85	10.80
		Median (mg/l)	7.83	7.44	7.44	7.08	7.03
	Copper	Mean (mg/l)	0.0069	0.0066	0.0066	0.0063	0.0063
		Median (mg/l)	0.0070	0.0066	0.0065	0.0062	0.0062

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-6 Mouth of Milwaukee River	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	445	396	383	230	160
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	95	96	97	99	99
		Geometric mean (cells per 100 ml)	78	74	73	47	35
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	352	357	358	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	229	203	180	139	107
		Percent compliance with single sample standard (<2,000 cells per 100 ml)[d]	98	98	98	99	99
		Geometric mean (cells per 100 ml)	26	23	23	18	14
		Days of compliance with geometric mean standard (<1,000 cells per 100 ml)[d]	152	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	9.46	9.55	9.55	9.58	9.59
		Median (mg/l)	9.97	10.10	10.11	10.13	10.13
		Percent compliance with dissolved oxygen standard (>2 mg/l)[d]	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0471	0.0473	0.0472	0.0418	0.0398
		Median (mg/l)	0.0424	0.0427	0.0426	0.0378	0.0364
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	97	97	97	98	99
	Total Nitrogen	Mean (mg/l)	1.51	1.44	1.44	1.24	1.21
		Median (mg/l)	1.44	1.39	1.39	1.20	1.16
	Total Suspended Solids	Mean (mg/l)	13.28	12.62	12.61	12.18	12.12
		Median (mg/l)	8.48	8.28	8.28	7.83	7.77
	Copper	Mean (mg/l)	0.0072	0.0069	0.0069	0.0066	0.0067
		Median (mg/l)	0.0073	0.0069	0.0069	0.0066	0.0066

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-7 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	91	84	78	53	41
		Percent compliance with single sample standard (<400 cells per 100 ml)	96	97	97	98	99
		Geometric mean (cells per 100 ml)	21	20	20	15	12
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	360	361	361	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	81	73	64	53	43
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	98	98
		Geometric mean (cells per 100 ml)	13	12	12	10	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	10.34	10.36	10.36	10.37	10.37
		Median (mg/l)	10.69	10.73	10.74	10.74	10.75
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0274	0.0276	0.0276	0.0258	0.0250
		Median (mg/l)	0.0242	0.0246	0.0246	0.0231	0.0226
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	99	99	100	100
	Total Nitrogen	Mean (mg/l)	1.15	1.13	1.13	1.06	1.05
		Median (mg/l)	1.09	1.08	1.08	1.03	1.02
	Total Suspended Solids	Mean (mg/l)	6.45	6.22	6.22	6.10	6.09
		Median (mg/l)	4.01	4.03	4.03	3.93	3.91
	Copper	Mean (mg/l)	0.0094	0.0093	0.0093	0.0092	0.0092
		Median (mg/l)	0.0096	0.0095	0.0095	0.0094	0.0094

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-8 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	66	61	55	39	30
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	99	99
		Geometric mean (cells per 100 ml)	15	15	15	11	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	363	363	363	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	65	59	51	42	34
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	98	98	99	99
		Geometric mean (cells per 100 ml)	11	10	10	9	7
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	10.51	10.52	10.52	10.53	10.53
		Median (mg/l)	10.80	10.83	10.83	10.84	10.84
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0236	0.0239	0.0238	0.0223	0.0217
		Median (mg/l)	0.0195	0.0199	0.0199	0.0190	0.0187
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	99	99	100	100
	Total Nitrogen	Mean (mg/l)	1.04	1.02	1.02	0.97	0.96
		Median (mg/l)	0.98	0.97	0.97	0.93	0.92
	Total Suspended Solids	Mean (mg/l)	5.74	5.55	5.55	5.45	5.44
		Median (mg/l)	3.51	3.54	3.54	3.44	3.43
	Copper	Mean (mg/l)	0.0095	0.0094	0.0094	0.0093	0.0093
		Median (mg/l)	0.0097	0.0096	0.0096	0.0096	0.0096

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-9 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	47	43	41	27	20
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	98	99	99	100
		Geometric mean (cells per 100 ml)	11	11	11	8	7
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	26	23	21	17	14
		Percent compliance with single sample standard (<400 cells per 100 ml)	99	99	99	99	100
		Geometric mean (cells per 100 ml)	6	6	6	5	4
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	10.68	10.70	10.71	10.71	10.71
		Median (mg/l)	10.94	10.97	10.98	10.99	11.00
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0205	0.0205	0.0205	0.0193	0.0189
		Median (mg/l)	0.0179	0.0182	0.0182	0.0172	0.0169
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.95	0.93	0.93	0.89	0.89
		Median (mg/l)	0.84	0.83	0.83	0.80	0.79
	Total Suspended Solids	Mean (mg/l)	4.64	4.50	4.50	4.40	4.39
		Median (mg/l)	3.19	3.20	3.20	3.16	3.15
	Copper	Mean (mg/l)	0.0097	0.0096	0.0096	0.0095	0.0096
		Median (mg/l)	0.0099	0.0098	0.0098	0.0098	0.0098

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-10 Outer Harbor	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	66	61	57	39	30
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	99	99
		Geometric mean (cells per 100 ml)	17	16	16	12	10
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	362	363	363	364	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	50	46	40	34	28
		Percent compliance with single sample standard (<400 cells per 100 ml)	98	98	98	99	99
		Geometric mean (cells per 100 ml)	11	11	10	9	8
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	152	152	152	153	153
	Dissolved Oxygen	Mean (mg/l)	10.37	10.38	10.39	10.39	10.39
		Median (mg/l)	10.75	10.78	10.78	10.79	10.80
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0262	0.0263	0.0263	0.0248	0.0242
		Median (mg/l)	0.0233	0.0236	0.0236	0.0225	0.0220
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	99	100	100	100	100
	Total Nitrogen	Mean (mg/l)	1.14	1.12	1.13	1.07	1.06
		Median (mg/l)	1.08	1.06	1.07	1.03	1.02
	Total Suspended Solids	Mean (mg/l)	5.64	5.45	5.45	5.34	5.32
		Median (mg/l)	3.68	3.71	3.71	3.62	3.61
	Copper	Mean (mg/l)	0.0096	0.0095	0.0095	0.0095	0.0095
		Median (mg/l)	0.0097	0.0096	0.0096	0.0096	0.0096

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-11 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	11	10	10	7	5
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	4	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6	5	5	4	3
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.21	11.21	11.21	11.21	11.21
		Median (mg/l)	11.49	11.50	11.50	11.51	11.51
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0095	0.0095	0.0095	0.0093	0.0092
		Median (mg/l)	0.0076	0.0077	0.0077	0.0075	0.0074
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.62	0.61	0.61	0.61	0.60
		Median (mg/l)	0.55	0.55	0.55	0.55	0.55
	Total Suspended Solids	Mean (mg/l)	2.64	2.61	2.61	2.58	2.57
		Median (mg/l)	2.34	2.34	2.34	2.33	2.33
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-12 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	12	11	11	8	6
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	4	4
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	6	6	6	5	4
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	4	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.18	11.19	11.19	11.19	11.19
		Median (mg/l)	11.46	11.48	11.48	11.48	11.48
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0099	0.0099	0.0099	0.0096	0.0095
		Median (mg/l)	0.0080	0.0080	0.0081	0.0078	0.0077
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.63	0.63	0.63	0.62	0.61
		Median (mg/l)	0.56	0.56	0.56	0.55	0.55
	Total Suspended Solids	Mean (mg/l)	2.71	2.67	2.67	2.64	2.63
		Median (mg/l)	2.39	2.38	2.38	2.37	2.37
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0098	0.0098
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-13 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	69	59	59	40	25
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	100	100
		Geometric mean (cells per 100 ml)	16	15	15	11	9
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	363	364	364	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	58	49	48	35	22
		Percent compliance with single sample standard (<400 cells per 100 ml)	97	98	98	99	100
		Geometric mean (cells per 100 ml)	10	9	9	8	6
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	10.87	10.89	10.89	10.88	10.88
		Median (mg/l)	11.14	11.16	11.17	11.16	11.15
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0195	0.0195	0.0195	0.0186	0.0182
		Median (mg/l)	0.0162	0.0164	0.0164	0.0157	0.0155
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.86	0.85	0.85	0.82	0.82
		Median (mg/l)	0.78	0.77	0.78	0.76	0.75
	Total Suspended Solids	Mean (mg/l)	4.24	4.04	4.04	3.97	3.96
		Median (mg/l)	2.84	2.82	2.82	2.78	2.77
	Copper	Mean (mg/l)	0.0098	0.0098	0.0098	0.0097	0.0097
		Median (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-14 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3	3	3	3	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2	2	2	2	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.36	11.36	11.36	11.36	11.36
		Median (mg/l)	11.64	11.66	11.66	11.66	11.66
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0068	0.0068	0.0068	0.0067	0.0067
		Median (mg/l)	0.0049	0.0049	0.0049	0.0048	0.0048
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.54	0.54	0.54	0.54	0.54
		Median (mg/l)	0.53	0.53	0.53	0.52	0.52
	Total Suspended Solids	Mean (mg/l)	2.39	2.38	2.38	2.37	2.37
		Median (mg/l)	2.33	2.32	2.32	2.32	2.32
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition: Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-15 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	5	5	4	4	3
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	8	7	6	5	4
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.31	11.32	11.32	11.31	11.31
		Median (mg/l)	11.59	11.59	11.59	11.60	11.60
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0086	0.0086	0.0086	0.0084	0.0083
		Median (mg/l)	0.0064	0.0065	0.0065	0.0063	0.0063
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.58	0.57	0.57	0.57	0.57
		Median (mg/l)	0.55	0.55	0.55	0.55	0.55
	Total Suspended Solids	Mean (mg/l)	2.67	2.63	2.63	2.63	2.63
		Median (mg/l)	2.31	2.31	2.31	2.30	2.30
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	“Extreme Measures” Condition[c]
LM-16 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	9	9	9	7	5
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	4	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	5	4	4	4	3
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	3	3	3	3	3
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.26	11.27	11.27	11.27	11.26
		Median (mg/l)	11.56	11.57	11.57	11.56	11.56
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0118	0.0119	0.0119	0.0117	0.0115
		Median (mg/l)	0.0101	0.0102	0.0103	0.0100	0.0099
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.65	0.65	0.65	0.64	0.64
		Median (mg/l)	0.62	0.62	0.62	0.61	0.61
	Total Suspended Solids	Mean (mg/l)	2.57	2.53	2.53	2.50	2.50
		Median (mg/l)	2.30	2.30	2.29	2.28	2.28
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-17 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	21	21	21	18	16
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	8	8	8	7	6
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	364	364	364	364	364
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	9	10	10	8	7
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	5	5	5	4	4
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.19	11.19	11.19	11.19	11.19
		Median (mg/l)	11.39	11.40	11.40	11.40	11.40
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0196	0.0207	0.0207	0.0206	0.0205
		Median (mg/l)	0.0161	0.0167	0.0167	0.0166	0.0165
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.97	1.02	1.02	1.01	1.01
		Median (mg/l)	0.88	0.92	0.92	0.91	0.91
	Total Suspended Solids	Mean (mg/l)	2.52	2.50	2.50	2.48	2.48
		Median (mg/l)	2.31	2.32	2.32	2.31	2.31
	Copper	Mean (mg/l)	0.0102	0.0102	0.0102	0.0102	0.0102
		Median (mg/l)	0.0101	0.0101	0.0101	0.0101	0.0101

Table N-6 (continued)

Assessment Point	Water Quality Indicator	Statistic	Condition				
			Existing	Revised 2020 Baseline	Revised 2020 Baseline with Five-Year LOP[b]	Recommended Plan[c]	"Extreme Measures" Condition[c]
LM-18 Nearshore Lake Michigan Area	Fecal Coliform Bacteria (annual)	Mean (cells per 100 ml)	3	3	3	2	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	365	365	365	365	365
	Fecal Coliform Bacteria (May-September: 153 days total)	Mean (cells per 100 ml)	2	2	2	2	2
		Percent compliance with single sample standard (<400 cells per 100 ml)	100	100	100	100	100
		Geometric mean (cells per 100 ml)	2	2	2	2	2
		Days of compliance with geometric mean standard (<200 cells per 100 ml)	153	153	153	153	153
	Dissolved Oxygen	Mean (mg/l)	11.37	11.37	11.37	11.37	11.37
		Median (mg/l)	11.63	11.63	11.63	11.63	11.63
		Percent compliance with dissolved oxygen standard (>5 mg/l)	100	100	100	100	100
	Total Phosphorus	Mean (mg/l)	0.0080	0.0080	0.0080	0.0080	0.0079
		Median (mg/l)	0.0062	0.0063	0.0063	0.0062	0.0062
		Percent compliance with recommended phosphorus standard (0.1 mg/l)	100	100	100	100	100
	Total Nitrogen	Mean (mg/l)	0.57	0.57	0.57	0.57	0.57
		Median (mg/l)	0.56	0.56	0.56	0.56	0.56
	Total Suspended Solids	Mean (mg/l)	2.20	2.20	2.20	2.19	2.19
		Median (mg/l)	2.18	2.17	2.17	2.17	2.17
	Copper	Mean (mg/l)	0.0099	0.0099	0.0099	0.0099	0.0099
		Median (mg/l)	0.0100	0.0100	0.0100	0.0100	0.0100

Table N-6 Footnotes

[a]*In certain limited cases, relatively minor anomalies in concentrations or percents compliance may occur among the five conditions for which model results are presented in this table. Those anomalies might indicate a slight decrease in water quality under the recommended plan and/or "extreme measures" conditions, relative to revised 2020 baseline and/or revised 2020 baseline with five-year LOP conditions. In those cases, it may be assumed that no significant change in water quality occurs among those various conditions. Since it was not always possible to explicitly represent certain components of the recommended plan and "extreme measures" conditions in the LSPC water quality model, adjustments were made to model parameters that served as surrogates for the actual water pollution control measure being represented. In the sense that those modifications sometimes alter parameters in the revised 2020 baseline and/or revised 2020 baseline with five-year LOP model versions, in limited cases, representation of a measure in the recommended plan or "extreme measures" models may have a side effect of introducing small, relatively insignificant anomalies in the comparative results.*

[b]*Five-Year LOP refers to a five-year recurrence interval level of protection against sanitary sewer overflows.*

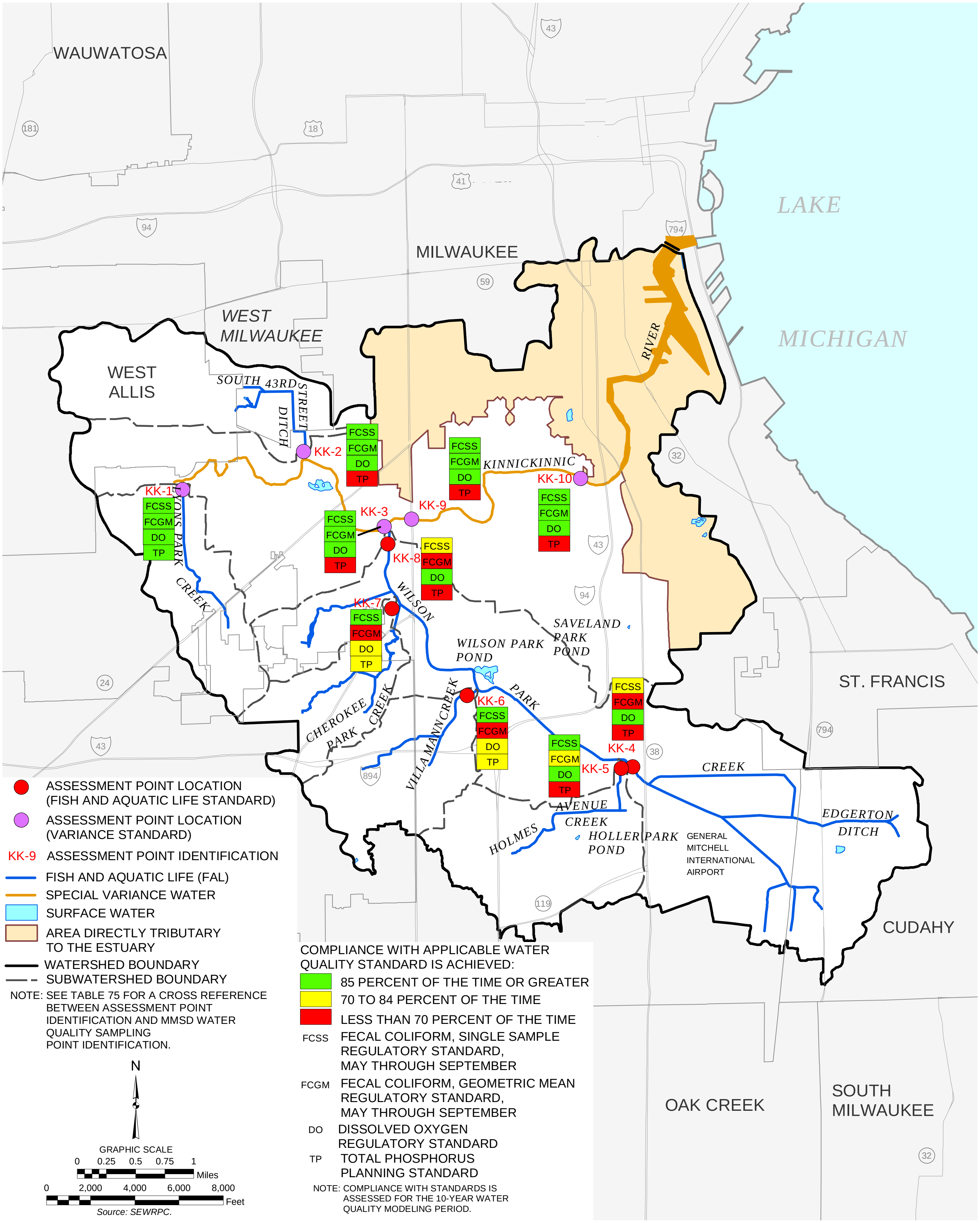
[c]*Within the water quality models for the recommended plan and extreme measures condition, the detection and elimination of illicit discharges to storm sewer systems and control of urban sourced pathogens, including those in stormwater runoff, are represented using stormwater disinfection units. Such units were initially considered as a recommended approach to treatment of runoff, but were eliminated from further consideration based on comments from the Technical Advisory Committee. However, the use of such units is considered to be appropriate as a surrogate representation of the varied and as yet undetermined means that would be applied to detect and eliminate illicit discharges and to control pathogens in urban stormwater runoff. Those units explicitly address the control of bacteria in stormwater runoff, and, based on the way that bacteria loads are represented in the calibrated model, they also implicitly provide some control of bacteria that may reach streams through illicit connections that contribute to baseflow.*

[d]*This assessment point is located within the estuary. Variance standards are from Chapter NR 104 of the* Wisconsin Administrative Code *apply.*

Source: HydroQual, Inc., and SEWRPC.

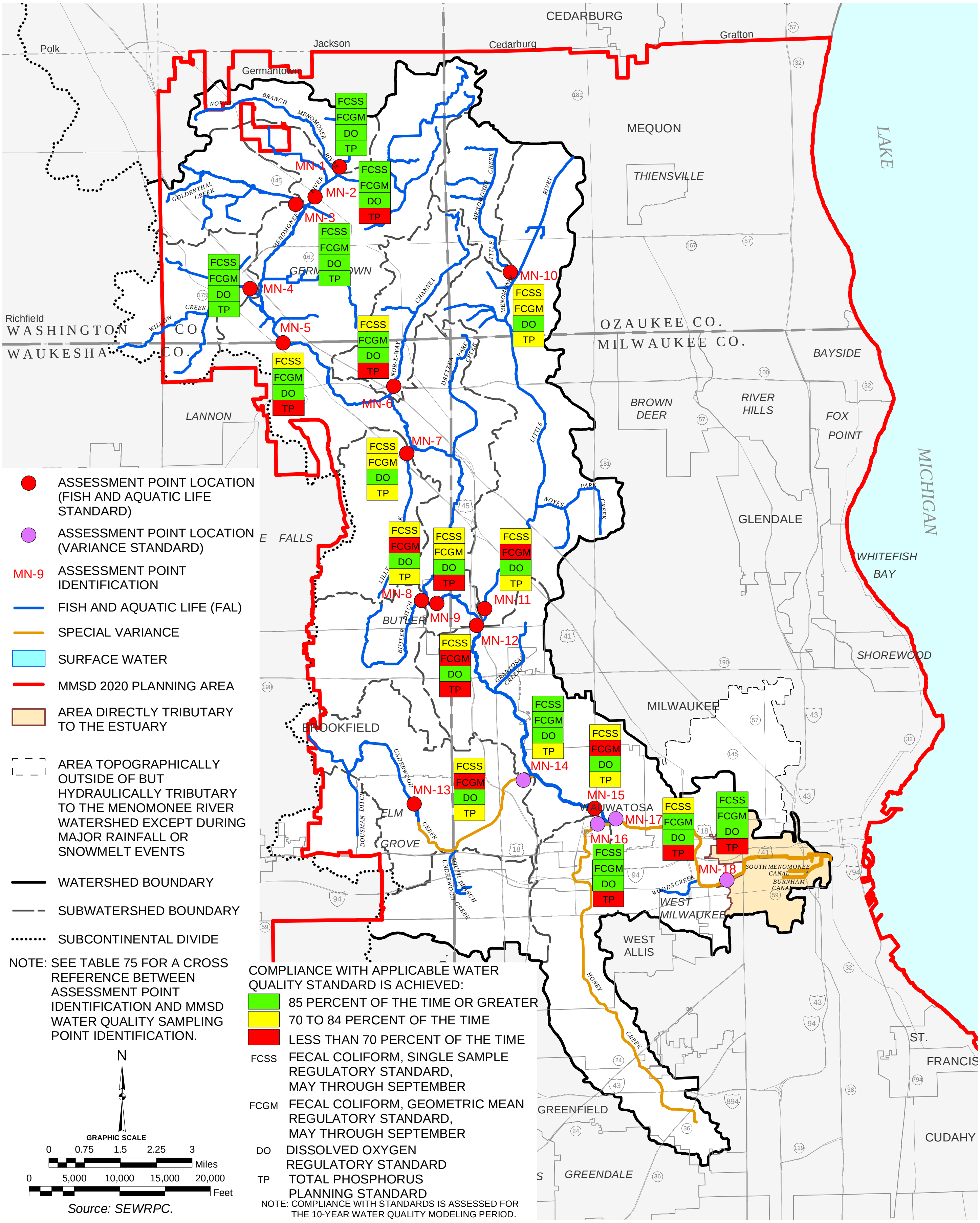
Map N-1

ASSESSMENT POINTS WITHIN THE KINNICKINNIC RIVER WATERSHED FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



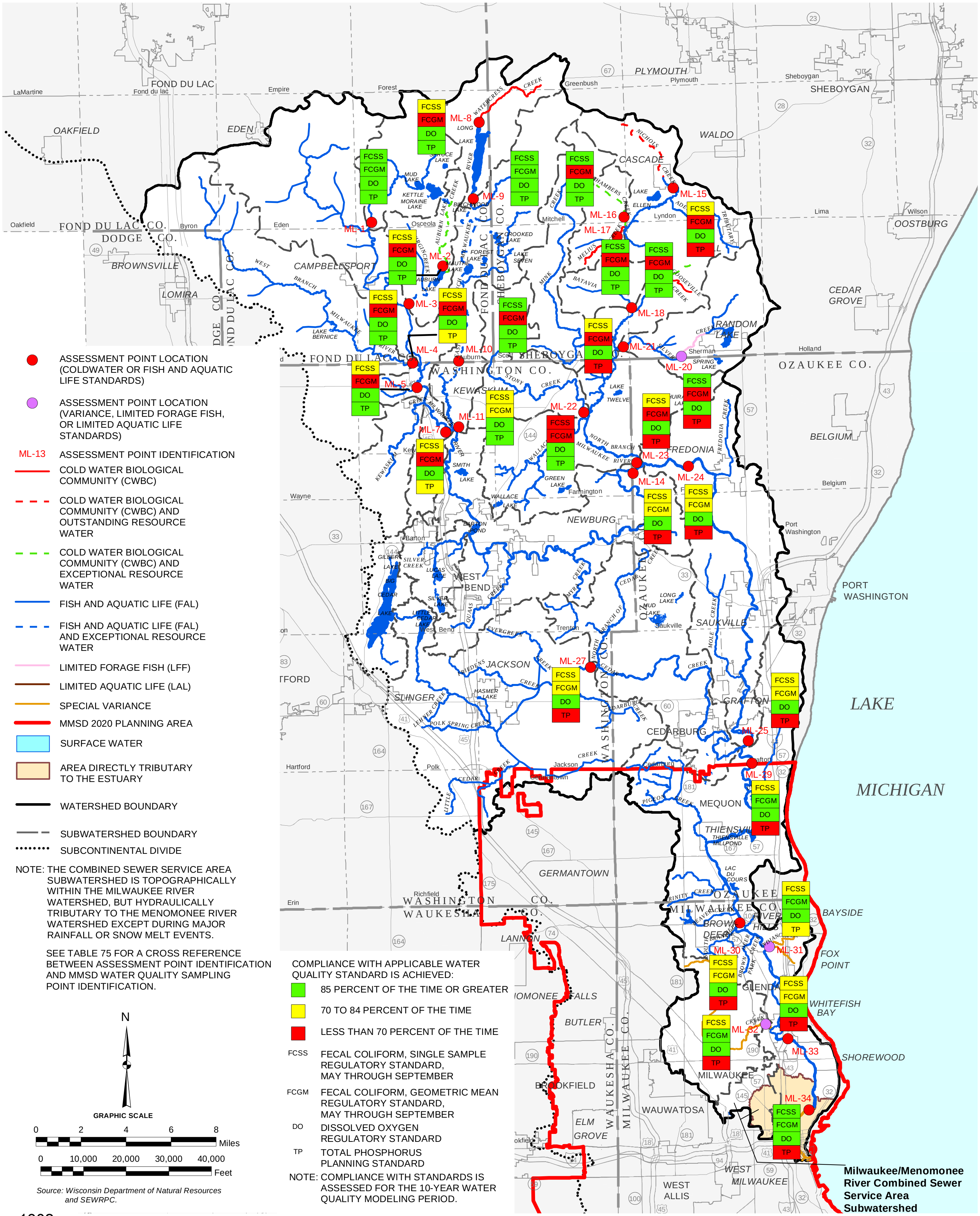
Map N-2

ASSESSMENT POINTS WITHIN THE MENOMONEE RIVER WATERSHED FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



Map N-3

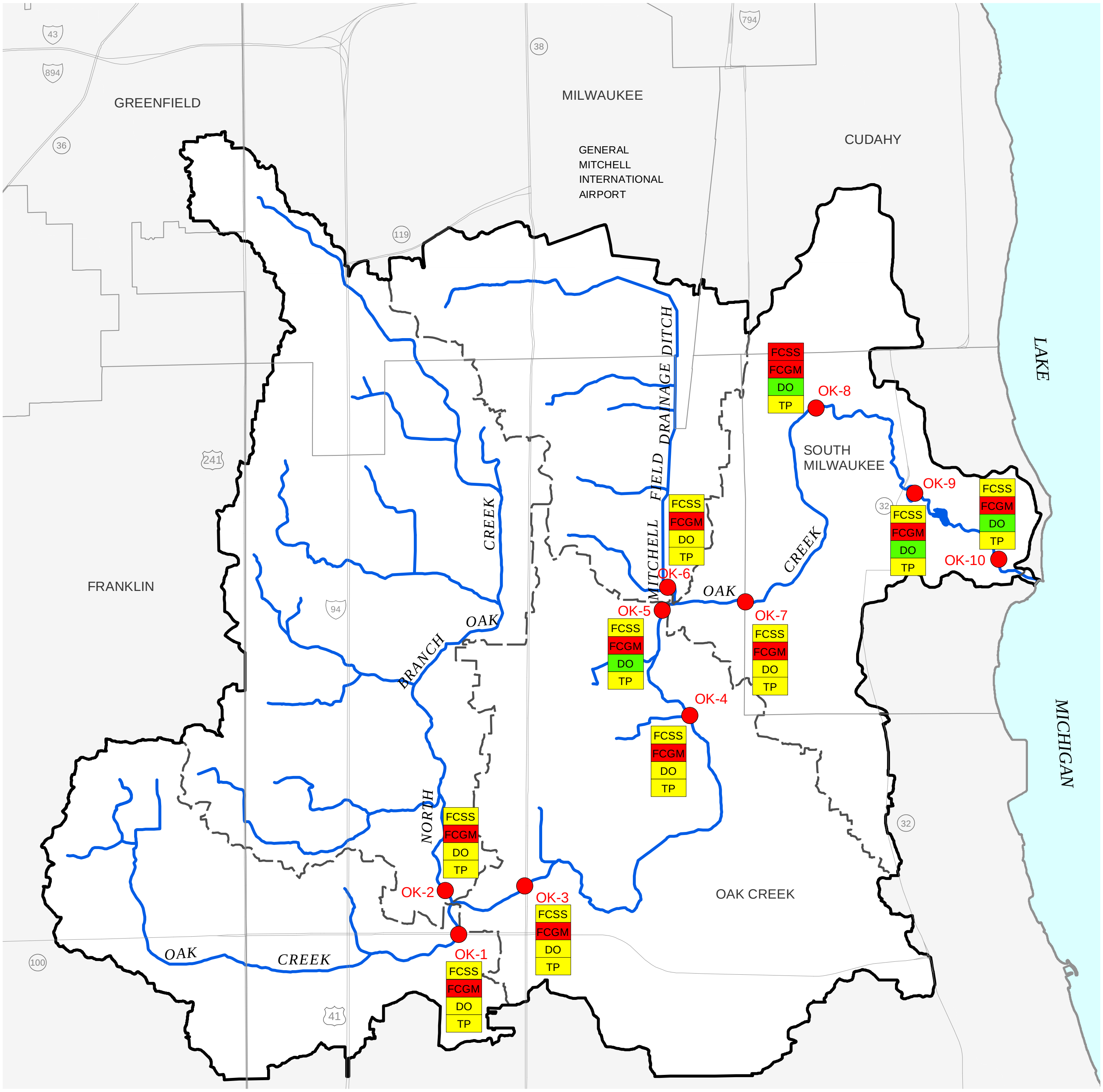
ASSESSMENT POINTS WITHIN THE MILWAUKEE RIVER WATERSHED FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map N-4

ASSESSMENT POINTS WITHIN THE OAK CREEK WATERSHED FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



ASSESSMENT POINT LOCATION (FISH AND AQUATIC LIFE STANDARD)

OK-9 ASSESSMENT POINT IDENTIFICATION

FISH AND AQUATIC LIFE (FAL)

SURFACE WATER

WATERSHED BOUNDARY

SUBWATERSHED BOUNDARY

NOTE: SEE TABLE 75 FOR A CROSS REFERENCE BETWEEN ASSESSMENT POINT IDENTIFICATION AND MMSD WATER QUALITY SAMPLING POINT IDENTIFICATION.

COMPLIANCE WITH APPLICABLE WATER QUALITY STANDARD IS ACHIEVED:

- 85 PERCENT OF THE TIME OR GREATER
- 70 TO 84 PERCENT OF THE TIME
- LESS THAN 70 PERCENT OF THE TIME

FCSS FECAL COLIFORM, SINGLE SAMPLE REGULATORY STANDARD, MAY THROUGH SEPTEMBER

FCGM FECAL COLIFORM, GEOMETRIC MEAN REGULATORY STANDARD, MAY THROUGH SEPTEMBER

DO DISSOLVED OXYGEN REGULATORY STANDARD

TP TOTAL PHOSPHORUS PLANNING STANDARD

N

GRAPHIC SCALE

0 0.25 0.5 0.75 1 Miles

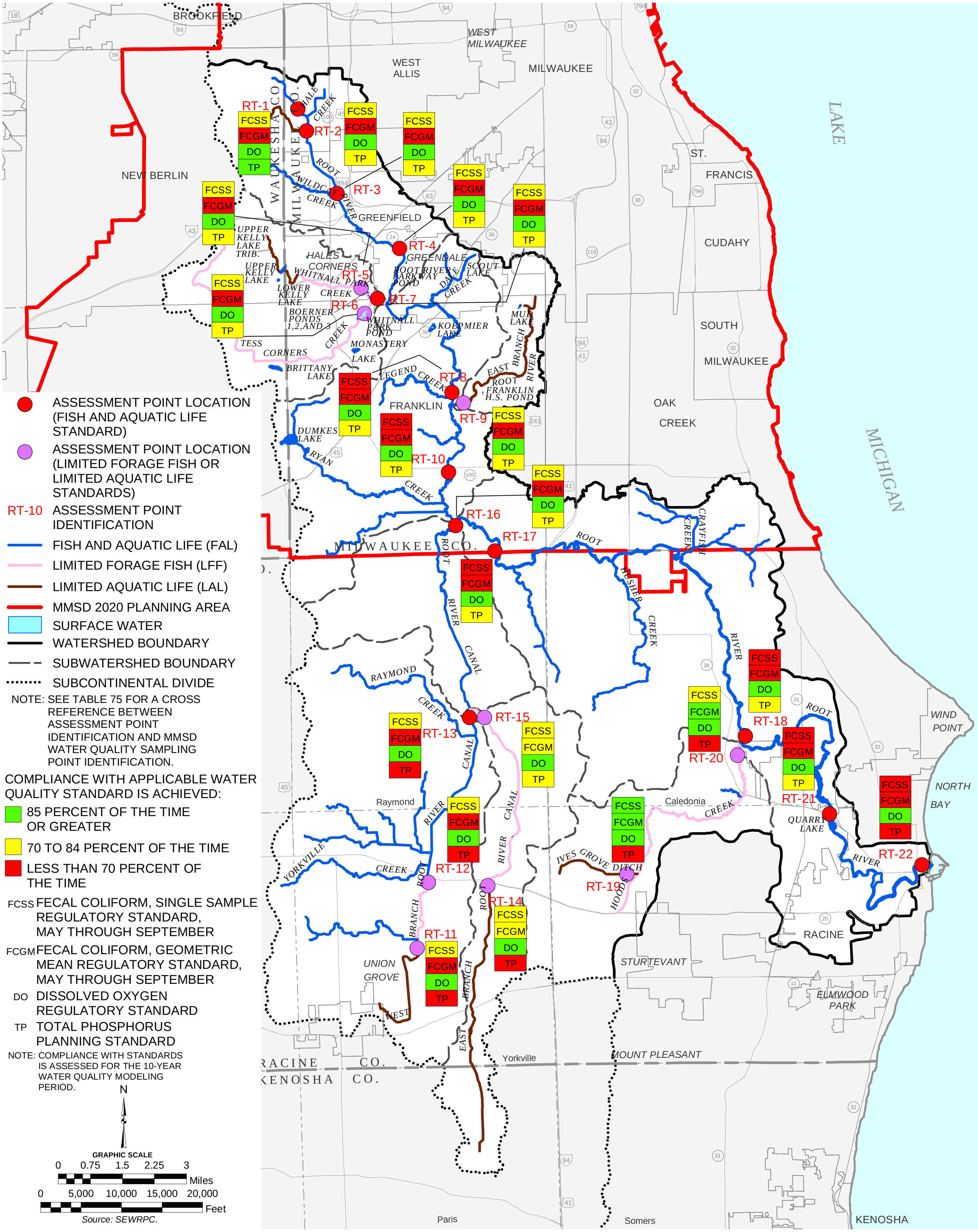
0 2,000 4,000 6,000 8,000 Feet

Source: SEWRPC.

NOTE: COMPLIANCE WITH STANDARDS IS ASSESSED FOR THE 10-YEAR WATER QUALITY MODELING PERIOD.

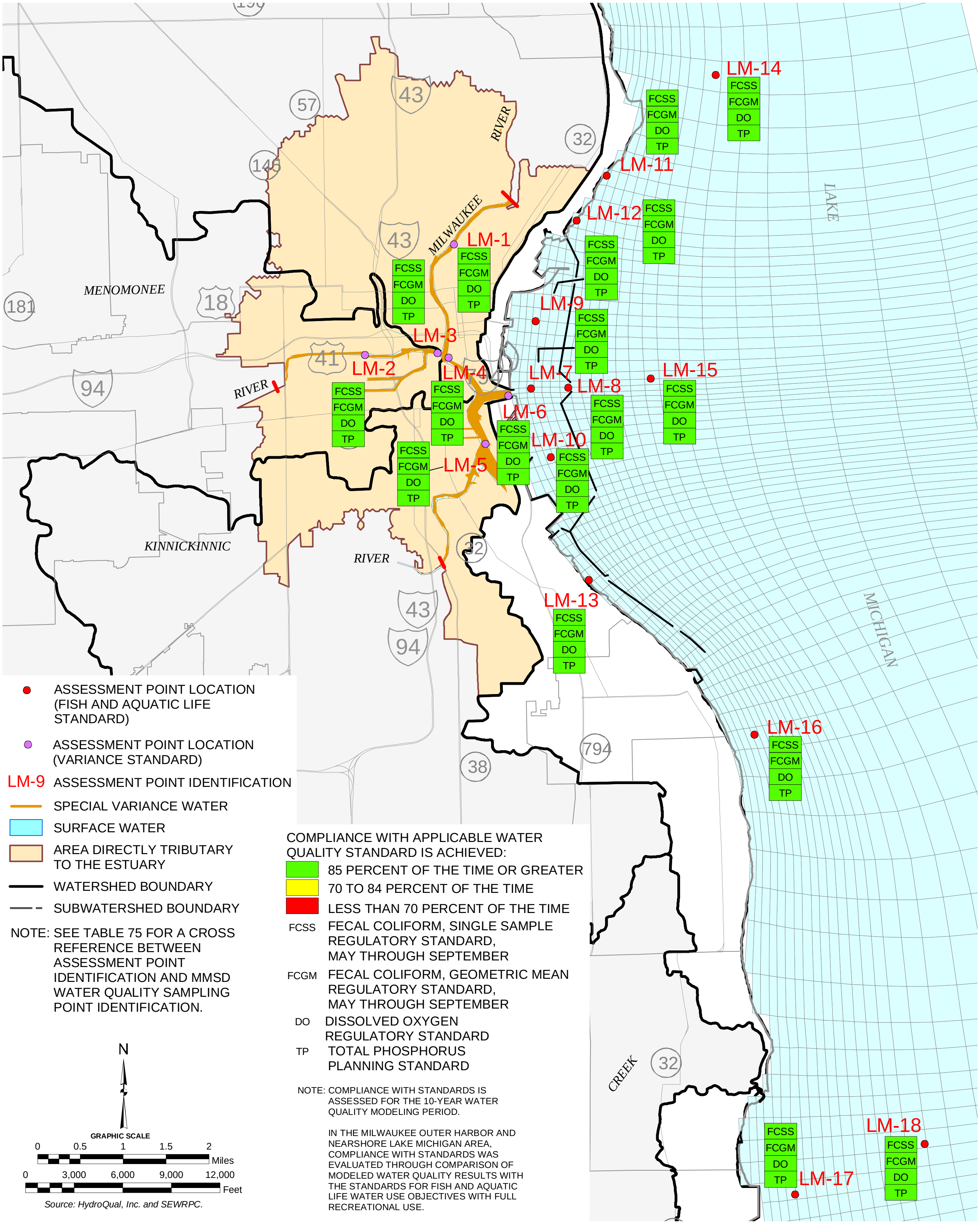
Map N-5

ASSESSMENT POINTS WITHIN THE ROOT RIVER WATERSHED FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



Map N-6

ASSESSMENT POINTS WITHIN THE MILWAUKEE HARBOR ESTUARY AND NEARSHORE LAKE MICHIGAN AREA FOR THE RECOMMENDED WATER QUALITY MANAGEMENT PLAN



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Amendment to SEWRPC Planning Report No. 50

A REGIONAL WATER QUALITY MANAGEMENT PLAN UPDATE FOR THE GREATER MILWAUKEE WATERSHEDS

May 2013

Attachment A

TETRA TECH MEMORANDUM

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TETRA TECH

3200 Chapel Hill-Nelson Hwy, Suite 105 • PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 • Fax 919-485-8280

Memorandum

To:	**Michael Hahn (SEWRPC) and Tim Bate (MMSD)**	Date:	**March 13, 2012**
From:	**Scott Job, Kevin Kratt, Jon Butcher**	Subject:	**Nutrient Output for Milwaukee HSPF Models (Revised)**
cc:		Proj. No.	**100-CLE-T27944**

1 Nutrient Output Processing Error

While post-processing results for the Milwaukee Climate Change Risk Modeling Project, we discovered an error in the HSPF input files that affected the summation and reporting of total nitrogen (TN) and total phosphorus (TP) used in the development of the RWQMPU. The error *did not* involve the parameterization or water quality calibration of the models, but it did affect reported output for TN and TP from the second-tier set of assessment points, specifically for concentration-based statistical measures.

The models simulate ammonia-N, nitrate-N, nitrite-N, organic-N, orthophosphate-P, and organic-P individually and were calibrated for these nutrient species. The error was a result of an improper conversion factor applied to the inorganic fraction of N and P when calculating sums for TN and TP. The lines in the UCI model files containing the improper factor were added following the calibration of the models to provide text file output of simulation results for assessment points not covered by water quality calibration sites. Assessment results coincident with the calibration sites had output stored in the project WDMs, and these locations had the proper factors. Text file output was used to prevent the model WDM from becoming overly large.

It is important to distinguish what *was* and *was not* affected in the results:

Not Affected

- The Milwaukee River model
- Model calibration/validation
- All load predictions
- Boundary conditions to the estuary model
- Direct drainage areas
- Internal calculations, and any reported results for nutrient species
- Statistical measures for

- Fecal coliform bacteria
- Dissolved oxygen
- BOD
- Metals
- Sediment

- Statistical measures for TN and TP reported at the initial set of analysis locations (co-located with calibration monitoring stations)

Affected

- Kinnickinnic River, Menomonee River, Oak Creek, and Root River models only
- TN and TP statistical measures for assessment points other than those at monitoring stations, for:
  - Mean and median TN and TP
  - Percent of time TP exceeds the 0.1 mg/L criterion

Specific stations affected are listed below.

Watershed	PR-50 Map ID #	Model Reach
Root River	RT-5	620
Root River	RT-6	817
Root River	RT-7	819
Root River	RT-8	850
Root River	RT-9	837
Root River	RT-11	866
Root River	RT-12	870
Root River	RT-13	883
Root River	RT-14	856
Root River	RT-15	860
Root River	RT-16	897
Root River	RT-18	120
Root River	RT-19	125
Root River	RT-20	128
Root River	RT-21	132
Root River	RT-22	140
Oak Creek	OK-2	240
Oak Creek	OK-5	52
Oak Creek	OK-6	130

Watershed	PR-50 Map ID #	Model Reach
Kinnickinnic	KK-1	831
Kinnickinnic	KK-2	801
Kinnickinnic	KK-3	710
Kinnickinnic	KK-4	828
Kinnickinnic	KK-5	830
Kinnickinnic	KK-6	820
Kinnickinnic	KK-7	19
Kinnickinnic	KK-8	818
Menomonee	MN-1	6
Menomonee	MN-2	803
Menomonee	MN-3	812
Menomonee	MN-4	820
Menomonee	MN-6	834
Menomonee	MN-7	841
Menomonee	MN-8	855
Menomonee	MN-10	861
Menomonee	MN-11	871
Menomonee	MN-13	890
Menomonee	MN-14	905
Menomonee	MN-15	883
Menomonee	MN-16	914

The conversion factor for translating fecal coliform from mass count to concentration (8.107E-8) was used in place of the factor for lb/ac-ft to mg/L (0.368). This was applied to inorganic species in the summation of TN and TP only. As a result, the concentration in the model text output files essentially represents the organic fraction of TN and TP, which is an underestimate.

2 Impacts of the Error

The influence on results is variable, depending largely on the relative contribution of the inorganic fraction to the total value. Assessment points downstream of point sources with high output of inorganic nutrient mass are the most affected, since the reporting error reflected conditions in the reach. In addition, our comparisons to date have been conducted only for the climate scenario results, which (with the exception of Oak Creek) used altered meteorological inputs. Even so, a before-and-after comparison of underreported versus corrected results provides an indication of the discrepancy. Two examples are shown here. The first shows typical changes; mean TP is about 57 percent high, and mean TN is about 100 percent higher. Most stations appear to follow this pattern within a range of +/- 30 percent. The degree of change in TP percent compliance is more variable, depending heavily on how close the mean is to 0.1 mg/L. Example B shows the location with the largest change, in a small channel downstream of GE and several smaller industrial discharges. The difference is much larger (on the order of a 300 percent increase for TP), and TP percent compliance drops to a single digit once the inorganic component of TP from the discharges in this effluent-dominated watercourse is included in the accounting.

Example A – Typical Difference (OK-2: North Branch of Oak Creek)

Parameter	Measure	Original	Corrected
Total Phosphorus	Mean (mg/l)	0.0457	0.0721
	Median (mg/l)	0.0243	0.0298
	Percent compliance with 0.1 mg/l standard	88	80
	Percent compliance with 0.075 mg/l standard	83	76
Total Nitrogen	Mean (mg/l)	0.45	0.91
	Median (mg/l)	0.41	0.8

Example B – Large Difference (KK-2: S. 43rd Street Ditch)

Parameter	Measure	Original	Corrected
Total Phosphorus	Mean (mg/l)	0.0834	0.3303
	Median (mg/l)	0.0721	0.3179
	Percent compliance with 0.1 mg/l standard	85	2
	Percent compliance with 0.075 mg/l standard	65	1
Total Nitrogen	Mean (mg/l)	0.77	1.55
	Median (mg/l)	0.75	1.54

3 Fixing the Error in the UCI Files

As noted above, the error only affects the additional reporting stations. Within the NETWORK block there is a separate section for each new station. Each of these follows a consistent format and is labeled as "*** new station", as in the following example from the Kinnickinnic model (highlights added), except that the RCHRES, PLGTEN, COPY, and GENER numbers will change.

```
NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>    #    #        <Name> # #  ***
...
*** new station 1
RCHRES 818 OXRX   BOD    1 1               PLTGEN   81      INPUT  MEAN   1
RCHRES 818 PLANK  PHYCLA 1 1               PLTGEN   82      INPUT  MEAN   1
RCHRES 818 CONS   CON    1 1               PLTGEN   83      INPUT  MEAN   1
RCHRES 818 OXRX   DOX    1 1               PLTGEN   84   85 INPUT  MEAN   1
RCHRES 818 GQUAL  RSQAL  4 1               COPY     86      INPUT  MEAN   1
RCHRES 818 GQUAL  RDQAL  1 1               COPY     86      INPUT  MEAN   1
COPY    86 OUTPUT MEAN   1                 GENER   186      INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER   186      INPUT  TWO
GENER  186 OUTPUT TIMSER      8.107E-8     PLTGEN   86   87 INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  2 1               PLTGEN   88      INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  1 1               COPY     89      INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  3 1               COPY     89      INPUT  MEAN   1
COPY    89 OUTPUT MEAN   1                 PLTGEN   89      INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  4 1               PLTGEN   90      INPUT  MEAN   1
RCHRES 818 HYDR   RO     1 1               PLTGEN   91   92 INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   1 1               COPY     93      INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   2 1               COPY     93      INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   3 1               COPY     93      INPUT  MEAN   1
COPY    93 OUTPUT MEAN   1                 GENER   193      INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER   193      INPUT  TWO
RCHRES 818 PLANK  PKST3  4 1               PLTGEN   93      INPUT  MEAN   1
GENER  193 OUTPUT TIMSER      8.107E-8     PLTGEN   93      INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   4                 GENER   194      INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER   194      INPUT  TWO
GENER  194 OUTPUT TIMSER      8.107E-8     COPY     94      INPUT  MEAN   1
RCHRES 818 PLANK  PKST3  5 1               COPY     94      INPUT  MEAN   1
COPY    94 OUTPUT MEAN   1                 PLTGEN   94      INPUT  MEAN   1
RCHRES 818 SEDTRN SSED   4 1               PLTGEN   95      INPUT  MEAN   1
RCHRES 818 SEDTRN SSED   4 1               GENER   196      INPUT  ONE
RCHRES 818 HYDR   RO     1 1               GENER   196      INPUT  TWO
GENER  196 OUTPUT TIMSER      1.0          PLTGEN   96      INPUT  MEAN   1
RCHRES 818 CONS   CON    2 1               PLTGEN   97      INPUT  MEAN   1
GENER  186 OUTPUT TIMSER      8.107E-8     PLTGEN   78      INPUT  MEAN   1
RCHRES 818 OXRX   DOX    1 1               PLTGEN   79      INPUT  MEAN   1
COPY    94 OUTPUT MEAN   1 1               PLTGEN   80      INPUT  MEAN   1
```

The error occurs in the multiplication factors column – specifically in the second and third non-blank multipliers, which respectively point (in this case) to PLTGEN 93 and 94. The PLOTINFO block shows that these PLTGENs are associated with file numbers 93 and 94, and that these in turn are the output for TN and TP. Specifically, the lines in question are routing (1) the concentration calculated from the sum of inorganic N storages (from NUST 1, NUST 2, and NUST 3) and (2) the concentration calculated from the PO_4 storage (from NUST 4) to the concentration summations for TN and TP. The lines should occur in the same order in each new station output block.

The conversion factor is to convert mass (or bacterial number) divided by volume (in AF) to concentration. The factor 8.107E-8 is the appropriate factor for producing fecal coliform concentrations in #/100 ml, and properly occurs twice in the block. The correct factor for converting mass (lbs) divided by volume (AF) to concentration in mg/L is 0.368. Each "new station" section within the NETWORK block should thus be corrected as follows:

```
*** new station 1
RCHRES 818 OXRX   BOD    1 1               PLTGEN  81     INPUT  MEAN   1
RCHRES 818 PLANK  PHYCLA 1 1               PLTGEN  82     INPUT  MEAN   1
RCHRES 818 CONS   CON    1 1               PLTGEN  83     INPUT  MEAN   1
RCHRES 818 OXRX   DOX    1 1               PLTGEN  84  85 INPUT  MEAN   1
RCHRES 818 GQUAL  RSQAL  4 1               COPY    86     INPUT  MEAN   1
RCHRES 818 GQUAL  RDQAL  1 1               COPY    86     INPUT  MEAN   1
COPY    86 OUTPUT MEAN   1                 GENER  186     INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER  186     INPUT  TWO
GENER  186 OUTPUT TIMSER       8.107E-8    PLTGEN  86  87 INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  2 1               PLTGEN  88     INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  1 1               COPY    89     INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  3 1               COPY    89     INPUT  MEAN   1
COPY    89 OUTPUT MEAN   1                 PLTGEN  89     INPUT  MEAN   1
RCHRES 818 NUTRX  DNUST  4 1               PLTGEN  90     INPUT  MEAN   1
RCHRES 818 HYDR   RO     1 1               PLTGEN  91  92 INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   1 1               COPY    93     INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   2 1               COPY    93     INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   3 1               COPY    93     INPUT  MEAN   1
COPY    93 OUTPUT MEAN   1                 GENER  193     INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER  193     INPUT  TWO
RCHRES 818 PLANK  PKST3  4 1               PLTGEN  93     INPUT  MEAN   1
GENER  193 OUTPUT TIMSER       0.368       PLTGEN  93     INPUT  MEAN   1
RCHRES 818 NUTRX  NUST   4                 GENER  194     INPUT  ONE
RCHRES 818 HYDR   VOL                      GENER  194     INPUT  TWO
GENER  194 OUTPUT TIMSER       0.368       COPY    94     INPUT  MEAN   1
RCHRES 818 PLANK  PKST3  5 1               COPY    94     INPUT  MEAN   1
COPY    94 OUTPUT MEAN   1                 PLTGEN  94     INPUT  MEAN   1
RCHRES 818 SEDTRN SSED   4 1               PLTGEN  95     INPUT  MEAN   1
RCHRES 818 SEDTRN SSED   4 1               GENER  196     INPUT  ONE
RCHRES 818 HYDR   RO     1 1               GENER  196     INPUT  TWO
GENER  196 OUTPUT TIMSER       1.0         PLTGEN  96     INPUT  MEAN   1
RCHRES 818 CONS   CON    2 1               PLTGEN  97     INPUT  MEAN   1
GENER  186 OUTPUT TIMSER       8.107E-8    PLTGEN  78     INPUT  MEAN   1
RCHRES 818 OXRX   DOX    1 1               PLTGEN  79     INPUT  MEAN   1
COPY    94 OUTPUT MEAN   1 1               PLTGEN  80     INPUT  MEAN   1
```

Note that this block is in column-sensitive, fixed format. Therefore, the user should ensure that (1) the new factor begins in column 32, and (2) the following PLTGEN or COPY key word continues to begin in column 44.