

INSIDE

the GREATER MILWAUKEE WATERSHEDS



Edeee Daniel

A Summary of the Southeast Wisconsin Regional Water Quality Management Plan Update 2007
A project of the Southeastern Wisconsin Watersheds Trust, Inc.



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ABOUT THIS SUMMARY

In 2008, the Southeastern Wisconsin Watersheds Trust, Inc. (Sweet Water, for short) was created as a collaborative effort to implement the Southeastern Wisconsin Regional Water Quality Management Plan Update. As one of its first activities, Sweet Water saw the need for a comprehensive summary of the regional plan that would fill a niche somewhere between the highly technical summary of the plan and MMSD's brief overviews of the individual watersheds. This document intends to fill that niche. The goal has been to faithfully summarize the findings and recommendations of the regional water quality plan in a style and format that would be easily accessible to members of the public, including public officials.

For the most part, everything in this summary can be found in the original report. At times, additional background or explanation is added so the reader can more easily follow the logic of the story that unfolds about our waters and how we will need to work together to improve them in the future.



TABLE OF CONTENTS

CHAPTER ONE: Introduction	6	Remaining Challenges	23
What is the Water Quality Plan	7	Status of Lakes and Ponds	29
Fishable and Swimmable Water	9	Sources of Pollution	33
What is a Watershed?	10		
CHAPTER TWO: A Watershed Approach	12	CHAPTER FOUR: Recommendations	40
The Planning Process	13	Cleaning Up Our Waters	41
		Alternatives Studied	43
CHAPTER THREE: In the Report	16	Results of Different Alternatives	45
Three Decades of Data	17	Recommended Plan	48
State of Our Waters and Trends	19	Appendix A: Components and Costs	51
		Appendix B: Modeled Performance	56

READ THE SEWRPC REPORTS

The SEWRPC reports are contained in two documents, both available online.

SEWRPC Planning Report 50

A Regional Water Quality Management Plan Update For The Greater Milwaukee Watersheds.

<http://www.sewrpc.org/SEWRPC/Environment/RegionalWaterQualityManagement.htm>

SEWRPC Planning Report 39

Water Quality Conditions and Sources of Pollution in the Greater Milwaukee Watersheds, Technical Report

Link is in right-hand menu on SEWRPC page

FORWARD

In 2003, the Southeastern Wisconsin Regional Planning Commission (SEWRPC) launched a multi-year project to produce a regional water quality plan for the watersheds within the SEWRPC seven-county region that flow to Lake Michigan. An unprecedented partnership was undertaken by SEWRPC, the Milwaukee Metropolitan Sewerage District (MMSD), and the Wisconsin Department of Natural Resources (DNR) to do the planning. The plan would update SEWRPC's 1979 Regional Water Quality Management Plan.

In the two decades since 1979, many things changed in the watersheds of southeastern Wisconsin. Policy-makers at the local, regional, and state level needed an updated look at the waters and the changes that had occurred to identify strategies that could move us closer to the goals of abundant, clean water for the decades to come.



IN THIS REPORT

This report offers a summary of the main findings and recommendations of the SEWRPC regional water quality plan.

- The planning process used for the regional water quality plan;
- The “watershed approach” to water quality planning;
- The main pollutants and water quality impairments found in the waters of the greater Milwaukee watersheds;
- The causes of those problems;
- The alternatives considered for cleaning up our waters; and
- The recommendations of the regional water quality plan.

THE PLANNING PROCESS

This effort, completed in 2007, resulted in a detailed plan—really two plans: the SEWRPC Regional Water Quality Management Plan Update, and the MMSD 2020 Facilities Plan.

The voluminous reports (several thousand pages in all) are detailed and far-reaching. They are being used by scientists and regulators, by DNR fisheries managers, by sewage treatment plant managers, and local municipalities’ stormwater program managers. Local and statewide environmental organizations, such as Milwaukee Riverkeeper (formerly Friends of Milwaukee’s Rivers), the Milwaukee River Basin Partnership, Root-Pike Watershed Initiative Network, and Clean Wisconsin are using the plan to formulate priorities and programs.



MORE RESOURCES

MMSD has created a series of brief pamphlets describing the conditions in each watershed where it provides sewer services. Each pamphlet describes the actions that MMSD is taking to improve conditions in the streams and Lake Michigan. The pamphlets also describe actions that individuals can take in their own homes and yards to make improvements in the area’s waters.

The pamphlets are available online at: www.mmsd.com/wqi/publications.cfm

CHAPTER ONE

Any weekend in the summer, a trip across southeast Wisconsin will find thousands of people enjoying the splendor of our waters—our inland lakes, our rivers and streams, and our greatest water asset, Lake Michigan.

People can be found fishing, canoeing, water skiing, swimming, hunting for frogs in tiny creeks, and spotting heron at marsh ponds.



What is the Regional Water Quality Management Plan Update?

Everything seems right. The water sparkles in the sunlight. The fish flashes as it breaks the water before being reeled in. The water refreshes and cools.

But not everywhere. And even where the water seems right, some people know that the appearance is an illusion. The avid angler wonders whether she should feed her children the fish caught with such anticipation. In some streams, canoeists take an extra precaution, dousing their hands in antiseptic lotion before digging into their picnic lunch. The jet skiers, before leaving the boat launch at the end of the day, scrub down their craft to make sure they don't inadvertently take along unwanted hitchhikers, like zebra mussels, Quagga mussels, or Eurasian milfoil that could invade the waters of their other favorite lakes. In some places, the water doesn't even look clean and in a few places, it smells—no, it actually stinks.

At one beach, signs are posted advising bathers to stay out of the water, or head to another beach up the road where it is safer to swim that day. The 10 year-olds, scrambling up the shoreline looking for frogs don't notice that the stream bank has been carved away by a recent torrent; they don't know that their pleasure in chasing frogs is a cramped version of their grandparents' experience on the same stream, when frogs and other critters came in 57 varieties: salamanders, turtles, snakes, and exotic looking bugs.



We live in a paradox of water. Our waters are abundant, but they are also threatened. Despite over 40 years of serious work to clean up and restore our rivers, streams, and lakes, the waters of southeastern Wisconsin remain troubled. In many places, our waters are not fishable and swimmable.

Some experts doubt that “fishable and swimmable” can ever be achieved in some of our waterways.

Forty years of experience have taught us that “end of pipe” strategies are insufficient to achieve “fishable and swimmable” goals. We now understand that achieving the first goal of the Clean Water Act—eliminating all pollution discharges that come out of the end of a pipe—would need to be just the first goal. Achieving “fishable and swimmable” waters will take much longer and require much more far-reaching change.

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“END OF PIPE” STRATEGIES FOCUS ON REDUCING THE QUANTITY AND CONCENTRATION OF POLLUTANTS DISCHARGED BY WASTEWATER PIPES FROM FACTORIES AND SEWAGE TREATMENT PLANTS. ”

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The regional water quality plan is a “first level” plan. It takes a broad, multi-watershed look, identifies the primary issues and threats, and recommends broad strategies to improve water quality. More detailed study will be needed of the individual watersheds and sub-watersheds, and even of specific stream reaches, to fully understand the opportunities and challenges in achieving fishable and swimmable waters.

A first level plan is a “high altitude” look, analogous to looking at the ground from a plane flying at 35,000 feet. This first look allows scientists, regulators, and other policy makers to understand the general contours of the problem and the major features that will pose obstacles and opportunities. It allows planners to spot pollutants or conditions that merit a closer look.

That closer look, zooming in on a particular geographic area or category of problem, is now occurring. Since the Regional Water Quality Plan was completed in 2007, MMSD and the Southeastern Wisconsin Watersheds Trust, Inc. (Sweet Water) have embarked on “second level planning” for the Kinnickinnic and Menomonee river watersheds. Ultimately, these more detailed studies will be completed for each of the watersheds in the “Greater Milwaukee watersheds.”



Achieving Fishable and Swimmable Waters

People often refer to the goals of the federal Clean Water Act in a short-hand way, saying that the Act calls for waters to be “fishable and swimmable.” But what does that really mean? In fact, the Clean Water Act never uses the words “fishable” or “swimmable”. The Act used longer phrases that have been shortened to “fishable and swimmable.”

FISHABLE: “Achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife.” This means that the water should be clean enough to support the animal life that would have inhabited in the waters before it was polluted and degraded.

That requires more than just chemically clean water. To be fishable, the water needs to have the appropriate physical structure to provide:

- shelter from predators,
- breeding areas,
- a rich food web of plants and tiny organisms that fish and other wildlife eat.

In addition, in order to be “fishable,” the waters need to be clean enough so people can safely eat the fish, without limitations on eating fish because substances like PCBs or mercury that accumulate in them.

SWIMMABLE: Achieve a level of water quality that “provides for recreation in and on the water.” This goal



includes boating, canoeing, swimming, snorkeling, wading, and just plain fooling around. Swimmable means that it should be safe to be fully immersed in the water without getting a rash or absorbing toxic substances. It means that it should be safe to swallow the occasional gulp of water during a frolic in a lake and not get diarrhea or an intestinal parasite.

In both instances, Congress hedged these goals with the phrase “wherever attainable.” What is “attainable” is determined by both the geology of the watershed and the history of abuse and human-induced change that has occurred in a particular body of water.

What is a Watershed?

A watershed is defined as the area of land that drains to a specific body of water. A watershed is defined by the topography of the land. If the surface of the land was completely solid and did not absorb any water, a drop of water that fell anywhere in the watershed would flow downhill to the river, stream, or lake that defines the watershed. Watersheds can be large or small. In addition, different terms are used to refer to collections of watersheds and to subareas within watershed. The term “basin” is used to refer to a collection of watersheds that flow to a much larger body of water. For example, we refer to the Great Lakes basin, which includes all of the watersheds that flow to any of the Great Lakes. Subareas of watersheds may be called subwatersheds, and within subwatersheds, we can identify still smaller areas called drainage areas. The SEWRPC regional water quality plan looked at the entire Lake Michigan basin located in southeastern Wisconsin.

WHAT IS THE WATERSHED APPROACH?

The watershed approach has been promoted by the U.S. Environmental Protection Agency (EPA) since the 1990s and has been used by SEWRPC in all of its previous regional water quality plans.

The EPA emphasizes the watershed approach as a way to focus attention on the highest priority issues in a watershed. It avoids looking at problems in silos, recognizing that our most challenging water quality problems are a product of the cumulative effects of many activities on the water, on the land, and in the air.

The EPA has found that a watershed approach can result in more cost-effective strategies, achieving better results at lower cost. In addition, a watershed approach builds new communication networks among stakeholders in the watershed, leading to commitment to work together to solve the problems identified in the planning process.

Source: US EPA, “Watershed Approach Framework”, June 1996. <http://www.epa.gov/owow/watershed/framework/>



Greater Milwaukee Watersheds

The regional water quality plan defined “greater Milwaukee watersheds” as all of the five watersheds which lie entirely or partially in any of the counties in the SEWRPC planning area and that drain to Lake Michigan rather than to the Mississippi River. It included the watersheds of the Kinnickinnic River, Menomonee River, Milwaukee River, Oak Creek, and Root River. Although parts of these watersheds lie in Sheboygan, Fond du Lac, and Dodge Counties, the entire watershed was included in the analysis, not just those portions within the counties normally covered by SEWRPC recommendations. The “greater Milwaukee watersheds” also included the Milwaukee Harbor estuary, an area that lies near the mouths of the Milwaukee, Menomonee, and Kinnickinnic Rivers that are directly affected by Lake Michigan and that are, in a sense, part of the lake. Finally, the greater Milwaukee watersheds included a portion of nearshore Lake Michigan and the coastal lands that drain directly into the lake rather than flowing first to a river.

Source: Chapter 1, Regional Water Quality Management Plan Update (2007), page 1, footnote 1



CHANGES IN THE WATERSHEDS

Population in the Greater Milwaukee watersheds declined by more than 3 percent, but the number of households grew by over 20 percent. The proportion of the watersheds in urban uses (*compact housing, commercial, and industrial areas*) increased by 34 percent, while the proportion of land in the watersheds devoted to rural uses (*agriculture, forest, and scattered housing*) decreased by more than 15 percent. Approximately 27 percent of the land area is served by sewers, but those sewers serve over 95 percent of the population in the entire study area.

Since 1979, new regulations have come into effect requiring the management of stormwater to remove the amount of water pollution reaching lakes and streams.

CHAPTER TWO

The regional water quality plan used a “watershed approach” to understand the causes of water pollution and the opportunities to clean up. A watershed approach uses “nature’s boundaries” rather than the artificial boundaries imposed by political subdivisions, like counties, towns, cities, sewerage districts, and regional planning commissions.



The Planning Process

By focusing on nature's boundaries, we can better understand how actions and conditions on the land—often some distance away from the body of water—can have far-reaching effects on water quality and habitat for fish and other aquatic life. In addition, the watershed approach recognizes from the outset that many different units of government, businesses, and individuals will need to coordinate their efforts. A watershed functions as a system, with connections upstream and downstream and up and down between surface water and groundwater.

Once the basic framework for the work was established, the project partners conducted a number of detailed studies to understand the current status of the waters in the study area and the sources of pollution remaining. SEWRPC published a technical report summarizing its findings, [Technical Report No. 39](#), is available on the SEWRPC website (www.sewrpc.org).

The planning took five years, involving thousands of hours of work by consultants and the staff at MMSD and SEWRPC. Throughout the planning process, MMSD, SEWRPC, and the DNR communicated regularly to direct the planning process. In addition, the work was guided by a number of citizen committees, including a Technical Advisory Committee, a Citizen Advisory Council, and the Watershed Officials Forum. An annual conference, called “Clean



Rivers, Clean Lake” brought together hundreds of interested citizens each year to learn more about the planning process. Periodically, public “open house” events were held to allow the public to learn about the progress of the planning and ask questions. In addition, the planners reached out to the public through a variety of opportunities, such as Farm Technology Days, local comprehensive planning meetings, newsletters, and other events.

SEWRPC assembled data from DNR, US Geological Survey, MMSD, and other sources about historic and current conditions in the watershed. These data covered issues as diverse as the amount of water flowing in various streams, the fish species present in different places, and the chemical profile of water samples taken at different points over many years time.

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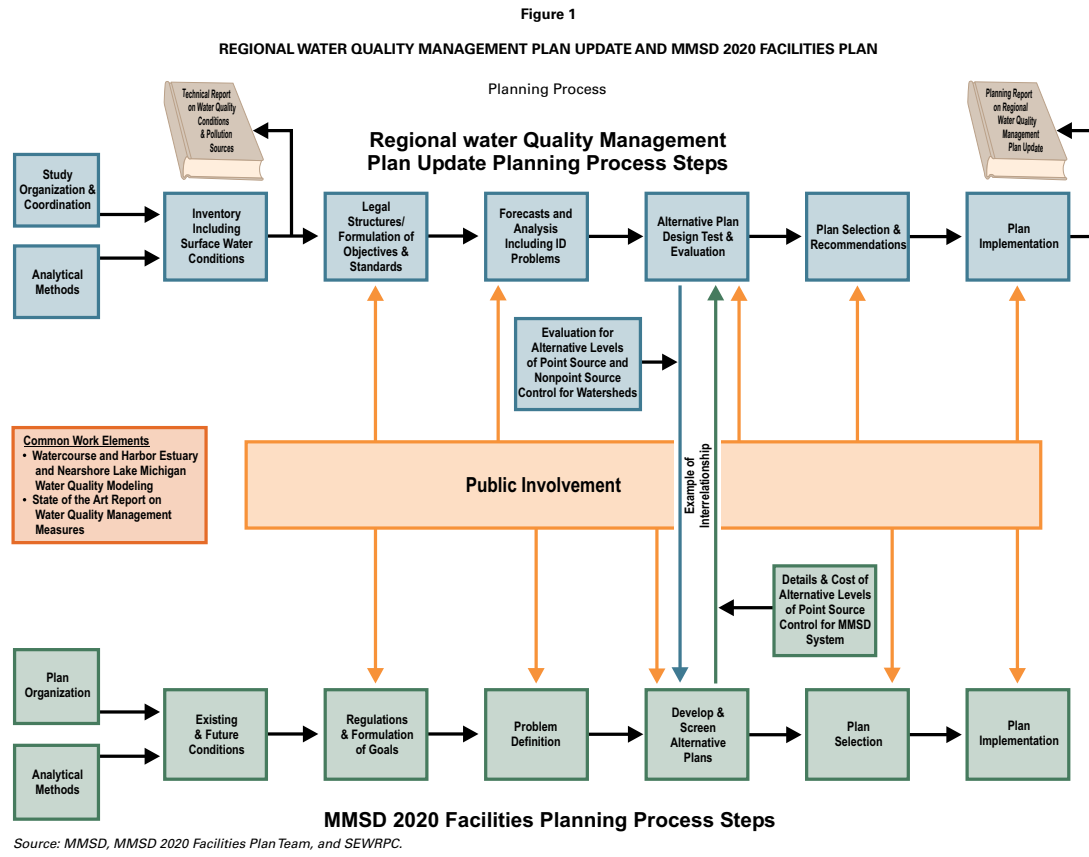
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SEWRPC and the planning consultants also compiled a “State of the Art” report to inform the development of alternatives. The report summarized hundreds of potential management strategies, best management practices, and water quality technologies.

Next, a sophisticated computer model crunched all of the data about the water, the land, and the climate over the past decade to try to understand how water quality will change under a range of alternative strategies for improving the waters.

The water quality plan modeled expected loads of six pollutants, each measured in multiple ways:

- **Total phosphorus:** excess phosphorus can result in nuisance plant growth, including aquatic weeds and algae. In addition to reducing the aesthetics of water and making the water unattractive for swimming and fishing, excessive plant growth contributes to a reduction in dissolved oxygen as plants decay during their normal life cycle. Low levels of dissolved oxygen, in turn, reduces the number of species of fish that can survive in the water.
- **Fecal coliform:** an indicator of contamination by human or animal feces; presence of fecal coliform does not mean that disease-causing organisms are present, but signifies a high risk that disease organisms could have reached the water in human or animal feces. Fecal



coliform is the most commonly used screening indicator for fecal contamination of waters.

- **Total suspended solids,** also referred to as TSS: composed of silt, decaying animal and plant material, sewage, and industrial wastes. The DNR’s NT 151 stormwater regulations focus on reducing TSS.
- **Total nitrogen:** excess nitrogen also contributes to nuisance plant growth.
- **Biochemical Oxygen Demand:** a measure of the amount of organic matter in the water

which, as it decomposes, robs oxygen from the water and from the fish that depend on it.

- **Copper:** toxic to aquatic life at high concentrations and representative of metals found in stormwater runoff.

The results reported in the Water Quality Plan are of two types: a look backward and a look forward. Looking backward, water quality data and habitat conditions in lakes and streams can identify current problems and the trend—whether the problems have been getting better or worse over time.

Looking forward, the regional water quality model can project what is likely to happen in the future. The future stream concentrations of those 6 pollutants plus Dissolved Oxygen (DO) were modeled for the year 2020. This projection of the future looked at both the “base case” (what will happen if we just keep doing what we have been doing or have already committed to doing in the near term) and future

scenarios (what will happen if we begin to do things differently).

The next chapter looks at the current situation and trends, looking backward at the record of water quality and habitat data. Chapter 4 will look at what the water quality modeling tells us about the challenges in the future and the strategies that will be most useful in meeting those challenges.



▲ Farmers first dug trenches to drain wet areas, exposing rich, wetland soils for cultivation. Later, they laid mile after mile of drainage tiles all across the region, creating the lush croplands that contributed to Wisconsin’s emergence as an agricultural powerhouse.



▲ Rivers and wetlands were dredged to improve the ability of boats to move people and goods.



MEASURING WATER QUALITY

The EPA, under the authority of the Clean Water Act, requires the State of Wisconsin to set numeric limits on water pollutants.

“Water quality assessment begins with water quality standards. States and other jurisdictions adopt water quality standards for their waters. EPA must then approve these standards before they become effective under the Clean Water Act.

“Water quality standards have three elements: the **designated uses** assigned to waters (e.g., swimming, the protection and propagation of aquatic life, drinking), the **criteria** or thresholds that protect fish and humans from exposure to levels of pollution that may cause adverse effects, and the **anti-degradation** policy intended to prevent waters from deteriorating from their current condition.

“After setting standards, states assess their waters to determine the degree to which these standards are being met. To do so, states may take biological, chemical, and physical measures of their waters; sample fish tissue and sediments; and evaluate land use data, predictive models, and surveys.”

Source: US EPA, Assessing and Reporting Water Quality (Questions and Answers), http://www.epa.gov/waters/ir/attains_q_and_a.html#1, accessed May 25, 2009).

FOOTNOTE DATA CAVEATS

The report drew from thirteen separate data sources, including data from MMSD, DNR, USGS, and EPA. “These data were collected and analyzed over an approximately 30-year period for many different purposes using different field and laboratory methods” (SEWRPC Technical Report No 39, Chapter 3, p. 81). As a result, some data are not strictly comparable across watersheds or time periods. In addition, the standards for different pollutants changed over time as rules became more stringent or laboratory techniques dictated different ways of defining the standard. So answering the basic questions posed by this report—how have water conditions changed and do conditions meet water quality standards—is surprisingly complex. Simple, straightforward answers are always bound up with caveats and cautions because of these inconsistencies across data sources and time periods.

The detailed SEWRPC reports are meticulous in their detail about these caveats and cautions. In this summary, the focus will be on “the bottom line.” Readers who want to understand all of the details and caveats that surround these conclusions should refer to the Technical Report chapters.

CHAPTER THREE

The Water Quality Report looked at a wide range of indicators to assess the status and trends of the many lakes and streams in the Greater Milwaukee Watersheds. The report's assessment of the current status and major trends addressed five basic questions:

How have water quality conditions changed since 1975?

How have toxicity conditions changed since 1975?

What is the current condition of the fishery?

To what extent are the water use objectives and water quality standards being met?

What are the sources of water pollution?



Looking Backward: Three Decades of Water Data

SEWRPC assessed both water quality chemistry and physical conditions, like temperature and suspended solids. In addition, the studies looked at the quality of fisheries and fishery habitat. An assessment was also made of the macroinvertebrate species in different areas. (See page 24 for more information on macroinvertebrates.)

The water quality report also discussed the growing problem of exotic plant and animal species as a challenge in local lakes and streams and in Lake Michigan. The challenge includes changes in aquatic habitat and competition with native species, aesthetic issues associated with uncontrolled growth of exotic weeds, and a range of economic impacts, including costs of removing exotic species that become a nuisance to industry or recreational use of the water.

The report examines rivers and streams separately from lakes and ponds. Relatively little information is available regarding lakes and ponds. The modeling studies provided no projection of future conditions for inland lakes, only for nearshore Lake Michigan. For this reason, this summary will focus on rivers and streams as well. Readers interested in the information about Lake and Ponds should refer to Chapter 3 of the SEWRPC report.



▲ Scientists and water resource managers use data to understand the health of fish and other aquatic life and threats to their long-term health.

18 CHAPTER THREE: In the Report—Status and Trends



▲ MMSD Water Quality Lab TSS Test



TOTAL SUSPENDED SOLIDS (TSS)

Total Suspended Solids are bad for fish and the ecosystems that fish depend on for survival. TSS also makes the water look unattractively murky, even muddy. Finally, TSS also can transport pollutants that can affect human health.

TSS blocks sunlight, reducing beneficial plant growth, which can reduce dissolved oxygen levels.

In addition, TSS causes the water to absorb more heat from sunlight, increasing water temperatures. Warmer water cannot hold as much oxygen, so some species of fish will not be able to survive. TSS also reduces water clarity, which has an aesthetic effect for people, but seriously affects survival rates for fish. When water is murky, fish cannot find food.

TSS CAN ALSO:

clog fish gills, reduce growth rates, decrease resistance to disease, and prevent egg and larval development. When suspended solids settle to the bottom of a water body, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can fill in spaces between rocks which could have been used by aquatic organisms for homes. (Mitchell and Stapp, 1992; GREEN Hands-On Center website)

Finally, suspended solids also serve as a carrier for other pollutants. On land, bacteria, pesticides, and metals attach to sediment particles. When rain water washes sediment into the water, these pollutants hitch a ride and then are released into the water (Federal Interagency Stream Restoration Working Group, 1998).

Source: Sheila Murphy, "BASIN: General Information on Solids," City of Boulder/USGS Water Quality Monitoring, <http://bcn.boulder.co.us/basin/data/BACT/info/TSS.html> (accessed May 26, 2009).

Water Quality Status and Trends in Rivers and Streams



The DNR categorizes many of the stream segments in the Greater Milwaukee watersheds as impaired, and others that are not currently designated as impaired are not meeting water quality standards on a regular basis. Substantial portions of the Kinnickinnic, Menomonee, and Milwaukee Rivers are classified as unsuitable for full recreational use. The designation of “impaired” is strongly influenced by the availability of data. In some areas, a long stream

reach may be categorized as impaired even though the pollution data comes from just one point along that stream reach. In other cases, the water may be clearly impaired, in terms of casual observation of water quality conditions, but lack of properly collected data prevent the stream reach from being legally categorized as impaired.

This chapter provides a basic overview of the current status of the waters and important trends over time.

FECAL COLIFORM VS. E. COLI

Historically, water quality managers have monitored fecal coliform in water because it could be relatively easily measured. In 1986, the EPA recommended that **Escherichia coli**, or **E. coli** for short, be used to measure potential pathogens in the water, instead of the fecal coliform measure which had been used for decades. Although not all strains of *E. coli* cause illness, the EPA found a statistically significant relationship between *E. coli* levels and swimming-related illness at freshwater beaches.

For the period of time from which data was compiled for the Water Quality Report (approximately 1975-2004), *E. coli* measures were available only for the nearshore Lake Michigan area.

Source: Christopher Redman, Memorandum to Water Quality Division, State of Oregon, Department of Environmental Quality, “E. coli methods and holding time,” June 11, 2003, <http://cwwuc.org/reference/prehearingstmt/Exhibit5.pdf>, accessed June 22, 2011.)

Overall, Our Waters Are Becoming Cleaner



In many ways, and by many measures, the status of the waters in Milwaukee's streams and nearshore Lake Michigan has improved. The completion of MMSD's Water Pollution Abatement Program, especially the "Deep Tunnel" project in 1994, has resulted in dramatic reductions in combined sewer overflows and substantial reductions in the levels of biochemical oxygen demand (BOD), fecal coliform, and ammonia. By 2003, compliance with ammonia and DO standards was almost perfect at monitored locations in the study area.

Change in the types of industries in southeast Wisconsin, along with a higher proportion of industrial discharges undergoing treatment, has resulted in improvements: lower levels of BOD, increased dissolved oxygen, and lower levels of phosphorus.

Cleanup of contaminated sediments from streambeds, brownfield cleanups of industrial and commercial properties, and the elimination of lead in gasoline have also resulted in improvements in the levels of toxic metals, PCBs, and polycyclic aromatic hydrocarbons (PAHs, for short—basically, petroleum-related compounds). The concentrations of PCBs found in fish tissues have decreased since 1975. Mercury concentrations are decreasing in all the watersheds except the Root. But, in some places, PAHs and PCBs are so high that small organisms, which maintain water quality and serve as food to



fish, cannot survive the levels. This can be observed in the estuary portions of the Menomonee and Kinnickinnic Rivers. High PCB levels have resulted in fish consumption advisories in Lake Michigan.

BOTTOM LINE: public and private investments—often driven by state and federal law—have resulted in real improvements in water quality in our streams, inland lakes, and Lake Michigan. In addition, as a

result, point sources—things like sewage treatment plant outfalls, combined and separate sewer overflows, and industrial discharges—are becoming a smaller and smaller component of water quality impairment. Consequently, to make further improvements in water quality, we need to continue to maintain the improvements in point source reductions in pollutants while shifting focus to nonpoint sources of pollution—specifically, urban stormwater and agricultural runoff.



Fish Consumption Advisories



CAN YOU EAT THE FISH?

In general, the answer is yes. Although all waters in the state of Wisconsin are under a general consumption advisory, the vast majority of people and the vast majority of fish in the Greater Milwaukee watersheds are safe to eat as long as people follow “safe eating” guidelines.

The DNR advises that consumers:

- select smaller rather than larger fish;
- understand the proper way to prepare the fish to reduce exposure to PCBs, which are stored in the fatty tissues;
- limit the number of meals of fish, depending on the size and species you are eating.

Finally, and importantly, women of childbearing age, those who are nursing, and children under 15 years old are advised to restrict their consumption more sharply than older women and men.

SPECIAL PCB ADVISORIES FOR THE GREATER MILWAUKEE WATERS

For waters in the study area, mercury is not of special concern (so the statewide recommendations apply), but PCBs are of special concern in Lake Michigan and its tributaries up to the first dam, where fish migrate

from Lake Michigan. In addition, some waters in areas where sediment or groundwater has been contaminated are under special consumption advisories. These include:

- Cedar Creek from Bridge Road in Cedarburg, including Zeunert Pond, downstream to the Milwaukee River;
- Milwaukee River from the city of Grafton downstream to Estabrook Falls;
- Milwaukee River from Estabrook Falls downstream to the estuary, including Menomonee River, Kinnickinnic River, and Lincoln Creek;
- Pike River in Kenosha County from Carthage College in the city of Kenosha downstream to the mouth;
- Root River from the Horlick Dam in the city of Racine downstream to the mouth.

Again, even in these locations, eating the fish occasionally is considered safe, as long as precautions are taken in preparing the fish and consumption is limited to the frequency suggested by the DNR.

Finally, the DNR advises consumers not to eat Lake Michigan trout larger than 27 inches in length, including those caught in the rivers below the first dam.

For more details about fish consumption advisories, especially details for special, sensitive populations of consumers, see:

Wisconsin DNR, Fish Consumption Advisories, <http://dnr.wi.gov/fish/consumption/>

The Remaining Challenges

THE GREATEST CHALLENGES REMAINING INCLUDE:

- **Reducing fecal matter from entering our waters.** Our waters carry an enormous quantity of fecal coliform bacteria. Fecal coliform is an indicator of “poop” in the water. Fecal matter can be a source of disease-carrying organisms, including certain strains of *E. coli*, viruses, and chytrid sporidium. The presence of fecal matter in the water makes the water unsuitable for swimming and other activities, like wading, frog-hunting, and even canoeing.
- **Reducing phosphorus loads.** Phosphorus contributes to the growth of nuisance algae and weeds. In recent years, the load of Cladophora algae that washes up on beaches in Lake Michigan in great stinking masses is caused in part by increasing phosphorus loadings to our rivers and, ultimately, Lake Michigan. Phosphorus is also associated with occasional blooms of toxic blue-green algae.
- **Cleaning up contaminated sediment, groundwater, and brownfield sites** to remove toxic substances, reduce acute and chronic toxicity to fish and other aquatic organisms, and eliminate

the need for fish consumption advisories. PCBs, mercury, and other toxic materials in the water also make the water unsuitable for swimming and other activities that put people in direct contact with the water.

- **Improving habitat** by opening up streams that have been channeled underground, eliminating concrete lining of stream channels, reducing erosion of streambanks, and improving aquatic and streambank vegetation.
- **Reducing the amount of fine solids** washing into streams and lakes, called Total Suspended Solids (TSS). These small particles are made up of toxic metals, residue from cars and tires, excess nutrients from lawns and farm fields, and fine sediments scoured from streambanks.
- **Understanding and monitoring emerging pollutants**, including pharmaceuticals and personal care products and the compounds that such materials become as they break down in our own bodies and in the environment (known as metabolites). Deodorizers, caffeine, detergent components, flavoring and fragrance compounds, perfume, cosmetic compounds, and DEET have been detected in Milwaukee-area waters.



Habitat Quality



In addition to water quality, the quality of instream and shoreline vegetation and habitat has an enormous impact on a stream's ability to support fish and aquatic life. Surveys looking at the number and diversity of fish and macroinvertebrates suggest that habitat is severely degraded. Detailed surveys of the condition of streambanks is not available for large parts of the watershed. Where streambanks have been examined, large areas of streambank are unstable. Some streams

REMOVING FECAL MATTER FROM THE WATER IS ONE OF OUR HIGHEST PRIORITIES.

also have an exceptionally high proportion of their entire stream length enclosed in conduit or concrete channel, completely destroying natural habitat, increasing stream velocities, and creating conditions where temperature and dissolved oxygen levels cause fish to die.

Buffer strips, planted areas along streams that catch runoff from fields and streets, help to keep pollutants from entering the water. SEWRPC found that 56 percent of streams in the watersheds had buffers of 75 feet or more. But 25 percent of streams had buffers of less than 25 feet wide.



MACROINVERTEBRATES

Macroinvertebrates are a collection of non-vertebrate species, including worms, snails, mussels, insects, and other critters that live in the sediment at the bottom of rivers and lakes. The presence or absence and relative abundance of different species of these animals are a measure of the biological condition of the water. Together with data on oxygen and toxic substances in the water, macroinvertebrates offer a direct confirmation of the impact of pollution on the biological status of the water.



Exotic Species of Lake Michigan

“SCIENTISTS HAVE IDENTIFIED 145 NONINDIGENOUS FISHES, INVERTEBRATES, FISH DISEASE PATHOGENS, PLANTS, AND ALGAE IN THE GREAT LAKES.”



Some of them established as early as the 1830s in Lake Ontario. When the Welland Canal was “improved” in 1919, creating a pathway around Niagara Falls, Atlantic species began to travel throughout the Great Lakes.

Source: SEWRPC, Report No. 39, Chapter 12, p. 1258.

EXOTIC SPECIES INCLUDE:

SEA LAMPREY: a large fish parasite, entered the Great Lakes when the Welland Canal eliminated a natural barrier to its movement upstream in the Great Lakes. “Sea lampreys were a major cause of the collapse of lake trout, whitefish, and chub populations in the Great Lakes during the 1940s and 1950s”

Source: Great Lakes Fishery Commission, Sea Lamprey: A Great Lakes Invader,” <http://www.seagrant.umn.edu/downloads/x106.pdf>.

ALEWIFE: arrived in Lake Michigan in 1949. During the 1960s, masses of dead and dying alewives on Milwaukee area beaches chased beachgoers away because of the stench and potential hazards from bacteria growing on the rotting carcasses. The greater threat from alewife is in their prolific appetite, removing a substantial proportion of the zooplankton, outcompeting native species, and contributing to the water clarity that has increased algae growth.

SALMON: introduced into the Great Lakes as early as 1877, their intensive introduction to control alewife populations did not occur until the 1960s. Although an exotic species in the lake, salmon have not become a nuisance because they have not successfully reproduced in the lakes. Populations are controlled by the stocking programs on the states around Lake Michigan.

ZEBRA MUSSELS: “an efficient filter feeder that competes with native mussels and impacts fish populations by reducing food and available spawning habitat.”

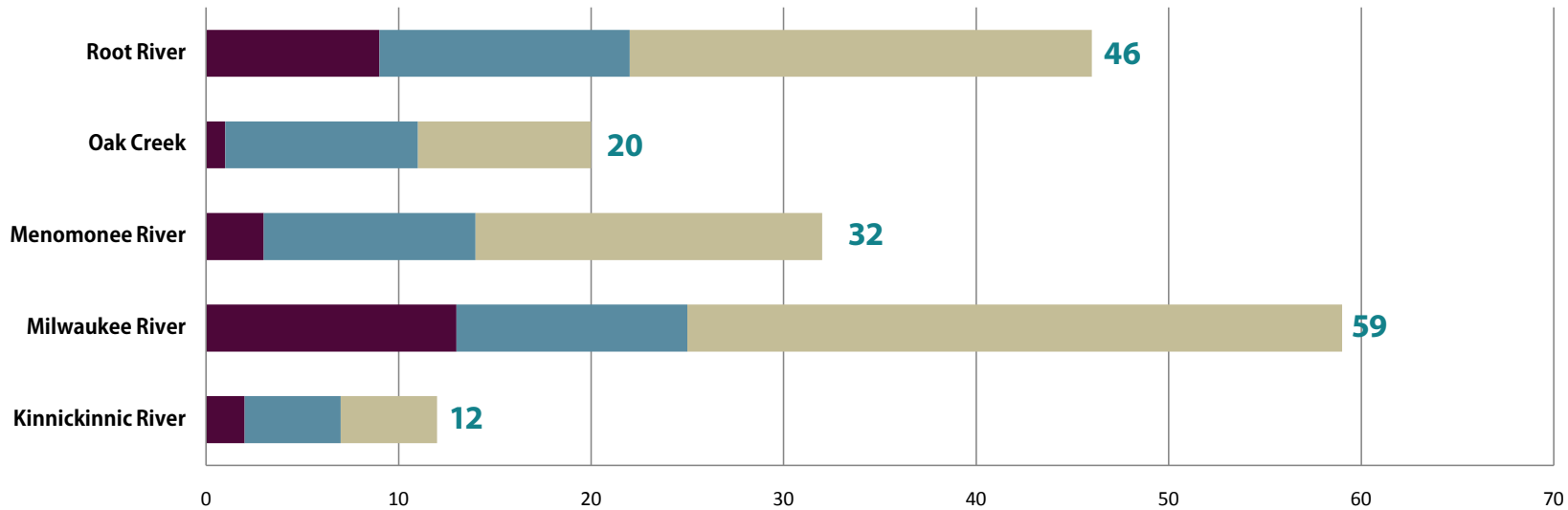
Source: Great Lakes Commission, “Great Lakes Aquatic Nuisance Species,” <http://www.glc.org/ans/>.

Zebra mussels are also an expensive nuisance to municipalities and industry, clogging up water intake pipes. The water clarifying action of zebra mussels also appears to be a factor in the increased Cladophora growth observed in the past decade.

ROUND GOBY: a more recent arrival in Lake Michigan, just 20 years ago in ballast water. Gobies are predator fish that outcompete native fish in foraging for food and eat the eggs of native fish.

Source: Jeff Alexander, “Invasive Species Round Goby Has Population Explosion in Lake Michigan,” Muskegon Chronicle, January 11, 2009.

Fish species composition in the Greater Milwaukee Watersheds: 1998-2004



	Kinnickinnic River	Milwaukee River	Menomonee River	Oak Creek	Root River
Tolerant	2	13	3	1	9
Intolerant	5	12	11	10	13
Intermediate	5	34	18	9	24
TOTAL SPECIES	12	59	32	20	46

TOLERANT FISH SPECIES ARE CAPABLE OF PERSISTING UNDER A WIDE RANGE OF DEGRADED CONDITIONS AND ARE ALSO TYPICALLY PRESENT WITHIN HIGH-QUALITY WARMWATER STREAMS

INTOLERANT FISH SPECIES ARE PARTICULARLY SENSITIVE TO WATER POLLUTION AND HABITAT DEGRADATION

INTERMEDIATE FISH SPECIES ARE LESS SENSITIVE THAN INTOLERANT SPECIES, BUT NOT AS TOLERANT OF DEGRADED CONDITIONS AS TOLERANT SPECIES

Note: Fish tolerance classifications are based upon work published by John Lyons, 1992, "Using the Index of Biotic Integrity (IBI) to measure environmental quality in warmwater streams of Wisconsin," USDA Forest Service, General Technical Report NC-149, St. Paul Minnesota.

Concrete Channels and Stream Stability



▲ Monitoring in the Kinnickinnic River

Rivers like the Kinnickinnic pose special challenges for improving habitat. The Kinnickinnic (or KK) is located in a heavily urbanized watershed that developed before modern stormwater management practices were required as part of the development of new homes and businesses. As a result, when it

rains, water flows more rapidly toward the KK than in other watersheds and less water soaks into the ground before it reaches the KK. This leads to large volumes of stormwater hitting the river channel.

To prevent these high flows from overtopping the river banks, engineers lined the river channel with concrete to speed up the flow away from the land and out to Lake Michigan. Concrete provides no habitat.

Removing the concrete is an obvious goal. The challenge is beyond stormwater. The KK River needs to be able to handle extreme storms—about 6 inches of rain in a 24-hour period. With homes and businesses cheek-by-jowl in the neighborhoods around the river, engineers cannot find anywhere to hold back and store the water without removing some existing development. A more natural river channel is possible, but requires careful planning and coordination with neighborhoods and local government.

Watershed	Proportion of stream length inventoried for stability	Proportion of inventoried streambank with stability problems	Proportion of stream length in conduit or concrete channel
Milwaukee	9%	50%	2%
Menomonee	68%	5%	22%
Kinnickinnic	27%	>95%	58%
Oak Creek	>95%	>90%	7%
Root	49%	66%	<1%

Source: SEWRPC Technical Report No. 39, Chapter 12, pp. 1259-1260.



EMERGING POLLUTANTS

The effect so-called “emerging pollutants” on human health and on aquatic organisms is not yet well understood. Evidence is mounting, however, that some of these compounds—including pharmaceuticals, gasoline additives, and personal care products—can produce negative effects on humans and aquatic organisms when present in the water. In addition, these pollutants are not yet regulated and, for the most part, travel through current treatment systems either unaffected or broken down into other compounds that may also have health effects. Evidence has shown that some of these compounds bioaccumulate,

accumulating in the bodies of animals at the top of the food chain and increasing the probability that some biological effect may occur. Of particular concern is evidence that some of these chemicals mimic endocrine hormones.

The Water Quality Plan does not include specific recommendations for dealing with emerging pollutants, but these are likely to be the subject of increased monitoring in future years.

A number of emerging pollutants were also considered, but could not be assessed across the entire watershed because of lack of data (see Technical Report No 39, Chapter 2, for details).

Emerging pollutants include:

- Pharmaceutical and personal care products
- Endocrine disrupting compounds (which may enter the environment from industrial pollution, pesticides, or household products entering the sewage system—for example, detergents, disinfectants, dyes, flame retardants, fragrances, and solvents)
- Mercury
- PCBs
- Polycyclic aromatic hydrocarbons (from *combustion of petroleum products and coal*).

Status of Inland Lakes and Ponds

Limitations in regular monitoring data for most lakes and ponds limited SEWRPC's ability to comprehensively evaluate these bodies of water. Thus, almost all of the data analysis and modeling were focused on rivers and streams. As a result, detailed tables of status and trends in the Greater Milwaukee lakes and ponds are limited.

Lakes throughout the Greater Milwaukee watersheds are showing increased chloride concentrations. "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" (*SEWRPC Technical Report No. 39, p. 437*). Although salinity in the lakes is still well below the level where biological impacts can be observed, salt is an emerging area of concern.

In general, lakes and ponds in the greater Milwaukee watersheds contain fish populations dominated by species that can tolerate somewhat polluted water, such as green sunfish, black bullhead, carp, and white sucker. Many lakes have largemouth bass, northern pike, yellow perch, and walleye. In some lakes, stocking efforts by the DNR supplement natural fish populations (*SEWRPC Technical Report No. 39, Chapter 12, p. 1256*). "Exotic invasive species have been recorded in several lakes and ponds within the greater Milwaukee watersheds. Carp are found in at least 26



Invasive Mussels



Weed eater



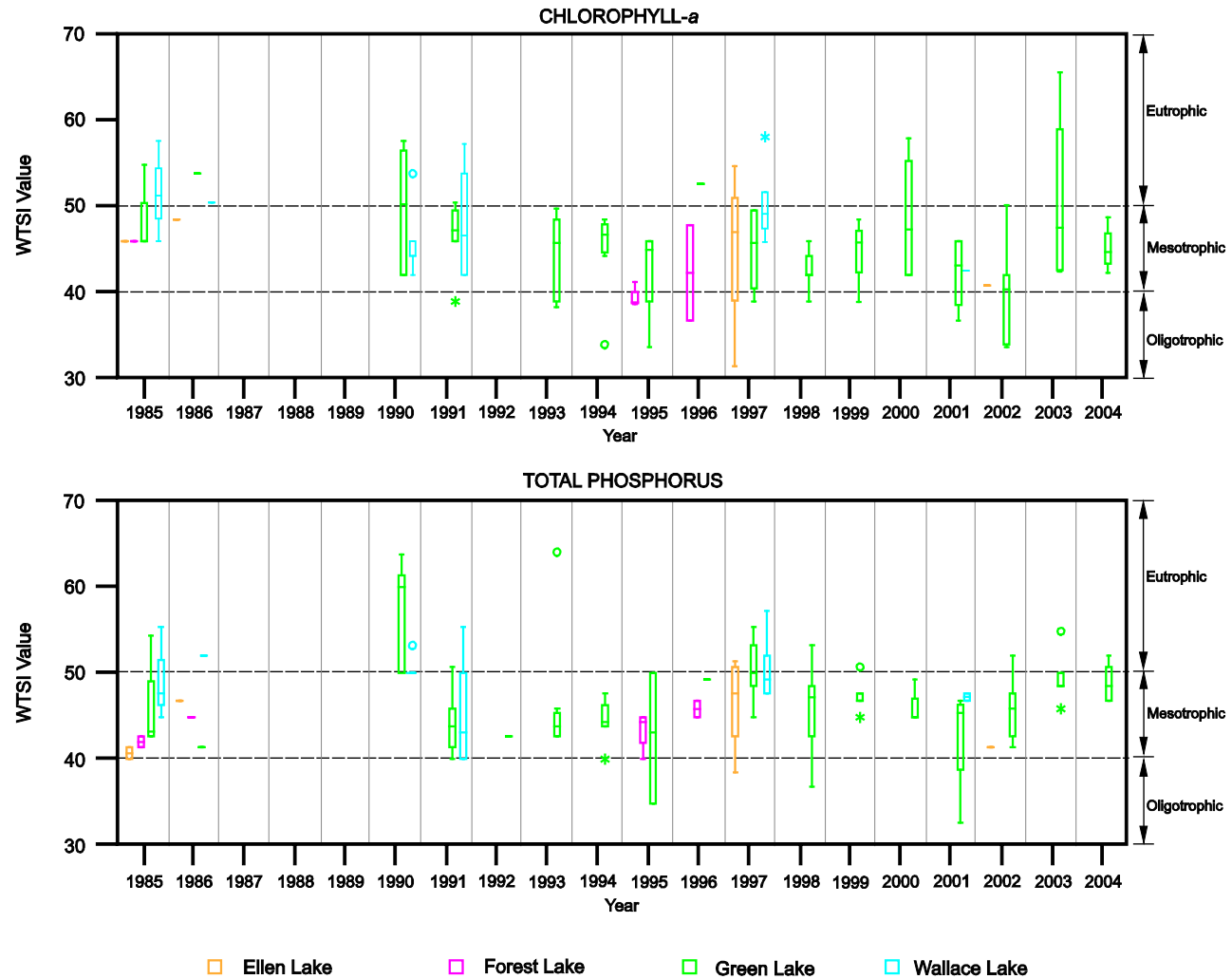
Milfoil



Carp

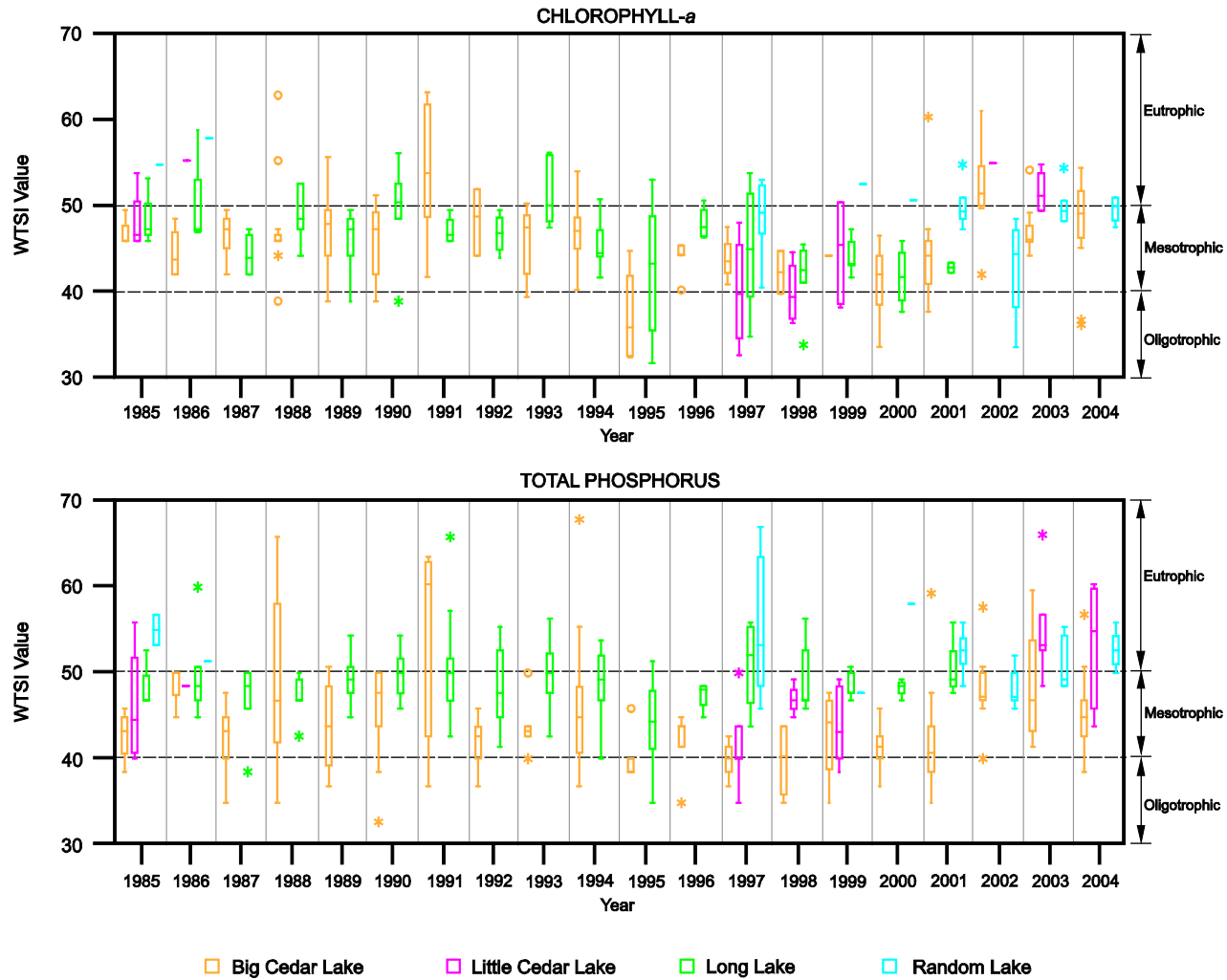
lakes and ponds. Zebra mussels have been recorded in seven lakes. Eurasian water milfoil is known to exist in 20 lakes and ponds. Curly-leaf pondweed is known to exist in each of the Counties within the greater Milwaukee watersheds" (*SEWRPC Technical Report No. 39, Chapter 12, p. 1256*).

Figure 142
**WISCONSIN TROPIC STATE INDEX (WTSI) OF LAKES UNDER
 200 ACRES IN THE MILWAUKEE RIVERSHED: 1985—2004**



NOTE: See Figure 109 for description of symbols.
 Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 143
**WISCONSIN TROPIC STATE INDEX (WTSI) OF LAKES OVER
 200 ACRES IN THE MILWAUKEE RIVERSHED: 1985—2004**





STATUS OF NEARSHORE LAKE MICHIGAN AND ESTUARY

Conditions in the estuary, outer harbor, and nearshore areas of Lake Michigan are closely related to overall conditions in the Lake. Although conditions in the nearshore area are affected by the activities in the Greater Milwaukee watersheds, they are also influenced by the larger Lake Michigan basin, a drainage basin of over 45,000 square miles with a population of over 10 million people.

Issues of concern in the estuary, outer harbor, and nearshore areas include the following.

- Cladophora, a native algae species, has become a serious nuisance in recent years. When wind and wave action cause large masses of Cladophora to break free from the bottom and wash up on the lakeshore, the

Cladophora mats decompose on the beach, causing both health concerns and foul odors along the lake shore. The rotting Cladophora may promote the growth of harmful bacteria. In addition, the tiny crustaceans living on the algae attract gulls, which carry high concentrations of *E. coli* bacteria in their feces. As a result, piles of Cladophora on beaches can lead to beach closings and potential health risks.

- The Great Lakes International Joint Commission has designated the Milwaukee harbor and estuary as a Great Lakes Area of Concern (AOC) because of toxic contaminants in sediments in the estuary.
- Because fish from Lake Michigan migrate into the estuary and up streams to the first physical barriers (dams, drop structures, and

box culverts), the lower reaches of the rivers have an abundance and variety of fish. Dam removal, such as the removal of the North Avenue dam in Milwaukee in 1997, allow fish greater access to upper reaches of the river. Within the watersheds, 88 dams and 62 drop structures continue to hamper further migration of fish. In removing these structures, analysis will be needed to determine whether some of the exotic species in Lake Michigan might harm localized populations of fish upstream if the barriers were to be removed.

- Lake Michigan is home to a wide variety of invasive species which have migrated into the Great Lakes since the opening of the St. Lawrence seaway. Today, new exotics arrive in ship ballast water, released as unused fishing bait, or escape from cultivation,

Sources of Pollution

Pollution comes from many sources. The proportion of pollution coming from point sources has declined over time, while the amount of pollution coming from polluted runoff is increasing. Runoff includes farm runoff of fertilizer, pesticides, and soil from fields, manure piles, and damage to streambanks from grazing cattle. Runoff also includes urban stormwater. Rain falls on roofs, lawns, driveways, streets, and parking lots. It flows overland until it reaches a ditch or stream or it enters a storm drain and is carried in an underground pipe to discharge in the nearest stream or drainage ditch.

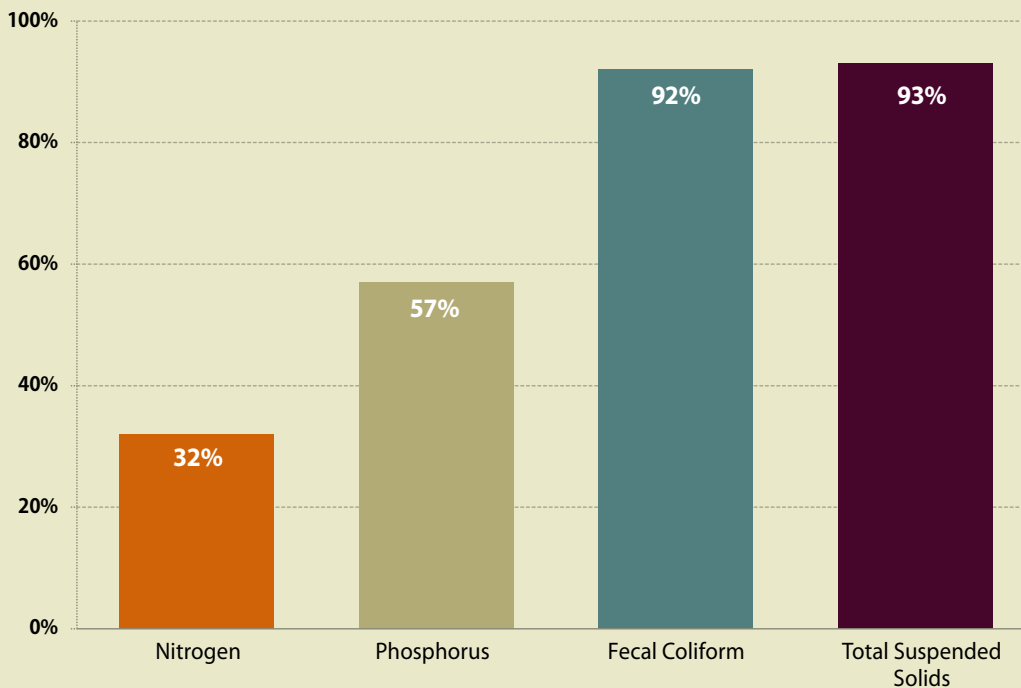
Even though most stormwater enters streams at a specific point (a storm sewer outfall), SEWRPC's data analysis treated all stormwater as "nonpoint," even though it may have moved through a pipe at some point in its journey toward a body of water.

Finally, nonpoint also includes discharges from septic systems—both those that are operating properly and those that are malfunctioning in some way. Although properly functioning septic systems are highly efficient in eliminating bacteria and nitrogen from household waste, even a well-functioning system may discharge substantial quantities of phosphorus and chloride. A poorly functioning septic system may also discharge fecal bacteria, ammonia, and nitrogen.



Another source of pollution includes leaching of underground contaminants into surface water. Finally, some pollutants, such as mercury, can be picked up by raindrops as they fall through the atmosphere. Although the SEWRPC study looked at these sources, the overwhelming evidence showed that the immediate focus of concern should be on point and nonpoint pollution.

PROPORTION OF TOTAL POLLUTANT LOAD DISCHARGED FROM STREAMS



This table shows the percentage of the total load of each pollutant discharged anywhere in the watershed, including into Lake Michigan, that is discharged to streams. While a significant share of the nitrogen and phosphorus in the watershed is discharged directly to Lake Michigan, primarily from sewer discharges, the overwhelming share of fecal coliform and total suspended solids are discharged to streams, largely from polluted runoff, as the next set of graphs show.

POLLUTANT CONCENTRATIONS VS. POLLUTANT LOADS

The contrast between pollutant sources and water quality conditions during wet and dry weather also highlights two methods of measuring pollution: pollutant concentration versus pollutant load. Pollutant concentrations are important because high concentrations of pollutants stress natural resources and pose human health risks and aesthetic concerns (smells and unsightly conditions).

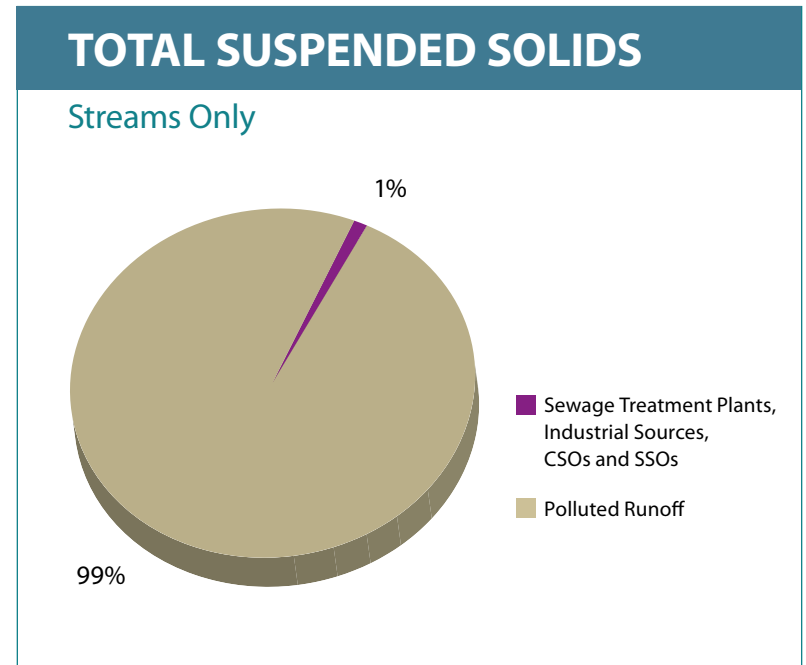
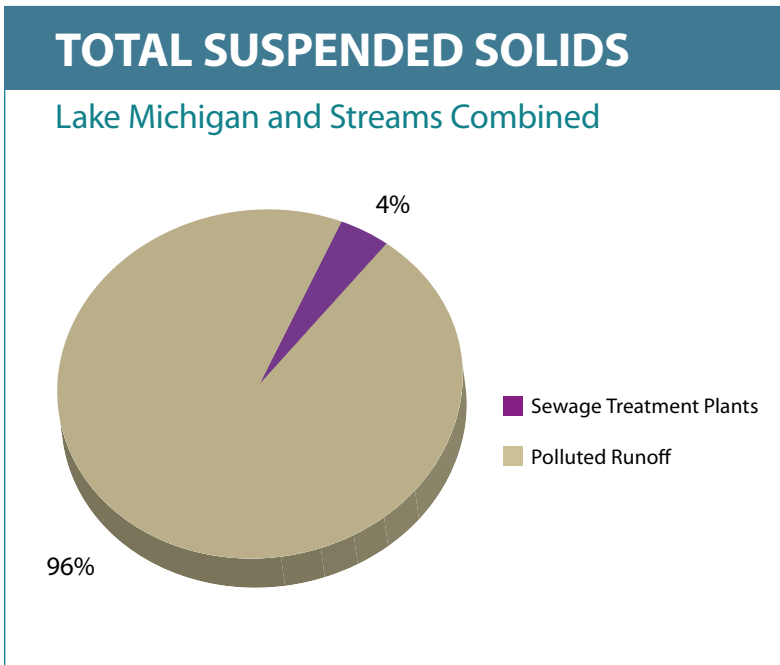
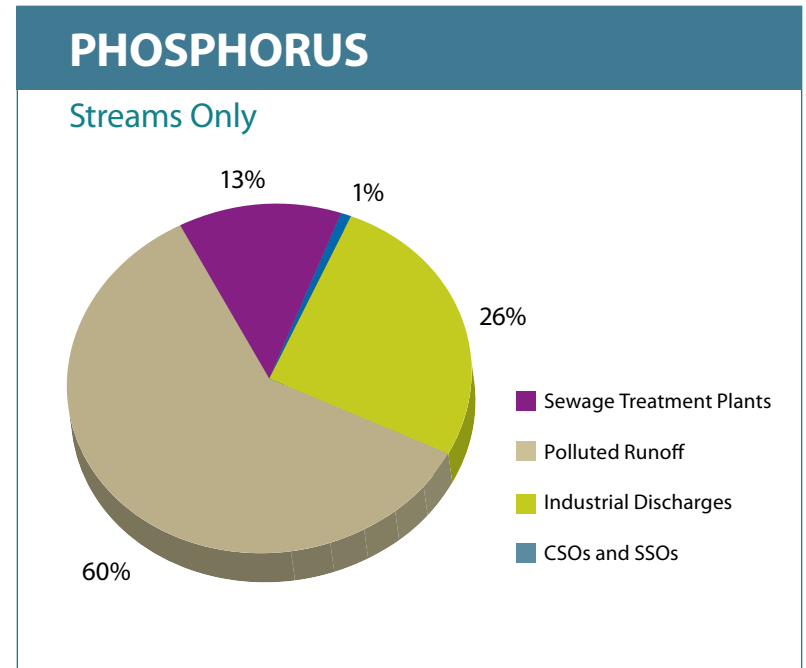
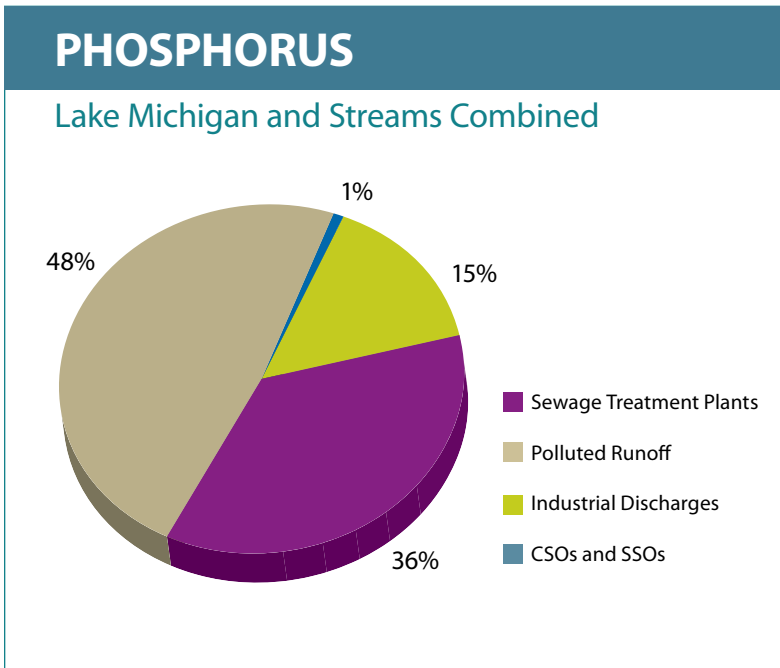
POLLUTED RUNOFF IS THE OVERWHELMING SOURCE OF FECAL POLLUTION.

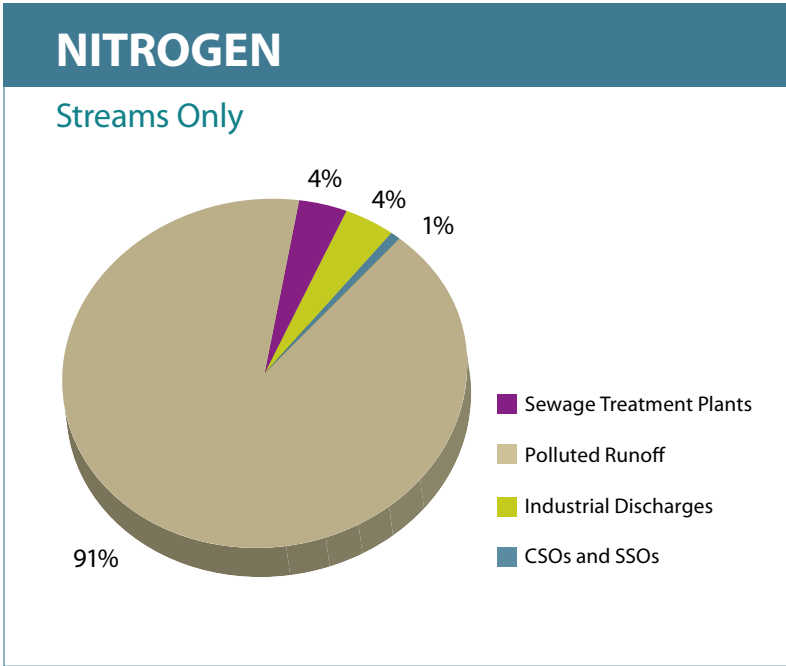
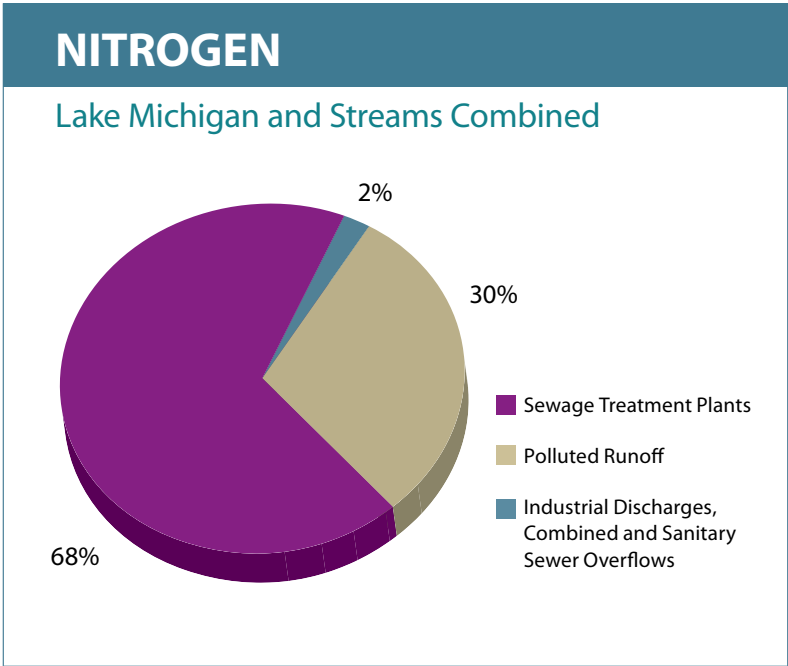
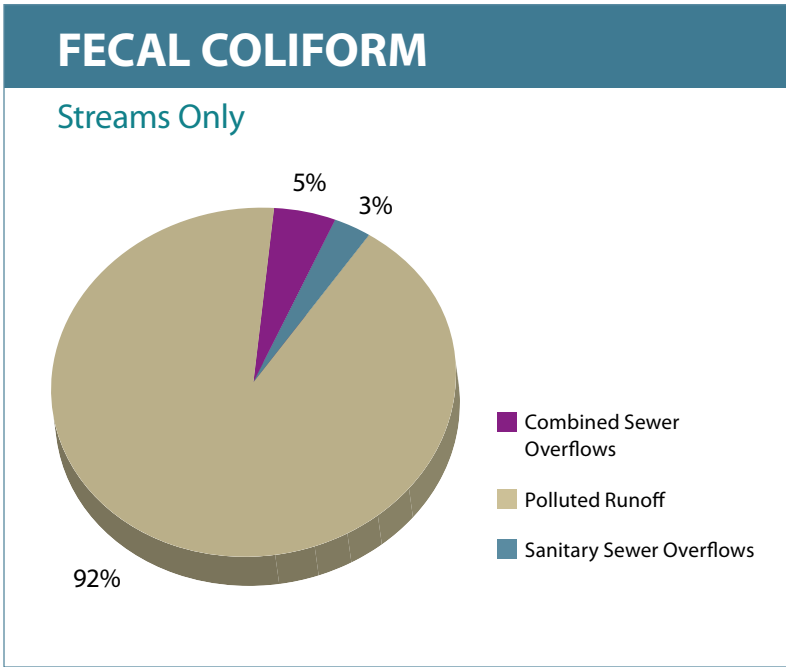
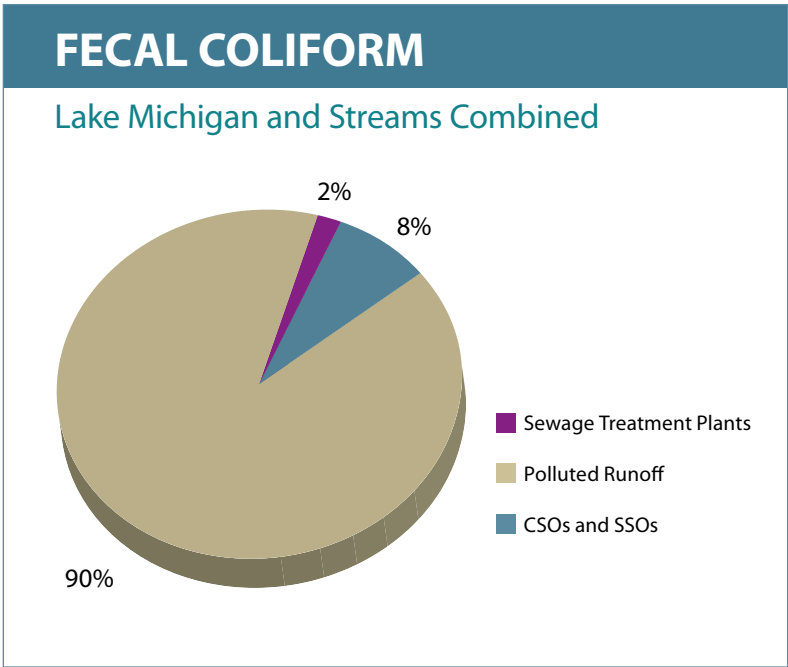
In contrast, pollutant loads measure the total amount of a pollutant deposited in a body of water over a period of time. Pollutant loads are important because they accumulate downstream in lakes.

The pollution concentration in a stream might never exceed regulatory standards, and yet the polluting effect on the lake fed by the stream could be excessive. As massive quantities of polluted rainwater flows downstream, the pollutants are diluted in the large quantity of rainwater. The pollutant concentration remains low because the pollutant is mixed in with so much rainwater.

But once the pollutant enters the lake, the overall quantity creates a giant load of pollution.

“In some situations, over half of the total contaminant load to a system can be transported into the surface water system by two or three major storms. Thus, wet weather conditions are likely to be as critical in terms of adverse water quality conditions as dry weather conditions” (*SEWRPC, Technical Report No 39, Chapter 2, p. 44*)





SUMMARIZING THE TABLES

The previous chapter showed that in most places, most of the time, dissolved oxygen and ammonia are in compliance. The problems, currently, are high loads of phosphorus and fecal coliform bacteria. Polyaromatic hydrocarbons and heavy metals also pose serious challenges, but data are too limited to evaluate these pollutants through modelling.

A substantial proportion of nitrogen and phosphorus is discharged directly to Lake Michigan from sewage treatment plants. Once again, the distinction between concentration and load is important. MMSD has a high level of compliance with effluent standards in its water quality permit

controlling the concentration of nitrogen and phosphorus. Added up over time, of course, this represents a significant load.

For fecal coliform and total suspended solids (TSS), the overwhelming majority of the discharges are made directly to streams which then flow into Lake Michigan and contribute to the total pollutant loadings in the lake. For these pollutants, over 90 percent of the pollutant load comes from polluted runoff.

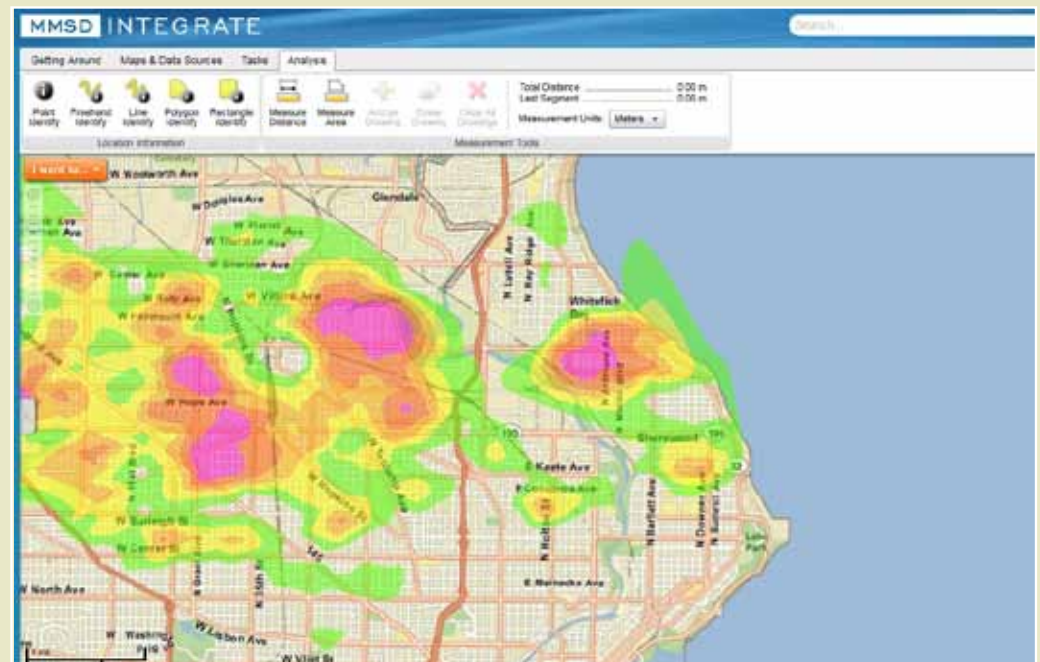
Finally, when looking at loadings to streams only, polluted runoff is the overwhelming source for all pollutants except phosphorus, accounting for almost all of the fecal coliform, nitrogen, and total suspended solids in

COMPUTER MODELING

A major activity in any watershed planning process is detailed computer modeling of the watershed. Computer modeling requires massive quantities of data about the topography of the land, the volume of flows in rivers during different times of year, the character of the water in different places under different weather conditions, and hundreds of other factors that affect the watershed. A computer crunches this data to try to simulate the current conditions in the watershed. This is called calibrating the model.

Once the model is able to simulate current, known conditions, then the model is ready to be used to project how conditions might change in the future. For example, planners can ask the model to project what might happen to water quality if all combined sewer overflows were eliminated. Or they might ask the model to project the future volume of water flowing in streams under changed rainfall conditions that might be expected as a result of climate change.

The model allows planners to get a glimpse of how different management strategies could improve water quality or, alternatively, how failing to take the right management actions may result in further worsening of conditions. When combined



with information about the cost of implementing different management strategies, the model allows planners to identify the actions that will result in the greatest water quality improvement for the least expenditure of funds.

Each of these predictions is made for many dozens of specific places in the watershed. For example, the model predicts what might happen in the

Kinnickinnic River watershed upstream of the confluence with Wilson Park Creek or in the Menomonee River at the Washington-Waukesha County Line.



THE PROBLEM OF ILLICIT CONNECTIONS

With such high levels of fecal coliform showing up in urban stormwater, some scientists have wondered whether all of that fecal matter can be coming from pet waste and wildlife. Might sewage be finding its way into stormwater pipes?

As a result, MMSD funded a study of bacteria at storm sewer outfalls in the Honey Creek subwatersheds of the Menomonee River. The study found that a form of bacteria found only in human feces were detected in discharges from 11 of 17 stormwater outfalls sampled. Moreover—and perhaps even more importantly, high levels of human fecal coliform counts were found even when it had not rained for days.

This finding has led to further studies, many of which are still underway. The clear indication, however, is that some proportion—perhaps a quite substantial proportion—of the fecal pollution attributed to urban stormwater may actually be the result human sewage making its way into storm sewers. This can occur in a number of ways. The discovery in 2007 of an improperly plumbed bathroom at Miller Park, which allowed toilets to flush directly into the Menomonee River, may be just the tip of the iceberg (*Don Behm, "Ballpark Sewage Discharge Fixed," Milwaukee Journal Sentinel, March 18, 2007; <http://www.jsonline.com/business/29353174.html>*). Such mistakes in connecting pipes may be more common than previously understood.

In addition, scientists are exploring whether old sewage pipes that are cracked and leaking are located close enough to storm sewers to allow sewage to seep into the storm sewers in both wet and dry weather.

streams. That's right—polluted runoff accounts for almost ALL of the fecal coliform, nitrogen, and TSS in streams.

WET WEATHER VARIATIONS

To fully understand the sources of pollution, we need to consider the difference between average loadings and the source contributions on any particular day. Average loadings take all of the loads contributed from a source over the course of a year and averages it over the full 365 days. On some days, however, the actual proportion of the pollutant load coming from each source can vary substantially.

For example, on a dry day, the proportion of the load coming from sewage treatment and industrial plant discharges may be somewhat higher than the average values, because runoff and sewer overflows are events that occur only when it rains. On a day with a moderate amount of rainfall, when sewage treatment plants and sewer pipes can handle the increased flow, the proportion of pollutants coming from runoff is likely to be an even larger percentage than the average numbers. Studies show that the "first flush" of rainfall on a street, parking lot or lawn carries 90 percent of the pollutants from a storm.

Finally, during intense or extended rain storms, when sewage treatment plants need to by-pass secondary treatment and when combined and sanitary sewers overflow, the proportion of fecal coliform and total suspended solids coming from sewer-related sources may spike for a few hours or for a couple of days.

Even so, polluted runoff is the overwhelming source of fecal coliform and total suspended solids over the course of the year. For this reason, municipalities are required under the federal Clean Water Act to have a program for managing stormwater in order to reduce the pollutants from runoff and stormwater



WET VS. DRY CONDITIONS

Water quality conditions—for human health, aesthetics, and the health of aquatic wildlife—are strongly affected by weather conditions, especially by wet weather versus dry weather conditions. This poses special challenges in understanding our water quality challenges. On the one hand, during dry weather conditions, when water levels are low, the concentration of pollutants and high temperatures can put special stresses on aquatic life. But on the other hand, when it rains even a little, enormous quantities of pollutants can be flushed into streams and lakes. The rain carries pollutants with it, including large quantities of fecal coliform bacteria.

In addition, while the total loading of some pollutants from particular sources, such as the amount of fecal coliform from sewer overflows, may be quite low over the course an entire year, during extreme rainfalls, when an overflow event occurs, the amount of fecal coliform in the water from sewer overflows is a big part of the total fecal load in the water at that point in time.

SHARE OF EACH POLLUTANT FROM URBAN LAND USE

Watershed	Urban Share Pollutant			
	Phosphorus	TSS	Fecal Coliform	Total Nitrogen
Milwaukee	35.8%	30.8%	62.7%	11.6%
Lincoln Creek Subwatersheds (urban)	99.1%	98.3%	100.0%	98.8%
West Branch Subwatersheds (rural)	12.3%	11.3%	45.8%	2.4%
Menomonee	87.7%	89.0%	97.3%	63.9%
Kinnickinnic	99.3%	99.4%	100.0%	97.8%
Oak Creek	80.1%	83.2%	93.5%	62.7%
Root	32.8%	10.7%	78.4%	14.5%
Nearshore Lake Michigan	85.5%	81.9%	96.2%	69.7%

entering streams through storm sewers. In Wisconsin, the rules municipalities must follow are in NR 151 of the administrative code.

MORE ON POLLUTED RUNOFF: URBAN AND RURAL SOURCES

Polluted runoff comes from two major categories of sources:

- streets, parking lots, and lawns
- rural runoff from farm fields, cattle grazing in and along streams, improperly managed manure piles, and malfunctioning septic systems.

The share of pollutants arriving at streams coming from urban and rural sources depends on the degree to which a watershed is in urban or rural uses. Both are significant sources of pollution. This table shows the proportion of “nonpoint” pollution coming from urbanized areas in the watershed.

In heavily urbanized watersheds, like Lincoln Creek and the Kinnickinnic River (92 percent urbanized), almost all of the phosphorus, TSS, fecal coliform and nitrogen running off the land comes from urban lands. In more rural watersheds, like

the West Branch subwatersheds of the Milwaukee River and the Root River watershed (32.9 percent urbanized), the share of polluted runoff from urban land is much reduced—almost a mirror image of the urban watersheds. Taken as a whole, runoff of phosphorus and TSS in the Milwaukee River watershed (with 21.2 percent urbanized land) is largely from rural land uses, but fecal coliform runoff is largely from urban land uses, even in this fairly rural watershed.

Overall, the proportion of runoff containing fecal coliform from urban uses is substantially higher than for other pollutants across all of the watersheds. This fact seems surprising. Not only are sewer discharges not responsible for the fecal coliform loads, but cows are not the biggest source either.

At present, a number of possible sources of high levels of fecal coliform from urban runoff are being studied. Pets and urban wildlife are potential sources. However, the high levels that are sometimes observed in dry weather suggest that a significant proportion of the fecal contamination may be the result of improper connections of sanitary sewers to stormwater lines. “Second level planning,” like that recently completed for the Kinnickinnic and Menomonee River watersheds should shed more light on the sources of this common, and potentially harmful, pollutant.

CHAPTER FOUR

Our streams and lakes are under stress. Many native fish are unable to spawn, and in some places, are unable to survive because of pollutants and degraded habitat. In some streams, water can sometimes be so polluted with fecal matter that it is unsafe to swim or wade in the water. Exotic species, nuisance algae, and weed growth are taking a toll as well.

The next task in the planning was to understand how conditions might change in the future, depending on expected development patterns and public policies taken to address current problems. Computer modeling was done in order to be able to make some predictions about which actions might be most effective in improving the state of the waters and achieving the goal of fishable and swimmable water.



Cleaning Up Our Waters



The next task in the planning was to understand how conditions might change in the future, depending on expected development patterns and public policies taken to address current problems. Computer modeling was done in order to be able to make some predictions about which actions might be most effective in improving the state of the waters and achieving the goal of fishable and swimmable water.

To identify the most cost-effective means of cleaning up the waters, SEWRPC examined five “screening alternatives”. Each alternative looked at a different bundle of strategies, from improving the MMSD sewer system to aggressive implementation of stormwater Best Management Practices. None of the alternatives were intended, in their design, to be a full and complete solution to the water quality problems observed. Rather, these alternatives allowed planners

to screen for the best potential combination of strategies to reach our goals.

This exercise of analyzing screening alternatives lead to several important conclusions that influenced the way alternatives were further developed.

- Separating the combined sewers in central Milwaukee and Shorewood would not be a cost-effective means of reducing pollutant loads.
- Managing stormwater more effectively will be critical in achieving better water quality.

After reaching a better understanding of the relative costs and benefits of different approaches to achieving water improvement goals, five alternatives were created to guide the selection of a recommended alternative.

Taking a Deeper Look at Deep Tunnel Operation

Its official name is the Inline Storage System, but most people in the region know it as simply the “Deep Tunnel.” The Deep Tunnel was built as part of a \$3 billion Water Pollution Abatement Program that began in 1977. It took 9 years to build almost 20 miles of underground storage. Completed in 1994, the Deep Tunnel has accomplished the goals it was designed to meet.

In rainy weather, the treatment plant cannot accommodate all of the flow coming off of streets in the combined sewer area, where sewage and stormwater are collected in a single pipe, plus all of the rain water infiltrating into leaky sanitary sewer pipes when the ground gets saturated. Before 1994, the only alternative was to allow the combined sewers to overflow, dumping a mixture of raw sewage, street runoff, and rainwater directly into urban streams. The Deep Tunnel allows MMSD to prevent most combined sewer overflows by storing the water underground rather than dumping it into streams. Combined sewer overflows, and loads of fecal coliform and phosphorus, have been greatly reduced since the Deep Tunnel came online.

Meanwhile, infiltration of rain water into leaky sanitary sewers in outlying parts of Milwaukee and suburban communities swells the flows in sanitary sewers in wet weather. The treatment plant cannot handle the additional volume of water—much of it relatively clean rainwater that has soaked into the ground and seeped into sewer pipes.

Because pollutants in sanitary sewage is assumed to be more concentrated than in combined sewage flows, the US EPA has

a zero-tolerance policy toward sanitary sewer overflows. As it rains, that leaves MMSD with few choices.

MMSD manages space in the Deep Tunnel to avoid sanitary sewer overflows. Using real-time data and modeling of rainfall and the location of storms in the sewer service area, MMSD receives estimates of how much space it needs to save in the Deep Tunnel to prevent a sanitary sewer overflow. To conserve that space for the sanitary sewer flows, MMSD shuts off flow of the combined sewers to the Deep Tunnel. Sometimes, inevitably, MMSD guesses wrong, causing SSOs even though the tunnel never completely filled.

Alternative B2 looked at changing this operational approach. Because stormwater entering the combined sewer system is very polluted and because sanitary sewer flows are very diluted by rainwater leaking into sewer pipes, in rainy weather the concentrations of pollutants are not that different in SSOs and CSOs. Holding combined sewer flows for treatment and allowing a few Sanitary Sewer Overflows might be as effective in reducing pollutants as the current strategy of trying to avoid SSOs.

Alternative B2 performed well, especially in the combined sewer area. Ultimately, because of the better performance of other strategies and the unlikely prospect of convincing the EPA to change its policy toward sanitary sewer overflows, the plan rejected the idea of making changes to the operation of the Deep Tunnel.



▲ Old and deteriorated sewer pipes, especially the pipes between homes and the municipal sewer main, may be a cause of a number of the pollution problems the region is facing. Infiltration occurs when the joints in sewer pipes become loose over time. Inflow occurs when manhole covers are leaky or when roof drains and sump pumps are improperly connected to sanitary sewer pipes. If a large number of such improper connections exist, the impact on the quantity of water flowing during a heavy rain can be substantial. When too much water enters sanitary sewer pipes from I & I, they back up and cause an overflow into streams, called an SSO.



▲ Inside the Deep Tunnel

Alternatives

A FUTURE 2020 BASELINE:

The Future 2020 baseline took into account population and land use changes that are anticipated between now and 2020. The 2020 baseline allowed SEWRPC to model the water quality changes expected to occur because of increasing urbanism in some areas. In addition, some facility upgrades and regulatory programs are already committed for implementation by 2020: facility improvements in the MMSD 2006 Capital Budget and Six-Year Capital Improvements Program; the urban stormwater requirements of NR 151, and MMSD's Chapter 13 regulations to reduce the volume of stormwater runoff. Regarding agricultural runoff, Alternative A assumed only partial implementation of NR 151's agricultural requirements. Specifically, it assumed that soil erosion from cropland would be in compliance, since the majority of croplands already meet this standard. Alternative A assumed that manure storage, clean water diversions, and nutrient management would remain unchanged through 2020 because current regulations do not require these practices unless substantial funding is provided to participating farms.

B1 REGULATORY COMPLIANCE FOCUS:

Alternative B1 included all of the changes and actions already anticipated in Alternative A, but

GREEN INFRASTRUCTURE, LOW IMPACT DEVELOPMENT, AND LEED DEVELOPMENT

Alternative C2 considered the potential effectiveness of broader implementation of a set of tools that have emerged in the past fifteen years to reduce the environmental impacts of development. These approaches involve designing the built environment to function more like the natural environment. New development or retrofits of existing development are designed to slow the movement of stormwater, encourage the infiltration of water into the ground, and create connected networks of wildlife habitat.

Green corridors can be used to channel water through "bioswales," stormwater ponds, and other "best management practices" to filter out pollutants, restore streambanks, and re-connect riparian (stream-side) habitat. Stormwater Park in the Menomonee Valley is an example of green infrastructure in the highly urbanized industrial area just south of Milwaukee's downtown.

Low Impact Development and LEED standards focus more at the scale of individual buildings or groups of buildings and may include green roofs and other building elements to manage stormwater on building sites.

The modeling suggested that these techniques, if more widely adopted, could improve water quality at a lower cost than grey infrastructure like storm sewers and treatment facilities.

added measures aimed directly at compliance with water quality regulations, for both point and non-point sources. It included capacity upgrades to the MMSD sewage conveyance, storage, and treatment system, additional pumping capacity for the Deep Tunnel, and conventional best management practices for urban and rural nonpoint pollution.

B2 REGULATORY COMPLIANCE AND CHANGES IN THE DEEP TUNNEL OPERATIONS:

Alternative B2 included all of the facility and stormwater compliance measures included in Alternative B1. B2 differed in only one respect; it included a change in the way MMSD operates the Deep Tunnel. Currently, because federal and state laws consider a Separate Sewer Overflow (SSO) to be a more serious type of violation than a CSO (Combined

Sewer Overflow), MMSD operates the Deep Tunnel to minimize the chances of an SSO. It does this by reserving a portion of the Deep Tunnel capacity to anticipate the increased flow into the system from the separate sewer area during wet weather.

As it rains, MMSD runs a complex modeling system to obtain predictions about the amount of Deep Tunnel space that will likely be needed to contain all of the extra flow from the Separate Sewer area. Preliminary studies suggested that if MMSD was able to fill the Deep Tunnel fully, allowing water from the Combined Sewer Area to fill the entire volume of the tunnel rather than saving some portion of tunnel capacity for separate sewer flows coming from outlying areas of the City of Milwaukee and suburban communities, pollutant loads might be reduced. A change in federal and state law would be required to implement Alternative B2.



C1 WATER QUALITY FOCUS “TRADITIONAL APPROACH”:

Alternative C1 takes a different approach entirely. Rather than focusing on compliance with existing laws and regulations—Clean Water Act laws governing the number of CSOs and SSOs and state regulations related to urban and agricultural nonpoint pollution (aka runoff), Alternatives C1 and C2 both focus on achieving water quality standards by going beyond current regulatory requirements for nonpoint pollution. Alternative C1 includes the committed actions included in the 2020 Baseline; continuation of current operational efforts by MMSD to control SSOs and CSOs, but no further facility improvements to reduce SSOs and CSOs would be undertaken beyond those included in the base case (Alternative A). The additional nonpoint pollution control efforts are divided among three different geographic areas: rural areas, separate sewer areas, and combined sewer areas.

RURAL NONPOINT MEASURES INCLUDE:

- 50 foot buffer strips along the entire length of streams in rural areas (cropland and pasture)
- Fencing along 50 percent of pastures adjacent to waterways
- Manure management for all livestock operations
- Expanded septic system inspection
- Fertilizer management education program

URBAN NONPOINT MEASURES INCLUDE:

- Extend infiltration requirements to include all existing institutional and commercial development—focusing on infiltration of runoff from parking lots and roofs.
- Require enhanced infiltration for all redeveloped institutional and commercial

development and all new residential development (going beyond NR 151’s requirements)

- Provide “end-of-pipe” water quality treatment devices for 100 percent of parking lots, double the level of such devices assumed in other alternatives for NR 151 implementation.
- Install stormwater disinfection at targeted storm sewer outfalls, using chlorine (bleach) to kill fecal bacteria, with removal of the chlorine before discharge of treated stormwater to stream.
- Disconnect downspouts from storm sewers from 30 percent of homes in the study area, installing rain gardens (15%) and rain barrels (15%) to manage the stormwater more effectively.

C2 WATER QUALITY FOCUS “GREEN” APPROACH:

Alternative C2 is similar in most respects to Alternative C1. Included in C2 were newer approaches to stormwater management, adopting what have been called “green” or “green infrastructure” strategies. Specific elements that are highlighted in the summary of Alternative C2 include requiring LEED development for 50 percent of new commercial and industrial development and converting 10 percent of cropland and pasture in the study area to wetland or prairie. In addition, Alternative C2 explored the use of ultraviolet disinfection of storm sewer discharges, rather than chlorine disinfection which was included in Alternative C1.

Appendix A summarizes the components of each alternative and the anticipated costs of each component.

Results: Understanding the Likely Effects of the Alternatives

The first conclusion that emerges from the modeling results conducted by SEWRPC is that substantial improvements in key pollutants can be expected simply by completing the efforts already underway, including facility improvements committed to by MMSD, full implementation of the urban stormwater rules of NR 151 and partial implementation of the rural nonpoint rules of NR 151. The table *(right)* compares existing conditions to the Future 2020 baseline. For all pollutants and all watersheds, if we simply keep doing what we are doing and complete the improvements that we already have committed to, we will achieve significant reductions in TSS, fecal coliform, and nitrogen, and significant reductions in phosphorus in all watersheds except for the Milwaukee where phosphorus would increase slightly.

The most consistent and dramatic improvements across all watersheds will occur in the amount of TSS entering our waters. These improvements are directly related to the legally-mandated reductions in urban nonpoint runoff of TSS, as required in NR 151. Improvements in the other pollutants are more variable across watersheds. Except for a slight increase in phosphorus in the Milwaukee River watershed and in phosphorus and nitrogen in the nearshore Lake Michigan waters, reductions range from 3 percent to 31 percent.

Percent change in total pollutant loads from comparing Existing Conditions to modeled Future 2020 Conditions (A negative sign means reduced pollutant loads and improved conditions; a positive sign means loads will increase despite commitments already underway.)

Watershed	Phosphorus	TSS	Fecal coliform	Nitrogen
Milwaukee	+4%	-4%	-31%	-3%
Menomonee	-27%	-18%	-14%	-21%
Kinnickinnic	-8%	-21%	-9%	-9%
Oak Creek	-8%	-32%	-8%	-22%
Root	-13%	-25%	-14%	-18%
Nearshore Lake Michigan	+16%	-5%	-6%	+16%

The alternatives that included expansions of MMSD facilities (Alternatives “B1 Regulatory Compliance” and “B2 Compliance and Deep Tunnel Operations”) generally performed worse than the alternatives focusing on reducing nonpoint pollution (C1 and C2). Geographic differences are apparent. In general, the benefits of improving MMSD’s facilities were concentrated within the sewered areas of Milwaukee County, while the benefits of reducing nonpoint pollution were more widely distributed throughout the watersheds.

The alternatives that focused on improving water quality, with an extra emphasis on controlling nonpoint pollution achieved the best pollutant reductions

for phosphorus, fecal coliform, and nitrogen. Surprisingly, the alternatives that focused on regulatory compliance and that included facility upgrades for MMSD resulted in the best performance in reducing Total Suspended Solids (TSS).

The table *(next page)* shows how well each alternative performed across all pollutants combined (phosphorus, TSS, fecal coliform, Nitrogen, Biochemical Oxygen Demand (or BOD), and copper). The numbers in the table show comparisons for each alternative to the average performance of all the alternatives combined, excluding the Future 2020 baseline alternative. Negative numbers mean that

[Cont'd on next page »](#)



CONTROLLING BEACH LITTER AND GULLS

Litter on beaches is more than unsightly. Litter attracts gulls, and gulls are a potent source of *E. coli* bacteria, including strains that can cause people to become ill. Removing litter and algae piles that attract gulls can be an effective way of reducing gull populations at beaches, and that makes the beaches safer places for people to enjoy the Lake.

Although research is still underway, scientists at the UWM School of Freshwater Sciences, using DNA technology, have found a large number of beach closings triggered by high fecal coliform counts that have probably been caused by gull droppings and stormwater outfalls on or alongside the beach.

the alternative performs below average, positive numbers that the alternative performs better than average. The size of the number indicates how much better or worse the alternative performs.

Again, the “C1: Traditional Nonpoint” and “C2: Green Nonpoint” alternatives, which focus on reducing nonpoint pollution, perform above average in every watershed, while the B1 and B2 “Regulatory Compliance” alternatives performed less well.

THE COSTS OF IMPROVEMENT

The goal of the Water Quality Plan is not merely to find the best means of reducing pollution, but to find the most cost-effective means of achieving a high level of performance in improving water quality.

The table (*next page*) compares the alternatives in terms of the overall costs of implementing them. While some costs could not be estimated, these figures allow a reasonable comparison of the costs of achieving water quality using the different strategies explored in the planning.

Just completing the efforts already committed to will cost an additional \$1 billion dollars. The costs of the alternatives ranges between \$2 billion and \$2.6 billion, with the alternatives focusing on basic regulatory compliance falling at the lower end of the range and those focusing on improving water quality coming in at the higher end of the range. While the “C1: Traditional Nonpoint” and “C2: Green Nonpoint” alternatives performed better in terms of modeled pollutant loads than the Regulatory Compliance alternatives, the differences were of a much smaller size compared to the greater costs associated with the nonpoint alternatives. Importantly, however, the C1 and C2 alternatives included additional benefits that cannot be captured in the water quality model, such as improvements to aquatic habitat, recreational value, and flooding reduction.

In addition to the analysis of the costs and benefits of the alternatives described above, planners also conducted sensitivity analyses to understand which components of each alternative were producing the biggest impact—and at the lowest cost. By running the model with different components, planners were able to tease out another alternative that became the Recommended Plan.

Modeled Future 2020 of Alternatives Compared to Baseline:

Phosphorus, TSS, Fecal coliform, Nitrogen, Biochemical Oxygen Demand, and Copper

Plan Alternative	Watershed						Total
	Kinnickinnic River	Menomonee River	Milwaukee River	Oak Creek	Root River	Lake Michigan ^a	
B1	-0.356	-0.871	-0.128	-0.739	-1.113	-1.377	-4.583
B2	-0.393	-0.868	-0.128	-0.739	-1.111	-0.034	-3.274
C1	0.374	0.757	0.594	0.721	0.887	-0.437	2.582
C2	0.374	0.982	0.851	0.757	1.337	-0.974	5.275

^aLake Michigan assessment points include sites in the Milwaukee Harbor estuary, outer harbor and nearshore Lake Michigan areas. Source: SEWRPC

Appendix A shows the elements of the Recommended Plan side-by-side with the other alternatives analyzed for the report. Like the other alternatives, it includes all of the baseline measures included in the Future 2020 alternative. The Recommended Plan includes components from both the “Regulatory Compliance” alternatives and the “Water Quality” alternatives. Like the Regulatory Compliance alternatives, the Recommended Plan includes upgrading the capacity at the MMSD South Shore treatment plant, increasing Deep Tunnel pumping capacity, and also includes wastewater treatment upgrades for systems outside of the MMSD system.

Like the “Water Quality” alternatives, the Recommended Plan calls for full rural

runoff implementation, including 75 foot buffers along rural streams, fencing cattle out of streams, converting cropland and pasture to wetland and prairie, expanding septic system inspection and replacement, and manure management. For urban runoff, the Recommended Plan calls for disconnecting residential roof drains from sanitary and combined sewers and providing infiltration through rain gardens and similar measures. The Recommended Plan also calls for the implementation of a chloride reduction program throughout the study area like that already in place in Madison and Brookfield. Pet litter management, waterfowl control at beaches, and litter control programs focused on beaches and streambank areas are similar to the efforts included in the Water Quality

alternatives. An important component of the Recommended Plan is a program to detect and eliminate illicit discharges to storm sewers.

The Recommended Plan also included recommendations focusing on habitat, rather than the more narrow focus on water quality reflected in the modeling results for the alternatives. The plan recommends:

- Concrete channel removal where such removal can be accomplished without creating flood or erosion hazards;
- Dam abandonment and restoration plans;
- Limiting stream crossings, such as culverts and drop structures.
- Protecting and enhancing fish habitat.

Cost of Study Alternatives and Recommended Plan

	Capital Cost	Operation and Maintenance Cost	Equivalent Annual Cost
Future 2020 Baseline	\$1 billion	\$68 million	\$134 million
Alternative B1: Regulatory Compliance	\$2 billion	\$91 million	\$223 million
Alternative B2: Regulatory Compliance with Deep Tunnel Operation Changes	\$2 billion	\$91 million	\$223 million
Alternative C1: Water Quality Focus “Traditional”	\$2.5 billion	\$117 million	\$294 million
Alternative C2: Water Quality Focus “Green”	\$2.2 billion	\$133 million	\$280 million
Recommended Alternative	\$1.5 billion	\$28 million	NA

All capital costs are rounded to the nearest tenth of a billion. All operation and maintenance and annual equivalent costs are rounded to the nearest million.

Note: Equivalent Annual Cost based on annual interest rate of 6 percent and a 50-year amortization period.

*The \$68 million includes the operational and maintenance cost for programs that are existing and are to continue, plan elements that have been committed to in other planning efforts, and programs that are to be implemented to meet regulatory requirements.



Recommended Plan

Finally, the Recommended Plan also identifies additional water quality and habitat monitoring that will be needed to measure progress and do a better job of planning in the future. The recommendation calls for the preparation of lake management plans for 17 major lakes, expanding water quality and habitat monitoring, and conducting assessments of emerging pollutants.

The table (right) shows how the costs are distributed across components of the plan. Rural nonpoint measures, estimated to cost \$243 million, includes \$114 million for improved inspection and replacement of septic systems (private onsite wastewater treatment systems, or POWTs). In addition, \$129 million is anticipated to be spent on agricultural runoff controls.

Urban nonpoint above and beyond the requirements of NR 151 are estimated to be \$43 million in capital costs.

WHAT IMPROVEMENTS SHOULD WE EXPECT?

SEWRPC modeled the recommended plan, which allows a comparison with the other alternatives studied during the planning process. In most watersheds, the recommended plan performed better, often much better, than the other alternatives explored, despite its lower price tag.

Facilities and Programs	Capital	Operation and Maintenance
New MMSD facilities and programs	\$1 billion	\$2.5 million
Wastewater and conveyance upgrades outside of the MMSD service area	\$62 million	\$0.67 million
Rural nonpoint control measures	\$171 million	\$6.5 million
Urban nonpoint control measures	\$43 million	\$2.5 million
TOTAL	\$1.5 billion	\$28.4 million
Plus committed actions and regulatory compliance	\$1.2 billion	\$32.6 million

Fecal coliform levels are frequently above regulatory standards in all of the watersheds. The Recommended Plan increases the number of days that the waters meet fecal coliform standards.

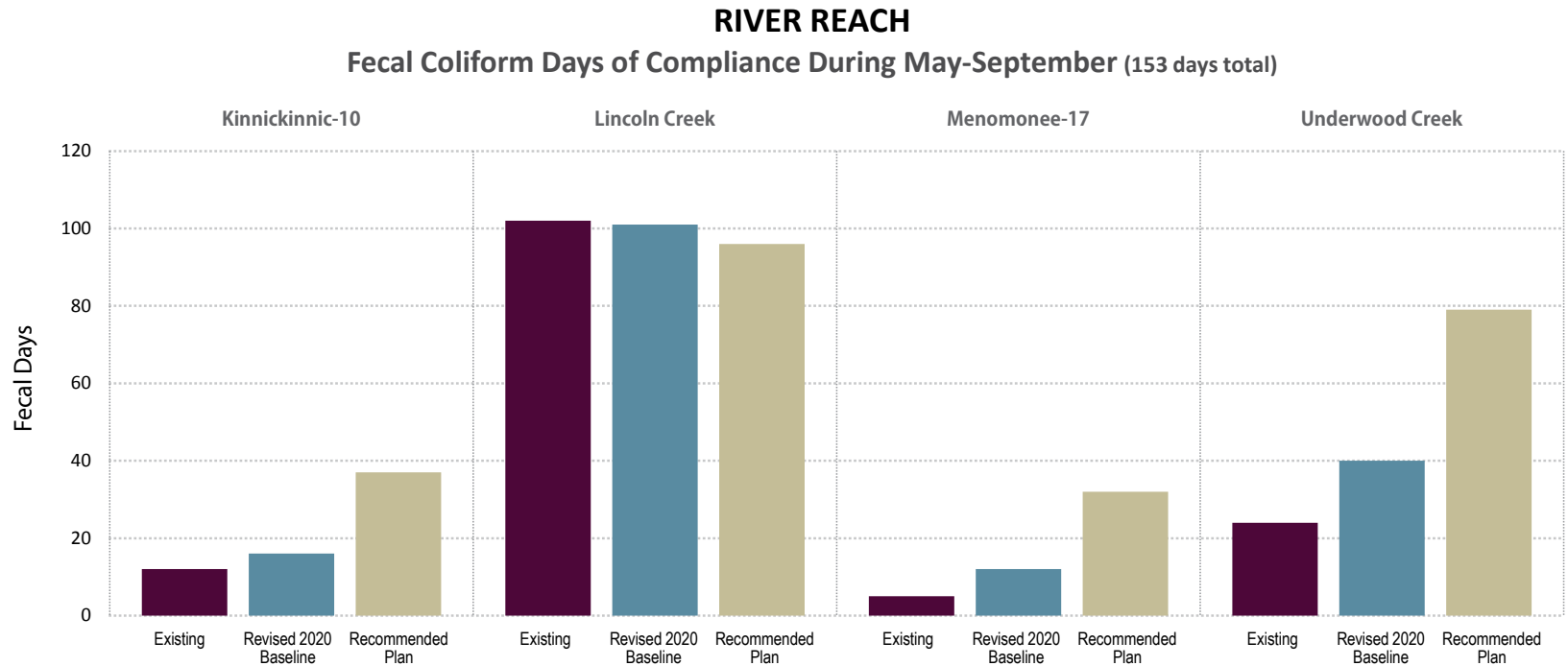
In the Root River watershed, high levels of phosphorus exceed standards more than half the time. Details about the modeled performance of the Recommended Plan by pollutant and watershed are presented in Appendix B.

Of course, modeled results are not real results. If the plan is not implemented, the benefits of the plan cannot be realized.

WHAT DOES THIS MEAN?

When the plan is fully implemented, will we have achieved fishable and swimmable water? The SEWRPC Plan attempts to answer this question by looking at future conditions related to dissolved oxygen (fishable) and fecal coliform (swimmable). The fecal coliform standard is the most germane because many, many other conditions may make the water not fishable and because most waters (except for the Kinnickinnic River and Oak Creek) already meet the dissolved oxygen standards most of the time.

The fecal coliform results, however, provide a glimpse at what we might expect in terms of our freedom to recreate in and on the water in the year 2020—if



..... *In all river reaches, the standards under the “Recommended Plan Conditions” are NOT met more than 85% of the time*

we implement the plan. The table shows results for the Kinnickinnic River mainstem, a portion of the Menomonee River mainstem (Reach 17), Underwood Creek in the Menomonee River watershed, and Lincoln Creek.

Except for the estuary, where fecal coliform standards will be achieved during the recreational season, none of the reaches for which SEWRPC forecast water quality conditions met the fecal coliform standard after implementation of the Recommended Plan. In almost every case, however, the number of days that the reach would be in compliance increased dramatically. (Lincoln Creek is the exception.)

These results lead to the conclusion that many of the most stressed waters will continue to experience limits on full recreational use even after the plan is fully implemented. So swimmable standards will not be achieved. But improvements are likely to be apparent throughout the watersheds. Clearly, the effort will move the watersheds closer, sometimes much closer, to removing the public health risks of water-based recreation.

Studies completed during 2008 and 2009 for the Kinnickinnic and Menomonee River watersheds suggest additional actions that will be required to reduce fecal coliform levels to reach regulatory standards. Specifically, those studies suggested that intensive efforts to find incorrect connections

of sanitary sewers to stormwater pipes—or to fix leaky pipes—may be the answer.

IMPLEMENTATION

The report closes with a chapter on implementation. SEWRPC is a planning agency, without implementation powers or responsibilities. SEWRPC works with management agencies, including the Wisconsin Department of Natural Resources, municipalities, counties, sewage treatment plants, and other entities to carry out components of the plan consistent with their mission and authority.

The Southeastern Wisconsin Watersheds Trust, Inc., (or Sweet Water) has been established to pursue



implementation of the Water Quality Plan. Sweet Water is a collaborative effort to achieve healthy and sustainable water resources throughout the Greater Milwaukee Watersheds. The Steering Council includes representatives from the Wisconsin DNR, SEWRPC, MMSD, municipalities, counties, towns, the agriculture, business, and development communities, environmental NGOs, and universities.

**IF THE PLAN IS NOT
IMPLEMENTED, THE BENEFITS
CANNOT BE REALIZED.**

In 2009, Sweet Water was awarded a three-year \$1.9 million grant from the Joyce Foundation to pursue implementation of the SEWRPC plan through the

work of environmental NGOs in the region. In addition, MMSD funded two Watershed Restoration Plans, one for the Menomonee watershed and one for the Kinnickinnic watershed. These planning processes were supervised by Sweet Water, its Science Committee, and Watershed Action Teams organized by Sweet Water for each watershed.

Today, we are working together to implement the SEWRPC plan and to be watchful for opportunities to take actions that achieve its goals more quickly and at lower cost. Together, municipalities, sewage treatment plants, stormwater and drainage management districts, lake districts, businesses, farmers, and local residents will be making important changes on the land and in the water. Together, we are moving toward cleaner water in southeast Wisconsin.

PRIMARY PURPOSES OF SWEET WATER INCLUDE:

To achieve water resource goals and objectives – such as clean water, conservation, and ecological function – through innovative and sustainable practices.

To improve water quality in the Greater Milwaukee Watersheds to support a healthy regional economy and improve quality of life.

To test and then implement innovative approaches and practices that will achieve improvements in water resources in a cost-effective way.

To build partnerships and enhance collaborative decision-making and joint project implementation, engaging government, business, the building industry, agriculture, environmental, and other stakeholder organizations to obtain broad agreement and recommend where to invest funds to get the greatest benefit.

Through collaborative action, to increase the region's success in attracting new funding and leverage existing funding for water quality and water resource improvements.

51 APPENDIX A Components and Costs of Alternatives and Recommended Plan

	-----Modeled Alternatives-----								Recommended Plan		
	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Equivalent Annual Cost (thousands)	Future 2020	B1: Regulatory	B2: Regulatory with Deep Tunnel Operations Change	C1: Water Quality: Traditional	C2: Water Quality: Green	Capital Cost of Recommended Plan	O&M Cost of Recommended Plan	Recommended Plan
Maintain current levels of I/I for MMSD and community sewers	\$0	\$36,493	\$36,493								
Implementation of MMSD Chapter 13: runoff volume	NA	NA	NA	+	+	+	+	+			+
Increase in sewer system discharges consistent with population growth and location with current effluent characteristics	NA	NA	NA	+	+	+	+	+			+
Current level of industrial discharges maintained	NA	NA	NA	+	+	+	+	+			+
Current level of septic system loadings maintained	NA	NA	NA	+	+	+	+	+			+
NR 151 Nonpoint Pollution Controls											
Urban runoff requirements fully implemented (included in baseline total)				+	+	+	+	+			+
Baseline details, urban NR 151 compliance:	\$192,624	\$31,552	\$44,476								
Infiltration systems	\$8,970	\$439	\$1,225	+	+	+	+	+	\$7,910	\$387	+
Stormwater treatment systems	\$86,560	\$26,813	\$32,282	+	+	+	+	+	\$97,087	\$27,862	+
Wet detention basins	\$75,767	\$3,788	\$8,589	+	+	+	+	+	\$67,346	\$3,367	+
Vacuum sweeping of roadways	\$21,327	\$512	\$2,380	+	+	+	+	+	\$24,634	\$591	+
Rural Runoff requirements only partially implemented (conservation tillage)				+							
Total for All Baseline Conditions	NA	NA	NA								
MMSD committed facility expansions and upgrades	\$842,000	\$0	\$53,383	+	+	+	+	+	\$1,026,200	\$600	+
MMSD new facilities and programs (2020 plan as adopted)									\$1,106,900	\$2,600	+
Maintain current levels of I/I for MMSD and community sewers		\$36,493	\$36,493	+	+	+	+	+	\$400,000		+
Other sewage system upgrades outside of MMSD									\$66,814	\$756	+
Rural Runoff requirements fully implemented					+	+	+	+	\$243,284	\$21,813	+
Urban stormwater details: Beyond NR 151 requirements											
Downspout disconnection with rain barrels or rain gardens at 30 percent of homes in Combined Sewer area	\$37,125	\$1,196	\$3,550		+	+	+				

Note: The Recommended Plan is based on revised population and land use estimates, taking the 2020 population and land use estimates from the SEWRPC 2035 Regional Land Use Plan. Cost estimates for the Recommended Plan include more detailed analysis than for the Alternatives. Numbers will not add to the totals because some items have been omitted from this summary.

52 APPENDIX A Components and Costs of Alternatives and Recommended Plan

	-----Modeled Alternatives----->								Recommended Plan		
	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Equivalent Annual Cost (thousands)	Future 2020	B1: Regulatory	B2: Regulatory with Deep Tunnel Operations Change	C1: Water Quality: Traditional	C2: Water Quality: Green	Capital Cost of Recommended Plan	O&M Cost of Recommended Plan	Recommended Plan
Downspout disconnection with rain barrels or rain gardens at 30 percent of homes throughout the study area	\$133,592	\$4,305	\$12,771					+			
Disconnect residential roof drains from sanitary and combined sewer and infiltrate roof runoff	\$22,171	\$350							\$22,171	\$350	+
Extend infiltration requirements in Separate Sewer area to all existing institutional and commercial development; enhance infiltration for all redeveloped institutional and commercial development and all new residential development	\$57,725	\$2,826	\$7,882				+	+			
Double implementation of end-of-pipe water quality solutions (100 percent of parking lots included) from assumption under full urban NR 151 implementation	\$259,679	\$7,095	\$23,554				+	+			
Rooftop storage equaling 14 million gallons on 50 percent of buildings in MMSD downspout disconnection study (Combined Sewer area)	\$24,800	\$0	\$2,173		+	+	+	+			
Enhanced infiltration in the Combined Sewer area for new well-drained industrial, commercial, and institutional development	\$400	\$20	\$55				+				
Storm sewer inlet restrictors in Combined Sewer area provide 15 million gallons of street storage	\$32,500	\$650	\$2,710		+	+	+	+			
Targeted disinfection of stormwater using chlorine and dechlorination prior to release at storm sewer outfalls	\$616,941	\$7,652	\$58,709				+				
Targeted disinfection of stormwater using ultraviolet light prior to release at storm sewer outfalls	\$152,100	\$6,868	\$19,452					+			
Chloride reduction program modeled after Madison and Brookfield programs (apply to 25 percent of roads, 25 percent of water softeners, and 100 percent of new water softeners)--NOTE: cost estimate in recommended plan slightly higher due to refined analysis.	\$394	\$1,183	\$1,216				+	+	\$449	\$1,496	+(a)
Sewer separation for seven parking lots identified in MMSD stormwater disconnection study	\$7,330	\$0	\$465				+	+			
Pet litter management programs	NA	NA	NA				+	+			+
Waterfowl control programs at all Lake Michigan beaches	NA	NA	NA				+	+		\$165	+

APPENDIX A Components and Costs of Alternatives and Recommended Plan 55

	-----Modeled Alternatives-----								Recommended Plan		
	Capital Cost (thousands)	Annual Operation and Maintenance Cost (thousands)	Equivalent Annual Cost (thousands)	Future 2020	B1: Regulatory	B2: Regulatory with Deep Tunnel Operations Change	C1: Water Quality: Traditional	C2: Water Quality: Green	Capital Cost of Recommended Plan	O&M Cost of Recommended Plan	Recommended Plan
Remove abandoned bridges and culverts	NA	NA	NA								+
Ryan Road Interceptor	\$51,386	\$70									
Manage contaminated sediments and increase storage at Jones Island Confined Disposal Facility	\$3,500								\$3,500	\$12	+
Protect fisheries and enhance habitat											+
Implement trophic state monitoring programs for 20 major lakes										\$120	+
Prepare lake management plans for 17 major lakes	\$850								\$850		+
Continue and expand water quality and habitat monitoring at selected sites	\$145	\$592									+
Maintain MMSD and watershed modeling tools		\$30									
Evaluate beaches with bacterial problems and expand beach grooming	NA	NA								\$710	+
Conduct assessment of emerging pollutants and water quality issues	NA	NA									+
Implement programs for collecting unused household hazardous wastes and pharmaceuticals	NA	\$414								\$414	+
Continue ongoing programs not detailed above (e.g., Milwaukee Estuary Remedial Action Plan, navigational dredging, beach grooming, control of exotic species, etc.)	NA	NA									+(c)
Other (no cost estimates provided for remaining items not detailed or aggregated above)											+(d)

(a) Recommended alternative did not specify percentages to be included

(b) Focused litter programs on beach and riparian areas only

(c) A large number of existing programs and activities are recommended for continuation, consideration, or expansion, see Table 82 in the SEWRPC report (d) The recommended plan includes a large number of recommendations related to fisheries, monitoring, research needs, sewer system upgrades, and groundwater not included in the modeled alternatives. Details of these programs can be found in Table 82 and accompanying text of the SEWRPC report.

Note: Equivalent Annual Cost based on annual interest rate of 6 percent and a 50-year amortization period.

Pollutant: TSS (pounds)

Best Performing Alternative: Point, Nonpoint, and Total, by watershed	
B1	
B2	
C1	
C2	
Recommended	
Noteworthy	

In Milwaukee and Root, for point sources, TSS gets worse under all conditions, with B2 performing the best. Menomonee and KK, point sources much better with Bs than Cs. For nonpoint, Bs perform equally or better. Overall, Bs perform better.

WATERSHED	ALTERNATIVE	POINT SOURCES	PERCENT	NONPOINT SOURCES	PERCENT	TOTAL	PERCENT
Milwaukee	2020 Future (base case)	994,420	0.00%	54,870,000	0.00%	55,864,420	0.00%
	B1 Regulatory-Based Approach	1,024,400	3.01%	46,452,000	-15.34%	47,476,400	-15.01%
	B2 Reg-Based with ISS changes	1,007,670	1.33%	46,452,000	-15.34%	47,459,670	-15.04%
	C1 Water-Quality "Traditional" Approach	1,068,280	7.43%	49,700,000	-9.42%	50,768,280	-9.12%
	C2 Water-Quality "Green" Approach	1,068,280	7.43%	50,428,000	-8.10%	51,496,280	-7.82%
	Recommended Alternative	966,090	-2.85%	30,758,000	-43.94%	31,724,090	-43.21%
Menomonee	2020 Future (base case)	193,900	0.00%	14,517,870	0.00%	14,711,770	0.00%
	B1 Regulatory-Based Approach	139,430	-28.09%	14,412,430	-0.73%	14,551,860	-1.09%
	B2 Reg-Based with ISS changes	87,860	-54.69%	14,412,430	-0.73%	14,500,290	-1.44%
	C1 Water-Quality "Traditional" Approach	172,060	-11.26%	14,227,200	-2.00%	14,399,260	-2.12%
	C2 Water-Quality "Green" Approach	172,060	-11.26%	14,150,060	-2.53%	14,322,120	-2.65%
	Recommended Alternative	152,790	-21.20%	13,585,670	-6.42%	13,738,460	-6.62%
Kinnickinnic	2020 Future (base case)	106,010	0.00%	4,092,760	0.00%	4,198,770	0.00%
	B1 Regulatory-Based Approach	36,610	-65.47%	4,092,760	0.00%	4,129,370	-1.65%
	B2 Reg-Based with ISS changes	45,070	-57.49%	4,092,760	0.00%	4,137,830	-1.45%
	C1 Water-Quality "Traditional" Approach	109,110	2.92%	4,092,760	0.00%	4,201,870	0.07%
	C2 Water-Quality "Green" Approach	109,110	2.92%	4,092,760	0.00%	4,201,870	0.07%
	Recommended Alternative	45,330	-57.24%	4,049,850	-1.05%	4,095,180	-2.47%
Oak Creek	2020 Future (base case)	2,430	0.00%	3,625,640	0.00%	3,628,070	0.00%
	B1 Regulatory-Based Approach	2,430	0.00%	3,622,430	-0.09%	3,624,860	-0.09%
	B2 Reg-Based with ISS changes	2,430	0.00%	3,622,430	-0.09%	3,624,860	-0.09%
	C1 Water-Quality "Traditional" Approach	2,430	0.00%	3,624,640	-0.03%	3,627,070	-0.03%
	C2 Water-Quality "Green" Approach	2,430	0.00%	3,622,880	-0.08%	3,625,310	-0.08%
	Recommended Alternative	2,430	0.00%	3,334,050	-8.04%	3,336,480	-8.04%
Root	2020 Future (base case)	15,850	0.00%	62,674,380	0.00%	62,690,230	0.00%
	B1 Regulatory-Based Approach	16,170	2.02%	47,630,400	-24.00%	47,646,570	-24.00%
	B2 Reg-Based with ISS changes	16,110	1.64%	47,630,400	-24.00%	47,646,510	-24.00%
	C1 Water-Quality "Traditional" Approach	17,630	11.23%	57,177,950	-8.77%	57,195,580	-8.76%
	C2 Water-Quality "Green" Approach	17,630	11.23%	47,540,790	-24.15%	47,558,420	-24.14%
	Recommended Alternative	16,020	1.07%	49,018,770	-21.79%	49,034,790	-21.78%
Nearshore Lake Michigan	2020 Future (base case)	7,771,230	0.00%	5,204,780	0.00%	12,976,010	0.00%
	B1 Regulatory-Based Approach	7,766,570	-0.06%	4,546,850	-12.64%	12,313,420	-5.11%
	B2 Reg-Based with ISS changes	7,759,880	-0.15%	4,546,850	-12.64%	12,306,730	-5.16%
	C1 Water-Quality "Traditional" Approach	7,770,070	-0.01%	5,126,420	-1.51%	12,896,490	-0.61%
	C2 Water-Quality "Green" Approach	7,770,070	-0.01%	4,989,480	-4.14%	12,759,550	-1.67%
	Recommended Alternative	7,224,370	-7.04%	5,082,590	-2.35%	12,306,960	-5.16%

Pollutant: Phosphorus (pounds)

WATERSHED	ALTERNATIVE	POINT SOURCES	PERCENT	NONPOINT SOURCES	PERCENT	TOTAL	PERCENT
Milwaukee	2020 Future (base case)	162,970	0.00%	122,300	0.00%	285,270	0.00%
	B1 Regulatory-Based Approach	161,970	-0.61%	109,080	-10.81%	271,050	-4.98%
	B2 Reg-Based with ISS changes	162,190	-0.48%	109,080	-10.81%	271,270	-4.91%
	C1 Water-Quality "Traditional" Approach	162,580	-0.24%	112,600	-7.93%	275,180	-3.54%
	C2 Water-Quality "Green" Approach	162,580	-0.24%	105,300	-13.90%	267,880	-6.10%
	Recommended Alternative	162,310	-0.40%	97,680	-20.13%	259,990	-8.86%
Menomonee	2020 Future (base case)	7,640	0.00%	31,180	0.00%	38,820	0.00%
	B1 Regulatory-Based Approach	6,890	-9.82%	31,080	-0.32%	37,970	-2.19%
	B2 Reg-Based with ISS changes	6,530	-14.53%	31,080	-0.32%	37,610	-3.12%
	C1 Water-Quality "Traditional" Approach	7,600	-0.52%	28,890	-7.34%	36,490	-6.00%
	C2 Water-Quality "Green" Approach	7,600	-0.52%	28,890	-7.34%	36,490	-6.00%
	Recommended Alternative	25,350	231.81%	28,870	-7.41%	35,930	-7.44%
Kinnickinnic	2020 Future (base case)	2,900	0.00%	8,760	0.00%	11,660	0.00%
	B1 Regulatory-Based Approach	1,740	-40.00%	8,760	0.00%	10,500	-9.95%
	B2 Reg-Based with ISS changes	1,960	-32.41%	8,760	0.00%	10,720	-8.06%
	C1 Water-Quality "Traditional" Approach	3,030	4.48%	8,150	-6.96%	11,180	-4.12%
	C2 Water-Quality "Green" Approach	3,030	4.48%	8,150	-6.96%	11,180	-4.12%
	Recommended Alternative	1,860	-35.86%	8,310	-5.14%	10,170	-12.78%
Oak Creek	2020 Future (base case)	20	0.00%	9,720	0.00%	9,740	0.00%
	B1 Regulatory-Based Approach	20	0.00%	9,720	0.00%	9,740	0.00%
	B2 Reg-Based with ISS changes	20	0.00%	9,720	0.00%	9,740	0.00%
	C1 Water-Quality "Traditional" Approach	20	0.00%	9,070	-6.69%	9,090	-6.67%
	C2 Water-Quality "Green" Approach	20	0.00%	9,070	-6.69%	9,090	-6.67%
	Recommended Alternative	20	0.00%	8,580	-11.73%	8,600	-11.70%
Root	2020 Future (base case)	4,350	0.00%	68,680	0.00%	73,030	0.00%
	B1 Regulatory-Based Approach	4,350	0.00%	64,310	-6.36%	68,660	-5.98%
	B2 Reg-Based with ISS changes	4,350	0.00%	64,310	-6.36%	68,660	-5.98%
	C1 Water-Quality "Traditional" Approach	4,380	0.69%	63,870	-7.00%	68,250	-6.55%
	C2 Water-Quality "Green" Approach	4,380	0.69%	60,860	-11.39%	65,240	-10.67%
	Recommended Alternative	4,350	0.00%	59,030	-14.05%	63,380	-13.21%
Nearshore Lake Michigan	2020 Future (base case)	371,840	0.00%	13,380	0.00%	385,220	0.00%
	B1 Regulatory-Based Approach	371,780	-0.02%	12,540	-6.28%	384,320	-0.23%
	B2 Reg-Based with ISS changes	371,710	-0.03%	12,540	-6.28%	384,250	-0.25%
	C1 Water-Quality "Traditional" Approach	371,830	0.00%	12,490	-6.65%	384,320	-0.23%
	C2 Water-Quality "Green" Approach	371,830	0.00%	12,480	-6.73%	384,310	-0.24%
	Recommended Alternative	338,050	-9.09%	12,640	-5.53%	350,690	-8.96%

Best Performing Alternative: Point, Nonpoint, and Total, by watershed	
B1	
B2	
C1	
C2	
Recommended	
Noteworthy	

For point, in the Menomonee and Kinnickinnic, B1 and B2 have a much better performance than C1 and C2. Everywhere else, C1 and C2 perform better, with C2 having the better overall results.

The analysis for the Recommended Plan used the "Revised 2020" population estimates, which were lower than the estimates used to run the model on the other alternatives. The difference, however, is too small to affect the overall conclusions from the modeling. Source, PR 50, Appendices Band M.

Pollutant: Nitrogen (pounds)

Best Performing Alternative: Point, Nonpoint, and Total, by watershed	
B1	
B2	
C1	
C2	
Recommended	
Noteworthy	

Point source on Men, KK, and Root, Bs perform better. On nonpoint Cs perform equal or better, except nearshore, where Bs slightly better. Overall, C2 best, except on KK.

Overall: C2 performs better across pollutants and watersheds. For point sources, B1 and B2 perform better, especially in the Men and KK, but also on the Mke. For Phosphorus, moderate reductions across all alts, but Cs better than Bs, except on KK. For TSS, Bs perform equally or better for all watersheds. Bs substantially better performance on TSS in the Mke and Root. For fecal, C2 performs equally or better (often substantially better) everywhere, except KK. For nitrogen, C2 performs equally or better, substantially better for the Mke and Root, except for the KK, where B1 performs slightly better. Range of improvements are: Phos, 6-10% improvement, except KK, where B1 yields 40% improvement; TSS, highly variable: KK (B1) 65%, Mke (B2) 15%, Men (C2) 2%, Oak 0% on all options, and Root 24% by any option except C1 (9%); Fecal, 12-25% on C2, except for KK (B1) 29%; Nitrogen, 3-16% on C2, except for KK where Bs yield 4%.

WATERSHED	ALTERNATIVE	POINT SOURCES	PERCENT	NONPOINT SOURCES	PERCENT	TOTAL	PERCENT
Milwaukee	2020 Future (base case)	249,310	0.00%	1,870,490	0.00%	2,119,800	0.00%
	B1 Regulatory-Based Approach	243,170	-2.46%	1,798,040	-3.87%	2,041,210	-3.71%
	B2 Reg-Based with ISS changes	241,210	-3.25%	1,798,040	-3.87%	2,039,250	-3.80%
	C1 Water-Quality "Traditional" Approach	245,570	-1.50%	1,836,780	-1.80%	2,082,350	-1.77%
	C2 Water-Quality "Green" Approach	245,570	-1.50%	1,540,600	-17.64%	1,786,170	-15.74%
	Recommended Alternative	245,830	-1.40%	1,359,790	-27.30%	1,605,620	-24.26%
Menomonee	2020 Future (base case)	32,710	0.00%	278,160	0.00%	310,870	0.00%
	B1 Regulatory-Based Approach	30,050	-8.13%	276,630	-0.55%	306,680	-1.35%
	B2 Reg-Based with ISS changes	26,050	-20.36%	276,630	-0.55%	302,680	-2.63%
	C1 Water-Quality "Traditional" Approach	31,640	-3.27%	269,700	-3.04%	301,340	-3.07%
	C2 Water-Quality "Green" Approach	31,640	-3.27%	262,790	-5.53%	294,430	-5.29%
	Recommended Alternative	30,690	-6.18%	261,430	-6.01%	292,120	-6.03%
Kinnickinnic	2020 Future (base case)	10,620	0.00%	56,590	0.00%	67,210	0.00%
	B1 Regulatory-Based Approach	7,950	-25.14%	56,590	0.00%	64,540	-3.97%
	B2 Reg-Based with ISS changes	8,050	-24.20%	56,590	0.00%	64,640	-3.82%
	C1 Water-Quality "Traditional" Approach	10,690	0.66%	54,790	-3.18%	65,480	-2.57%
	C2 Water-Quality "Green" Approach	10,690	0.66%	54,790	-3.18%	65,480	-2.57%
	Recommended Alternative	8,360	-21.28%	56,510	-0.14%	64,870	-3.48%
Oak Creek	2020 Future (base case)	360	0.00%	75,350	0.00%	75,710	0.00%
	B1 Regulatory-Based Approach	360	0.00%	75,340	-0.01%	75,700	-0.01%
	B2 Reg-Based with ISS changes	360	0.00%	75,340	-0.01%	75,700	-0.01%
	C1 Water-Quality "Traditional" Approach	360	0.00%	73,060	-3.04%	73,420	-3.02%
	C2 Water-Quality "Green" Approach	360	0.00%	73,000	-3.12%	73,360	-3.10%
	Recommended Alternative	360	0.00%	70,640	-6.25%	71,000	-6.22%
Root	2020 Future (base case)	35,450	0.00%	906,830	0.00%	942,280	0.00%
	B1 Regulatory-Based Approach	35,470	0.06%	847,560	-6.54%	883,030	-6.29%
	B2 Reg-Based with ISS changes	35,460	0.03%	847,560	-6.54%	883,020	-6.29%
	C1 Water-Quality "Traditional" Approach	35,520	0.20%	883,370	-2.59%	918,890	-2.48%
	C2 Water-Quality "Green" Approach	35,520	0.20%	770,300	-15.06%	805,820	-14.48%
	Recommended Alternative	35,460	0.03%	740,940	-18.29%	776,400	-17.60%
Nearshore Lake Michigan	2020 Future (base case)	9,648,240	0.00%	109,370	0.00%	9,757,610	0.00%
	B1 Regulatory-Based Approach	9,647,910	0.00%	102,060	-6.68%	9,749,970	-0.08%
	B2 Reg-Based with ISS changes	9,647,440	-0.01%	102,060	-6.68%	9,749,500	-0.08%
	C1 Water-Quality "Traditional" Approach	9,648,150	0.00%	106,470	-2.65%	9,754,620	-0.03%
	C2 Water-Quality "Green" Approach	9,648,150	0.00%	103,720	-5.17%	9,751,870	-0.06%
	Recommended Alternative	8,781,460	-8.98%	107,330	-1.87%	8,888,790	-8.90%

Pollutant: Fecal (trillions of cells)

WATERSHED	ALTERNATIVE	POINT SOURCES	PERCENT	NONPOINT SOURCES	PERCENT	TOTAL	PERCENT
Milwaukee	2020 Future (base case)	2,007	0.00%	26,165	0.00%	28,172	0.00%
	B1 Regulatory-Based Approach	1,284	-36.04%	26,165	0.00%	27,449	-2.57%
	B2 Reg-Based with ISS changes	1,244	-38.01%	26,165	0.00%	27,409	-2.71%
	C1 Water-Quality "Traditional" Approach	1,220	-39.24%	21,599	-17.45%	22,818	-19.00%
	C2 Water-Quality "Green" Approach	1,220	-39.24%	19,678	-24.79%	20,888	-25.86%
	Recommended Alternative	1,562	-22.17%	17,883	-31.65%	19,445	-30.98%
Menomonee	2020 Future (base case)	1,816	0.00%	12,733	0.00%	14,549	0.00%
	B1 Regulatory-Based Approach	1,017	-44.00%	12,726	-0.06%	13,743	-5.54%
	B2 Reg-Based with ISS changes	792	-56.37%	12,726	-0.06%	13,518	-7.09%
	C1 Water-Quality "Traditional" Approach	1,937	6.64%	10,901	-14.39%	12,838	-11.76%
	C2 Water-Quality "Green" Approach	1,937	6.64%	10,900	-14.39%	12,837	-11.77%
	Recommended Alternative	1,216	-33.05%	8,758	-31.22%	9,973	-31.45%
Kinnickinnic	2020 Future (base case)	1,613	0.00%	2,832	0.00%	4,445	0.00%
	B1 Regulatory-Based Approach	339	-79.01%	2,832	0.00%	3,170	-28.67%
	B2 Reg-Based with ISS changes	575	-64.37%	2,832	0.00%	3,406	-23.36%
	C1 Water-Quality "Traditional" Approach	1,791	11.03%	2,447	-13.59%	4,237	-4.66%
	C2 Water-Quality "Green" Approach	1,791	11.03%	2,447	-13.59%	4,237	-4.66%
	Recommended Alternative	473	-70.67%	1,851	-34.63%	2,324	-47.71%
Oak Creek	2020 Future (base case)	10	0.00%	2,560	0.00%	2,570	0.00%
	B1 Regulatory-Based Approach	10	0.00%	2,560	-0.01%	2,570	-0.01%
	B2 Reg-Based with ISS changes	10	0.00%	2,560	-0.01%	2,570	-0.01%
	C1 Water-Quality "Traditional" Approach	10	0.00%	2,560	-0.01%	2,570	-0.01%
	C2 Water-Quality "Green" Approach	10	0.00%	2,266	-11.51%	2,275	-11.47%
	Recommended Alternative	10	0.00%	1,491	-41.78%	1,500	-41.62%
Root	2020 Future (base case)	36	0.00%	10,099	0.00%	10,135	0.00%
	B1 Regulatory-Based Approach	42	16.93%	10,099	0.00%	10,141	0.06%
	B2 Reg-Based with ISS changes	41	13.48%	10,099	0.00%	10,140	0.05%
	C1 Water-Quality "Traditional" Approach	70	94.01%	8,863	-12.24%	8,993	-11.86%
	C2 Water-Quality "Green" Approach	70	94.01%	8,829	-12.57%	8,899	-12.19%
	Recommended Alternative	39	8.59%	7,102	-29.68%	7,141	-29.54%
Nearshore Lake Michigan	2020 Future (base case)	2,457	0.00%	3,444	0.00%	5,901	0.00%
	B1 Regulatory-Based Approach	2,418	-1.59%	3,255	-5.48%	5,673	-3.86%
	B2 Reg-Based with ISS changes	2,366	-3.72%	3,255	-5.48%	5,621	-4.75%
	C1 Water-Quality "Traditional" Approach	2,447	-0.41%	3,096	-10.10%	5,543	-6.06%
	C2 Water-Quality "Green" Approach	2,447	-0.41%	3,095	-10.11%	5,543	-6.07%
	Recommended Alternative	2,260	-8.02%	2,290	-33.49%	4,550	-22.89%

Best Performing Alternative:
Point, Nonpoint, and Total, by watershed

B1	
B2	
C1	
C2	
Recommended	
Noteworthy	

In Root, for point sources, fecal gets worse under all conditions, with B2 performing the best. Menomonee and KK, point sources much better with Bs than Cs; Cs perform much worse here. For nonpoint, Cs perform much better; Bs produce no change. Overall, Cs perform better, except on the KK.

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