MUSKEGON LAKE WATERSHED

WATERSHED MANAGEMENT PLAN

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EXECUTIVE SUMMARY

The Muskegon Lake Watershed Management Plan (WMP) was developed as part of the National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Program by the Muskegon Area Storm Water Committee (MASWC). This document provides a description of watershed characteristics, identifies watershed pollutants, and makes recommendations for the treatment, prevention, and reduction of pollution in the Muskegon Lake Watershed (Watershed).

DESCRIPTION OF WATERSHED

Muskegon Lake is a 4,150-acre inland coastal lake located on the west shoreline of Michigan's Lower Peninsula. The Watershed is part of the larger Muskegon River Watershed and drains approximately 130 square miles. The drainage area covers parts of two counties and fourteen municipalities. Forests (38%), development (17%), agriculture (13%), wetlands (12%), grasslands and shrublands (10%), and open water/barren land (10%) cover the landscape. The Muskegon River feeds into Muskegon Lake, which ultimately empties into Lake Michigan through a navigation channel. Other waterways that discharge directly into Muskegon Lake include Ruddiman Creek, Ryerson Creek, Green Creek, and the Bear Lake Channel. Muskegon Lake and the adjacent wetland habitats comprise one of the four major freshwater estuary wetland complexes along the east shoreline of Lake Michigan. Residents rely on these resources for recreation, tourism, and industrial use.

REPORTED CONDITION AND DESIGNATED USES OF THE MUSKEGON LAKE WATERSHED

Muskegon Lake is less degraded than nearby Mona Lake or White Lake, most likely due to its large size, large inputs of high-quality water from the Muskegon River, short hydraulic retention time, and rare periods of anoxia (total lack of dissolved oxygen). Water quality of Muskegon Lake markedly improved between 1954 and 1972, although localized areas were degraded due to storm water and urban runoff discharges. Further improvement occurred in 1975 when a substantial amount of wastewater was diverted to the Muskegon County Wastewater Treatment Facility.

Current water quality conditions impair several of the Watershed's designated uses due to nonpoint source (NPS) pollution and past point source pollution. Pollutants and impairments of concern include sediment, heavy metals, toxic substances, hydrocarbons, nutrients, pathogens, thermal pollution, and unstable hydrology. Poor water quality has resulted in the following impaired and threatened designated uses of the Watershed: coldwater fishery, warmwater fishery, other indigenous aquatic life and wildlife, and partial and total body recreation. Biological surveys and other watershed studies have found a number of Muskegon Lake's tributaries have poor macroinvertebrate and fish communities. In addition, Muskegon Lake and several subwatersheds do not meet water quality standards.

GOALS AND OBJECTIVES

The overall goal established for the Watershed is to restore and improve its impaired and threatened designated uses. Six long-term goals were established to achieve this overall watershed goal:

1. Prevent soil erosion and reduce sedimentation in Muskegon Lake and its tributaries.

2. Reduce concentrations of heavy metals, toxic substances, and hydrocarbons in the Muskegon Lake Watershed, focusing initial efforts on Ryerson Creek, Ruddiman Creek, and the Division Street outfall area.

3. Reduce nutrient loading of Muskegon Lake and its tributaries, giving particular attention to sources of phosphorus.

4. Prevent pathogens from entering surface waters of the Watershed and strive to meet applicable water quality standards in Ruddiman Creek.

5. Reduce sources of thermal pollution impacting Muskegon River, Bear Creek, and Little Bear Creek.

6. Stabilize stream flows to moderate hydrology and increase base flow; this is especially important in the urban wetland areas of Ruddiman Creek, Ryerson Creek, and Four Mile Creek, which are impacted by unstable hydrology from storm water flows.

Short-term objectives were also created by examining the long-term goals and determining how they would be best met. All goals and objectives are intended to address the current Watershed conditions and improve water quality over time.

IMPLEMENTATION STRATEGY

The MASWC discussed, reviewed, and recommended potential Best Management Practices (BMPs) for the Watershed. BMPs were chosen after considering sources and causes of Watershed pollution and their impacts on designated uses. BMPs include structural, vegetative, and managerial practices. Information and Education (I&E) activities were also recommended to inform the public about Watershed concerns and motivate people to action. Implementation of these practices will make progress toward meeting long-term goals and short-term objectives.

Evaluation methods were selected for each proposed action to determine its success at preventing, reducing, and treating water pollution. I&E efforts will be evaluated on their effectiveness at informing and educating the public, as well as inspiring individuals to take action. Qualitative and quantitative evaluation methods were recommended, as well as methods to measure Watershed activities and water quality results. Measurement of Watershed activities evaluate the effort shown by the permittee to implement storm water controls, while measurements of water quality results show how implemented activities have affected the Watershed.

In addition to selecting evaluation methods, the MASWC also determined the cost/benefit of each BMP. Proposed actions were flagged as having "minimal" (< $500), "moderate" ($500 to $5,000), or "high" costs (>$5,000) to help permittees determine what can feasibly be implemented. Recommendations were also identified as having a "minimal," "moderate," or "high" benefit in terms of either social awareness or water quality improvements. Actions identified as most beneficial are those considered the most effective at preventing, treating, or reducing water pollution.

SUSTAINABILITY

Muskegon Area Storm Water Committee

In 2004, the MASWC began coordination with the Muskegon Lake Public Advisory Committee (PAC) and the Muskegon River Watershed Assembly (MRWA) to develop the Muskegon Lake WMP. This WMP will provide the MASWC with the necessary information to implement recommendations to meet short-term objectives and long-term goals, in accordance with the NPDES Phase II Storm Water Program.

Muskegon Lake PAC

The Muskegon Lake PAC is "a coalition of community interests dedicated to working cooperatively for the improvement of the Muskegon Lake ecosystem through the Remedial Action Plan (RAP) process." The Muskegon Lake PAC was formed in October 1993 to address the concerns of Muskegon Lake, designated as an Area of Concern (AOC) in 1985. The Muskegon Lake PAC has continued to involve the public in the implementation of the Muskegon Lake RAP and works toward delisting Muskegon Lake as an AOC.

Muskegon River Watershed Assembly

The Muskegon River Watershed Assembly works to “preserve, protect, and enhance the natural, historic, and cultural resources of the Muskegon River Watershed.” The MRWA has been involved in numerous projects including the Bear Creek Transition/Implementation Project, the Muskegon Lake and Estuary Emergent Vegetation Restoration Demonstration Project, and the Muskegon River Watershed Project. Recently, the MRWA received notice that their volunteer stream monitoring grant proposal was approved for funding. This project will train volunteers and provide the necessary equipment to conduct water monitoring in the Watershed.

INTRODUCTION

In 1740, the Ottawa Tribe established a village on the mouth of the Muskegon River, which they called "Maskigon," meaning river with marshes. Native Americans began settling along the river 2,500 years ago and engaged in hunting, fishing, and fur trading. Since that time, the lumbering era of the 1800's and the industrial era of the 1900's have vastly changed the landscape. Today, the water quality of Muskegon Lake has greatly suffered from these past activities. Only proper management of land activities and remediation efforts will help restore and protect this valued resource.

This document provides a description of watershed characteristics, identifies watershed pollutants, and makes recommendations for the treatment, prevention, and reduction of pollution in the Muskegon Lake Watershed (Watershed). The Muskegon Lake Watershed Management Plan (WMP) was developed as part of the National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Program by several communities within Muskegon County.

THE NPDES PHASE II STORM WATER PROGRAM

In 1987, Congress amended the Clean Water Act to protect water bodies from the impacts of urban runoff. The 1987 amendments required the U.S. Environmental Protection Agency to address storm water runoff in two phases. The Phase I NPDES Storm Water Program began in 1990 and applied to medium and large municipal separate storm sewer systems (MS4s) located in incorporated places or counties with populations of 100,000 or more. Five cities in Michigan were required to comply with Phase I including Ann Arbor, Flint, Grand Rapids, Lansing, and Warren. The Michigan Department of Transportation was also required to comply. Phase I also required permit coverage for discharges from 11 industrial categories of activities, including construction sites disturbing 5 acres of land or more. The Phase II NPDES Storm Water Program required permit coverage by March 2003 and applied to MS4s located in areas with populations between 50,000 and 100,000 and with surrounding areas of greater than 1,000 people per square mile. Construction sites required permits if disturbing land equal to or greater than one, but less than 5 acres. Under Phase II, operators of regulated small MS4s are required to design their programs to reduce the discharge of pollutants in storm water to the "maximum extent practicable."

DEVELOPMENT OF THE MUSKEGON LAKE WATERSHED MANAGEMENT PLAN

The Muskegon Lake WMP was written in compliance with the requirements of the NPDES Phase II Storm Water Program. The main purpose of this document is to identify implementation actions needed to protect and restore designated uses and resolve water quality and quantity concerns. Development of the Muskegon Lake WMP was completed by several Phase II Storm Water Permittees (Permittees) within the Watershed, in accordance with the Public Participation Process (PPP) submitted to Michigan Department of Environmental Quality (MDEQ) in April 2004. These Permittees joined those of the Mona Lake Watershed and the Lower Grand River Watershed to form the Muskegon Area Storm Water Committee (MASWC) in order to begin controlling direct discharges into the surface waters of the State of Michigan. Permittees located in the Watershed include the City of Muskegon, City of Muskegon Heights, Egelston Township, Dalton Township, Laketon Township, Muskegon Charter Township, and the City of Roosevelt Park. Muskegon County Administration, Muskegon County Drain Commissioner, and Muskegon County Road Commission are also permittees.

PUBLIC PARTICIPATION

A PPP was developed to solicit public participation in the development of the Muskegon Lake WMP. The PPP required the formation of a Watershed Committee (Committee) during the first six months of implementation. This Committee was formed to assess and characterize the Watershed's resources, identify problems and opportunities, and recommend actions and management options to the MASWC. Participants in this Committee, referred to as the Nonpoint Source (NPS) Committee, included representatives from MASWC, Muskegon Lake Public Advisory Council (PAC), Muskegon River Watershed Assembly, Muskegon County Health Department, local decision makers, and Watershed residents. The PPP specified several methods for engaging the public in the development of the WMP, as well as a timeline for implementation. Communication methods included meetings, public meetings, newsletters and print media, and an email distribution list.

Meetings

Representatives from the MASWC attended meetings of the Muskegon Lake PAC from 2004 through 2005, to offer opportunities for public input and provide information on the progress of Muskegon Lake WMP. The Muskegon Lake PAC is a coalition of community interest groups dedicated to working cooperatively for the improvement of the Muskegon Lake ecosystem through the remedial action plan process. The MASWC and the Muskegon Lake PAC jointly formed the NPS Committee in May 2005 to focus on the development of the Muskegon Lake WMP and allow for additional public input. The NPS Committee met on August 22 and September 15, 2005, and included twelve participants representing the

MASWC, Muskegon Lake PAC, Muskegon River Watershed Assembly, Muskegon County Health Department, local decision makers, and Watershed residents.

Public Meetings

The MASWC held two public meetings, on May 3 and October 18, 2005, to provide opportunities for public comment on the Muskegon Lake WMP; seventeen Watershed stakeholder groups (Table 1) from the Watershed attended these meetings. Public meetings provided an opportunity for Watershed residents, local decision-makers, and Watershed coordinators to share their concerns, offer solutions, and provide feedback regarding the management of the Watershed.

Table 1 - Participating Watershed Stakeholder Groups

1. Annis Water Resources Institute of Grand Valley State University
2. Cedar Creek Township
3. City of Muskegon
4. City of Norton Shores
5. Laketon Township
6. Michigan Department of Environmental Quality
7. Muskegon Area Storm Water Committee
8. Muskegon Charter Township
9. Muskegon County Administration
10. Muskegon County Health Department
11. Muskegon County Road Commission
12. Muskegon County Wastewater Plant
13. Muskegon Lake Public Advisory Council
14. Muskegon River Watershed Assembly
15. Paper, Allied-Industrial, Chemical and Energy Workers Union (PACE) Local 6-1015
16. Timberland Resource, Conservation & Development Area Council
17. Watershed Residents

Newsletter and Print Media

To encourage attendance, the MASWC members posted public notices at their township and city halls announcing the public meeting on October 18, 2005. Residents were encouraged to attend in order to offer their comments on the final draft of the Muskegon Lake WMP.

E-mail Distribution List

An e-mail distribution list was created to convey information about planning activities and public input opportunities. Watershed stakeholder groups included on the distribution list are noted in Table 2.

Table 2 - E-mail Distribution List

Annis Water Resources Institute	Muskegon County Drain Commissioner
Bridgeton Township	Muskegon County Environmental Coordinating Council
Cedar Creek Township	Muskegon County Health Department
City of Muskegon	Muskegon County Health Project
City of Roosevelt Park	Muskegon County Road Commission
Consumers Energy	Muskegon County Waste Management System
Dalton Township	Muskegon Lake Public Advisory Council
Fishbeck, Thompson, Carr & Huber, Inc.	Muskegon Public Schools
Fruitland Township	Muskegon River Watershed Assembly
Great Lakes Marina	National Oceanic and Atmospheric Administration (NOAA) Great Lakes Environmental Research Laboratory
Lake Michigan Federation	Natural Resources Conservation Service
Laketon Township	Office of Senator Stabenow
Michigan Anglers	PACE Local 6-1015
Michigan Department of Environmental Quality	Parmenter O'Toole
Michigan House of Representatives	Ruddiman Creek Task Force
Michigan Senate	Save Our Shoreline
Mona Lake Watershed Council	Timberland Resource, Conservation & Development Area Council
Moorland Township	United Way
Muskegon Area Storm Water Committee	Volunteer Muskegon
Muskegon Charter Township	Watershed Residents
Muskegon Chemical Council	West Michigan Shoreline Regional Development Commission
Muskegon Conservation Club	West Michigan United Labor Volunteers
Muskegon Conservation District	Westshore Consulting
Muskegon County Cooperating Churches	YMCA

CHAPTER 1 - DESCRIPTION OF WATERSHED

1.0 STUDY AREA

Muskegon Lake is a 4,150-acre inland coastal lake located on the west shoreline of Michigan's Lower Peninsula. Muskegon Lake is fed by the Muskegon River, which ultimately empties into Lake Michigan through a navigation channel. For the purpose of this Watershed Management Plan (WMP), the watershed boundary for Muskegon Lake was defined as the vicinity drained by the urbanized area within Muskegon County, excluding the Mona Lake Watershed and the Lower Grand River Watershed (Figure 1).

The Muskegon Lake Watershed (Watershed) drains approximately 130 square miles and covers all or parts of two counties, nine townships, and five cities (Table 3). Included in the system are several creeks, rivers, drains, and lakes. Waterways that discharge directly into Muskegon Lake include Ruddiman Creek, Ryerson Creek, Muskegon River, Green Creek, and the Bear Lake channel. Forests (38%), development (17%), agriculture (13%), wetlands (12%), grasslands/shrublands (10%), and open water/barren land (10%) cover the landscape.

Table 3 - Communities Located in the Muskegon Lake Watershed

Community	County	Percentage of Community within Watershed
Blue Lake Township	Muskegon	< 1%
Cedar Creek Township	Muskegon	13%
City of Muskegon	Muskegon	87%
Dalton Township	Muskegon	71%
Egelston Township	Muskegon	57%
Fruitland Township	Muskegon	9%
Moorland Township	Muskegon	25%
Muskegon Charter Township	Muskegon	77%
Muskegon Heights	Muskegon	18%
Norton Shores	Muskegon	6%
Roosevelt Park	Muskegon	66%
North Muskegon	Muskegon	100%
Ashland Township	Newaygo	2%
Bridgeton Township	Newaygo	28%

1.1 GEOLOGY AND TOPOGRAPHY

Glacial processes shaped Muskegon County during the last glacial period, called the Wisconsin Era. As the glaciers retreated between eight and ten thousand years ago, they left a glacial deposit, 150 to 400 feet in thickness, on the surface of Muskegon County (USDA, 1968). As a result of the glacier activity, the majority of the Watershed's quaternary geology is made up of Lacustrine sand and gravel (70%) (Figure 2). Lacustrine sand is moderately well-sorted, silty, and generally consists of quartz grains. It is usually a near-shore deposit or near a sand source. Lacustrine gravel is silty and commonly consists of angular to sub-rounded pebbles and cobbles. The rest of the Watershed is covered in dune sand (11%), end moraines (8%), and glacial outwash (5%). Surface water covers the remaining 6% of land.

A belt of dune sand can be found along Lake Michigan's shoreline. These dunes are postglacial in origin but are now generally stationary (USDA, 1968). Several miles inland, smaller dunes are scattered throughout the poorly drained areas of the lake plain. Located in a narrow linear belt above Muskegon Lake are end moraines of fine-textured till, which consist of non-sorted glacial debris. Glacial outwash sand and gravel and postglacial alluvium occur in the extreme north and east ends of the Watershed and are typically fine to coarse sand, alternating with layers of small gravel to heavy cobbles.

Generally, elevations within the Watershed vary from 577 to 600 feet, near the Muskegon River corridor and area surrounding Muskegon Lake, to a height of 751 to 800 feet near the far eastern portion of the Watershed (Figure 3). Most of the Watershed is fairly level to rolling and hilly (USDA, 1968) with slopes between 0% and 6% (Figure 4). The Muskegon River corridor has topographic slopes that are nearly level and depressional (USDA, 1968).

1.2 SOILS

The *Soil Survey of Muskegon County, Michigan* (1968) indicates that approximately two-thirds of the Watershed contains sandy soils (Figure 5). The second predominant soil type is poorly-drained peat and muck, which comprise approximately 14% of the Watershed area. A large band of this hydric soil extends northeast of Muskegon Lake to the eastern edge of the Watershed within the floodplain of the Muskegon River. This area contains soil primarily composed of decaying plant material, extending in some areas to a depth of more than 42 inches.

The soils south of the band of wetland soil generally consist of well-drained sand on rolling hills and nearly level plains, extending inland from Lake Michigan. Sand extends to a depth of 4 feet or more, and has a low-moisture-holding capacity and low natural fertility. Soil blowing is likely in cultivated areas and may be severe. This area is not well suited for farming, but is valued for recreational uses and its suitability for building construction.

The area north of Muskegon Lake and the Muskegon River floodplain contains areas of both well-drained and poorly-drained sandy soil. Small wetland areas are prevalent throughout this area, especially in depressions and along the creeks and drains that bisect this area. According to the *Soil Survey of Muskegon County, Michigan*, some farming occurs in this area and is mostly limited to blueberry cultivation.

Less than 4% of the Watershed contains prime farmland (Figure 6). Most of the prime farmland is located within the Muskegon River floodplain at the eastern end of the Watershed. To be productive, this soil must be drained and protected from flooding by dikes. If these fields dry out, they are also susceptible to soil blowing. Onions and celery are commonly grown in this area.

1.2.1 HYDROLOGIC SOIL GROUPS

Figure 7 indicates the hydrologic soil groups mapped within the Watershed. These groups indicate the soils' runoff potential and drainage characteristics. The grouping is based on the inherent capacity of the soil, without vegetation, to permit infiltration. Group A soils have rapid infiltration and low runoff potential, and Group D soils have very slow drainage and high runoff potential. When soils are classified with two groups (i.e., A/D), the first letter represents the artificially-drained condition, and the second letter represents the soil's natural drainage condition. If a Group D soil is artificially drained with a resulting hydrologic characteristic of a Group A soil, the soil would be classified as a Group A/D soil.

Group A Soils: High Infiltration rate, low runoff potential. Well drained to excessively drained sands or gravelly sands. High rate of water transmission.

Group B Soils: Moderate infiltration rates. Moderately well to well drained. Moderately-fine to medium-coarse texture. Moderate rate of water transmission.

Group C Soils: Slow infiltration rate. Has layer that impedes downward movement of water moderately-fine to fine texture. Slow rate of water transmission.

Group D Soils: Very slow infiltration rate, high runoff potential. Clays with high shrink/swell potential. Permanent high water table. Clay pan or clay layer at or near surface. Shallow over nearly-impervious material. Very slow rate of water transmission.

1.3 HYDROLOGY

The Watershed is part of the larger Muskegon River Watershed, which covers 2,725 square miles and has forty subbasins. The Muskegon River, approximately 219 miles in length, flows from Higgins and Houghton Lakes to its mouth at Muskegon Lake. The Muskegon River is fed by an estimated 94 tributaries including the West Branch of the Muskegon River, Butterfield Creek, Clam River, Middle Branch River, Hersey River, Little Muskegon River, Bigelow Creek, Brooks Creek, Maple River, and Cedar Creek (Annis Water Resources Institute of Grand Valley State University [AWRI-GVSU], 2002).

Muskegon Lake is a drowned river mouth that supports a warm water fishery (EPA, 2002) and covers approximately 4,150 acres. Waterways that discharge directly into Muskegon Lake include the Muskegon River, Ruddiman Creek, Ryerson Creek, Green Creek, and the Bear Lake Channel. Other waterways within the Watershed include Little Bear Creek, Bear Creek, Four Mile Creek, Spring Creek, Mosquito Creek, and the Maple River. These waterways are runoff driven with moderate to low base flow, moderate to high peak flows, have the potential to be flashy during heavy precipitation, and are eutrophic (AWRI-GVSU, 2002). The main trunk of the Muskegon River, however, is groundwater fed with high to moderate base flow, low to moderate peak flows, and is mesotrophic with moderate amounts of nutrients (AWRI-GVSU, 2002). The Muskegon River, Little Bear Creek, and Muskegon River tributaries (from Section 18 of the City of North Muskegon, east to Section 18 of Croton Township) are designated trout streams (coldwater streams) (MDNR, 2002).

Several drains are present in the Watershed including the Fred Dow Drain, which flows into Green Creek, and the Erickson, Staples, Ribe, Furnman, and Brandstorm Drains, which flow into Bear Creek. In addition, five registered dams, located within Muskegon County, control the flow of several tributaries and drains that ultimately discharge into Muskegon Lake (AWRI-GVSU, 2002). Other major lakes in the Watershed are the Wolf, Maple, Bear, North, West, and Twin Lakes.

Municipal separate storm sewer systems (MS4s) that convey and control storm water within the Watershed are now regulated under the National Pollutant Discharge Elimination System (NPDES) Phase II storm water program. MS4s collect storm water runoff from impervious surfaces (i.e., roads and roof tops) through a network of waterways and constructed storm drains, which then discharge to surface waters within the Watershed. Heavy rainstorms can convey large volumes of storm water directly to surface waters, along with various storm water pollutants such as sediment, oil, and grease. Operators of these regulated MS4s are required to develop storm water pollution prevention initiatives through the Phase II program, which will include measures to reduce the amount of storm water pollutants conveyed to local waterways by the MS4s.

1.4 POPULATION

According to the 2000 U.S. Census, the Watershed has its highest population density in the region surrounding Muskegon Lake (Figure 8). Roosevelt Park and Muskegon Heights are the most dense (2,501 to 3,850 people per square mile), followed by the City of Muskegon (1,001 to 2,500 people per square mile). North Muskegon, Norton Shores, and Muskegon Charter Township have between 501 to 1,000 people per square mile, while the rest of the Watershed has between 44 to 500 people per square mile.

Although the Cities of Muskegon and Muskegon Heights are densely populated, a decline in total population was recorded by the U.S. Census Bureau (Figure 9). The Cities of Muskegon and Muskegon Heights experienced a -0.4 and -8.6 change, respectively, in total population between 1990 and 2000. However, the rest of the Watershed's population increased between 1% and 33%, with the exception of Blue Lake Township, which experienced a 61% increase in population. Norton Shores, Roosevelt Park, North Muskegon, Mooreland Township, and Cedar Creek Township increased their populations from 1% to 9%, while Dalton, Egelston, and Bridgeton Townships experienced a larger increase of 24% to 33%.

Overall, the average rate of 7.1% population growth between 1990 and 2000 for Muskegon County exceeded Michigan's average rate of population growth, 6.9% (U.S. Census Bureau).

1.5 LAND USE

Prior to widespread European settlement in the 1800's, over half (51%) of the Watershed was covered by White Pine - White Oak forests (Figure 10). Mixed conifer swamps (10%), Hemlock - White Pine forests (9%), and mixed hardwood swamps (8%) were the other major types of vegetation. Since European settlement, the Watershed's landscape has changed significantly. By 1890, the Watershed's dense White Pine forest was almost completely harvested and in the 1900's major factories, including the Central Paper Company, began locating to the Muskegon Lake shoreline (Alexander, 1999).

Present land use/cover is predominately forests (38%), according to the 1992 National Land Cover Dataset (Figure 11). However, development encompasses 17% of the Watershed with high-intensity development (7%) concentrated south of Muskegon Lake and low intensity development (10%) mainly surrounding lakes, waterways, and major roadways. Agriculture covers 13% of the Watershed and is concentrated in an area north of the Muskegon County Wastewater Treatment Facility. This 5,200-acre area of crop-producing farmland is an integral part of the Muskegon County Wastewater Management System. Wetlands (12%) are found primarily along the Muskegon River corridor, and grasslands and shrublands (10%) can be found where forests are located. Open water and barren land make up the remaining 10% of the Watershed.

1.6 NATURAL FEATURES

The City of Muskegon has five main groups of natural features: lakes/lakeshore, dunes, wetlands, rivers/streams, and woodlands, according to the *City of Muskegon Master Land Use Plan* (1997). These natural features are present throughout the Watershed and support a variety of species.

The *City of Muskegon Master Land Use Plan* indicates that Muskegon Lake supports primarily perch, walleye, large- and small-mouth bass, sunfish, northern pike, crappie, bullhead, sucker, steelhead, brown trout, Chinook, and Coho salmon. Wildlife in the undeveloped areas of shorelines consists of Whitetail deer, muskrats, Green/Blue Heron, raccoons, and various waterfowl. Several of the animal and plant species within the Watershed have been listed as endangered, threatened, or species of concern. The Michigan Natural Features Inventory has compiled a database of Muskegon County's native plants, animals, aquatic animals, and natural ecosystems. Information has been gathered from field surveys, museum and herbaria records, published works, and communication with scientists.

Tables 4 and 5 provide a listing of all known occurrences of species that are threatened, endangered, and of special concern, as well as high-quality natural communities occurring within Muskegon County. This list is based on known and verified sightings and represents the most complete data set available as of January 4, 2005. This list is not considered to be a comprehensive listing of every potential species found in the county. Additional species that are considered threatened, endangered, or of special concern may be present in the county and may not appear on this list.

Table 4 - Threatened, Endangered, and Species of Special Concern in Muskegon County

Common Name	Scientific Name	State Status
1. Atlantic Blue-eyed-grass	Sisyrinchium atlanticum	Threatened
2. Bald Eagle	Haliaeetus leucocephalus	Threatened
3. Bald-rush	Psilocarya scirpoides	Threatened
4. Bastard Pennyroyal	Trichostema dichotomum	Threatened

Table 4 - Threatened, Endangered, and Species of Special Concern in Muskegon County

Common Name	Scientific Name	State Status
5. Black Rat Snake	Elaphe obsoleta obsoleta	Special Concern
6. Black-fruited Spike-rush	Eleocharis melanocarpa	Special Concern
7. Blanding's Turtle	Emydoidea blandingii	Special Concern
8. Broad-leaved Puccoon	Lithospermum latifolium	Special Concern
9. Cerulean Warbler	Dendroica cerulea	Special Concern
10. Cross-leaved Milkwort	Polygala cruciata	Special Concern
11. Dune Cutworm	Euxoa aurulenta	Special Concern
12. Dusted Skipper	Atrytonopsis hianna	Threatened
13. Dwarf-bulrush	Hemicarpha micrantha	Special Concern
14. Eastern Box Turtle	Terrapene carolina carolina	Special Concern
15. Eastern Massasauga	Sistrurus catenatus catenatus	Special Concern
16. Ellipse	Venustaconcha ellipsiformis	Special Concern
17. Few-flowered Nut-rush	Scleria pauciflora	Endangered
18. Frosted Elfin	Incisalia irus	Threatened
19. Furrowed Flax	Linum sulcatum	Special Concern
20. Ginseng	Panax quinquefolius	Threatened
21. Great Blue Heron Rookery	Great Blue Heron Rookery	Not Available
22. Great Plains Spittlebug	Lepyronia gibbosa	Threatened
23. Hall's Bulrush	Scirpus hallii	Threatened
24. Henslow's Sparrow	Ammodramus henslowii	Threatened
25. Hill's Thistle	Cirsium hillii	Special Concern
26. Hooded Warbler	Wilsonia citrina	Special Concern
27. Karner Blue	Lycaeides melissa samuelis	Threatened
28. Kirtland's Snake	Clonophis kirtlandii	Endangered
29. Lake Cress	Armoracia lacustris	Threatened
30. Lake Floater	Anodonta subgibbosa	Threatened
31. Louisiana Waterthrush	Seiurus motacilla	Special Concern
32. Marsh Wren	Cistothorus palustris	Special Concern
33. Meadow-beauty	Rhexia virginica	Special Concern
34. Mikania	Mikania scandens	Not Available
35. Missouri Rock-cress	Arabis missouriensis var. deamii	Special Concern
36. Northern Goshawk	Accipiter gentilis	Special Concern
37. Northern Prostrate Clubmoss	Lycopodium appressum	Special Concern
38. Northern Prostrate Clubmoss	Lycopodiella margueriteae	Threatened
39. Osprey	Pandion haliaetus	Threatened
40. Persius Duskywing	Erynnis persius persius	Threatened
41. Pine Katydid	Scudderia fasciata	Special Concern
42. Pinetree Cricket	Oecanthus pini	Special Concern
43. Piping Plover	Charadrius melodus	Endangered

Table 4 - Threatened, Endangered, and Species of Special Concern in Muskegon County

Common Name	Scientific Name	State Status
44. Pitcher's Thistle	Cirsium pitcheri	Threatened
45. Prairie Warbler	Dendroica discolor	Endangered
46. Prairie-smoke	Geum triflorum	Threatened
47. Prothonotary Warbler	Protonotaria citrea	Special Concern
48. Purple Spike-rush	Eleocharis atropurpurea	Endangered
49. Rainbow	Villosa iris	Special Concern
50. Sand Grass	Triplasis purpurea	Special Concern
51. Scirpus-like Rush	Juncus scirpoides	Threatened
52. Slippershell Mussel	Alasmidonta viridis	Special Concern
53. Spindle Lymnaea	Acella haldemani	Special Concern
54. Spotted Gar	Lepisosteus oculatus	Special Concern
55. Spotted Turtle	Clemmys guttata	Threatened
56. Sprague's Pygarctia	Pygarctia spraguei	Special Concern
57. Swamp Rose-mallow	Hibiscus moscheutos	Special Concern
58. Tall Beak-rush	Rhynchospora macrostachya	Special Concern
59. Tall Green Milkweed	Asclepias hirtella	Threatened
60. Tall Nut-rush	Scleria triglomerata	Special Concern
61. Three-birds Orchid	Triphora trianthophora	Threatened
62. Tinted Spurge	Euphorbia commutata	Threatened
63. Tooth-cup	Rotala ramosior	Special Concern
64. Trailing Wild Bean	Strophostyles helvula	Special Concern
65. Umbrella-grass	Fuirena squarrosa	Threatened
66. Virginia Water-horehound	Lycopus virginicus	Threatened
67. Wahoo	Euonymus atropurpurea	Special Concern
68. Whorled Mountain-mint	Pycnanthemum verticillatum	Special Concern
69. Wild-rice	Zizania aquatica var. aquatica	Threatened
70. Wood Turtle	Clemmys insculpta	Special Concern
71. Yellow-throated Warbler	Dendroica dominica	Threatened
72. Zigzag Bladderwort	Utricularia subulata	Threatened

Table 5 - High Quality Natural Communities in Muskegon County

Natural Communities	
1. Coastal Plain Marsh	Infertile Pond/Marsh, Great Lakes Type
2. Dry Sand Prairie	Dry Sand Prairie, Midwest Type
3. Dry-Mesic Northern Forest	-
4. Great Lakes Marsh	-
5. Hardwood-Conifer Swamp	-
6. Interdunal Wetland	Alkaline Shoredunes Pond/Marsh, Great Lakes Type
7. Mesic Northern Forest	-
8. Mesic Southern Forest	Rich Forest, Central Midwest Type
9. Oak-Pine Barrens	-
10. Open Dunes	Beach/Shoredunes, Great Lakes Type
11. Southern Floodplain Forest	-

CHAPTER 2 - REPORTED CONDITION OF WATERSHED

Numerous studies have been completed in the Muskegon Lake Watershed (Watershed) providing water quality information for Muskegon Lake, Ruddiman Creek, Ryerson Creek, Little Bear Creek, Bear Creek, Bear Lake, and Four Mile Creek. A data repository, maintained by the Muskegon River Watershed Assembly, provides many of these studies electronically and can be accessed at http://www.mrwa.org. Appendix 1 - Muskegon Lake Watershed Studies, provides a list of pertinent studies from the data repository, as well as studies provided by the Michigan Department of Environmental Quality (MDEQ), the Annis Water Resources Institute of Grand Valley State University (AWRI - GVSU), and the Muskegon Conservation District. Several of these studies indicate the presence of the several nonpoint source (NPS) and point source pollutants and impairments in the Watershed including sediment, heavy metals, toxic substances, hydrocarbons, nutrients, pathogens, thermal pollution, and unstable hydrology.

2.1 BIOLOGICAL AND SEDIMENT CONTAMINANT SURVEYS

2.1.1 RUDDIMAN CREEK AND UNNAMED TRIBUTARY (WEST BRANCH)

The Michigan Department of Natural Resources (MDNR) completed two biological and sediment contaminant surveys within the Ruddiman Creek Watershed in 1988 and 1989. Surveys were completed in response to concerns regarding environmental impacts to Muskegon Lake from past industrial and municipal discharges. Survey results were compiled in a report completed by the MDNR in 1990 (Appendix 2 - Biological and Sediment Contaminant Surveys of Ruddiman Creek and Unnamed Tributary).

Field work involved collecting fish and macroinvertebrate data, sediment samples, and physical measurements at two sites along Ruddiman Creek and two sites along the unnamed tributary to Ruddiman Pond, also referred to as the “West Branch.” The surveys revealed that Ruddiman Creek was not supporting aquatic life or fish typically associated with a warmwater fishery due to deep deposits of organic matter (up to 3 ft deep) that were covering desirable habitat. Deep deposits of organic matter, deposited from an upstream wetland, were also found at a downstream location on the unnamed tributary to Ruddiman Pond and were responsible for limiting stream habitat. Lastly, sediment samples taken along Ruddiman Creek and the unnamed tributary to Ruddiman Pond were found to have elevated levels of arsenic (8.3 - 11 mg/kg), cadmium (3.5 - 10 mg/kg), chromium (67.9 - 1690 mg/kg), copper (109 - 270 mg/kg), lead (65.8 - 668 mg/kg), mercury (0.25 - 0.35 mg/kg), nickel (5 - 208 mg/kg), and zinc (687 - 815 mg/kg).

2.1.2 RYERSON CREEK

Between 1988 and 1989, biological and sediment contaminant surveys were completed along Ryerson Creek by the MDNR in response to concerns regarding environmental impacts to Muskegon Lake from past industrial and municipal discharges (Appendix 3 - Biological and Sediment Contaminant Surveys of Ryerson Creek). Fish and macroinvertebrate data, sediment samples, and physical measurements were collected at three locations along the creek. The surveys revealed reduced water quality at the Wood Street crossing due to turbidity, bacterial slimes, and sanitary odors. All three sites were found to have limited stream habitat quality due to either deep deposits of sand or organic sediments. Lastly, sediment samples taken along Ryerson Creek revealed elevated concentrations of arsenic (5.2 - 6.3 mg/kg), cadmium (2 - 4 mg/kg), chromium (31 - 69.4 mg/kg), copper (93 - 188 mg/kg), lead (313 - 702 mg/kg), zinc (300 - 657 mg/kg), and nickel (13 - 29 mg/kg).

2.1.3 LITTLE BEAR CREEK AND UNNAMED TRIBUTARY

In 1985, the MDNR completed *A Biological Survey of Little Bear Creek and Unnamed Tributary in the Vicinity of Organic Chemical Contaminated Groundwater Seepage from the Cordova Chemical Property (*Appendix 4 - Biological Survey of Little Bear Creek and Unnamed Tributaries*)*. The assessment evaluated the impacts on Little Bear Creek and its unnamed tributary caused by the seepage of groundwater polluted with organic chemical contaminants from the Cordova Chemical Plant. It was determined that the stream quality of a 700-foot reach of the unnamed tributary, located upstream of its confluence, was “grossly degraded.” The chemical 1,1-dichloroethane, which is used primarily to make other chemicals that dissolve substances such as paint, varnish, and finish removers, and to remove grease, was found in the surface waters of Little Bear Creek. The contaminated groundwater plume has increased in size between 1978 and 1985, extending 250 feet upstream of the unnamed tributary’s confluence with Little Bear Creek.

2.1.4 BEAR LAKE

The MDNR conducted a sediment survey of Bear Lake in 1988 and in 1989 finalized the report, titled *Sediment Survey of Bear Lake* (Appendix 5 - Sediment Survey of Bear Lake). The survey was conducted to determine if lake sediments were a potential source of polychlorinated biphenyl (PCBs) and chlordane, a pesticide banned in the United States in 1988. In 1987, a carp collected from Bear Lake contained PCB and chlordane concentrations that exceeded the Michigan Department of Public Health’s restricted consumption guidelines. Sediment samples were collected at two locations in Bear Lake. High sulphur concentrations within the sediment samples prevented the detection of the chemicals in question. Survey

results were inconclusive in determining if Bear Lake sediments were a potential source of PCBs and chlordane.

2.1.5 MUSKEGON LAKE

In a report on Mona, White, and Muskegon Lakes, the U.S. Environmental Protection Agency (EPA) assessed historical macroinvertebrate (bottom-dwelling organisms) data collected by the MDNR from 1954 to 1980 (Appendix 6 - Mona, White, and Muskegon Lakes Report). The analysis indicated that Muskegon Lake appeared less degraded than Mona Lake or White Lake, most likely due to its large size, large inputs of high quality water from the Muskegon River, short hydraulic retention time, and rare periods of anoxia (total lack of dissolved oxygen). The report states that water quality had markedly improved between 1954 and 1972; however, localized areas remained severely degraded due to storm water and urban runoff discharges. Further improvement occurred in 1975 when a substantial amount of wastewater began to be diverted to the Muskegon County Wastewater Treatment Facility. Further sampling is recommended to assess conditions since 1972. To note, macroinvertebrate samples were collected in July 2002 by the AWRI. The results were reported in a *Preliminary Investigation of the Extent of Sediment Contamination in Muskegon Lake.* Benthic macroinvertebrate communities examined throughout Muskegon Lake were found to be indicative of organically-enriched conditions.

2.2 MDEQ HYDROLOGIC STUDIES

2.2.1 BEAR CREEK WATERSHED

A hydrologic model of the Bear Creek Watershed was completed in July 29, 2003, by the Hydrologic Studies Unit (HSU) of the MDEQ. Using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS), a hydrologic model was developed to help determine how future land-use changes in the Bear Creek Watershed would impact the hydrology of Bear Creek and its tributaries.

The hydrologic model considered four scenarios corresponding to 1800, 1978, 1997, and build-out land-use data. Using this information, the model predicted increases in runoff volumes and peak flows from 1800 to 1978/1997 and from 1978/1997 to build-out for all four design storms analyzed. The report states that the projected runoff volume and peak flow increases from the 10-year, 25-year, and 50-year, 24-hour design storms would aggravate flooding problems unless mitigated through the use of effective storm water management techniques. The report also suggests that the projected increases in runoff volumes and peak flows from the 2-year, 24-hour storm would increase channel-forming flows and have more effect on the channel than extreme flood flows due to their higher frequency. The report notes that watershed activities that increase this flow will cause Bear Creek and its tributaries to become unstable and will result in excessive erosion throughout the stream stretch. It is suggested that best management

practices (BMPs), designed to address flooding, can also mitigate channel-forming flows, but only when designed to address the 2-year storm.

For more information on the hydrology of the Bear Creek Watershed, see the *Hydrologic Study of the Bear Creek Watershed* in Appendix 7 - Hydrologic Study of the Bear Creek Watershed.

2.2.2 RYERSON CREEK WATERSHED

A hydrologic model of the Ryerson Creek Watershed was developed by the HSU of the MDEQ and Westshore Consulting. Results from the model, developed using HEC-HMS, were included in a December 2000 report prepared by Westshore Consulting and titled *Stormwater Management Plan for the Ryerson Creek Watershed, Muskegon County, Michigan*. To further refine and calibrate the original model, the MDEQ continued to collect watershed monitoring data in Ryerson Creek from May 8 to November 1, 2000. The results of the refined model were reported in the *Hydrologic Study of the Ryerson Creek Watershed*, completed on May 8, 2002, by the MDEQ (Appendix 8 - Hydrologic Study of the Ryerson Creek Watershed).

The refined model predicts significant increases in storm water runoff volume and peak flows from current conditions (1997) to build-out conditions for all three design storms. Peak flows and runoff volumes from the 2-year, 24-hour storm are predicted to increase more, on a percentage basis, than flow from the 10-year, 24-hour storm or the 100-year, 24-hour storm. Increases in runoff volumes from the 10-year and 100-year storms are predicted to affect flood elevations. According to the report, these projected increases can be moderated through the use of effective storm water management practices. The report suggests that measures taken to improve storm water management would be most valuable in the upper half of the watershed.

2.3 WATERSHED MANAGEMENT PLANS

2.3.1 BEAR CREEK AND BEAR LAKE WATERSHED

The *Bear Creek and Bear Lake Watershed Management Plan* was completed in March 2004 by the Muskegon Conservation District (Appendix 9 - Bear Creek and Bear Lake Watershed Management Plan). The management plan identifies, documents, and prioritizes NPS pollutants and recommends measures to address watershed concerns. The known and suspected watershed pollutants and impairments identified in the plan include, in order of rank, sediment, toxic substances, nutrients, invasive species, thermal pollution, and fecal coliform/*E. coli*. The management plan notes the following sources of these pollutants:

- Streambank erosion
- Construction sites
- Road/stream crossings
- Residential fertilizer use
- Agricultural runoff
- Failing septic systems
- Storm water runoff
- Animal waste
- Impervious surfaces
- Removal of shoreline vegetation
- Introduction of invasive species

An information and education strategy was developed to educate residents on ways they can reduce pollutant sources within the Watershed. Key audiences, messages, and delivery mechanisms were identified. BMPs were also recommended to address these concerns and included fertilizer/pesticide management, streambank stabilization, grade stabilization structures, vegetated filter strips, riparian buffer strips, sediment basins, and watercourse crossings. The management plan states that the overall goal of the Watershed is to improve water quality and to restore, improve, and protect the designated uses of the Watershed. Designated uses considered impaired include the coldwater fishery, aquatic life and wildlife, and partial and total body contact recreation. Threatened uses include navigation and the use of the Watershed as a warmwater fishery.

2.3.2 MUSKEGON RIVER WATERSHED

The Muskegon River Watershed Management Plan (WMP) was completed in 2002 by AWRI-GVSU. The WMP identifies pollutants and recommends measures to improve and protect the impaired and threatened designated uses of the Watershed. Known pollutants to the Watershed include thermal pollution and excessive nutrient loading, which are threatening the warm and cold water fisheries, as well as other aquatic life and wildlife of the river. Sedimentation, unstable hydrology, and invasive species were also indicated as known threats to the biological community. Toxic substances, from polluted sediments and urban runoff, threaten partial and total body contact recreational uses of the river. Various BMPs were recommended to address the concerns of the Watershed and include agricultural practices, runoff storage measures, road/stream crossing improvements, sedimentation control structures, vegetative establishments, constructed wetlands, and public education practices, among others. Future efforts include additional monitoring to assess environmental conditions, installation of BMPs, and further public education efforts. For more information on the pollutants, pilot project areas, or recommended practices of the Watershed, see Appendix 10 for the Executive Summary of the WMP.

2.4 SEDIMENT INVESTIGATIONS

2.4.1 MUSKEGON RIVER, FOUR MILE, AND RYERSON CREEK

In 2004, Gannett Fleming, of Michigan, Inc., was retained by the MDEQ to evaluate sediment contamination of three tributaries to Muskegon Lake: the Muskegon River, Four Mile Creek, and Ryerson Creek. The resulting report was titled *Sediment Survey of Three Tributaries of Muskegon Lake.* The Muskegon River study area extended approximately 3.5 miles from its mouth at Muskegon Lake, in the vicinity of Veteran's Memorial and Richards Parks. The Four Mile Creek study area was approximately 3.5 miles long from its mouth at the Muskegon River and 0.25 mile wide, while the Ryerson Creek study area was approximately 3 miles long from its mouth at Muskegon Lake and 0.33 mile wide. The main objective of the project was to identify potentially-impacted sediments in the three study areas. The following tasks were completed to meet the project's objective: 1) review available data from previous investigations in the study areas; 2) identify preferred sampling stations; 3) vertically sample sediments for target chemicals of potential concern; 4) perform whole sediment toxicity tests on sediments from selected stations; and, 5) assess the impact of contamination at the sampling stations.

During the investigation, 27 sites were sampled. Sampling stations were selected based on historic land uses, the presence of potential pollutant sources, and public access locations. Survey results revealed target metals were present in all three study areas; however, Four Mile Creek (copper, lead) and Ryerson Creek (arsenic, cadmium, copper, lead, nickel, and zinc) had the higher concentrations when compared to Muskegon River (arsenic, chromium, nickel). Polycyclic Aromatic Hydrocarbons (PAHs) were reported at all three study areas, and volatile organic compounds (VOCs) were reported at one sampling station on Muskegon River. No PCBs or pesticides were reported at any of the sampling stations. Based upon the data collected during the investigation, the contaminants within sediments of Ryerson Creek were determined to be impacting localized populations of aquatic organisms. It was recommended that future studies focus primarily on Ryerson Creek from Getty Street downstream to the mouth. To review sampling methodology and complete analytical results for each sampling location, refer to the sediment survey (Appendix 11 - Sediment Survey of Three Tributaries of Muskegon Lake).

2.4.2 RUDDIMAN CREEK

The *Technical Summary of Environmental Data and Issues Report* developed for the Ruddiman Creek Watershed by the AWRI-GVSU was finalized on March 19, 2004, for the U.S. Army Corps of Engineers (USACOE) (Appendix 12). The report states that historical wastewater and storm water discharges, improper hazardous waste management, and the input of contaminated groundwater have all contributed to the degradation and contamination of the Ruddiman Creek Watershed. A series of investigations of Ruddiman Pond, the three branches of Ruddiman Creek, and the surrounding wetlands were conducted by the USACOE, the MDEQ, and several consultants. The executive summary of the report states the following conclusions of those investigations:

- Sediments in the main branch of Ruddiman Creek and Ruddiman Pond are highly contaminated with toxic metals (cadmium, chromium, and lead) and PCBs at concentrations that exceed the MDEQ's site-specific Sediment Quality Criteria (SQCs) for human contact and aquatic life. (Note: Arsenic, copper, mercury, nickel, and zinc were also detected, but below SQC.)

- Concentrations of heavy metals and organic chemicals in the sediments in the West Branch and the North Branch of Ruddiman Creek do not exceed the MDEQ's site-specific SQCs.

- Contaminated groundwater was found to be entering the creek at various locations in the three branches. A disposal area for waste drums was found next to the creek in a residential area. The waste materials and surrounding soils were found to contain drums with high levels of heavy metals and solvents. The cleanup of the drum dump would require the removal of approximately 16,000 cubic yards of waste materials and contaminated soil. (Note: The highest concentration of PAHs occurs near the drum dump at Glenside Boulevard.)

- Ruddiman Pond and the adjacent wetlands function as deposition and storage areas for contaminants. In many cases, the highest levels of contaminants were found in the top three feet of the sediment. This pattern suggests that heavy metals and organic chemicals are still entering the system from NPSs.

- Approximately 51,178 cubic yards of contaminated sediment were recommended for removal to achieve concentrations that were below the SQCs.

The report suggests several reasons why the contaminated sediments and industrial waste are problematic for the Watershed and its residents. First, children living in the area have unrestricted access to contaminated areas of Ruddiman Creek where levels of lead and PCBs are high. Second, the reports imply that the presence of contaminants at concentrations that exceed SQCs suggests adverse ecological impacts. The report recommends that remediation of contaminated sediments in Ruddiman Creek take place as soon as possible.

Since this study was completed, the cleanup of Ruddiman Creek and Ruddiman Pond has begun. In August 2005, contractors began dredging 80,000 cubic yards of sediment laced with lead, cadmium, PCBs, and other hazardous compounds. The $10.6 Million project, mainly funded by the Great Lakes Legacy Act, is expected to be completed by June 2006.

2.4.3 MUSKEGON LAKE

A *Preliminary Investigation of the Extent of Sediment Contamination in Muskegon Lake* was completed in July 2002 by the AWRI-GVSU and the EPA, with assistance from several additional partners. Sediment chemistry, solid-phase toxicity, and macroinvertebrates were examined at 15 locations within Muskegon Lake. Three core samples were also taken and analyzed using radiodating and stratigraphy to determine sediment stability and contamination deposition. The following heavy metals were found in Muskegon Lake: arsenic, barium, cadmium, chromium, copper, nickel, lead, zinc, mercury, and selenium. Investigation conclusions identify three areas of significant sediment contamination in Muskegon Lake: the Division Street outfall area, the lakeshore industrial area, and the Ruddiman Creek confluence.

- The Division Street outfall area had the highest concentrations of heavy metals, significant sediment toxicity, and an impacted benthic invertebrate community. There was also indirect evidence that sediments from this area are being transported into the central region of Muskegon Lake. The report recommends that potential sources of sediment contamination be evaluated and controlled.

- The lakeshore industrial area, near the MichCon/Lakey Foundry, had elevated levels of PAH compounds and high sediment toxicity. The report recommends that the extent of sediment contamination be further defined and the possibility of a venting groundwater plume, or the leaching of contaminants from a submerged deposit, be evaluated. This site is considered a priority area for further investigation.

- Heavy metals were found near the confluence of Ruddiman Creek and in the downstream deposition basin, suggesting that the Ruddiman Creek Watershed is a continuing source of sediment contamination. The report recommends that a combination of sediment removal and source control is necessary to complete the remediation efforts begun by the MDEQ and USACOE.

To review sampling methodology, analytical results, and specific recommendations of this study, refer to the preliminary investigation (Appendix 13 - Preliminary Investigation of the Extent of Sediment Contamination in Muskegon Lake).

2.5 HEALTH CONSULTATIONS

2.5.1 RYERSON CREEK

The health consultation prepared for Ryerson Creek (Appendix 14 - Ryerson Creek Health Consultation) was finalized on August 22, 2005, by the Michigan Department of Community Health under a cooperative agreement with the U.S. Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR). An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material.

The Ryerson Creek Health Consultation states that the creek's sediments contain elevated levels of metals and PAHs. The concentrations of these pollutants exceed the state's generic cleanup criteria for residential soils; however, they do not pose an apparent current public health hazard. The effect of mercury levels on human health was indeterminate. Although mercury has not been detected in groundwater samples taken near the creek, no surface water data exist to indicate whether mercury has entered the system from sediments.

The health consultation also states that Benzo(a)pyrene, found in natural gas, and average arsenic concentrations in the soils around the Muskegon Farmer's Market do not pose an apparent public health hazard, while average lead concentrations in this area pose an indeterminate current and future public health hazard. The average lead concentration in the soils around the Muskegon Farmer's Market did not exceed the state residential cleanup criterion; however, one sampling location had a high concentration of lead (1,900 parts per million).

2.5.2 RUDDIMAN CREEK

This Ruddiman Creek Health Consultation (Appendix 15 - Ruddiman Creek Health Consultation) was finalized on January 9, 2003, by the Michigan Department of Community Health (MDCH) under a cooperative agreement with the ATSDR. The MDCH reviewed existing sediment chemistry data and determined that no apparent public health hazard exists for the sediments in Ruddiman Pond or the north and west branches of Ruddiman Creek. However, the MDCH determined that sediments in the main branch of Ruddiman Creek, especially in the area between Glenside Avenue and Barclay Road, pose an indeterminate public health hazard. Sediments in this area have been found contaminated with PCBs and lead; however, the report recommends additional sampling to further characterize contaminated sediments in this area.

2.6 COMMUNITY ACTION PLAN

The CAP was prepared by the Muskegon Conservation District for the Muskegon Lake PAC in 2002. The CAP is an update to the Muskegon Lake remedial action plan (RAP) completed in 1987 by the MDNR. RAPs are developed and implemented for all designated Areas of Concern (AOCs) in the Great Lakes Basin. Muskegon Lake was designated as an AOC in 1985 due to concerns regarding past industrial and municipal discharges.

The CAP, also known as the 2002 RAP Update, lists several NPS pollutants of the Watershed including sediment, nutrients, heavy metals, oil and grease, toxics, pathogens, and debris and trash. The plan is designed to guide the Watershed community in actions that will restore the Muskegon Lake's nine Beneficial Use Impairments (BUIs) listed in Table 6.

Table 6 - Beneficial Use Impairments of Muskegon Lake

1. Restrictions on human consumption of fish and wildlife
2. Loss of fish and wildlife habitat
3. Degradation of fish and wildlife populations
4. Degradation of benthos (bottom dwelling organisms)
5. Restrictions on dredging
6. Degradation of aesthetics
7. Beach closings
8. Eutrophication or undesirable algae
9. Restriction on drinking water consumption

Recommended action steps listed in the CAP address each BUI in order to assist in the restoration and delisting of Muskegon Lake as one of the Great Lakes' 43 AOCs. Targets for restoration, indicators of success, and actions to address the restoration of impaired BUIs are organized by 15 categories:

1. Pollution Prevention
2. Near Shore Aquatic Habitat
3. Contaminated Sediments
4. Fisheries
5. Invasive Species
6. Shoreline and Wetland Habitat
7. Land Use, Green Space, and Brownfields
8. Subwatersheds in the Area of Concern
9. Muskegon Lake's Total Maximum Daily Load (TMDL) Subwatersheds
10. Groundwater
11. Storm Water Runoff
12. Erosion and Sedimentation
13. Wastewater Management
14. Human Health
15. Public Education and Stewardship

To review the specific problems, goals, and recommended action steps for Muskegon Lake, refer to the Muskegon Lake CAP (Appendix 16 - Muskegon Lake CAP).

2.7 TOTAL MAXIMUM DAILY LOAD REPORTS

The MDEQ is responsible for identifying water bodies within the State of Michigan that are not meeting Water Quality Standards (WQS). WQS are state rules established to protect surface waters of the state. Section 303(d) of the federal Clean Water Act and the EPA require states to develop TMDLs for surface waters that do not meet WQS. A TMDL is used as an acronym to describe the process used to determine how much of a pollutant load a waterbody can assimilate. To identify these waterbodies, a study is completed to determine the amount of a pollutant that can be put in a waterbody from point sources and NPSs and still meet WQS, including a margin of safety. Waterbodies not meeting WQS are placed on the non-attainment list published as part of a 303(d) report.

Within the Watershed, five waterbodies have been placed on the non-attainment list published as part of the Water Quality and Pollution Control in Michigan: 2004 Sections 303(d) and 305(b) Integrated Report. Pollutants of concern in these waterbodies include PCBs, mercury, phosphorous, and pathogens. After approval from the EPA, the state will be required to take corrective action to meet WQS by the designated "TMDL year."

- **BEAR LAKE**

  County: Muskegon

  Size: 415 acres

  Location: Tributary to Muskegon Lake is located north of Muskegon Lake, Laketon Township

  Problems: Fish consumption advisory for PCBs, nuisance algal growths, and phosphorus

  TMDL Years: 2008 and 2009

- **MUSKEGON LAKE AND MUSKEGON RIVER**

  County: Muskegon and Newaygo

  Size: 53 miles

  Location: Lake Michigan confluence upstream to Croton Dam

  Problems: Fish consumption advisory for PCBs, fish tissue mercury concentrations, and WQS exceedances for PCBs and mercury

  TMDL Years: 2008 and 2011

- **RUDDIMAN CREEK**

  County: Muskegon

  Size: 2 miles

  Location: Upstream of Muskegon Lake confluence

  Problems: Pathogens and fish and macroinvertebrate communities are rated poor

  TMDL Year: 2008

- **RUDDIMAN CREEK (WETLAND)**

  County: Muskegon

  Size: 9.5 acres

  Location: Wetland/lagoon is at terminus of Ruddiman Creek, just prior to confluence with Muskegon Lake

  Problem: Fish consumption advisory for PCBs

  TMDL Year: 2013

- **RYERSON CREEK**

  County: Muskegon

  Size: 3 miles

  Location: Upstream of Muskegon Lake confluence

  Problem: Fish and macroinvertebrate communities rated poor

  TMDL Year: 2008

2.8 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PHASE II STORM WATER PROGRAM OUTFALL SCREENING

Industrial and municipal point sources are generally well regulated across the country and are no longer a large threat. Municipal storm water, however, remains a pollutant source that has been unregulated in the past, but is currently the focus of new regulations mandated from the EPA. Programs are being implemented in municipalities to remedy municipal storm water pollution.

The communities that are required to participate in the National Pollutant Discharge Elimination System (NPDES) Phase II Storm Water Program that incorporate portions of the Watershed including the City of Roosevelt Park, City of Muskegon, City of Muskegon Heights, City of Norton Shores, Dalton Township, Egelston Township, Laketon Township, and Muskegon Charter Township. The Muskegon County Administration, Muskegon County Drain Commissioner, and Muskegon County Road Commission are also participating in the NPDES Phase II Storm Water Program. All of these permittees are required to obtain storm water permits through the NPDES Phase II Storm Water program. These communities have recognized the importance of monitoring and reducing storm water runoff into the streams and drains in their communities and have initiated an Illicit Discharge Elimination Plan (IDEP) through the watershed-based Phase II permit.

The initial IDEP was implemented in summer 2003, completing the investigation of 417 storm water outfalls in the urbanized areas of the Muskegon Lake and Mona Lake Watersheds. If dry-weather flow was present, water quality sampling with field kits was conducted to detect the presence of a pollutant. If intermittent dry-weather flow was suspected, the outfall was flagged for follow-up investigation. Within the Watershed, four outfalls were found that were suspected of discharging pollutants. Three outfalls showed elevated conductivity levels, and two of these outfalls also had elevated fecal coliforms. The fourth outfall was not found to be discharging pollutants, but is historically a source of pollution. The appropriate municipality will be responsible for finding the source of the discharge and correcting or eliminating the illicit connection.

The small number of illicit discharges found in the Watershed is confirmation that Municipal Separate Storm Sewer Systems (MS4s) are not a significant contributor to the water quality problems in Muskegon Lake. NPS, the diffuse runoff from upland and impervious areas, continues to be the most significant contributor of pollution to the surface waters and must be addressed through the holistic watershed management planning effort that is able to identify NPS pollution.

2.9 SUPERFUND SITES ON THE NATIONAL PRIORITIES LIST

The National Priorities List is a list of environmentally-contaminated sites, published by the EPA, which pose an immediate or significant pubic health threat to the local community. These sites are eligible for extensive, long-term cleanup action under the Superfund program. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 provides a federal "Superfund" to clean up uncontrolled or abandoned hazardous waste sites, as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. The Superfund sites located in the Watershed, as of October 1, 2003, are listed below:

- **DUELL & GARDNER LANDFILL**
  CERCLIS ID: MID980504716
  1285 East Bard Road, Dalton Township
  Bear Creek and Bear Lake Subwatershed
  Groundwater contamination: VOCs. Onsite soil contamination: PCBs, crystal violet, aniline, and N,N-dimethylaniline.

- **KAYDON CORPORATION**
  CERCLIS ID: MID006016703
  2860 McCracken Street, Muskegon
  Ruddiman Creek Subwatershed
  Onsite soil contamination: chromium, copper, lead, and nickel. Groundwater contamination: chlorinated organic solvents, including 1,1-dichloroethane and 1,2-dichloroethylene.

- **OTT/STORY/CORDOVA CHEMICAL COMPANY**
  CERCLIS ID: MID060174240
  500 Agard Road, Dalton Township
  Bear Creek and Bear Lake Subwatershed
  Groundwater contamination: vinyl chloride, 1,1-dichloroethene, and 1,2-dichloroethane. Onsite soil contamination: benzoic acid, 1,2-dichlorobenzene, 4-chloroaniline, 1,1,1- trichloroethane, xylene, toluene, 1,4-dichlorobenzene, hexachlorobenzene, 4,4'-DDT, and dioxin. Little Bear Creek surface water contamination: 1,1-dichloroethane.

CHAPTER 3 - DESIGNATED USES OF THE MUSKEGON LAKE WATERSHED

3.1 DESIGNATED USES

Designated uses are defined as recognized uses of water established by state and federal water quality programs. All waters of the State of Michigan must meet eight designated uses (Table 7) according to Public Act 451 of 1994, Chapter I, Part 31, Part 4.

Table 7 - Designated Uses for Surface Waters in the State Of Michigan

Designated Use	General Definition
Agricultural use	Livestock watering, irrigation, and crop spraying
Public water supply at point of intake	Surface waters meet human cancer and non-cancer values set for drinking water
Navigation	Navigation of inland waters
Warmwater or coldwater fishery	Supports warm or cold water species
Other indigenous aquatic life and wildlife	Supports other indigenous animals, plants, and macroinvertebrates
Partial body contact recreation	Supports boating, wading, and fishing activities
Total body contact recreation (between May 1 and October 31)	Supports swimming activities between May 1 and October 31
Industrial water supply	Water utilized in industrial or commercial applications

These designated uses provide a starting point for discussion about the goals for the Muskegon Lake Watershed (Watershed) project. It was determined by the Nonpoint Source (NPS) Committee that the surface waters of the Watershed were not used as a public water supply. The NPS Committee evaluated the remaining seven designated uses to determine if they are being impaired or threatened by pollutants.

Designated uses that are impacted by pollutants, which exceed the State's Water Quality Standards (WQS), are said to be impaired. Designated uses that are threatened by pollutants that currently meet the State's WQS, but may not in the future, are said to be threatened. The *Water Quality Standards Nonattainment List for Waterbodies Requiring TMDLs,* developed by the Michigan Department of Environmental Quality (MDEQ), was used to determine which waterbodies in the Watershed are impaired. The status of each designated use of waterbodies in the Watershed is listed in Table 8.

Table 8 - Met, Impaired, or Threatened Designated Uses of the Muskegon Lake Watershed

Designated Use	Met, Impaired, or Threatened
Agricultural use	**Met**
Navigation	**Met**
Warmwater fisheries	**Impaired** for Ruddiman Creek, Ryerson Creek, Bear Lake, and Muskegon Lake **Threatened** for Bear Creek and Four Mile Creek
Coldwater fisheries	**Impaired** for Little Bear Creek and Muskegon River
Other indigenous aquatic life and wildlife	**Impaired** for Ruddiman Creek, Ryerson Creek, Muskegon Lake, Muskegon River, and Bear Lake **Threatened** for Bear Creek, Little Bear Creek, and Four Mile
Partial body contact recreation	**Impaired** for Ruddiman Creek, Bear Lake, and Muskegon Lake **Threatened** for Ryerson Creek
Total body contact recreation (between May 1 and October 31)	**Impaired** for Ruddiman Creek, Bear Lake, and Muskegon Lake **Threatened** for Ryerson Creek
Industrial water supply	**Met**
Public water supply	**Not a Use**

Coldwater and Warmwater Fisheries

A coldwater fishery is considered to have summer temperatures below 60° Fahrenheit and able to support natural or stocked populations of trout, salmon, whitefish, or cisco (lake herring). Muskegon River, Little Bear Creek, and Muskegon River tributaries (from Section 18 of the City of North Muskegon, east to Section 18 of Croton Township) are designated coldwater streams within the Watershed. According to MDEQ biological surveys, of the seven species of fish found in Little Bear Creek, trout, salmon, whitefish, and cisco were not among them. Although a total maximum daily load (TMDL) is not currently being developed for Little Bear Creek, MDEQ biological surveys state that Little Bear Creek does not support a coldwater fishery, even though it is a designated coldwater stream. In addition, the MDEQ is in the process of developing a TMDL for the Muskegon River, from its confluence with Lake Michigan to Croton Dam, due to WQS exceedances for polychlorinated biphenyls (PCBs) and mercury. Possible PCB effects on fish include impaired reproductive, endocrine, and immune system function, increased lesions and tumors, and death. High mercury concentrations can cause fish embryo mortality, decrease spawning success, and adversely effect fish growth and development. Therefore, Little Bear Creek and the Muskegon River, from its confluence with Lake Michigan to Croton Dam, are not meeting their designated uses as a coldwater fishery, and this use is considered impaired for both waterways.

A warmwater fishery is defined by the MDEQ as a water body that is capable of supporting fish species that thrive in relatively warm water, including any of the following: bass, pike, walleye, and pan fish. Generally, summer temperatures are between 60° Fahrenheit and 70° Fahrenheit and are capable of supporting warmwater fish on a year-around basis. The MDEQ Biological Surveys state that Ruddiman Creek does not support a warmwater fishery due to deep deposits of inorganic materials eliminating desirable habitat for fish. Surveys of Ryerson Creek, also a designated warmwater stream, found only minnows and carp at the two sites sampled. Because of these assessments, the MDEQ is in the process of developing TMDLs for Ruddiman Creek and Ryerson Creek due to the poor rating of their fish communities. Therefore, Ruddiman Creek and Ryerson Creek are not meeting their designated uses as a warmwater fishery, and this use is considered impaired for both waterways.

The MDEQ is in the process of developing a TMDL for Muskegon Lake due to WQS exceedances for PCBs and mercury. Furthermore, the 1987 Muskegon Lake Remedial Action Plan (RAP) lists the following beneficial use impairments (BUIs) to the Muskegon Lake Area of Concern (AOC): 1) loss of fish and wildlife habitat and 2) degradation of fish and wildlife populations. In addition, a TMDL is being developed for Bear Lake due to nuisance algal growths and phosphorus. Algal blooms can cause fish kills when their decay depletes dissolved oxygen concentrations. Therefore, Muskegon Lake and Bear Lake are not meeting their uses as a warmwater fishery, and this use is considered impaired for both waterbodies.

According to the Bear Creek and Bear Lake Watershed Management Plan (WMP), the warmwater fishery of Bear Creek is threatened by pollutants such as excessive sediment and nutrients. The MDEQ has not determined any WQS exceedances for Bear Creek; therefore, Bear Creek's use as a warmwater fishery is considered threatened rather than impaired.

Four Mile Creek has been reported to have heavy metal concentrations (i.e., lead and copper). Although effects on fish species from heavy metals within Four Mile Creek are unknown, heavy metals can affect the health of fish at certain concentrations (Hodson, 1984). Since the MDEQ has not determined any WQS exceedances for Four Mile Creek, Four Mile Creek's warmwater fishery is classified as threatened for aquatic life use rather than impaired.

Other Indigenous Aquatic Life and Wildlife

In addition to fish, other aquatic life and wildlife in the ecosystem should be considered in all management strategies. A stable and healthy habitat supports populations of wildlife that provide outdoor recreational opportunities like sport fishing, bird watching, and hunting. Healthy habitats have water conditions that are capable of supporting native plant and animal species. Near-shore habitats in the Great Lakes are extremely important to aquatic life and wildlife that depend on coastal habitat for feeding, spawning, and shelter. According to MDEQ biological surveys, Ruddiman Creek does not support its aquatic life use due to deep deposits of inorganic materials eliminating desirable habitat for macroinvertebrates. Habitat quality in Ryerson Creek was also reported as limited due to deep sand deposits. Because of these assessments, the MDEQ is in the process of developing TMDLs for Ruddiman Creek and Ryerson Creek due to the poor rating of their macroinvertebrate communities. Therefore, Ruddiman Creek and Ryerson Creek are not meeting their aquatic life use.

The MDEQ is also in the process of developing a TMDL for the Muskegon River, from its confluence with Lake Michigan to Croton Dam, due to WQS exceedances for PCBs and mercury. Pollutants such as PCBs, mercury, and other toxic substances are known to increase turbidity, causing certain macroinvertebrates such as mayflies, stoneflies, and caddisflies to be replaced by silt-tolerant and pollution-tolerant macroinvertebrates. Therefore, the aquatic life of the Muskegon River, from its confluence with Lake Michigan to Croton Dam, is impaired.

Due to water quality standard exceedances for PCBs and mercury, the MDEQ is in the process of developing a TMDL for Muskegon Lake. Furthermore, the 1987 Muskegon Lake RAP lists the following BUIs to the Muskegon Lake AOC: 1) loss of fish and wildlife habitat; 2) degradation of fish and wildlife populations; and 3) degradation of benthos (bottom-dwelling organisms). In addition, a TMDL is being developed for Bear Lake due to nuisance algal growths and phosphorus. Extreme algal growth, caused by excessive nutrients, can deplete dissolved oxygen concentrations, and very low dissolved oxygen levels can result in invertebrate mortality. Therefore, the aquatic life use of Muskegon Lake and Bear Lake is considered impaired for both waterbodies

According to the Bear Creek and Bear Lake WMP, the aquatic life of Bear Creek is threatened by pollutants such as excessive sediment and nutrients. In addition, MDEQ biological surveys state that Little Bear Creek's macroinvertebrate community, at River Road, has reduced numbers of individuals and taxa, indicating reduced stream quality. The MDEQ has not determined any WQS exceedances for Bear Creek or Little Bear Creek; therefore, the aquatic life uses of these waterways is considered threatened rather than impaired.

Four Mile Creek has been reported to have heavy metal concentrations (lead and copper) above Probable Effect Concentrations (PECs). PECs describe a level of contamination in the sediment above which adverse effects are more likely to occur to aquatic life (primarily macroinvertebrates [bottom-dwelling organisms]). Since the MDEQ has not determined any WQS exceedances for Four Mile Creek, Four Mile Creek is classified as threatened for aquatic life use rather than impaired.

Total and Partial Body Contact Recreation

Escherichia coli (E. coli), harmless bacteria, are useful in indicating the presence of disease causing pathogens. *E. coli* and microbial pathogens are found in the intestinal tracts of humans and warm-blooded animals. The extent to which *E. coli* are present in surface waters can indicate general water quality and the likelihood that the water is contaminated with microbial pathogens.

Water quality must meet standards of less than 300 count/100 milliliter (ml) in a sample of *E. coli* for areas to be safe for total body contact recreation, such as swimming, from May 1 to October 31 (MDEQ, 1999). Water related activities, like fishing and boating, that do not require full body immersion are referred to as partial body contact recreation. Water quality must meet standards of less than 1,000 count/100 ml of *E. coli* for this type of recreational use (MDEQ, 1999).

The MDEQ is currently in the process of developing a TMDL for Ruddiman Creek due to elevated levels of pathogens. In addition, the health consultation for Ruddiman Creek (2003) determined that sediments in the main branch of Ruddiman Creek, especially in the area between Glenside Avenue and Barclay Road, pose an indeterminate public health hazard. Sediments in this area have been found contaminated with PCBs and lead.

Ryerson Creek, like Ruddiman Creek, was also found to have heavy metals. The health consultation prepared for Ryerson Creek determined that mercury levels detected in the sediments of and soils near Ryerson Creek pose an indeterminate public health hazard. Although mercury has not been detected in groundwater samples taken near the creek, no surface water data exist to indicate whether mercury has entered the system from sediments. The health consultation also states that average lead concentrations around the Muskegon Farmer's Market pose an indeterminate current and future public health hazard. One sampling location near the Muskegon Farmer's Market exceeded the state residential cleanup criterion.

In conclusion, although *E. coli* data collected by the MDEQ was not available prior to the completion of this plan, Ruddiman Creek's partial and total body recreational uses were both classified as impaired, since the MDEQ is currently developing a TMDL for Ruddiman Creek due to elevated pathogen levels.

The partial body contact and total body contact recreational uses of Ryerson Creek were determined to be threatened by the NPS Committee due to the presence of heavy metals.

It was determined that Bear Lake is not meeting partial and total body contact recreational uses due to a public advisory issued for Bear Lake during summer 2005. This advisory was based on samples collected by the National Oceanic & Atmospheric Administration, which contained an excess of 20,000 parts per million for *Microcystis*. *Microcystis aeruginosa* is a common species of cyanobacteria (often called blue-green algae) that can produce natural toxins, called microcystins, which can be harmful to wildlife and humans. Although the MDEQ has not determined any WQS exceedances for Bear Lake, the NPS Committee has classified Bear Lake as impaired for partial and total body recreational uses.

The MDEQ is in the process of developing a TMDL for Muskegon Lake due to WQS exceedances for PCBs and mercury. The 1987, Muskegon Lake RAP lists 10 of 14 potential BUIs to the Muskegon Lake AOC. Beach closings were listed among the 10 BUIs due to the presence of toxic substances and sediments contaminated with heavy metals. *Microcystis Aeruginosa* has also been found in Muskegon Lake. Therefore, Muskegon Lake is classified as impaired for partial and total body contact recreational uses.

Agricultural Use

Surface waters used for irrigation, livestock watering, and produce spraying must be consistent and safe. Water resources should be free of pathogens and toxic substances that could pose a health risk to livestock and humans. Most agricultural water use in the Watershed occurs in the Green Creek and Bear Creek Subwatersheds. Surface waters are used for watering horses and cattle. Use of surface waters in the Green Creek and Bear Creek Subwatersheds is safe for agricultural use, since pathogens and toxic substances have not been identified as a problem.

Industrial Water Supply

Industrial water supplies must have cool water with low turbidity. SAPPI's Muskegon Paper Mill and Consumers Energy withdraw water from Muskegon Lake for industrial use. Because past water quality reports for Muskegon Lake do not indicate suspended solids or thermal pollution as concerns, the NPS Committee considers the use of Muskegon Lake for industrial purposes met.

Navigation

Waterways and waterbodies that provide adequate depth and width for recreational boating, canoeing, and kayaking must maintain navigable conditions. Muskegon River is used frequently by canoeists and kayakers and hence the use of the Muskegon River for navigation is being met. Muskegon Lake is

frequented by boaters and whereas in some lakes algal blooms hinder navigation, this is not the case in Muskegon Lake. The use of Muskegon Lake for navigation is therefore being met.

3.2 IMPAIRMENTS TO DESIGNATED USES

Muskegon Lake was designated as a Great Lakes AOC in 1985 due to impacts from direct discharges of industrial wastewater, municipal wastewater treatment plant effluent, combined sewer overflows, and urban runoff. Muskegon Lake is 1 of 43 AOCs designated by the United States and Canada listed in Annex 2 of the Great Lakes Water Quality Agreement. Geographic areas are designated as an AOC when they fail to meet the "general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use of the area's ability to support aquatic life." In the Great Lakes basin, an AOC is required to have a RAP developed and implemented. Muskegon Lake's RAP was originally written in 1987 and was updated in 1994 and 2002. The 2002 RAP Update, also known as the Muskegon Lake CAP, discusses several impairments to Muskegon Lake. The biological and sediment contamination surveys, health consultations, hydrologic studies, sediment investigations, and additional studies completed within the Watershed shed additional light on impairments. The impairments to the designated uses of the Watershed, both point source and NPS pollutants, noted in past studies and by the NPS Committee are summarized in this section and listed in Table 9 - Pollutants of the Muskegon Lake Watershed.

3.2.1 POINT SOURCE POLLUTION

Prior to 1900, the lumbering era began to decline in Muskegon and was beginning to be replaced by heavy industry. Among the first major factories to locate to Muskegon Lake's shoreline was the Central Paper Company, currently SAPPI Fine Paper - North America (Alexander, 1999). The paper mill, foundries, oil tank farms, and other factories that located to the City of Muskegon, City of Roosevelt Park, City of Norton Shores, and City of Muskegon Heights, polluted Muskegon Lake with heavy metals and toxic chemicals, still present today.

In 1972, the U.S. Congress passed the federal Clean Water Act (CWA). The CWA established the basic structure for regulating discharges of pollutants into the waters of the United States. The CWA made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. Point source pollution is defined by the U.S. Environmental Protection Agency (EPA) as "any discernible, confined, and discrete conveyance such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container and includes vessels or other floating craft, from which pollutants are or may be discharged."

Today, point source discharge facilities are required to hold a National Pollutant Discharge Elimination System (NPDES) wastewater discharge permit. However, Muskegon Lake is still polluted with industrial wastes from past point source pollution.

For a list of controlled point source discharges located in Muskegon and Newaygo Counties, see Appendix 17 - NPDES Permitted Discharges.

3.2.2 NONPOINT SOURCE POLLUTION

The majority of point source pollution has been successfully eliminated from impairing Michigan's water resources; however, water quality impairments still exist. Unlike discharges from wastewater treatment plants and industrial wastewater discharge, lingering impairments come from many diffuse sources called NPS pollution. NPS pollution results from rain or snowmelt moving over or through the ground and picking up pollutants and depositing them in lakes, rivers, streams, and groundwater.

NPS pollution affects water quality and impairs water resource use in many different ways. Storm water runoff may contain nutrients that cause excessive plant growth. Toxics, such as pesticides, can interfere with aquatic organisms. Sediment can fill small pools and rocky areas that fish depend upon for spawning or feeding.

Table 9 - Pollutants of the Muskegon Lake Watershed

Pollutant	Muskegon Lake	Muskegon River	Ruddiman Creek	Ruddiman Pond	Ryerson Creek	Four Mile Creek	Bear Creek	Little Bear Creek	Bear Lake	Muskegon Lake Watershed
Sediment	Known	Known	Known		Known		Known	Known	Known	Known
Heavy Metals	Known[1]	Known[2]	Known[3]	Known[3]	Known[4]	Known lead and copper				Known
Toxic Substances	Known - PCBs	Known - PCBs and VOCs	Known - PCBs	Known - PCBs				Known[5]	Known - PCBs and microcystins	Known
Hydrocarbons	Known - PAHs	Known - PAHs	Known - PAHs	Known - PAHs	Known - PAHs	Known - PAHs	Suspected		Suspected	Known
Nutrients	Known	Known					Known		Known	Known
Pathogens			Known				Suspected			Known
Thermal Pollution		Known					Known	Known		Known
Unstable Hydrology		Known	Known		Known	Known	Known	Known		Known

[1] Arsenic, barium, cadmium, chromium, copper, nickel, lead, zinc, mercury, and selenium

[2] Arsenic, chromium, mercury, and nickel

[3] Arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc

[4] Arsenic, cadmium, chromium, copper, lead, zinc, and nickel

[5] 1,1-dichloroethane, an organic chemical contaminant

* If no information is listed for a particular pollutant, then the pollutant is not a concern for that waterbody/waterway or more research is needed.

Sediment

Inorganic fine sediments are naturally present to some extent in all streams, but are considered pollutants at excessive levels. Precipitation, including secondary events such as floods and melting snow packs, will transport sediment from eroded uplands to nearby water bodies. In addition, channel movement will scour streambanks and streambeds and contribute additional amounts of inorganic sediment. Because storm events increase stream velocity, more sediment is added by channel movement during rainfall events. Sediment can be suspended, causing turbidity, or deposited on the streambed, causing a loss of benthic productivity and fish habitat. The deposit of an excessive amount of sediment in a stream will cover spawning habitat, clog fish gills, and generally degrade the aquatic habitat of fish and macroinvertebrate species. Human activities, related to agriculture, forestry, mining, and urban development, contribute excessive amounts of sediment that often overwhelms the "assimilative capacity" of a stream (Cairns, 1977) and affects aquatic life.

Heavy Metals

Heavy metals are defined as any metallic chemical element that has a relatively-high density and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), and lead (Pb).

As trace elements, some heavy metals (e.g., copper, selenium, and zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking water contamination, high ambient air concentrations near emission sources, or intake via the food chain. Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.

Heavy metals are dangerous because they tend to bioaccumulate. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted.

Toxic Substances

The MDEQ defines toxic substances as "a substance, except for heat, that is present in sufficient concentration or quantity that is or may be harmful to plant life, animal life, or designated uses" (R 323.1044 1100 of Part 4, Part 31 of PA 451, 1994, revised 4/2/99). For the purposes of this document, toxic substances include all toxics, besides heavy metals, which have been defined as a separate pollutant. Toxic substances can affect the reproductive health of aquatic life and may pose a health risk to recreational users who use a water body for partial/total body contact recreational uses or consume its fish. Toxic substances can include, but are not limited to: synthetic organic contaminants such as pesticides and herbicides, and volatile organic contaminants, such as xylenes, toluene, and benzene. The contaminants mentioned above, are designated as drinking water contaminates by the EPA (EPA, 2002).

Hydrocarbons

Hydrocarbons are defined as organic compounds (as acetylene or butane) containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal, and bitumens (asphalt and tar are the most common forms of bitumen). The presence of hydrocarbons in a waterbody can result from the input of road runoff containing automotive petroleum products, illicit dumping of used motor oil into storm drains, or discharge from industrial sites. Leaking Underground Storage Tanks (LUSTs) are another major source of hydrocarbons that can enter into groundwater reserves and eventually seep into surface waters. Within the City of Muskegon, there are 99 "open" sites containing LUSTs (http://www.deq.state.mi.us/lustcs/). These 99 open LUST sites have had a release occur from an underground storage tank system, but have not yet had corrective actions completed to meet the appropriate land-use criteria.

Polycyclic aromatic hydrocarbons (PAHs) are a group of more than a hundred organic compounds composed of two or more carbon rings derived from benzene. They are emitted into the environment from both natural and anthropogenic (human) sources. PAHs, although present in low concentrations virtually everywhere, occasionally reach elevated concentrations as the result of prolonged industrial activities involving burning, or by releases of materials such as creosote-based wood preservatives. PAHs are a concern because some of them can cause cancers in humans and are harmful to fish and other aquatic life. Sources of industrial emissions include:

- Coal and oil-fired power plants
- Waste incinerators
- Coke and asphalt production
- Aluminum smelting
- Carbon black production
- Wood preservation

Nutrients

Nutrients are rated as the second most important factor, next to siltation, adversely affecting the nation's fishery habitat (Judy et al., 1984). Excessive nutrients, carried by storm water runoff, can cause dense algal growths known as an algal bloom. After the elevated nutrient source has been depleted, the algal bloom will die and decompose, reducing dissolved oxygen (DO) levels. If DO levels reach levels intolerant to fish species, a fish kill may result. If DO levels are consistently low, a shift toward more tolerant aquatic species will arise, reducing species diversity within the stream. Nitrogen and phosphorus have been identified as the two most common nutrients to enter surface waters. Polluted runoff can result from a variety of sources related to agricultural and urban land use practices.

Pathogens

The presence of coliforms, *E. coli* or fecal coliform, within a water body, indicates the possible presence of microbial pathogen contamination. Coliforms are mostly harmless bacteria that live in soil, water, and the intestinal tracts of humans and warm-blooded animals. Pathogens are microbes that cause disease and include several types of bacteria, viruses, protozoa, and other organisms. The extent to which total coliforms are present in surface waters can indicate general water quality and the likelihood that the water is contaminated with microbial pathogens. Improperly installed, operated, or maintained septic systems and waste water treatment sites can contribute pathogens from humans to surface waters, posing a potential health risk to recreational users. Runoff from animal pastures and improper disposal of pet waste also contribute animal pathogens to nearby water bodies.

Thermal Pollution

Thermal pollution can result from the input of heated liquids from industrial discharges or hot impervious surfaces, such as parking lots, roads, or rooftops. A significant lack of streamside vegetation and ditching practices will also lead to thermal pollution due to direct exposure of surface waters to the sun. A significant reduction in water levels from water withdrawals will also cause a stream to be more easily heated by the sun. Dark sediment particles absorb heat, increasing the temperature of surface water as well. Thermal pollution is harmful to cold water species such as brook trout because warm water holds less dissolved oxygen than cold water, which may lower the dissolved oxygen level beyond the species' tolerance level.

Unstable Hydrology

Harmful changes in a stream's flow regime, such as increased peak flows and decreased attenuation, can increase sediment pollution, cause flooding and damage aquatic habitat. Hydrology can be defined as the science of water, its properties, phenomena, and distribution over the earth's surface. The hydrologic cycle describes the movement of water, cycling between the atmosphere and earth through the processes of condensation, precipitation, infiltration, runoff, and evaporation. Precipitation will infiltrate into the soil as groundwater or run off the land into a nearby water body or waterway as surface water. Impervious surfaces, such as parking lots, roads, and rooftops associated with urban development and loss of wetlands, disrupt this natural cycle. Storm water runoff that would normally infiltrate into the soil will run off impervious surfaces and erode stream banks due to its greater force and may cause flooding due to its greater volume. Loss of wetlands further intensifies this situation due to the fact that loss of storage capacity will contribute to greater surface runoff volume.

3.2.3 PRIORITIZATION OF POLLUTANTS

Pollutants impacting designated uses of Muskegon Lake (Table 10) and Muskegon Lake's tributaries (Table 11) were prioritized into groups. Group 1 pollutants are considered to have the most detrimental impact to Muskegon Lake or Muskegon Lake's tributaries. Implementation efforts should focus on reducing Group 1 pollutants before targeting pollutants listed in Groups 2 or 3.

Table 10 - Pollutant Prioritization for Muskegon Lake

Group	Watershed Pollutants
Group 1:	Heavy metals, hydrocarbons, and toxic substances
Group 2:	Nutrients and excessive sediment

Table 11 - Pollutant Prioritization for Muskegon Lake's Tributaries

Group	Watershed Pollutants
Group 1:	Nutrients, pathogens, unstable hydrology, and excessive sediment
Group 2:	Heavy metals, hydrocarbons, and toxic substances
Group 3:	Thermal pollution

3.2.4 SOURCES AND CAUSES OF IMPAIRMENTS

In order to address current watershed pollutants and prevent future pollution problems from occurring, the sources and causes of each pollutant, identified as impacting designated uses, were identified (Table 12). Sources and causes of a pollutant should be considered when selecting Best Management Practices (BMPs).

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
Coldwater Fishery	Impaired for Little Bear Creek and Muskegon River	Sediment (k)	Agricultural and urban runoff
			Construction sites
			Lack of agricultural BMPs
			Road/stream crossings
			Storm sewer discharges
			Stream banks
			Unrestricted livestock access
			Unstable hydrology
		Heavy metals (k)	Industrial emissions
			Past industrial waste dumping
		Toxic Substances (k)	Improper pesticide/herbicide management
			Industrial emissions
			Past industrial waste dumping
			Road salt runoff
		Hydrocarbons (k)	Illicit dumping into storm drains
			Industrial emissions
			Leaking underground storage tanks
			Past industrial waste dumping
			Urban runoff
		Nutrients (k)	Agricultural and urban runoff
			Animal waste
			Failing septic systems

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
			Fertilizer runoff
			Lack of agricultural BMPs
			Yard waste dumping
		Thermal Pollution (k)	Impervious surfaces
			Removal of bank vegetation
			Sedimentation
		Unstable Hydrology (k)	Channelization
			Floodplain development and destruction
			Impervious surfaces
			Storm sewer discharge quantity and velocity
			Wetland destruction
Warmwater fishery	Impaired for Ruddiman Creek, Ryerson Creek, Bear Lake, and Muskegon Lake Threatened for Bear Creek and Four Mile Creek	Sediment (k)	Agricultural and urban runoff
			Construction sites
			Lack of agricultural BMPs
			Road/stream crossings
			Storm sewer discharges
			Stream banks
			Unrestricted livestock access
			Unstable hydrology
		Heavy Metals (k)	Industrial emissions
			Past industrial waste dumping
		Toxic Substances (k)	Improper pesticide/herbicide

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
			management
			Industrial emissions
			Past industrial waste dumping
			Road salt runoff
		Hydrocarbons (k)	Illicit dumping into storm drains
			Industrial emissions
			Leaking underground storage tanks
			Past industrial waste dumping
			Urban runoff
		Nutrients (k)	Agricultural and urban runoff
			Animal waste
			Failing septic systems
			Fertilizer runoff
			Lack of agricultural BMPs
			Yard waste dumping

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
		Thermal Pollution (k)	Impervious surfaces
			Removal of bank vegetation
			Sedimentation
		Unstable Hydrology (k)	Channelization
			Floodplain development and destruction
			Impervious surfaces
			Storm sewer discharge quantity and velocity
			Wetland destruction
Other Aquatic Life	Impaired for Ruddiman Creek, Ryerson Creek, Muskegon Lake, Muskegon River, Bear Lake Threatened for Bear Creek, Little Bear Creek, and Four Mile Creek	Sediment (k)	Agricultural and urban runoff
			Construction sites
			Lack of agricultural BMPs
			Road/stream crossings
			Storm sewer discharges
			Stream banks
			Unrestricted livestock access
			Unstable hydrology
		Heavy metals (k)	Industrial emissions
			Past industrial waste dumping

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
		Toxic substances (k)	Improper pesticide/herbicide management
			Industrial emissions
			Past industrial waste dumping
			Road salt runoff
		Hydrocarbons (k)	Illicit dumping into storm drains
			Industrial emissions
			Leaking underground storage tanks
			Past industrial waste dumping
			Urban runoff
		Nutrients	Agricultural and urban runoff
			Animal waste
			Failing septic systems
			Fertilizer runoff
			Lack of agricultural BMPs
			Yard waste dumping
		Thermal pollution	Impervious surfaces
			Removal of bank vegetation
			Sedimentation
		Unstable hydrology	Channelization
			Floodplain development and destruction
			Impervious surfaces
			Storm sewer discharge quantity and

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
			velocity
			Wetland destruction
Total body contact recreation Partial body contact recreation	Impaired for Ruddiman Creek, Bear Lake, and Muskegon Lake Threatened for Ryerson Creek	Heavy metals (k)	Industrial emissions
			Past industrial waste dumping
		Toxic Substances (k)	Improper pesticide/herbicide management
			Industrial emissions
			Past industrial waste dumping
			Road salt runoff
			Improper pesticide/herbicide management
		Hydrocarbons (k)	Illicit dumping into storm drains
			Industrial emissions
			Leaking underground storage tanks
			Past industrial waste dumping
			Urban runoff
		Pathogens (k)	Animal waste
			Failing septic systems
			Lack of agricultural BMPs
Agriculture	Met	NA	NA
Industrial Use	Met	NA	NA
Navigation	Met	NA	NA

Table 12 - Sources and Causes of Pollutants Impacting Designated Uses

Designated Use of Watershed	Status of Use	Watershed Pollutants Impacting Use	Sources and Causes of Pollutant
Public Water Supply	Not a Use	NA	NA

CHAPTER 4 - GOALS AND OBJECTIVES

The overall goal established for the Muskegon Lake Watershed (Watershed) is to restore and improve its designated uses. In order to achieve this overall watershed goal, six long-term goals have been established and are listed below.

1. Prevent soil erosion and reduce sedimentation in Muskegon Lake and its tributaries.

2. Reduce concentrations of heavy metals, toxic substances, and hydrocarbons in the Muskegon Lake Watershed focusing initial efforts on Ryerson Creek, Ruddiman Creek, and the Division Street outfall area.

3. Reduce nutrient-loading of Muskegon Lake and its tributaries giving particular attention to sources of phosphorus.

4. Prevent pathogens from entering surface waters of the Watershed, and strive to meet applicable water quality standards in Ruddiman Creek.

5. Reduce sources of thermal pollution impacting Muskegon River, Bear Creek, and Little Bear Creek.

6. Stabilize stream flows to moderate hydrology and increase base flow; this is especially important in the urban wetland areas of Ruddiman Creek, Ryerson Creek, and Four Mile Creek, which are impacted by unstable hydrology from storm water flows.

Short-term objectives were created by examining the long-term goals and determining how they would be best met. All goals and objectives are intended to address the current Watershed conditions and improve water quality over time. Goals and objectives are described in Table 13 based on their relationship with the Watershed's designated uses.

Table 13 - Goals and Objectives of the Muskegon Lake Watershed

Long-term Goals	Pollutants of Concern	Sources and Causes	Short-term Objectives
Prevent soil erosion and reduce sedimentation in Muskegon Lake and its tributaries	**Sediment**	Agricultural and urban runoff Construction sites Lack of agricultural BMPs Road/stream crossings Storm sewer discharges Stream banks Unrestricted livestock access Unstable hydrology	• Offer training to planning departments, road commissions, building/permitting officials, and contractors so that soil erosion control BMPs are considered an integrated part of the site planning and design process. • Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff. • Implement shoreline protection and restoration practices in riparian areas. • Increase knowledge and use of soil erosion reduction and runoff control techniques on agricultural and urban land. • Survey road-stream crossings and prioritize sites for future improvement. • Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas. • Additional state and local funding for enforcement of SESC.

Table 13 - Goals and Objectives of the Muskegon Lake Watershed

Long-term Goals	Pollutants of Concern	Sources and Causes	Short-term Objectives
Reduce concentrations of heavy metals, toxic substances, and hydrocarbons in the Muskegon Lake Watershed focusing initial efforts on Ryerson Creek, Ruddiman Creek, and the Division Street outfall area	**Heavy metals, toxic substances, and hydrocarbons**	Industrial emissions Past industrial waste dumping Improper pesticide/herbicide management Road salt runoff Illicit dumping into storm drains Leaking underground storage tanks Urban runoff	• Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff and discourage dumping into storm drains. • Increase knowledge about benefits of integrated pest management and the safe use of pesticides/herbicides among property owners. • Increase the number of small and medium size producers who complete chemical storage and handling assessments, particularly in areas with high water tables, porous soils, and those near surface or sensitive water resources. • Promote hazardous waste collection programs. • Minimize effects of Department of Public Works and Road Commission waste, chemical, and salt storage areas and control road salt runoff. • Eliminate illicit discharges. • Work with the Michigan Department of Environmental Quality to address leaking underground storage tanks and impacts from past industrial discharges.
Reduce nutrient loading of Muskegon Lake and its tributaries with particular attention to sources of phosphorus	**Nutrients**	Agricultural and urban runoff Animal waste Failing septic systems	• Increase property owner awareness about the value of properly designed, installed, and maintained septic systems, particularly in areas with high water tables, porous soils, and those near surface water and storm sewers. • Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and

Table 13 - Goals and Objectives of the Muskegon Lake Watershed

Long-term Goals	Pollutants of Concern	Sources and Causes	Short-term Objectives
		Fertilizer runoff Lack of agricultural BMPs Yard waste dumping	velocity of runoff. ● Increase the number of small and medium size producers that have certified nutrient management plans. ● Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration. ● Increase knowledge and use of soil erosion reduction and runoff control techniques on agricultural and urban land. ● Work with golf courses and parks departments to encourage proper fertilizer management and yard waste disposal. ● Promote residential soil testing, education about fertilizer use, and encourage proper yard waste disposal. ● Revise local weed and phosphorus limiting ordinances in urban areas to encourage the reduction of lawn areas and the use of natural landscaping and native plants. ● Upgrade or replace failing or faulty onsite sewage disposal systems.
Prevent pathogens from entering surface waters of the Watershed and strive to meet applicable water quality standards in Ruddiman Creek	**Pathogens**	Animal Waste Failing Septic Systems Lack of agricultural BMPs	● Increase property owner awareness about the value of properly designed, installed, and maintained septic systems, particularly in areas with high water tables, porous soils, and those near surface water and storm sewers. ● Find illicit connections in urban areas, such as illegal storm sewer hookups, and prevent illicit discharges from entering surface waters.

Table 13 - Goals and Objectives of the Muskegon Lake Watershed

Long-term Goals	Pollutants of Concern	Sources and Causes	Short-term Objectives
			• Develop and implement residential/commercial storm water education programs in urban areas. • Increase the development of certified manure management plans. • Reduce the amount of pet waste entering surface waters. • Encourage proper disposal of waste from recreational vessels. • Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration. • Upgrade or replace failing or faulty onsite sewage disposal systems. • Eliminate illicit discharges. • Find sources from agricultural areas and implement BMPs to prevent contamination of surface waters and increase the knowledge and use of runoff control techniques on agricultural land.
Reduce sources of thermal pollution impacting Muskegon River, Bear Creek, and Little Bear Creek	**Thermal pollution**	Impervious surfaces Removal of bank vegetation	• Implement shoreline protection and restoration practices in riparian areas. • Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by

Table 13 - Goals and Objectives of the Muskegon Lake Watershed

Long-term Goals	Pollutants of Concern	Sources and Causes	Short-term Objectives
		Sedimentation	encouraging storm water infiltration.
Stabilize stream flows to moderate hydrology and increase base flow; this is especially important in the urban wetland areas of Ruddiman Creek, Ryerson Creek, and Four Mile Creek, which are impacted by unstable hydrology from storm water flows	**Unstable hydrology**	Channelization Floodplain development and destruction Impervious surfaces Storm sewer discharge quantity and velocity Wetland destruction	• Follow recommendations from hydrologic models. • Discourage irrigation in certain areas where base flow must be maintained. • Protect floodplains and mitigate impacts. • Establish storm water management criteria for new developments. • Encourage LID practices. • Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration. • Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff.

Notes:
BMPs = Best Management Practices
SESC = Soil Erosion and Sediment Control
LID = Low Impact Development

CHAPTER 5 - IMPLEMENTATION STRATEGY

5.1 BEST MANAGEMENT PRACTICE RECOMMENDATIONS

Best Management Practices (BMPs) are land management practices that treat, prevent, or reduce water pollution and are classified into three groups: structural, vegetative, and managerial. Structural BMPs are physical improvements that require construction during installation. Examples of structural BMPs include check dams, detention basins, and rock riprap. BMPs that utilize plants to stabilize soils, filter runoff, or slow water velocity are categorized as vegetative BMPs. Managerial BMPs involve changing operating procedures to lessen water quality impairments. Conservation tillage and adoption of ordinances are examples of these types of BMPs.

In some cases, a BMP will not fall into any of the three categories described above. Educational programs are one such example. Information and Education (I&E) strategies are a necessary component of all watershed management plans (WMPs). An I&E strategy can be used to inform the public and motivate them to take action. Without I&E, land owners, residents, and municipal officials would not have an understanding of why BMPs are necessary.

The Nonpoint Source (NPS) Committee discussed, reviewed, and recommended potential BMPs for the Muskegon Lake Watershed (Watershed). BMPs were chosen after considering sources and causes of watershed pollution and their impacts on designated uses. The final set of BMPs recommended for the Watershed is listed in Table 12. Implementation of these practices will make progress toward meeting long-term goals and short-term objectives. It should be noted that BMP treatments may not work on all locations; therefore, it will be necessary to visit potential installation sites before final plans are made for implementation. In addition to physical conditions of the site, the willingness of the property owner should be considered when selecting BMP implementation sites. A BMP should not be installed if the property owner has not been made a cooperative partner in the decision-making process. Issues and recommendations of special concern, as outlined by the Muskegon Lake Public Advisory Council (PAC) are noted below:

1. Important urban wetland areas located in Ruddiman Creek, Ryerson Creek, and Four Mile Creek Watersheds are impacted by unstable hydrology from storm water flows. Runoff from impervious surfaces during storm events has resulted in increased sedimentation and proliferation of cattails in the wetlands. This results in poor diversity in the flora and fauna in addition to reducing the capacity of the wetlands to treat storm water. Storm water treatment methods, including rain gardens and retention/detention basins, need to be implemented in each of the Watersheds. Since

Ruddiman Creek is impacted to the greatest extent, incentive programs to turn abandoned factory parking lots into rain gardens, wetlands, or detention basins should be investigated.

2. Blooms of Cladaphora, a filamentous alga, in many storm drains and tributaries indicate the presences of excessive nutrients. High-nutrient levels stimulate plant production, which causes localized oxygen depletion and contributes to eutrophication in Muskegon Lake. Nutrient management programs are needed to lower phosphorus levels in storm water. Efforts to improve the hydrology in urban wetlands also will help lower nutrient levels.

3. Because very little is known about storm water quality and quantity, hydrological assessments and water quality monitoring is needed to help prioritize remedial actions.

5.2 COST/BENEFIT OF AND COMMITMENTS TO IMPLEMENTING BEST MANAGEMENT PRACTICES

Committing to actions without understanding the cost of the action can cause problems when it comes time for implementation. For this reason, proposed actions have been flagged as having “minimal” (< $500), “moderate” ($500 to $5,000), or “high” costs (>$5,000) to help permittees determine what can feasibly be implemented. These cost categories are included in column three of Table 14. Actual costs for BMP implementation will vary according to site conditions. Generally, costs will be lower when multiple BMPs are installed simultaneously.

It is also important for permittees to consider the benefits of each action as some actions are more beneficial than others. Actions with the most benefit should be considered before actions with a lesser benefit. Therefore, recommendations have been flagged as having a “minimal,” “moderate,” or “high” benefit in terms of either social awareness or water quality improvements (Table 14). Actions identified as most beneficial are those considered the most effective at preventing, treating, or reducing water pollution.

Prior to making final commitments in the Storm Water Pollution Prevention Initiative (SWPPI), permittees are required to make initial commitments to implementing actions. These initial commitments are also included in Table 14.

5.3 METHODS OF EVALUATION

In order to assess the effectiveness of each proposed action at reducing water pollution, an evaluation process is necessary. Evaluation methods have been selected for each proposed action to determine its success at preventing, reducing, and treating water pollution (Table 14). I&E efforts will be evaluated on

their effectiveness at informing and educating the public, as well as inspiring individuals to take action. Evaluation methods can be classified as qualitative or quantitative in nature.

Qualitative evaluation is an assessment process that measures how well something was done. Qualitative measurements that are recommended can be used to measure the success of stakeholder participation and community involvement in improving the quality of life in the Watershed. For example, the number of individuals attending a training session and receiving a certificate could be a measure of the program's success. These types of measurements are considered interim measures of success, those that mark milestones rather than environmental improvements.

Quantitative evaluation is an assessment process that measures how much of something was done or changed. Quantitative measurements are further defined by categories of indirect and direct indicators. Indirect indicators are those that measure practices and activities that could indicate water quality improvements, but do not actually measure water quality. For example, estimating the pollutant reduction that a practice will achieve is stating that a certain amount of that pollutant will be prevented from entering the stream, but not necessarily improving water quality. Direct environmental indicators measure water quality through scientific investigation. Sediment load reduction could be measured by secchi disks, and nutrient load reductions could be measured through chemical analysis of the water. Macroinvertebrate surveys are also direct indicators of water quality, since some insects are very sensitive to change in a stream's health.

Evaluation methods can also be categorized as methods to measure watershed activities or methods to measure water quality results. Watershed activities can be measured as a way to show what the permittee has implemented to carry out storm water controls. Examples of activity measurements include the number of brochures distributed, number of workshop participants, or number of watershed presentations. In addition, water quality results can be measured as a way to show how implemented activities have affected the watershed. Examples of result measurements include direct assessment of resource, tracking pollution removal or prevention, and social surveys. Measurements of watershed activities and water quality results are included in Table 14.

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
Prevent soil erosion and reduce sedimentation in Muskegon Lake and its tributaries	Offer training to planning departments, road commissions, building/permitting officials, and contractors so that soil erosion control BMPs are considered an integrated part of the site planning and design process	Moderate cost and a moderate social awareness benefit	Number of attendees at each training session Follow-up survey of attendees to determine if practices have been integrated	Create a contact list of planning departments, SESC enforcement agencies, road commissions, building/permitting officials, and contractors Develop list of soil erosion control BMPs to promote at workshops Develop materials for presentations	Hold workshops in each township/city	SESC enforcement agencies MS4 communities Road commission DPWs
	Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP	Implement PEP activities slated for 2005 to 2008	Implement PEP activities slated for 2008 to 2013	MS4 communities Health department Road commission DPWs
	Implement shoreline protection and restoration practices in riparian areas	Moderate cost and a high water quality improvement benefit	Evaluation methods outlined in PEP Number of demonstration sites implemented	Create contact list of riparian property owners, garden centers, lawn care companies, and nurseries in targeted areas Prioritize riparian properties to be targeted by geography, hydrology, natural features and sediment loading Create implementation schedule for demonstration sites based on prioritization Implement PEP activities slated for 2005 to 2008	Follow up with contacts made through mailings and technical assistance Establish demonstration sites Develop and adopt a stream buffer ordinance Implement PEP activities slated for 2008 to 2013	MS4 communities Conservation district Land conservancy Nature conservancy NRCS Drain commissioner Nurseries Garden centers Watershed organizations
	Increase knowledge and use of soil erosion reduction and runoff control techniques on agricultural and urban land	High to moderate cost and high to moderate water quality improvement benefit	Number of attendees at field walks and farmer meetings Record personal contacts made Number and locations of BMPs implemented Before and after photos of sites where BMPs installed Reduction in the amount of sediment loading per site Amount of material collected through street sweeping	Identify and prioritize erosion sites on agricultural land using pollution reduction calculations Host field walks and farmer meetings Publish articles in agricultural newspapers Make personal contacts with producers	Implement BMPs, such as cattle exclusion and filter strips, on agricultural land in high priority areas Encourage road commissions and departments of public works to implement a regular street sweeping schedule Install urban sediment controls such as oil/grit separators	NRCS Road commission Conservation districts MSUE County farm bureau Cities, townships, and villages
	Survey road-stream crossings and prioritize sites for future improvement	High to moderate cost and high to moderate water quality improvement benefit	Number of road stream crossings surveyed Prioritized list of crossings needing improvements Number of high priority sites improved Reduction in the amount of sediment loading per site	Train staff and volunteers to assess crossings Survey 10% of total crossings each year Develop a prioritized list of crossing needing improvements	Implement improvements to high priority crossings Complete survey of crossings	Road commissions DPWs MDEQ Watershed organizations Drain commissioners MS4 communities

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas	High cost and high water quality improvement benefit	Number of communities adopting ordinances Number of conservations easements established Number construction projects incorporating LID techniques or other BMPs Stream monitoring during storm events to measure flow, volume, and velocity	Develop model storm water ordinance Develop model wetland protection ordinance Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques Identify natural areas that help control runoff Protect urban wetlands by addressing unstable hydrology and implementing storm water controls such as rain gardens, porous pavement, and retention/detention ponds	Adopt storm water ordinance Adopt wetland protection ordinance Adopt regionally consistent ordinances for LID Implement LID techniques in high priority areas Protect natural areas through adoption of ordinances and establishment of conservation easements Implement storm water runoff controls	MS4 communities Developers Drain commissioners Land conservancy
	Additional state and local funding for enforcement of SESC	Minimal cost and high water quality improvement benefit	Amount of funding	Create list of potential funding sources Identify program needs Apply for funding Review current fee schedule	Increase overall funding allocations for SESC program	County enforcing agents Municipal enforcing agents MDEQ (technical assistance)
Reduce concentrations of heavy metals, toxic substances, and hydrocarbons	Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff and discourage dumping into storm drains	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP	Implement PEP activities slated for 2005 to 2008	Implement PEP activities slated for 2008 to 2013	MS4 communities
	Increase knowledge about benefits of integrated pest management and the safe use of pesticides/herbicides among property owners	Minimal cost and a minimal to moderate social awareness benefit	Number of attendees at workshops Number of brochures distributed (PEP Activity) Number of IPM plans implemented	Hold workshops on IPM and landscape management for property owners Distribute brochure on the effects of lawn and garden products on the environment (PEP activity)	Increase in number of producers with IPM plans	NRCS Conservation districts MSUE MS4 communities
	Increase the number of small and medium size producers who complete chemical storage and handling assessments, particularly in areas with high water tables, porous soils, and those near surface or sensitive water resources	Moderate cost and a high water quality improvement benefit	Number of farms completing assessments	Prioritize farms in need of chemical storage and handing assessments	Complete assessments on high priority farms	MSUE groundwater technicians NRCS Conservation districts
	Promote hazardous waste collection programs	Minimal cost and a minimal social awareness benefit	Amount of hazardous substances collected by the county household hazardous waste collection program Evaluation methods noted in the PEP	Implement PEP activities slated for 2003 to 2008 Distribute brochures and provide online information to promote the county household hazardous waste collection program	Implement PEP activities slated for 2008 to 2013 Continue to distribute brochures on the county household hazardous waste collection program	MS4 communities County DPW
	Minimize effects of DPW and road commission waste, chemical, and salt storage areas and control road salt runoff	Moderate cost and a moderate to high water quality benefit	Number of runoff control BMPs installed Number of practices implemented to control waste, chemical, and salt storage areas and control road salt runoff	Work with DPWs and road commission to manage dumpsters, street sweeping waste, and catch basin cleaning waste Work with DPWs and road commission to address chemical and salt storage areas and calibrate salt application equipment	Implement runoff control BMPs where necessary	Road commission DPW MS4 communities
	Eliminate illicit discharges	Moderate cost and a high water quality improvement benefit	Number of communities adopting IDEP ordinance	Adopt and enforce IDEP ordinance	Enforce ordinance	MS4 communities

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Work with the MDEQ to address leaking underground storage tanks and impacts from past industrial discharges	High cost and a high water quality improvement benefit	Number of sites with completed remedial actions	Use hydrological assessments and water quality monitoring to help prioritize remedial actions	Work with MDEQ and the EPA to complete remedial actions in watersheds impacted heavily with heavy metals, toxic substances, and hydrocarbons	MDEQ EPA MS4 communities
Reduce nutrient loading of Muskegon Lake and its tributaries with particular attention to sources of phosphorus	Increase property owner awareness about the value of properly designed, installed, and maintained septic systems, particularly in areas with high water tables, porous soils, and those near surface water and storm sewers	High cost and a high water quality improvement benefit	Number of realtors and homeowners participating in workshops Number of homeowners receiving guidebooks Number of failed OSDSs found during inspections	Develop mailing list from tax bills, deleting those with water and sewer services Distribute *Septic System Owner's Guidebook* to appropriate homeowners Hold workshops for homeowners on proper septic system maintenance Hold workshops for realtors to introduce material and establish distribution networks	Establish long-term program to distribute copies of the *Septic System Owner's Guidebook* to new homeowners with septic systems Develop time-of-sale septic system inspections	Association of realtors Health department MS4 communities
	Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP	Implement PEP activities slated for 2005 - 2008	Implement PEP activities slated for 2008 through 2013	MS4 communities
	Increase the number of small and medium size producers that have certified nutrient management plans	Moderate to high cost and a high water quality improvement benefit	Number of producers with approved CNMPs Reduction in amount of nutrients entering the waterways, based on pollution reduction calculations	Identify and prioritize agricultural operations in need of CNMPs	Develop CNMPs for high priority operations	NRCS Conservation districts MSUE MDA

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration	High cost and high water quality improvement benefit	Number of communities adopting ordinances Number of conservations easements established Number construction projects incorporating LID techniques or other BMPs Stream monitoring during storm events to measure flow, volume, and velocity	Develop model storm water ordinance Develop model wetland protection ordinance Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques Identify natural areas that help control runoff Protect urban wetlands by addressing unstable hydrology and implementing storm water controls such as rain gardens, porous pavement, and retention/detention ponds	Adopt storm water ordinance Adopt wetland protection ordinance Adopt regionally consistent ordinances for LID Implement LID techniques in high priority areas Protect natural areas through adoption of ordinances and establishment of conservation easements Implement storm water runoff controls	MS4 communities Developers Drain commissioners Land conservancy
	Increase knowledge and use of soil erosion reduction and runoff control techniques on agricultural and urban land	High to moderate cost and high to moderate water quality improvement benefit	Number of attendees at field walks and farmer meetings Record personal contacts made Number and locations of BMPs implemented Before and after photos of sites where BMPs installed Reduction in the amount of sediment loading per site Amount of material collected through street sweeping	Identify and prioritize erosion sites on agricultural land using pollution reduction calculations Host field walks and farmer meetings Publish articles in agricultural newspapers Make personal contacts with producers	Implement BMPs such as cattle exclusion and filter strips, on agricultural land in high priority areas Encourage road commissions and departments of public works to implement a regular street sweeping schedule Install urban sediment controls such as oil/grit separators	NRCS Conservation districts MSUE County farm bureau Cities, townships, and villages Road commission
	Work with golf courses and parks departments to encourage proper fertilizer management and yard waste disposal	Minimal cost and a moderate social awareness benefit	Number of brochures distributed Exit survey responses from meetings	Distribute brochures to golf courses and parks departments on the impacts of improper fertilizer management and yard waste disposal	Schedule meetings with golf courses and parks departments to encourage proper fertilizer management and yard waste disposal	MS4 communities
	Promote residential soil testing, education about fertilizer use, and encourage proper yard waste disposal	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP Number of website hits	Implement PEP activities slated for 2005 to 2008 Distribute brochures and provide online information on improper yard waste disposal on the environment Distribute brochures and provide online information to promote MSUE's soil testing program	Implement PEP activities slated for 2008 to 2013 Continue to distribute brochures on proper yard waste disposal and MSUE's soil testing program *Wishlist for the Future:* *County-wide ordinance requiring the use of low phosphorous fertilizers*	MS4 communities MSUE
	Revise local weed and phosphorus limiting ordinances in urban areas to encourage the reduction of lawn areas and the use of natural landscaping and native plants	High cost and a high water quality improvement benefit	Number of ordinances reviewed Number of ordinances needing revision Number of planning officials and commissions receiving educational materials Number of ordinances revised and adopted	Review existing ordinances Schedule meetings with planning officials and commissions to provide educational materials on the benefits of reducing lawn areas and the use of natural landscaping and native plants; discuss revisions to existing ordinances	Revise and adopt ordinances	MS4 communities

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Upgrade or replace failing or faulty onsite sewage disposal systems	High cost and a high water quality improvement benefit	Adoption of revised county OSDS ordinance Number of nutrient removal technologies implemented	Review existing county OSDS ordinance Schedule meetings with county health department to discuss possible revisions to the county OSDS ordinance Work with county health department and MDEQ on expanding use of nutrient removal technologies such as constructed wetlands for treatment	Revise existing OSDS county ordinance to allow for inspection of systems and the assessment of fines for noncompliance Implement accepted nutrient removal technologies for treatment *Wish list for the future:* *County-wide ordinance requiring inspection of wells and septic systems every three years and before a home's sale can be completed* *Install sanitary sewers in communities where soils are unsuitable for septic systems and where septic systems are utilized*	MS4 communities Health department MDEQ
Prevent pathogens from entering surface waters flowing to Muskegon Lake	Increase property owner awareness about the value of properly designed, installed, and maintained septic systems, particularly in areas with high water tables, porous soils, and those near surface water and storm sewers	High cost and a high water quality improvement benefit	Number of realtors and homeowners participating in workshops Number of homeowners receiving guidebooks Number of failed OSDSs found during inspections	Develop mailing list from tax bills, deleting those with water and sewer services Distribute *Septic System Owner's Guidebook* to appropriate homeowners Hold workshops for homeowners on proper septic system maintenance Hold workshops for realtors to introduce material and establish distribution networks	Establish long-term program to distribute copies of the *Septic System Owner's Guidebook* to new homeowners with septic systems Develop time-of-sale septic system inspections	Association of realtors Health department MS4 communities
	Find illicit connections in urban areas, such as illegal storm sewer hookups, and prevent illicit discharges from entering surface waters	Moderate to high cost and a moderate to high water quality improvement benefit	Evaluation methods outlined in PEP Number of calls to the telephone hotline to report an illicit discharge or connection (PEP activity) Number of illicit connections disconnected Number of illicit discharges addressed	Implement PEP activities slated for 2005 to 2008 Establish a telephone reporting system for residents to report illicit discharges and connections to the storm sewer (PEP activity) Implement the IDEP to identify and address illicit discharge and connections to the storm sewer	Implement PEP activities slated for 2008 to 2013 Implement the IDEP to identify and address illicit discharge and connections to the storm sewer.	MS4 communities Health department
	Develop and implement residential/commercial storm water education programs in urban areas	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP	Implement PEP activities slated for 2005 - 2008	Implement PEP activities slated for 2008 to 2013	MS4 communities
	Increase the development of certified manure management plans	Moderate to high cost and a high water quality improvement benefit	Number of producers with approved manure management plans Reduction in number of livestock with access to waterways	Identify and prioritize areas in need of manure management plans	Develop manure management plans in high priority sites	NRCS Conservation districts MSU extension MDA
	Reduce amount of pet waste entering surface waters	Low to moderate cost and a moderate water quality improvement	Number of plastic bags used for paper waste disposal Number of signs placed in parks Adoption of ordinances	Provide plastic bags and waste receptacles at parks for proper pet waste disposal	Place signage in parks to encourage proper pet waste disposal Adopt pet waste ordinances	MS4 communities Health department
	Encourage proper disposal of waste from recreational vessels	Moderate cost and a moderate to high water quality improvement benefit	Number of pump out and dump stations installed	Identify marinas that do not provide pump out options for recreational vessels	Install pump out and dump stations to dispose of vessel waste	Marinas MDNR Health department

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration	High cost and high water quality improvement benefit	Number of communities adopting ordinances Number of conservations easements established Number construction projects incorporating LID techniques or other BMPs Stream monitoring during storm events to measure flow, volume, and velocity	Develop model storm water ordinance Develop model wetland protection ordinance Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques Identify natural areas that help control runoff Protect urban wetlands by addressing unstable hydrology and implementing storm water controls such as rain gardens, porous pavement, and retention/detention ponds	Adopt storm water ordinance Adopt wetland protection ordinance Adopt regionally consistent ordinances for LID Implement LID techniques in high priority areas Protect natural areas through adoption of ordinances and establishment of conservation easements Implement storm water runoff controls	MS4 communities Developers Drain commissioners Land conservancy
	Upgrade or replace failing or faulty onsite sewage disposal systems	High cost and a high water quality improvement benefit	Adoption of revised county OSDS ordinance Number of nutrient removal technologies implemented	Review existing county OSDS ordinance Schedule meetings with county health department to discuss possible revisions to the county OSDS ordinance Work with county health department and MDEQ on expanding use of nutrient removal technologies such as constructed wetlands for treatment	Revise existing OSDS county ordinance to allow for inspection of systems and the assessment of fines for noncompliance Implement accepted nutrient removal technologies for treatment *Wish list for the future:* *County-wide ordinance requiring inspection of wells and septic systems every three years and before a home's sale can be completed* *Install sanitary sewers in communities where soils are unsuitable for septic systems and where septic systems are utilized*	MS4 communities Health department MDEQ
	Eliminate illicit discharges	Moderate cost and a high water quality improvement benefit	Number of communities adopting IDEP ordinance	Adopt and enforce IDEP ordinance	Enforce IDEP ordinance	MS4 communities
	Find sources from agricultural areas and implement BMPs to prevent contamination of surface waters and increase the knowledge and use of runoff control techniques on agricultural land	Moderate to high cost and a high water quality improvement benefit	Number of agricultural areas in need of BMPs to control animal waste runoff Number of producers attending workshops Number of personal contacts made with producers Number and locations of BMPs implemented Before and after photographs of sites where BMPs installed	Identify and prioritize agricultural areas in need of BMPs to control animal waste runoff Hold workshops for producers to distribute information on runoff control techniques Make personal contacts with producers	Implement BMPs on agricultural land in high priority areas	NRCS Conservation districts MSUE County farm bureau
Reduce sources of thermal pollution to Little Black Creek	Implement shoreline protection and restoration practices in riparian areas	Moderate cost and a high water quality improvement benefit	Evaluation methods outlined in PEP Number of demonstration sites implemented	Create contact list of riparian property owners, garden centers, lawn care companies, and nurseries in targeted areas Prioritize riparian properties to be targeted by geography, hydrology, natural features and sediment loading Create implementation schedule for demonstration sites based on prioritization Implement PEP activities slated for 2005 to 2008	Follow up with contacts made through mailings and technical assistance Establish demonstration sites Develop and adopt a stream buffer ordinance Implement PEP activities slated for 2008 to 2013	MS4 communities Conservation district Land conservancy Nature conservancy NRCS Drain commissioners Nurseries Garden centers Watershed organizations

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration	High cost and high water quality improvement benefit	Number of communities adopting ordinances Number of conservations easements established Number construction projects incorporating LID techniques or other BMPs Stream monitoring during storm events to measure flow, volume, and velocity	Develop model storm water ordinance Develop model wetland protection ordinance Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques Identify natural areas that help control runoff Protect urban wetlands by addressing unstable hydrology and implementing storm water controls such as rain gardens, porous pavement, and retention/detention ponds	Adopt storm water ordinance Adopt wetland protection ordinance Adopt regionally consistent ordinances for LID Implement LID techniques in high priority areas Protect natural areas through adoption of ordinances and establishment of conservation easements Implement storm water runoff controls	MS4 communities Developers Drain commissioners Land conservancy
Stabilize stream flows to moderate hydrology and increase base flow	Follow recommendations from hydrologic models	Moderate cost and a high water quality improvement benefit	Number of storm water controls installed Results of hydrographs if model run again after practices installed	Use hydrological assessments to address unstable hydrology issues by installing storm water controls	Use hydrological assessments to address unstable hydrology issues by installing storm water controls	Consultants Drain commissioners MDEQ MS4 communities
	Discourage irrigation in certain areas where base flow must be maintained	Minimal to moderate cost and moderate to high water quality improvement benefit	Number of farms irrigating in areas where flow must be maintained	Identify areas where flow must be maintained where irrigation is also occurring Contact agricultural producers irrigating in these areas and provide educational materials	Implement irrigation schedule where recommended	NRCS Conservation district MDA MDEQ
	Protect floodplains and mitigate impacts	High cost and a high water quality improvement benefit	Adoption of new or revised floodplain ordinances	Complete floodplain delineations	Adopt/enhance floodplain ordinance to protect areas	FEMA Cities, townships, and villages County planning departments
	Establish storm water management criteria for new developments	Moderate cost and a high water quality improvement benefit	Ease and frequency of use of storm water management criteria	Adopt storm water management criteria for new developments Provide workshops on storm water management criteria for new developments	Incorporate storm water management criteria in new developments	MS4 communities Drain commissioner County planning department
	Encourage LID practices	Moderate cost and a high water quality improvement benefit	Number of communities adopting ordinances Number of construction projects incorporating LID techniques Stream monitoring during storm events to measure flow, volume, and velocity	Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques	Adopt regionally consistent ordinances for LID Implement LID techniques	MS4 communities Developers Drain commissioners Land conservancy

Table 14 - Implementation Activities

Long-term Goals	Short-term Objectives	Cost/Benefit	Evaluation Method	Best Management Practices		Commitment
				Within 3 Years - 2008	Within 8 Years - 2013	
	Reduce the volume and velocity of storm water runoff entering surface waters in urban and developing areas by encouraging storm water infiltration	High cost and high water quality improvement benefit	Number of communities adopting ordinances Number of conservations easements established Number construction projects incorporating LID techniques or other BMPs Stream monitoring during storm events to measure flow, volume, and velocity	Develop model storm water ordinance Develop model wetland protection ordinance Develop model ordinances to encourage LID Identify and prioritize opportunities to implement LID techniques Identify natural areas that help control runoff Protect urban wetlands by addressing unstable hydrology and implementing storm water controls such as rain gardens, porous pavement, and retention/detention ponds	Adopt storm water ordinance Adopt wetland protection ordinance Adopt regionally consistent ordinances for LID Implement LID techniques in high priority areas Protect natural areas through adoption of ordinances and establishment of conservation easements Implement storm water runoff controls	MS4 communities Developers Drain commissioners Land conservancy
	Develop and implement residential/commercial storm water education programs in urban areas to reduce volume and velocity of runoff	Minimal cost and a minimal social awareness benefit	Evaluation methods outlined in PEP	Implement PEP activities slated for 2005 to 2008	Implement PEP activities slated for 2008 to 2013	MS4 communities

Notes:

BMPs = Best Management Practices
PEP = Public Education Plan
SESC = Soil Erosion and Sediment Control
MS4 = Municipal Separate Storm Sewer System
NRCS = USDA Natural Resources Conservation Service
MSUE = Michigan State University Extension
DPW = Department of Public Works
MDEQ = Michigan Department of Environmental Quality
IPM = Integrated Pest Management
LID = Low Impact Development
EPA - U.S. Environmental Protection Agency
OSDS = Onsite Sewage Disposal Systems
CNMPs = Comprehensive Nutrient Management Plans
MDA = Michigan Department of Agriculture
IDEP = Illicit Discharge Elimination Plan
FEMA = Federal Emergency Management Agency

CHAPTER 6 - SUSTAINABILITY

6.1 MUSKEGON AREA STORM WATER COMMITTEE

Several communities within the Muskegon Lake Watershed joined those of the Mona Lake Watershed and the Lower Grand River Watershed to form the Muskegon Area Storm Water Committee (MASWC) in order to begin controlling direct discharges into the surface waters of the state. In 2004, the MASWC began coordination with the Muskegon Lake Public Advisory Committee (PAC) and the Muskegon River Watershed Assembly (MRWA) to develop the Muskegon Lake Watershed Management Plan (WMP). This WMP will provide the MASWC with the necessary information to implement recommendations to meet short-term objectives and long-term goals in accordance with the National Pollutant Discharge Elimination System Phase II Storm Water Program.

6.2 MUSKEGON LAKE PUBLIC ADVISORY COMMITTEE

According to their website, the Muskegon Lake PAC is “a coalition of community interests dedicated to working cooperatively for the improvement of the Muskegon Lake ecosystem through the Remedial Action Plan (RAP) process.” The Muskegon Lake PAC was formed in October 1993 to obtain stakeholder input on the implementation of the RAP for Muskegon Lake, designated as an Area of Concern (AOC) in 1985. The Muskegon Lake PAC has continued to involve the public in the implementation of the Muskegon Lake RAP through monthly public meetings. Updates to the original Muskegon Lake RAP, written in 1987, were completed in 1994 and 2002. In 2001, the Muskegon Lake PAC adopted the U.S. RAP Workgroup’s Delisting Principles and Guidelines and is currently working toward delisting Muskegon Lake as an AOC.

6.3 MUSKEGON RIVER WATERSHED ASSEMBLY

According to the MRWA's website, their mission is to "preserve, protect, and enhance the natural, historic, and cultural resources of the Muskegon River Watershed through educational and scientific initiatives, while supporting positive economic development, agricultural, and quality of life initiatives of organizations working in the river watershed." The MRWA has been involved in numerous projects including the Bear Creek Transition/Implementation Project (2004 to 2006), the Muskegon Lake and Estuary Emergent Vegetation Restoration Demonstration Project (2002 to 2005), and the Muskegon River Watershed Project (2000 to 2002). The MRWA has four committees that meet three to six times per year: the Data Repository Committee, the Information/Education Committee, the Finance/Human Resources Committee, and the Resource Committee. In the spring of 2005, the MRWA received notice that their volunteer stream monitoring grant proposal was approved for funding. This project will train volunteers and provide the necessary equipment to conduct water monitoring in the Muskegon River Watershed. The four targeted areas of the project include the Tamarack Creek subwatershed, the Ryan/Mitchell Creek subwatershed, the Clam River subwatershed, and the West Branch Muskegon River subwatershed.

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