LOCAL SURFACE WATER MANAGEMENT PLAN

FOR THE

CITY OF ST. PAUL, MINNESOTA

FINAL DRAFT
JULY 2018

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List of Acronyms

BMP	Best Management Practices
CRWD	Capitol Region Watershed District
LGU	Local Government Unit
LMRWMO	Lower Mississippi River Watershed Management Organization
LSWMP	Local Surface Water Management Plan
BWSR	Board of Water and Soil Resources
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
FIRM	Flood Insurance Rate Map
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
MCBS	Minnesota County Biological Survey
MDH	Minnesota Department of Health
MGD	Million gallons per day
MGS	Minnesota Geological Survey
MNDNR	Minnesota Department of Natural Resources
MNDOT	Minnesota Department of Transportation
MNRRA	Mississippi Natural River and Recreation Area
MPCA	Minnesota Pollution Control Agency
MRCCA	Mississippi River Corridor Critical Area
MS4	Municipal Separate Storm Sewer System
MWMO	Mississippi Watershed Management Organization
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
PCB	Polychlorinated Biphenyls
RFC	Request For Comments
RWMWD	Ramsey-Washington Metro Watershed District
SONAR	Statement of Need and Reasonableness
SPRWS	St. Paul Regional Water Service
SSGI	Shared Stacked Green Infrastructure
SWPPP	Stormwater Pollution Prevention Plan
TCMA	Twin Cities Metropolitan Area
TMDL	Total Maximum Daily Load
TOD	Transit Oriented Development
TP	Total Phosphorus
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
WCA	Wetland Conservation Act of 1991
WD	Watershed District
WMO	Watershed Management Organization

SECTION 1

1. EXECUTIVE SUMMARY

1.1. Background

This report provides the City of St. Paul with a Local Surface Water Management Plan (LSWMP) that serves as a guide to managing the City's surface water system, and brings the City into compliance with Minnesota Statutes. This plan is an update to the 2006 LSWMP. The plan will guide stormwater activities in the City for the next 10 years (2018-2027). If significant changes to the plan are deemed necessary prior to that date, the City may revise this plan in its entirety.

The City of St. Paul (population 294,870) is located in Ramsey County in the seven county Twin Cities metropolitan area (**Figure A1**, **Appendix A**). The City covers over 56 square miles. All surface water eventually discharges into the Mississippi River. Few natural wetlands remain because of their removal and alteration from urbanization and development over the past century.

1.2. Local Surface Water Management Plan Purposes

The City of St. Paul's Local Surface Water Management Plan (LSWMP) is a local management plan that meets the requirements of Minnesota Statutes 103B.235, Minnesota Rules 8410 and Minnesota Statute 103B.201. St. Paul's LSWMP addresses the purposes of water management programs as listed by Minnesota Statute 103B.201:

- Protect, preserve, and use natural surface and groundwater storage and retention systems;
- Minimize public capital expenditures needed to correct flooding and water quality problems;
- Identify and plan for means to effectively protect and improve surface and groundwater quality;
- Establish more uniform local policies and official controls for surface and groundwater management;
- Prevent erosion of soil into surface water systems;
- Promote groundwater recharge;
- Protect and enhance fish and wildlife habitat and water recreational facilities; and
- Secure the other benefits associated with the proper management of surface and groundwater.

1.3. Surface Water Management Responsibilities and Related Agreements

In addition to being in conformance with the above state law, this LSWMP has been developed to meet the needs, requirements, and direction outlined by the watershed districts (WDs) and watershed management organizations (WMOs) whose rules and regulations apply to the City of St. Paul. **Figure A2** in Appendix A illustrates the Watershed Management Organization Boundaries in St. Paul.

- Capitol Region Watershed District (CRWD) Plan
- Ramsey-Washington Metro Watershed District (RWMWD) Plan
- Lower Mississippi River Watershed Management Organization (LMRWMO) Plan
- Mississippi Watershed Management Organization (MWMO) Plan

This LSWMP also incorporates the following regulations from the State level:

- State Laws and Rules concerning wetland management as outlined in the Wetland Conservation Act of 1991 and amendments
- State and Federal laws regarding the need to secure a National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge permit

The City has entered into water resource-related agreements that govern in part how the City must manage its water resources. These agreements include joint powers agreements between the City and Watershed Management Organizations having jurisdiction within its boundaries, agreements between the City and adjoining communities, or agreements it may have with other governmental units or private parties. Listed below is a description of the water resource related agreements which the City has entered into.

Cities of Inver Grove Heights, Lilydale, St. Paul, Mendota Heights, South St. Paul, Sunfish Lake, and West St. Paul

- Joint powers agreement for the establishment of the Lower Mississippi River Watershed Management Organization to provide an organization to preserve and use the natural water storage and retention of the Lower Mississippi River Watershed, 1985. This was updated in 2003.

Cities of Columbia Heights, Fridley, Hilltop, Lauderdale, Minneapolis, St. Anthony Village, St. Paul and Minneapolis Park and Recreation Board

- Joint Powers Agreement for the establishment of the Middle Mississippi River Watershed Management Organization, 1985.
- Amended Joint and Cooperative Agreement for the establishment of the Middle Mississippi River Watershed Management Organization, 1997.
- Restated Joint and Cooperative Agreement for the establishment of the Mississippi Watershed Management Organization, 2002.
- Joint and Cooperative Agreement for the Mississippi Watershed Management Organization, 2012

1.4. Executive Summary

The St. Paul Local Surface Water Management Plan is divided into six sections:

- **Section 1.0 Executive Summary** provides background information and summarizes the plan contents.
- **Section 2.0 Land and Water Resource Inventory** presents information about the topography, geology, groundwater, soils, land use, public utilities, surface waters, hydrologic system and data, and the drainage system.
- **Section 3.0 Agency Cooperation** outlines other governmental controls and programs that affect stormwater management.
- **Section 4.0 Assessment of Problems and Issues** presents the City's water management related problems and issues.
- **Section 5.0 Goals and Policies** outlines the City's goals and policies pertaining to water management.
- **Section 6.0 Implementation Program** presents the implementation program for the City of St. Paul, which includes defining responsibilities, prioritizing, and listing the program elements. **Table 6-1** outlines the projects, programs, studies, and Stormwater Management Program activities that have been identified as a priority to address water resource needs and problem areas within the City.

SECTION 2

2. LAND AND WATER RESOURCE INVENTORY

2.1. Topography and Geology

2.1.1.Topography

The topography of the City of St. Paul varies from steep river bluffs along the Mississippi River to moderately or gently rolling land north and south of the river. Stormwater runoff from the City is generally directed from higher elevations to depression areas. A majority of stormwater runoff drains to the Mississippi River either directly via storm sewer systems, or indirectly due to the topography.

The majority of St. Paul is urban with an elevation of 900 feet above sea level, approximately 200 feet above the Mississippi River. The area north of the bluff is relatively flat. The area south of the bluff gradually increases in elevation. The highest elevation within the City of St. Paul is 1,070 feet above sea level at Hillcrest Golf Course. The lowest elevation is 687 feet above sea level in the Mississippi River floodplain.

The City's hydrologic system is divided into many major watersheds. Drainage areas, which depict the topography for areas within the city, are shown in **Figure A3**. The City resides within four WDs and WMOs, which are described in Section 1.3.

2.1.2.Geology

The City of St. Paul is located in southern Ramsey County. Information regarding the City's surficial and bedrock geology and aquifers was obtained from the Ramsey County Geologic Atlas from the Minnesota Geological Survey (MGS) of 1992[1].

The geomorphology of the City in the uppermost geologic formation shows quaternary deposits that are more than 500 feet thick along some of the deeper valleys. Unconsolidated quaternary deposits of glacial and post glacial material conceal a majority of the bedrock within the City. All of the bedrock formations are marine sedimentary rocks of Early Paleozoic age when shallow seas covered southeastern Minnesota. Large-scale block faulting caused the formation of an elongated, northeast-trending basin beneath what eventually became the Twin Cities Metropolitan Area.
Six aquifers are located within the City boundaries: the St. Peter Aquifer, Prairie Du Chien-Jordan Aquifer, Franconia-Ironton-Galesville Aquifer, and the Mt. Simon Aquifer, which is the deepest high-yield aquifer available to Ramsey County.

2.2. Climate and Precipitation

2.2.1.Climate

The climate within the Minneapolis/St. Paul metropolitan area is described as a humid continental climate with moderate precipitation, wide daily temperature variations, warm humid

[1] Ramsey County Geologic Atlas, 1992.
http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/ramscga.html

summers and cold winters. Additional climatological information for the area can be obtained from the Minnesota State Climatology Office[2].

2.2.2.Precipitation

The total average annual precipitation in this area is approximately 31 inches, of which nearly one-third occurs in the months of June, July, and August. The annual snowfall average is 54.4 inches, equivalent to about 5.4 inches of water. Average monthly temperature and precipitation are shown in **Table 2-1**.

The probability of a rainfall event occurring in the City of St. Paul in any given year is illustrated in **Table 2-2**. The recurrence interval is a measure of the probability of occurrence of the storm event. The rainfall data was obtained from the Atlas 14 website produced by the National Oceanic and Atmospheric Administration (NOAA)[3].

Table 2- 1. Average Temperature and Precipitation Data for the City of St. Paul

Month	Average Temperature (F)	Precipitation (in)	Snowfall (in)
January	15.6	0.90	12.20
February	20.8	0.77	7.70
March	32.8	1.89	10.30
April	47.5	2.66	2.40
May	59.1	3.36	0.00
June	68.8	4.25	0.00
July	73.8	4.04	0.00
August	71.2	4.30	0.00
September	62.0	3.08	0.00
October	48.9	2.43	0.60
November	33.7	1.77	9.30
December	19.7	1.16	11.90
Totals	**46.2**	**30.61**	**54.40**

State Climatology Office for the Minneapolis/St. Paul Airport, 1981-2010

Table 2- 2. Storm Events in St. Paul

Recurrence Interval (years)	24-Hour Rainfall (inches)
2	2.49
10	4.19
100	7.42

National Oceanic and Atmospheric Administration, NOAA

2 Minnesota Climatology Working Group. http://www.climate.umn.edu/
3 NOAA's National Weather Service. http://hdsc.nws.noaa.gov/

2.3. Soils

The soils in St. Paul were mapped in the United States Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS) Soil Survey of Ramsey County (**Figure A4**), which was updated in 2015[4]. The original soils of the St. Paul area are largely unknown because the majority of the City is covered with impervious surface or has been subject to cut-and-fill activities. Onsite investigation is typically needed on a case-by-case basis to determine the soil type at a specific site.

Infiltration capacities of soils affect the amount of direct runoff resulting from rainfall; the higher the infiltration rate for a given soil, the lower the runoff potential. Conversely, soils with low infiltration rates produce high runoff volumes and high peak discharge rates. **Figure A5** illustrates soil infiltration potential throughout the City. Since St. Paul is fully developed, limited land grading will occur within the City in the future.

In planning for infiltration projects the City will also need to consider other factors such as depth to bedrock, karst, groundwater, and contaminated soils.

2.4. Land Use

St. Paul is designated by the Metropolitan Council as a "developed community," meaning that over 85 percent of the community is developed. Data patterns from 2016 show that developed land use is divided into the following percentages: 41% low density (single family) residential development, 5% medium-high density (multifamily and mixed use) residential, 6% commercial, 8% industrial, 7% institutional, 14% green and open space, 6% transportation including highways and rail, and 7% water. The remaining 4% is comprised of land that remains vacant.

Figure A6 illustrates existing land use, and **Figure A7** depicts the expected future land uses by 2040 as indicated in the Land Use Section of the City of St. Paul's Comprehensive Plan[5].

St. Paul's Land Use Plan indicates that growth will be targeted in unique neighborhoods by developing Neighborhood Centers, Corridors, the Central Corridor, and Downtown with the intention of creating communities where housing, employment, and other amenities are supported by transit and provide sufficiently for the needs of the people who live and work in them. In addition, land will be reclaimed and provided for employment centers or businesses that can provide living wage job.

Future land use projections are important in estimating surface water runoff. The impervious surface areas associated with each land use greatly affect the amount of runoff generated from an area. Current land use shows that approximately 43% of the City is impervious land cover. Over 90% of the runoff in St. Paul goes directly to the Mississippi River through storm sewers and surface drainage; the rest flows through various lakes, which eventually lead to the Mississippi. Although the projected additional 52 acres of parks and green space by 2040 will

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[4] NRCS Soil Survey. http://websoilsurvey.sc.egov.usda.gov
[5] Land Use, Saint Paul Comprehensive Plan, 2010. https://www.stpaul.gov/sites/default/files/Media%20Root/Planning%20%26%20Economic%20Development/web%20Land%20Use%202-18-10.pdf

increase pervious surface area and help treat runoff before draining into the river, total impervious area will also increase with development of new commercial industries, which will affect future runoff rates. The City incorporates land dedication fees as part of development to implement additional green space. The City's Comprehensive Plan provides additional detail on future land use and green space throughout the City. **Figure A7** in **Appendix A** shows the City's planned land use division by 2040; Section 2.6 discusses how these changes will affect surface water.

2.5. Public Utilities

St. Paul and the Metropolitan Council share the responsibility of collecting sanitary sewage. The City owns 806 miles of sanitary sewers and 24 sanitary sewage pumping stations. The Metropolitan Council treats 80 percent of the Twin Cities' wastewater. The Metropolitan Plant is the largest in the State of Minnesota, serving 1.8 million users with a maximum capacity of 251 million gallons per day. As of 2015, about 75 residential properties in St. Paul were not served by sanitary sewers, due to reasons such as high bedrock and low density development that led to high costs for sewer construction. No negative impacts have been identified to any surficial groundwater from inadequate drain fields. The City will address any future impacts as needed. Chapter 50 in the City's Legal Code provides requirements for individual sewage treatment systems. The City's Water Chapter in the Comprehensive Plan provides additional information on the co-managed utilities.

The City's water system is owned by the City of St. Paul, operated by the Saint Paul Regional Water Service (SPRWS), and provides retail water to many cities and over 400,000 residents of the East Metro. The water processed by SPRWS comes from three primary sources, including the Mississippi River, Vadnais Lake Watershed, and wells. River water is pumped from the Fridley intake and flows into the Vadnais chain of lakes. From Vadnais Lake, water flows through conduits to be treated. Several wells that draw from the Prairie du Chien-Jordan aquifer are connected to these conduits to provide sufficient flow when needed. For additional information regarding groundwater, see Section 2.7.

Storm sewers, ditches, curbs, and gutters provide drainage for the City. St. Paul operates over 450 miles of storm sewer pipes and tunnels. Future street maintenance and redevelopment will likely dictate the extension or reconstruction of the storm drainage system. The City inspects storm sewers on a ten-year cycle or prior to any street reconstruction activities to determine if replacement is required during the street project. Inspections conform to Pipeline Assessment and Certification Program and all inspectors (Contractors or In-house) are required to be certified. Storm sewers are then prioritized for rehabilitation (CIPP Lining), replacement (during Street Projects), or repair (via Contract or In-house Dig up). Additional information can be found on the City's website: https://www.stpaul.gov/departments/public-works/sewer-utility-divison/cleaning-and-televising.

Mapping of stormwater utilities will be updated as improvements of the system are completed to stay in compliance with the Minnesota Pollution Control Agency's (MPCA) Municipal Separate Storm Sewer System (MS4) requirements. **Figure A8** depicts the City's existing system of stormwater pipes.

RWMWD owns and manages the St. Paul Beltline Storm Sewer Interceptor, which drains a large portion of stormwater runoff from the east side of St. Paul. This interceptor conveys runoff from the entire Phalen Chain of Lakes subwatershed and the Beaver Lake subwatershed to the Mississippi River. Additional information on the St. Paul Beltline Interceptor and drainage areas can be found in RWMWD's Watershed Management Plan.

2.6. Surface Waters

2.6.1. Wetlands

Wetlands provide several valuable functions and therefore, are important resources to a city.
Wetlands are a critical part of the natural storm drainage system, help maintain water quality, reduce flooding and erosion, provide food and habitat for wildlife, and provide open spaces and natural landscapes for residents. Wetlands allow for groundwater interactions, whether it is recharge or discharge. Additionally, wetlands provide aesthetic value, nature observation areas, and areas for education and scientific research. Because of the importance of wetlands and the role wetlands play within a community, they must be considered during development review and city-wide planning in order to balance protection of the wetlands and development and growth in the City. Since the City of St. Paul is fully developed, protecting and restoring the remaining wetlands and their functions is a high priority.

Figure A9 presents the National Wetland Inventory (NWI) for St Paul. The NWI map provides guidance on where wetlands occur in the City, though the NWI wetland boundaries cannot replace wetland delineations for determining legal wetland boundaries.

In 2008, the City completed a Wetland Management Plan (WMP) that assessed approximately 152 wetlands using the Minnesota Routine Assessment Method (MnRAM). The WMP provides an approach for the protection and management of wetlands within the City. The Plan also provides greater flexibility and control over wetland management and protection, identifies regional wetland mitigation sites, identifies potential wetland restoration areas, and provides management strategies for different types of wetlands. The current Wetland Management Plan can be found in **Appendix D**.

The Wetland Conservation Act of 1991 (WCA) dictates that Local Government Units (LGUs) are responsible for administering their rules. The City is the LGU responsible for administering the WCA. MnDOT is the LGU responsible for administering the WCA on its rights-of-way. The intent of the WCA is to promote no net loss of wetlands. The City can issue or deny permits depending on whether or not the project is in conformance with the WCA or the requirements of this Plan. The WCA exemptions are discussed in Minn. Rules 8420 and are included by reference to this Plan. The procedures for wetland impact application, sequencing, and replacement are outlined within the WCA. Regardless of the LGU, Minnesota's statutory wetland protection standards mean uniform wetland protection throughout the City. Wetlands and lakes under MnDNR jurisdiction have an added level of protection.

Each watershed district has developed a watershed management plan that incorporates policies concerning wetland management within their boundaries. The MWMO and the LMWMO leave administration of the WCA as the responsibility of the cities as acting Local Government Units (LGUs). The CRWD and the RWMWD have additional wetland regulations that vary from the WCA and additional approvals are needed from these Watershed Districts for projects that impact wetlands. These rules concerning wetland management by the corresponding watershed district are available on each organization's web site listed in Section 3 of this Plan. The goal of St. Paul's WMP is to work in conjunction with these existing policies.

2.6.2. Water Quality Data

The City will continue to support monitoring of surface waters and stormwater BMPs within its jurisdictional boundaries and outside these boundaries for waters to which the City discharges. Data will be obtained through cooperation and coordination with other various agencies, including the Minnesota Pollution Control Agency, cities adjacent to St. Paul, the Metropolitan Council, the Minnesota Department of Natural Resources, Capitol Region Watershed District, Ramsey-Washington Metro Watershed District, Lower Mississippi River Watershed Management Organization, Mississippi Watershed Management Organization, Ramsey County and Three Rivers Park District. The links below provide monitoring and water quality information for each organization. Table 2-3 provides a summary of monitoring locations for each watershed district.

- Capitol Region Watershed District: http://www.capitolregionwd.org/our-work/monitoring-and-mapping/
- Ramsey-Washington Metro Watershed District: http://www.rwmwd.org/waterquality
- Mississippi Watershed Management Organization: https://www.mwmo.org/reports/water-quality-monitoring/
- Lower Mississippi River Watershed Management Organization: http://www.dakotaswcd.org/watersheds/lowermisswmo/monitor.html
- Metropolitan Council monitoring information, including the Citizen-Assisted Monitoring Program (CAMP), can be found at: http://www.metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management.aspx?source=child
- Minnesota Pollution Control Agency's Citizen Lake Monitoring Program (CLMP) information can be found at: http://www.pca.state.mn.us/water/clmp.html

Table 2- 3. Water Quality and BMP Monitoring Programs Operated by Entities Other Then the City of St. Paul

WD or WMO	Monitoring Sites
CRWD[6]	• Lake Como • Loeb Lake • Phalen Creek • Crosby Lake • Little Crosby Lake • Hidden Falls • East Kittsondale • Trout Brook Outlet • Trout Brook – West Branch • Sarita Outlet • St. Anthony Park • Arlington Pascal Stormwater Improvement BMPs • CCLRT BMP Project Area
LMRWMO[7]	• Monitors DNR public waters within its boundaries • Monitors select storm sewers and streams that outlet to the Mississippi River
MWMO[8]	• Kasota Ponds Wetlands • Mississippi River mercury TMDL
RWMWD[9]	• Monitors DNR public waters within its boundaries including Beaver Lake and Lake Phalen,

Water quality data for the City is available from the MPCA's Environmental Data Access site. This data provides a snapshot of overall water quality and health of local waterbodies and can be accessed here https://www.pca.state.mn.us/environmental-data . The database is utilized by participating agencies to compile water quality testing data and is almost entirely used for the storage of water quality parameters.

Refer to **Figure A10** for a map of water quality monitoring locations by the MPCA and various other organizations.

The City performs yearly monitoring for water quality and quantity. The focus of the City's stormwater monitoring program has been to monitor the effectiveness and maintenance needs of stormwater BMPs. Outfall monitoring data, collected by Capitol Region

6 CRWD Water Quality and Flow Monitoring. http://www.capitolregionwd.org/our-work/monitoring-and-mapping/flowmo/
7 LMRWMO Watershed Management Plan, 2015 http://www.dakotaswcd.org/watersheds/lowermisswmo/pdfs/2011%20Lower_Mississippi_River_WMO_adopted_plan_2015amend.pdf
8 MWMOP Annual Monitoring Report, 2015. http://cdn.mwmo.org/wp-content/uploads/2016/04/Annual-Monitoring-Report-2015-Final.pdf

9 RWMWD Water Quality Monitoring. http://www.rwmwd.org/WaterQuality/link.htm

Watershed District (CRWD), is used to evaluate pollutant loading from major sub-watersheds, and to estimate City-wide pollutant loading from the MS4. The most recent yearly report can be found on the City' Website.

2.6.3. Impaired Waters

The MPCA lists the following water bodies (Table 2.4) located within or near the City as being impaired, meaning that the waters are too polluted or otherwise degraded to meet the water quality standards set by governing bodies. A Total Maximum Daily Load (TMDL) study is undertaken to determine the amount of pollutant that is currently entering the water, and the maximum amount that can be present in the water while meeting water quality standards.

Table 2.4 – Impaired Waters

Waterbody/Watercourse	Year Added to Impaired List	Affected Use	Pollutant/Stressor	TMDL Status
Mississippi River (07010206-814)	1998	Aquatic Consumption	PCB in fish tissue	Not complete
Mississippi River (07010206-814)	2008 2014	Aquatic Consumption	PFOS in fish tissue and in water column	Not complete
Mississippi River (07010206-814)	2016	Aquatic Life	Excess nutrients	Not complete
Mississippi River (07010206-814)	1994	Aquatic Recreation	Fecal coliform	Not complete
Mississippi River (07010206-814)	1998	Aquatic Consumption	Mercury in fish tissue	Completed in 2007: State-wide Mercury Reduction Plan
**Battle Creek (07010206-592)	2017	Aquatic Life	Aquatic macroinvertebrate bioassessments, fishes bioassessments	Completed in 2017: RWMWD WRAPS
**Battle Creek (07010206-592)	2008	Aquatic Life	Chloride	Completed in 2016: TCMA Chloride Management Plan
Como Lake (62-0055-00)	1998	Aquatic Consumption	Mercury in fish tissue	Completed in 2008: State-wide Mercury Reduction Plan
Como Lake (62-0055-00)	2014	Aquatic Life	Chloride	Completed in 2016: TCMA Chloride Management Plan
Como Lake (62-0055-00)	2002	Aquatic Recreation	Excess nutrients	Completed in 2010: Como Lake TMDL
*Beaver Lake (62-0016-00)	2008	Aquatic Consumption	Mercury in fish tissue	Completed in 2008: State-wide Mercury Reduction Plan
**Phalen Lake (62-0013-00)	2012	Aquatic Consumption	Mercury in fish tissue	Completed in 2013: State-wide Mercury Reduction Plan

Pickeral Lake (19-0079-00)	2002	Aquatic Consumption	Mercury in fish tissue	Completed in 2010: State-wide Mercury Reduction Plan
Wakefield Lake (62-0011-00)	2002	Aquatic Recreation	Excess nutrients	Completed in 2017: RWMWD WRAPS
Fish Creek (07010206-592)	2014	Aquatic Recreation	Fecal coliform	Completed in 2017: RWMWD WRAPS
Unnamed Lake (Eagle Lake) (62-0237)	2008	Aquatic Consumption	Mercury in fish tissue	Completed in 2008: State-wide Mercury Reduction Plan
Unnamed Lake (Eagle Lake) (62-0237)	1998	Aquatic Consumption	PCB in fish tissue	Not complete

*Beaver Lake was originally listed as impaired for excess nutrients. It was delisted in 2014.
** Met Council Priority Lakes

Approved TMDL Report Summaries

- **State-wide Mercury Reduction Plan -** Approximately two-thirds of the water impairments on Minnesota's Impaired Waters List are due to mercury. The U.S. Environmental Protection Agency approved Minnesota's Statewide Mercury Total Maximum Daily Load study in March 2007. The TMDL study includes data collection and assessments and the development of a pollution reduction plan and implementation strategies. Every two years, the MPCA updates information in the approved statewide mercury TMDL by adding any new impaired waters or those that have been delisted. This plan can be located online here: https://www.pca.state.mn.us/water/statewide-mercury-reduction-plan

- **Ramsey-Washington Metro Watershed District WRAPS** – In 2017, Ramsey-Washington Metro Watershed District completed watershed-wide TMDL and WRAPS reports. The approved TMDL addresses nutrient impairments, bacteria impairments, and biotic impairments for lakes, streams and wetlands. Impaired waterbodies within the City of St. Paul that are addressed in this report include Fish Creek, Battle Creek, and Wakefield Lake. This plan can be located online here: https://www.pca.state.mn.us/water/tmdl/ramsey-washington-metro-watershed-district-watershed-restoration-and-protection-strategy

  Wakefield Lake was designated a wasteload allocation for total phosphorus of 93.1 lbs/year with an overall percent reduction of 43%. This allocation is to be split among the 3 MS4s within the drainage area: St. Paul, Maplewood, and North St. Paul. The City of Maplewood contains the majority of land that drains to Wakefield Lake.

  Battle Creek and Fish Creek were designated percent reductions for TSS and fecal coliform based on flow zones for MS4 communities located within the drainage areas. The City of St. Paul is within about half of the drainage area in the Battle Creek subwatershed and a very small portion of the drainage area in the Fish Creek subwatershed.

- **Como Lake TMDL** – The TMDL for Como Lake was approved in 2010. The City of St. Paul contains a majority of the land that drains to the lake. A load allocation for total phosphorus was designated to all MS4s within the Como Lake drainage area. This TP load allocation is 248.92 lbs/year. This plan can be located online here: https://www.pca.state.mn.us/water/tmdl/como-lake-excess-nutrients-tmdl-project

- **Twin Cities Metropolitan Area (TCMA) Chloride Management Plan** – The MPCA approved the TCMA Chloride Management Plan in 2016. This plan is intended to discuss the impacts of chloride on water quality, set performance based goals, and provide implementation strategies to communities to reduce salt runoff and usage. This plan can be located here: https://stormwater.pca.state.mn.us/index.php/Chloride_Management_Plan

The locations of these impaired water bodies are shown on the water resource problem areas map, **Figure A10. Appendix B** includes the approved TMDL plans for Como Lake and RWMWD WRAPS. All other plans can be found online at the links listed above.

2.6.4. Appropriations from Small Watercourses

The City is responsible for administering appropriations from small watercourses for those areas within MWMO boundaries. These include a public water basin or wetland that is less than 500 acres or a protected watercourse that has a drainage of less than 50 square miles (Minnesota Statute 103B.211 Subd. 4). The City will choose to defer to the watersheds in administering this policy.

2.7. Groundwater

The various agencies responsible for groundwater management and protection are summarized below:

The DNR regulates groundwater usage rate and volume as part of its charge to conserve and use the waters of the state. Suppliers of domestic water to more than 25 people or applicants proposing a use that exceeds 10,000 gallons per day or 1,000,000 gallons per year must obtain a water appropriation permit from the DNR. Many of the agencies charged with regulating water usage are currently involved in assessing and addressing concerns of water usage.

The Minnesota Department of Health (MDH) is the official state agency responsible for addressing all environmental health matters, including groundwater protection. For example, the MDH administers the Well Abandonment Program, and, along with the MNDNR, regulates installation of new wells.

The MPCA administers and enforces laws relating to pollution of the state's waters, including groundwater. The Minnesota Geological Survey (MGS) provides a complete account of the state's groundwater resources.

Ramsey County developed a Groundwater Quality Protection Plan in 1992 that coordinates groundwater planning and provides non-regulatory recommendations for protection techniques for each municipality, and the identification of abandoned wells in St. Paul that might need to be sealed as required by MDH rules. The plan received approval from the Minnesota Board of Water and Soil Resources (BWSR) in 1995. In 2016, county staff have been exploring the possibility of updating the 1995 Plan to address recent developments and opportunities in groundwater management. The City of St. Paul will coordinate with Ramsey County to implement goals and policies from the approved groundwater plan.

While very few people in the City of St. Paul still use well water for their drinking water, there are numerous abandoned wells in the area that should be sealed, as they are direct routes for groundwater contamination. There are currently six wells on reserve that provide an alternate source to the surface water supply from the Mississippi River, with a capacity of 26 million gallons per day (MGD). All wells draw from the Jordan aquifer. The City currently does not have a wellhead protection plan in place.

St. Paul has implemented a Source Water Protection Plan that meets the requirements of the Safe Drinking Water Act. This plan provides a means of reducing the risk of contamination of drinking water supplies by managing the potential sources of contamination within the area that supplies water to a public well or surface water intake. The plan also outlines Priority Areas and associated DWSMA locations to manage potential sources of contamination. A copy of the Plan can be requested from the St. Paul Public Works.

Potable water within the City and neighboring communities is provided by the Saint Paul Regional Water Services (SPRWS). SPRWS functions as an external entity, as their service area extends well beyond St. Paul. Additional. Additional information can be found in the City's Water Supply Plan. The City's existing water supply system meets the primary contaminant standards as set forth by regulating bodies listed above.

2.8. Hydrologic System and Data

The City's hydrologic/hydraulic system consists of ponds, wetlands, and storm sewer pipe systems within multiple subwatersheds that drain towards the Mississippi. The City is divided into approximately 23 subwatershed areas. Modeling projects have been completed in support of the sewer and street projects.

In 2010, the City completed the first phase of a program that includes stormwater modeling, a citywide volume reduction inventory and plan to address stormwater on the 2010 Residential Street Reconstruction Program. The modeling includes the development of an XPSWMM and P8 modeling and uses the CRWD monitoring data for calibration. Three major subwatersheds, as well as the 2010 street reconstruction subwatersheds, were modeled. In 2011, the City began modeling as a component of the storm tunnel rehabilitation program. The Saint Anthony Park and Davern subwatersheds have been modeled. In 2012, the City began modeling the Phalen Creek storm sewer interceptor. These models will be used by the City in the development of future stormwater programs and projects. A map of the Citywide modeling areas is located in **Appendix E**.

The peak runoff rates and volume from most subwatersheds in the City of St. Paul are not expected to change significantly due to future development. Stormwater runoff rate and volume controls will be required to be in conformance with City, Watershed, and State requirements. Modeling results and other studies regarding water quantity can be obtained from the St. Paul Public Works Department.

With the additional precipitation data provided by Atlas 14, dependent upon funding, the City may choose to complete additional risk assessments by updating their current H & H models. This will allow them to identify any potential flooding areas not listed in Section 4 of the plan.

2.9. Natural Communities and Rare Species

The Minnesota DNR produces the Minnesota County Biological Survey (MCBS) identifying natural communities and rare species. Completed in 1994, the Ramsey County survey identifies where evidence indicates the presence of federally or state listed plants. The survey shows rare plants and animals are present throughout St. Paul. **Figure A11** provides a map of these areas. The DNR has jurisdiction over these areas. Based on state statute, any work within these areas is required to meet DNR permit requirements. The watershed districts have also identified natural communities and rare species, which can be found in their Watershed Management Plans.

2.10. Flood Insurance Studies/Floodplain Management

In an effort to control flooding from the Mississippi River, the City of St. Paul has worked with the U.S. Army Corps of Engineers and other State agencies to construct permanent levees and headwalls. The City has also looked to maintain open space in flood prone areas. As part of this, the City administers floodplain and levee applications for developments along these areas.

FEMA completed the map modernization process for its Flood Insurance Study (FIS)[10] and Flood Insurance Rate Maps[11] (FIRMs) to identify flood risk within Ramsey County in 2010. Any Letter of Map Amendment (LOMA) and Letter of Map Revision (LOMR) can be located on the mapping function of FEMA's website[11].

Figure A12 illustrates the floodplain for the City of St. Paul.

2.11. Mississippi River Critical Corridor

The Minnesota State Legislature enacted the Critical Areas Act in 1973 and an executive order (79-19) was signed in 1976 declaring the Mississippi River corridor a Critical Area (MRCCA). The executive order states the following purposes for the Critical Area designation:

- To protect and preserve a unique and valuable state and regional resource for the benefit of the health, safety and welfare of the citizens for the state, region, and nation;
- To prevent and mitigate irreversible damage to this state, regional and national resource;
- To preserve and enhance its natural, aesthetic, cultural, and historical value for the public use;
- To protect and preserve the river as an essential element in the national, state and regional transportation, sewer and water and recreational systems; and
- To protect and preserve the biological and ecological functions of the corridor.

The MRCCA includes 72 miles of the river, extending from the Cities of Dayton and Ramsey to just south of the City of Hastings. The boundary of the MRCCA can generally be described as

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[10] FEMA Flood Insurance Study, 2016. ftp://ftp.dnr.state.mn.us/pub/waters/floodplain/County_data/Ramsey/Ramsey%20County%20MN%20Final%20FIS/27123CV000A.pdf
[11] FEMA Flood Insurance Rate Maps. https://msc.fema.gov

from the river bluff down to the river, with the corridor width varying.

In 1976, four corridor districts were established, corresponding to the following different types of land use along the Mississippi River: rural open space district, urban developed district, urban open space district, and urban diversified district. Each district has its own set of guidelines. The Critical Area Act requires that each city having jurisdiction over land within the Critical Area develop a Critical Area Plan. Executive Order 79-19 includes the rules and guidelines that each city must incorporate in its Critical Area Plan.

In 1988, the U.S. Congress designated the Mississippi River corridor as the Mississippi Natural River and Recreation Area (MNRRA), a unit of the National Park System. The boundaries of the MNRRA corridor are the same as the Critical Area corridor. The Mississippi River Coordinating Commission and the National Park Service adopted the MNRRA *Comprehensive Management Plan* in 1995.

The City's current Critical Area Plan is located on the City's website here: https://www.stpaul.gov/departments/planning-economic-development/planning/current-activities. The City will review and update the Plan to address the new rules released by the DNR. This item was added to Table 6-1 to be completed in 2019.

Additional information can be found on the DNR website. http://dnr.state.mn.us/waters/watermgmt_section/critical_area/index.html

The City of St. Paul's MRCCA Rulemaking Districts are shown in **Figure A13**.

3. AGENCY COOPERATION

There are a number of local, State, and Federal agencies that have rules and regulations related to local water management. The City recognizes the roles of these other agencies and will cooperate, coordinate, and when possible, partner with these agencies.

This Plan is in conformance with, but does not restate, all other agency rules that are applicable to water resource management. The following agencies deal with or regulate water resources throughout the City:

- Minnesota Department of Health www.health.state.mn.us
- Minnesota Pollution Control Agency www.pca.state.mn.us and the Minnesota Stormwater Manual www.pca.state.mn.us/water/stormwater/stormwater-manual.html
- Board of Water and Soil Resources www.bwsr.state.mn.us and the Wetland Conservation Act www.bwsr.state.mn.us/wetlands/wca/index.html
- Minnesota Department of Natural Resources www.dnr.state.mn.us
- US Army Corps of Engineers www.mvp.usace.army.mi
- Minnesota Department of Agriculture www.mda.state.mn.us
- US Fish and Wildlife Service www.fws.gov
- Ramsey County https://www.ramseycounty.us/
- Ramsey County Public Health https://www.ramseycounty.us/your-government/departments/health-and-wellness/public-health
- Lower Mississippi River Watershed Management Organization http://www.dakotaswcd.org/watersheds/lowermisswmo/
- Capitol Region Watershed District http://www.capitolregionwd.org/
- Ramsey-Washington Metro Watershed District http://www.rwmwd.org/
- Mississippi Watershed Management Organization http://mwmo.org/
- Minnesota Environmental Quality Board www.eqb.state.mn.us
- Metropolitan Council www.metrocouncil.org
- Federal Emergency Management Agency (FEMA) https://www.fema.gov/
- Minnesota Department of Transportation (MnDOT) http://www.dot.state.mn.us/

3.1. NPDES Permitting Process

The City of St. Paul is required to have a MS4 permit through the MPCA's National Pollutant Discharge Elimination System (NPDES) Phase I Program. MS4s, designated by rule, are urban areas with populations over 100,000.

As a MS4, the City will be required to implement the following eight minimum control measures:

1. Public Education and Outreach
2. Public Participation/Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management
6. Pollution Prevention/Good Housekeeping for Municipal Operations
7. Monitoring Analysis
8. Discharges to Impaired Waters with a TMDL

The City of St. Paul's MS4 Permit was first issued on December 1, 2000, and was reissued on January 21, 2011. This permit requires a revised Stormwater Permit Annual Report. A report summarizing 2016 activities is found on the City of St. Paul's website[12]. The current annual report can be found on the City's website.

NPDES Construction General Permits are also generally required for construction activities that result in land disturbance of equal to or greater than one acre or a common plan of development or sale[13]. Additionally, stormwater from large wastewater treatment plants and other privately-owned facilities that process wastewater must be permitted through the NPDES/SDS Industrial Stormwater Permit process.

3.2. Water Resource Management Ordinances and Policies

The City of St. Paul has adopted a number of ordinances and zoning overlay districts in an effort to protect water resources within the City and provide consistency with applicable agency requirements. Ordinances and zoning overlay districts currently in place are available on the City's website[14]. Items relevant to the City's LSWMP include the following:

- Chapter 51. Allowable Discharges to the Storm Sewer System
  This chapter is adopted in accordance with the city's national pollutant discharge elimination system (NPDES) municipal separate storm sewer (MS4) permit which authorizes the discharge of stormwater to surface water. Pursuant to permit regulations, the city is required to control the introduction of non-stormwater discharges to the city's municipal separate storm sewer system.

[12] City of Saint Paul's Stormwater Permit Annual Report, 2016. https://www.stpaul.gov/sites/default/files/Media%20Root/Public%20Works/Stormwater%20Permit%20Annual%20Report%20June%202016.pdf
[13] NPDES General Permit, 2013. https://www.pca.state.mn.us/sites/default/files/wq-strm2-68a.pdf
[14] St Paul Code of Ordinances. https://www.municode.com/library/mn/st._paul/codes/code_of_ordinances

- Chapter 52. Stormwater Runoff
  The purpose of this chapter is to control stormwater pollution associated with land disturbance and post construction runoff in the city. It establishes standards and specifications for practices and planning activities, which minimize stormwater pollution, soil erosion and sedimentation. Chapter 52 is currently being revised by the City and is scheduled to be adopted in 2018/2019.

- Section 63.600 Wetland Conservation
  The purpose of this section is to implement the Wetland Conservation Act and the accompanying rules of the Minnesota Board of Water and Soil Resources throughout the City.

- Section 68.402. Protection of shorelands, floodplains, wetlands, and bluffs

- Section 68.404. Protection of Water Quality
  The objective of standards and criteria is to maintain the aesthetic integrity and natural environment of the river corridor in conformance to the St. Paul Mississippi River Corridor Plan by reducing the effects of poorly planned shoreline and bluffline development; providing sufficient setback for sanitary facilities; preventing pollution of surface and groundwater; minimizing flood damage; preventing soil erosion; and implementing metropolitan plans, policies and standards.

- Chapter 72. Floodplain Management Overlay Districts
  This chapter is adopted to adopt regulations to minimize flood losses and guide development within the floodplain areas. This chapter also references applicable FEMA regulations and ensures compliance with the National Flood Insurance Program.

- Chapter 91. Water Code – Miscellaneous Provisions

- Saint Paul Sustainable Building Policy for Private Development
  The purpose of this policy requires private developers to meet the standards for a building rating systems for sustainability. Some of these include LEED, Minnesota Green Star, Silver and Saint Paul Port Authority Green Design Review. This policy applies for any new construction more than $200,000 in City and/or HRA funding.

- Sustainable Building Policy for New Municipal and HRA Owned Buildings
  This policy lists rating systems for the City and HRA to choose from when constructing facilities within St. Paul. The building must meet mandatory requirements established in the 2009 Sustainable Building Policy as the “Saint Paul Overlay”.

The full text for each of these ordinances or zoning overlay districts is included in **Appendix C.**

The City is currently in the process of reissuing their MS4 permit. This is anticipated to be complete by July 2018. A part of this permit renewal includes the updating of the City’s ordinances. Within 18 months of the MS4 reissuance date, the City will review and update their ordinances. For stormwater management, the City anticipates developing a revised ordinance with performance criteria, possibly supported by a comprehensive document that explains various development review related topics such as: volume reduction, rate control, erosion and sediment control, etc. Procedural requirements from Watershed Districts and Watershed Management Organizations will be incorporated into the document to aid developers in navigating various requirements within the City limits. The timeline associated with updating local controls will adhere to the schedule identified in the City's MS4 permit.

A tentative schedule is provided below.

- July 2018 - Finalize renewal of MS4 permit
- August 2018 – November 2018: Review current ordinances and perform a gaps analysis in comparison with watershed rules, MRCCA new rules, etc.
- December 2018-April 2019 - Create Design Standards document and provide a review period that includes all watersheds. Includes a draft review of the proposed ordinances.
- May 2019-July 2019 – Finalize ordinances and Design Standards with agency comments.
- August 2019 – October 2019 – Adopt ordinances with City Council.

3.3. City Coordination Processes

There is an existing Site Plan Review Committee that reviews public/private developments. There is also the Water Resource Work Group that meets on a regular basis to discuss water related topics ranging from coordinated projects to grant opportunities. Both of these groups are comprised of members from City Departments such as: Public Works, Parks, Planning, Safety and Inspections, etc. Additionally, staff from area Watershed Districts are also involved in these groups.

When there is a large development (West Side Flats, Ford Plant, Snelling-Midway Soccer Stadium), multi-faceted teams are brought together for the review of Stormwater management alternatives. These teams assist in design review, financing review, agreements, etc. As part of these three major redevelopments, an initiative is being led to develop the policy, design, and finance of green infrastructure. The City has developed a memo outlining the strategic roadmap to finance green infrastructure throughout the City through the updating of policy and legal framework. The City partnered with numerous agencies to outline the concept of "shared, stacked-function green infrastructure (SSGI)," seeking to manage stormwater as an asset that embraces environmental health, community livability and cost efficiencies.

The City is interested in pursuing public/private, district and/or regional stormwater management alternatives, and has partnered with such entities as: Watershed Districts, Saint Paul Public Schools, Saint Paul Port Authority, etc. This has resulted in the installation of many partnership BMPs including: Beacon Bluff, Trout Brook Nature Sanctuary, Como Senior High School, etc. Potential items that may limit the City's ability include: equitable means of sharing capital costs, assignment of operating and maintenance responsibilities for the life of the facility, equitable means of sharing maintenance costs, easement and access rights if the facility is located on non-city owned property, insurance and indemnity requirements. Ideally, these items would be addressed on a system-wide basis, but given complexities with potential partners, they may need to be addressed on a site by site basis.

4. ASSESSMENT OF ISSUES

Outlined below is an assessment of existing and potential local water resource-related issues that are known as of 2016. These issues have been identified based on an analysis of the land and water resource data collected during the preparation of this plan and through information provided by the City, its residents, and the watershed organizations. A description of any existing or potential issue within the City has been listed and potential future corrective actions have been incorporated into an implementation plan.

4.1. Water Quality Problems

Issue - The City discharges to the following impaired waters as listed by the Minnesota Pollution Control Agency (MPCA):

<u>Mississippi River (ID 07010206-505)</u>

A TMDL Plan for mercury approved in 2008. This stretch of the Mississippi River is impaired for fecal coliform, mercury and PCB in fish tissue, and total suspended solids (TSS). This stretch was added to the impaired waters list by the MPCA in 1996 for fecal coliform, and again in 1998 for the additional pollutants.

<u>Corrective Action</u>

The City will continue to work with the MPCA, watershed commissions, and surrounding communities to help improve these bodies of water and address the TMDL requirements. Many of the projects outlined in the implementation plan will help work toward achieving the TMDL improvement goals. The City is also interested in partnering with the watershed commission, neighboring cities, and other agencies on future projects or opportunities that arise that help achieve the goals of the TMDLs. Refer to the detailed TMDL report or implementation plans located on the MPCA website[15] for more information on each TMDL or refer to **Appendix B**. The City's annual NPDES Stormwater Reports[16] also provide additional detail on activities that have been completed.

<u>Battle Creek (ID 07010206-592)</u>

Battle Creek was added to the impaired waters list by the MPCA in 2008 for chloride, and in 2014 for aquatic macroinvertebrate and fish bioassessments.

<u>Corrective Action</u>

The Ramsey-Washington Metro Watershed District (RWMWD) established a TMDL in April, 2016 aimed at restoring aquatic recreation in Battle Creek. Elevated Total Suspended Solids (TSS) concentrations in Battle Creek are caused by high sediment loading mobilized by watershed runoff and erosion within the immediate stream channel and corridor. Excess TSS was identified as a primary stressor to the aquatic life. TSS load reductions of 66% to 91% are required to meet water quality standards, depending on the flow conditions.

The RWMWD TMDL focuses on collectively meeting the MPCA's water quality standards for Fish Creek and Wakefield Lake in Maplewood, and Bennett Lake in Roseville. This

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[15] MPCA TMDL Projects. https://www.pca.state.mn.us/water/total-maximum-daily-load-tmdl-projects

[16] Ctiy of St. Paul Stormwater Permit Annual Report, 2015. https://www.stpaul.gov/sites/default/files/Media%20Root/Public%20Works/June%202015%20report%20with%20appendix%20reduced.pdf

TMDL[17] has not yet been approved by the Environmental Protection Agency (EPA). The draft is provided in **Appendix B**.

The City of St. Paul should focus on implementing recommendations from the Twin Cities Metropolitan Area (TCMA) Chloride TMDL[18] as well as the TCMA Management Plan[19].

Como Lake (ID 62-0055-00)

A TMDL Plan for mercury was approved in 2008 and a TMDL Plan for nutrient/eutrophication biological indicators approved in 2010. Como Lake was added to the impaired waters list by the MPCA in 1998 for Mercury in fish tissue, 2002 for nutrient/eutrophication biological indicators, and again in 2014 for chloride.

Corrective Action

The primary pollutant load was identified as excess phosphorus. The watershed load to Como Lake represents approximately 34% of the total load to the lake, and internal load represents about 65%. A reduction in watershed load and a 97% reduction in internal load are required in the TMDL[20].

The reduction will be accomplished through the implementation of the techniques described in CRWD's 2002 Como Lake Strategic Management Plan[21]. Several structural Best Management Practices (BMPs) are recommended in the Management Plan, including water quality ponds, rain gardens, infiltration trenches, and alum treatment for stormwater. The Public Outreach group also developed an education and outreach plan to encourage public participation in the Como watershed community. BMPs will also be identified from the Como Regional Park Stormwater Master Plan once approved. CRWD will lead implementation items for in-lake load management.

The remaining load reduction is accomplished by allocating point sources, identified as permitted MS4 stormwater and construction stormwater.

Beaver Lake, Phalen Lake, Pickeral Lake

Beaver Lake (ID 62-0016-00) was added to the impaired waters list by the MPCA in 2002 for mercury in fish tissue and nutrients/eutrophication. Phalen Lake (ID 62-0013-00) was added to the impaired waters list by the MPCA in 2012 for mercury in fish tissue. Pickerel Lake was added to the impaired waters list by the MPCA in 2010 for mercury in fish tissue.

Corrective Action

Corrective action in the watershed, such as stormwater treatment, has removed Beaver Lake from the impaired waters list. The Minnesota Statewide Mercury TMDL[22] was approved by the MPCA in March, 2007.

[17] RWMWD TMDL Draft, 2016. https://www.pca.state.mn.us/sites/default/files/wq-iw8-54b.pdf
[18] Twin Cities Area Chloride TMDL Study, 2016. https://www.pca.state.mn.us/sites/default/files/wq-iw11-06e.pdf
[19] Twin Cities Metro Area Chloride Management Plan, 2016. https://www.pca.state.mn.us/sites/default/files/wq-iw11-06ff.pdf
[20] Como Lake TMDL, 2010. https://www.pca.state.mn.us/sites/default/files/wq-iw11-05e.pdf
[21] Como Lake Strategic Management Plan, 2002. http://www.capitolregionwd.org/wp-content/uploads/2012/09/CLSMPFinal.pdf
[22] MN Statewide Mercury TMDL, 2007. https://www.pca.state.mn.us/sites/default/files/wq-iw4-01b.pdf

Because the source for almost all mercury in Minnesota waters is atmospheric and shared by all mercury-impaired waters of the state, pollutant allocation applies state-wide. Human activity causes 70% of atmospheric deposition and natural sources make up the remaining 30%. Minnesota is divided into two regional TMDLs: northeast (NE) and southwest (SW). The two regions have the same target fish tissue level, with different necessary load reductions to achieve it. St. Paul falls in the SW region.

4.2. Flooding and Stormwater Rate Control Issues

Issue – Flooding that occurs in Bridal Veil Creek and Bridal Wetland.

Corrective Action – Flooding in this area is largely managed by the Eustis tunnel project, which is owned by the City of St. Paul. The City will maintain existing storm tunnels as identified in their Capital Improvement Plan.

Issue – Flooding in the Lowertown neighborhood.

Corrective Action – The City will evaluate and pursue permanent flood control options for this area. A study will be completed to identify BMP options and potential locations.

Issue – Localized flooding throughout the City.

Corrective Action - The City will continue to implement BMPs during road reconstruction projects and redevelopment to address general flooding city-wide. The City will also continue to do yearly storm sewer maintenance and storm tunnel rehabilitation projects.

4.3. Adequacy of Existing Regulations and Programs to Address Stormwater Management

Issue – The new Mississippi River Corridor Critical Area (MRCCA) Rules and Standards have been adopted by the DNR.

Corrective Action – The City will update its controls as required to meet the goals of the new MRCCA rules. This item is shown to be completed in Table 6-1 by 2019.

Issue – The City has experienced challenges in regulating stormwater management due to lack of consistency in city ordinances and rules governed by external agencies.

Corrective Action – Chapter 52 of the City Code will be revised to be consistent with watershed standards. A schedule for completion is provided in Section 3.2.

4.4. Impacts of Erosion and Sedimentation on Local Water Resources

Issue – Erosion and sedimentation issues have been occurring in the ravine near Cherokee Heights.

Corrective Action – The City will partner with West St. Paul, Mendota Heights, and the Lower Mississippi River WMO to complete a ravine stabilization project to limit sediment discharge and help intercommunity flows.

Issue – City-wide bluff erosion along the Mississippi River.

Corrective Action – The City will coordinate ongoing projects along the Mississippi River such as regular park maintenance, natural areas restoration, and lake management to prevent erosion and sediment discharge along the bluffs.

Issue – City owned ponds are in need of maintenance for vegetation management and sedimentation issues.

Corrective Action – The City performs maintenance on stormwater ponds as necessary to ensure they continue to provide the intended stormwater management benefit. The City will continue to prioritize inspection and maintenance needs for stormwater ponds and BMPs throughout the City. Dredging projects have been completed in 2013, 2016 and 2017.

4.5. Impact of Land Use Practices and Development on Local Water Resource Issues

Issue - The City of St. Paul is near full development and contains varying topography with the presence of many different soil classifications. These conditions can make it difficult for the City to implement stormwater management BMPs to efficiently meet watershed requirements on a site by site basis.

Corrective Action - The City will investigate opportunities to implement water quality and volume reduction BMPs during future reconstruction projects. In areas where project specific BMPs will be unfeasible, the City will consider completing regional water quality improvement projects to help meet future stormwater management requirements.

Issue – The City's Wetland Management Plan (WMP) was last completed in 2008 and is needs to be updated. This plan provides an approach for the protection and management of wetlands within the City as development occurs. The WMP provides greater flexibility and control over wetland management and protection, identifies regional wetland mitigation sites, identifies potential wetland restoration areas, and provides management strategies for different types of wetlands.

Corrective Action - The City will complete a Wetland Management Plan that will include a wetland inventory, habitat assessment, and management plan for wetlands and water bodies on public property. This is listed in the Implementation Plan as occurring by 2020.

4.6. Education Program

Issue –The City of St. Paul recognizes the need for local water education programs to increase public awareness of local water management and improve the quality of stormwater runoff.

Corrective Action – The City of St. Paul will continue to provide educational content and opportunities to residents, businesses, developers, and others. These efforts may include regular notices in the City's monthly newsletter, articles in the local paper, postings on the City website, and flyers in the utility bill. The City may work with the watershed districts to improve the efficiency of educational efforts and reduce duplication. Educational topics may include but are not limited to:

- Wetland buffers
- Yard/Pet waste management
- Illicit discharge to stormwater

- Utility Easements
- BMP functions
- Controlling invasive species
- Sustainable groundwater and recharge
- Adopt-a-Drain program
- Localized flooding

4.7. Identification of Potential Issues Which are Anticipated in the Next 20 Years

Issue – New and emerging contaminants are becoming more prevalent in water bodies throughout the City. These include:

- An increase in nutrient loading including phosphorus, sediment and nitrate.
- An increase in chloride concentrations from road salt use in the winter.
- The prevalence of polycyclic aromatic hydrocarbons (PAHs) in stormwater ponds from runoff of roadways and other surfaces.
- Prevalence of endocrine disruptors and pharmaceuticals.

Corrective Action – The City will implement the following measures to ensure the treatment of these contaminants.

- Addressing TMDLs and corresponding wasteload allocations for impaired water bodies through the implementation of water quality projects with new development, redevelopment, and street reconstruction projects.
- Implementing measures outlined in the TCMA Chloride Management Plan where possible.
- Identifying stormwater ponds that are contaminated and follow protocol for disposal of dredged material. The City also bans the use of materials for paved surfaces that contain PAHs for future development and redevelopment.
- Construct innovate BMP's and integrated systems to better treat a variety of contaminants. The City will look into undertaking a study that identifies these potential regional or watershed treatment areas that could benefit from integrated systems.

Issue – The changing climate will influence rainfall and flow patterns of water bodies within the City.

Corrective Action – The City will need to adapt an integrated water resource management approach to ensure the resiliency and longevity of stormwater treatment facilities as well as the management of the lakes and rivers. The City will look to invest in both green and gray infrastructure to store and transport stormwater runoff and will implement standards to help plan and cope with the climate variability. Green infrastructure will be the first priority of the City when looking to address the changing climate. The City will partner with MWMO and other watersheds to integrate green infrastructure opportunities and provide for a new system management approach.

Issue – While very few people in the City of St. Paul still use well water for their drinking water, there are numerous abandoned wells in the area that should be sealed, as they are direct routes for groundwater contamination.

Corrective Action – The City will work directly with the County and other agencies to identify and seal these abandoned wells within the timeframe of this Plan. The City will continue to implement groundwater protection initiatives listed in the Ramsey County Groundwater Protection Plan.

4.8. Availability and Adequacy of Technical Information to Manage Water Resources

Issue – Atlas 14 (updated precipitation probability information) was released by NOAA (National Oceanic and Atmospheric Administration) in 2013 and adopted by all watersheds within St. Paul as a design standard.

Corrective Action – Previously developed areas within the City (designed to meet TP-40 hydrologic demands) will continue to operate under this design criteria. New development, redevelopment, and areas where issues may exist will be evaluated (as needed) by completing a risk assessment using Atlas 14. The City will work with the DNR and the Watershed in FIRM updates as needed. The City will evaluate their current H&H models to incorporate Atlas 14 data. This will allow the City to provide a risk assessment for areas possibly affected by an increase in rainfall precipitation.

Issue - The City has mapped a majority of its storm sewer system. As new and redevelopment projects are completed, the storm sewer GIS database needs to continually be updated.

Corrective Action - The City will annually update its storm sewer GIS database to incorporate recent projects and associated storm sewer improvements

4.9. Stormwater Treatment in Redevelopment

Issue

The City is continuing to undergo significant redevelopment and requires modern, effective stormwater treatment to protect the Mississippi River and other surrounding water resources. The City is also experiencing competing needs between density and space for stormwater treatment.

Corrective Action

The City of St. Paul has shifted from a solely case-by-case to a more regional approach to address stormwater treatment in redevelopment and other street projects. The following studies summarize recent examples of the City's stormwater treatment solutions.

4.9.1. Ford Site

The Ford Site, labeled by the City as *A 21st Century Community,* will be a mixed-use neighborhood that will support many types of transportation, living, clean energy and technology, jobs and recreation. Rainwater reuse with man-made streams has been proposed throughout the development, which will flow into trees and raingardens rather than stormwater ponds.

4.9.2. Light Rail Transit Green Line

Shared stacked green infrastructure (SSGI) concepts (See Section 5.7) were introduced in the Twin Cities' Light Rail Transit Green Line Project, which is expected to spark additional redevelopment along its corridor, a trend referred to as Transit Oriented Development (TOD). SSGI was utilized to increase "location efficiency" and livability in a dense, mixed-use area. Green infrastructure is located in street boulevards using tree trenches, rain gardens, and boulevard swales. These green infrastructure solutions increase aesthetic value to the area surrounding the Light Rail, while providing stormwater treatment to reduce polluted runoff into the Mississippi River. The final document, *Strategic Stormwater Solutions for Transit-Oriented Development,*[23] is available on the City of St. Paul's Planning and Economic Development Department website.

4.9.3. West Side Flats

The West Side Flats Greenway will be an example application of a shared public-private stormwater management facility using green infrastructure in the City. The West Side Flats Master Plan and Development Guidelines[24] were adopted as an addendum to the St. Paul Comprehensive Plan in June 2015.

4.9.4. CHS Field

CHS Field was built in downtown St. Paul to help revitalize the Lowertown neighborhood. Providing sufficient water for the stadium was a challenge for the large development. The City of St. Paul, Saint Paul Saints, Metropolitan Council, and CRWD collaborated to implement a rainwater collection system. Roof space from CHS Field and the Green Line light rail Operations and Maintenance Facility next door harvest rainwater and use it to irrigate the ball field and flush toilets after it is treated with UV light. Project details are available at the CHS Field Project website[25].

4.9.5. Snelling-Midway Redevelopment Site

The new soccer stadium development will be encompassed by a completely redeveloped 34.5-acre superblock with a mixed use of commercial, residential, and retail lots. North of the stadium are two large open green spaces. Roof runoff sized for ultimate development will be collected in underground cisterns and treated and reused for irrigation on vegetated areas. The Stormwater Management Plan[26] for the project site is available on the City of St. Paul's Planning and Economic Development Department website.

[23] Strategic Stormwater Solutions for TOD, 2013. http://www.corridorsofopportunity.org/sites/default/files/Strategic_Stormwater_Solutions_for_TOD_Final_Report.pdf

[24] West Side Flats Master Plan & Development Guidelines, 2015. https://www.stpaul.gov/sites/default/files/Media%20Root/Planning%20%26%20Economic%20Development/WSFMP_FINAL_121715_Web.pdf

[25] CHS Field Project Details. http://chsfield.com/about/project-details

[26] Snelling-Midway Redevelopment Site Stormwater Management Plan, 2016. https://www.stpaul.gov/departments/planning-economic-development/planning/snelling-midway-redevelopment-site

5. GOALS AND POLICIES

5.1. General

The primary goal of St. Paul's LSWMP is to bring the City into statutory compliance with County, Regional, and State goals and policies, and provide the City a framework for effective surface water management. These goals and policies have been developed to complement County, Regional or State goals and policies, and to be in conformance with the policies required by comprehensive plans for the Capitol Region Watershed District (CRWD), Ramsey-Washington Metro Watershed District (RWMWD), Lower Mississippi River Watershed Management Organization (LMRWMO), and the Mississippi Watershed Management Organization (MWMO). Cooperation, collaboration, and partnering results in projects that are less likely to conflict with the goals of the affected entities, are better able to meet long-term goals, and are generally more cost-effective. Effective surface water management includes guiding redevelopment activities and identifying and implementing retrofits to the existing system.

The goals and policies described in this section are intended to incorporate the foundation of several regional, state, and federally mandated programs. They are not meant to replace or alter the regional, state and federally mandated programs, rules and regulations, but to serve as an enhancement and provide some general policy guidelines. The City is in the process of updating its comprehensive plan to plan until 2040. The goals address the management strategies dictated by the WDs and WMOs while addressing the vision and changing needs of the City. The various watershed districts in the City have a separate rule process. These rules will apply to projects within the City and separate approvals may be required for projects. Additional city goals and policies are contained throughout this section. The most recent rules and standards of the WDs and WMOs can be found at the following links:

CRWD: http://www.capitolregionwd.org/

LMRWMO: http://www.dakotaswcd.org/watersheds/lowermisswmo/

MWMO: http://mwmo.org/

RWMWD: http://www.rwmwd.org/

These goals and policies have also been developed to preserve and use natural water storage and retention systems in order to:

- Limit public capital expenditures that are necessary to control excessive volumes and rates of runoff.
- Improve water quality.
- Prevent erosion of soil into surface water systems.
- Promote groundwater recharge.
- Protect and enhance fish and wildlife habitat and water recreational facilities.
- Secure the other benefits associated with the proper management of surface water.

The goals and policies the City has developed address issues related to water quantity, water quality, recreation, fish and wildlife, enhancement of public participation, information and education, ground water management, wetland management, soil erosion management, Mississippi River management, the NPDES Stormwater Permit, and shared stack green infrastructure. Outlined below are the goals and policies that have been developed for each of the above areas of concern.

5.2. Water Quantity

5.2.1. Goals

Control excessive runoff volumes, rates, and downstream impacts from development and protect, preserve, and expand (where possible) the stormwater storage and detention systems to prevent flooding and protect public health and safety while limiting public capital expenditures.

5.2.2. Policies: Rate Control

1. Runoff rates into public storm sewers shall be controlled, reviewed, and approved in accordance with the department of public works policy. The City requires rate control according to Chapter 52 of the current City code. The City will update the rate control policy as necessary to ensure rate control is met.

2. Runoff rate control shall meet the performance standards of the LMRWMO requiring no increase in peak runoff rate for the Atlas-14 5- or 10-year event and the 100-year event. It is encouraged that there is also no rate increase for the 2-year event as well.

3. A hydrograph method based on sound hydrologic theory shall be used to analyze runoff rates and high water levels for proposed development and redevelopment projects.

4. The City will maintain maximum and average Atlas-14 100-year discharge rates and storage volume in regional detention areas.

5. Outlets for landlocked basins will be provided based on the following conditions:

    a. Only the existing tributary area may discharge to a landlocked basin, unless provision has been made for an outlet from the basin.

    b. The form of outlet may range from temporary pumps to gravity storm sewers. The outlet is to be in place before increased water levels are likely to affect vegetation, slope stability and property values.

    c. The City will encourage the reduction of impervious area coverage and increase infiltration opportunities in watersheds tributary to landlocked basins.

    d. In establishing high water elevations and whether outlets are needed for landlocked basins, the long duration events, such as multiple-year wet cycles and high runoff volume events will be considered (e.g. snowmelt events that last for many weeks).

e. Emergency overflows or outlets to drainage systems will be provided to any landlocked area if the available stormwater storage capacity is inadequate to prevent flooding of residences and if the available downstream conveyance system capacity is adequate to accept additional flow.

6. Detention facility design will include access for maintenance of the outlet structure and to the facility in general.

7. Easements over floodplains, detention areas, wetlands, ditches, and all other parts of the stormwater system are required as areas develop or redevelop.

8. Project proposers will need to contact the local watershed district or watershed management organization to determine if there are additional rate control requirements.

9. The City intends to use both designated and non-designated areas to store stormwater runoff. Non-designated areas include general depressions, areas lacking easements, low points, and streets where structures and/or property is not damaged and any inundation that occurs will only be temporary in nature.

10. Drainage and utility easements shall be dedicated over newly constructed private stormwater management features (volume, rate control, and water quality treatment infrastructure) including but not limited to ponds, infiltration basis, rain gardens, underground storage and treatment devices, tree trenches, etc. Easements shall be acquired as necessary for existing stormwater management features.

5.2.3. Policies: Flood Control

1. The level of flood protection to be provided along trunk conveyance systems streams, channels, wetlands, ponds, detention basins, and lakes shall be based on the critical-duration 100-year flood for Atlas-14.

2. A levee system is in place to protect certain areas of the City along the Mississippi River corridor. A levee permit will be required for developments in proximity to the City levee.

3. The critical 1% chance event will be defined as the event that requires the greatest stormwater storage volume in a storage facility. These facilities include lakes, ponds, and their outlets.

4. Trunk stormwater systems shall be designed to provide discharge capacity for the critical-duration runoff event that is not less than the Atlas-14 10-year frequency event. For open channel conveyance systems, the design criteria shall be for the critical Atlas-14 100-year event.

5. All minor drainage systems (non-trunk) and local stormwater collection systems analyses and design will be based on the Atlas-14 5-year event unless otherwise specified.

6. New storm sewers and open channels shall be designed using a technical method approved by the City.

7. The high-water levels of stormwater detention facilities shall be based on a minimum Atlas-14 100-year frequency storm event. Freeboard requirements shall meet the requirements in Chapter 52 of the City Code. The 100-year high water level shall be determined based on the more restrictive of the City's hydrologic/hydraulic model, FEMA floodplain and watershed districts.

8. Emergency overflow structures (e.g. swales, spillways) are to be incorporated, where feasible, into pond outlet structure designs to prevent undesired flooding resulting from storms larger than the Atlas-14 100-year (one percent) event or plugged outlet conditions.

9. Emergency overflow drainage routes shall be provided at all low point locations a minimum of 1.5 feet below the lowest adjacent building opening. Emergency overflow drainage routes shall be constructed in a manner that will accommodate the Atlas-14 100-year storm event.

10. Uses or activities within the 100-year floodplain are regulated under Chapter 72 of the City Code. Refer to Chapter 72 for more information regarding floodplain management within the City.

11. The City will work with the local watershed districts and watershed management organizations to monitor lake levels and modify predicted flood levels when necessary

12. The minimum building elevation for new or redevelopment shall meet the following criteria:

    a. The basement floor will be 4 feet above the currently observed groundwater elevations in the area.

    b. The basement floor elevation will be 2 foot above the 100-year high surface water elevation for the area.

    c. Apply to all areas within the City except the River Corridor Overlay Districts which are required to be in conformance with Chapter 68 of the Zoning Code.

5.2.4. Policies: Infiltration and Volume Control

1. The City will require the development of enhanced infiltration practices wherever practical and feasible to reduce impervious areas. The City will not maintain private infiltration areas.

2. Pretreatment will be required prior to discharge to any new infiltration system to preserve the function of the system. Pretreatment practices shall be sized and designed per the recommendations set in the Minnesota Stormwater Manual.

3. For projects that disturb one or more acres of land, the following volume control standard must be applied: stormwater runoff shall be retained onsite in the amount equivalent to 1.1 inches of runoff over the impervious surfaces of the development. Volume control requirements must also be met for the relevant watershed requirements depending on the

project location within CRWD, RWMWD, MWMO, and LMRWMO.

4. St. Paul's flood control strategy is to reduce the volume of its runoff through regional stormwater facilities and reuse or infiltration projects. The City will work with the CRWD, LMRWMO, MWMO, RWMWD, and surrounding communities to achieve their flood control goals.

5. Drainage calculations must be submitted and approved as part of any development or redevelopment applications for sites larger than one quarter acre or greater in accordance with to the Stormwater Ordinance and the Stormwater Management Site Plan Review Worksheet prior to the issuance of any building or grading permit.

6. The City maintains a hydrologic model of the stormwater system. A hydrologic model was developed for the City of St. Paul Sewer Separation project. This model is included in the Comprehensive Sewer Plan for the City of St. Paul and is available at the St. Paul Public Works Department.

7. The City will ensure that City development, redevelopment, and/or infrastructure projects will not overtax the existing downstream stormwater drainage system.

5.3. Water Quality

5.3.1. Goal

Maintain and/or enhance the water quality of the lakes, streams, or rivers within and immediately downstream of the City of St. Paul.

5.3.2. Policies

1. The watershed districts and watershed management organizations have developed the following lake classification system for lakes within their watershed:

Capitol Region Watershed District		
Lake Name	**Plan**	**Status**
Como Lake	Strategic Lake Management Plan	Complete
Crosby Lake	Lake and Natural Resource Plan	Complete
Loeb Lake	Strategic Lake Management Plan	Complete

Strategic Lake Management Plan identifies important management issues through input from key stakeholder groups, prioritizes the issues and associated goals, and identifies implementation activities, including institutional and public roles, time frames, and funding.

Lake and Natural Resource Plan to address resource concerns and future management. Cooperation between the City, residents, businesses, watershed district, and non-profit organizations will aid in developing the plan.

Ramsey-Washington Metro Watershed District		
Lake Name	**Use Level**	**Management Class**
Beaver Lake	3	Restore/Improve
Lake Phalen	1	Restore/Improve

Level-1 activities require excellent lake water clarity. As water begins to appear green, clarity and color appeal decline. Clarity for swimming and scuba diving should be at least 5.25 feet.

Level-3 activities require good lake habitat for fish and wildlife, along with public boat access for fishing. In the urban setting it is wise to manage for less than or equal to 60 ug/L TP to minimize the potential for foul odor when poor conditions occur, such as long periods of hot days.

Fish production is affected by a lake's dissolved-oxygen concentration under the ice during the winter months. Lake depth is critical in predicting the tendency of a lake toward winterkill conditions, when large numbers of fish perish due to low dissolved-oxygen concentrations during the late winter. A minimum depth of 13 feet is generally needed to avoid winterkill. Lake aeration can also be used to provide oxygenated water during winter months.

Lower Mississippi River WMO		
Lake Name	**Classification**	**Minimum Action Needed**
Pickerel Lake*	Category III	Trend Analysis; Secchi disc monitoring

Category III water body classification recommends water quality monitoring to include secchi disc monitoring (i.e. MPCA's Citizen Lake Monitoring Program).

*Intercommunity water resources are the responsibility of the WMO.

Mississippi River WMO
No designated water bodies currently exist within St. Paul for this watershed.

More information regarding the lake classification system can be obtained in the watershed district or watershed management organization comprehensive plans. The City adopts the lake classification system policies for each watershed by reference through the adoption of the LSWMP.

2. Continue the cooperative monitoring programs with WDs and WMOs to collect stormwater data from the subwatersheds and stormwater BMPs. The City will coordinate with local, state, and federal agencies to establish, implement, and evaluate lake, wetland, and stream monitoring programs. Section 2.6.2 provides detail on the extent of the monitoring programs within St. Paul.

3. The City will require adherence to the NPDES/SDS Construction Permit for all construction sites disturbing 1 acre or more.

4. In the design and construction of new, or modifications to the existing stormwater conveyance systems, pretreatment of stormwater runoff to Nationwide Urban Runoff Program (NURP) recommendations must be provided prior to discharge from the site and/or to a wetland, lake, or stream. Utilize, where feasible, regional stormwater detention facilities when possible to enhance water quality by removing sediment and nutrients from runoff.

5. The City's natural ponding areas, such as wetlands and lakes, currently provide and

will continue to provide for the impoundment and treatment of surface water runoff as appropriate and according to local, state, and federal regulations.

6. The City has adopted the NURP design recommendations for the design of stormwater treatment basins as required in the Minnesota Stormwater Manual.

7. The City will work with the watershed districts and watershed management organizations when practical and feasible to construct regional detention basins to treat stormwater runoff when upstream facilities cannot effectively reduce sediment and nutrient loads to target levels.

8. Project proposers will need to contact the local watershed district or watershed management organization to determine if there are additional water quality requirements.

9. The owner of a detention basin, water quality pond or water quality treatment device shall provide either the City, CRWD, or RWMWD with an executed copy of an Agreement for Maintenance and Inspection of Utility and Storm Drainage Systems in an acceptable form.

10. The City will continue to respond to hazardous spills as required by state law.

11. The City will continue to work cooperatively with Ramsey County to implement the household hazardous waste disposal program and educate residents on the proper disposal of household hazardous waste. For more information see http://www.co.ramsey.mn.us/.

12. The City has worked to eliminate illegal connections to the City's stormwater conveyance system and will continue this work when additional connections are identified.

13. The City anticipates working with neighboring municipalities to control runoff rates and provide water quality treatment prior to the discharge of stormwater across municipal boundaries.

14. The City will continue to follow the MPCA NPDES Phase I guidelines and has obtained a Municipal Storm Sewer Permit in 2000 as part of the MPCA requirements.

15. The City will share water quality data and trends with the surrounding cities, watershed districts, and watershed management organizations.

16. The City requires implementation of best management practices during development and redevelopment to achieve the goal of reducing non-point source pollution. The City will work to reduce small non-point sources of pollution through community education, demonstration projects, and various housekeeping practices and maintenance procedures in compliance with the Municipal Storm Sewer Permit.

17. The City will reference the Minnesota Stormwater Manual for water quality guidance for new development and redevelopment projects.

18. The City will encourage the reduction in the amount of impervious surface upon development or redevelopment.

19. The City will promote Low Impact Development (LID) design concepts into development and redevelopment projects to the greatest extent feasible. Additional information on LID is available in the St. Paul Department of Public Works.

20. The City has adopted the Stormwater Ordinance, which includes established standards and specifications for practices and planning activities, which minimize stormwater pollution, soil erosion, and sedimentation.

21. The City will adopt and implement MnDNR shoreland ordinances when required by the MnDNR.

22. Utilize the Watershed Restoration and Protection Strategy (WRAPS) Study[27] in Cooperation with the MPCA to identify and address threats to water quality. The information from the WRAPS Study serves as the basis for TMDL reports published by the MPCA. Battle Creek, Beaver Lake, and Lake Phalen were all evaluated as a part of WRAPS. The WRAPS Study areas and impaired waters are illustrated in **Figure A14.**

5.4. Recreation, Fish and Wildlife

5.4.1. Goal

Protect and enhance recreational facilities and fish and wildlife habitat.

5.4.2. Policies

1. The City will cooperate with the Minnesota Department of Natural Resources, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and other appropriate agencies in promoting public enjoyment and protecting fish, wildlife, and recreational resources in the City.

2. The City will work to preserve wetlands that provide habitat for wildlife and spawning of fish.

3. The City will encourage land owners to maintain wetlands and open space areas for the benefit of wildlife.

4. The City will participate with local watershed districts, watershed management organizations, and the MnDNR Natural Heritage Program to identify high value natural communities, and collectively discourage, critically review, and modify proposals where appropriate to avoid the loss of high value natural resources (wetlands, forests, shrublands, grasslands, and open spaces).

5. The City will update their current Wetland Management Plan that includes a wetland inventory, habitat assessment, and management plan for wetlands and water bodies on public property. The City will request assistance from the local Watershed Districts.

[27] MPCA WRAPS. https://www.pca.state.mn.us/water/watershed-approach-restoring-and-protecting-water-quality

6. The City will require buffers on private land to be implemented around storm ponds, lakes, wetlands, and streams upon new development or redevelopment. These buffers will be promoted and encouraged for all existing properties adjacent to lakes, streams, and wetlands and promoted through public education.

7. The City will establish and maintain vegetative buffer areas around lakes, wetlands, and streams on public property where practical. The extent and location of these buffers will be assessed as part of the Wetland Management Plan development.

8. Encourage alternative landscape designs into proposed projects that:

    a. Increase beneficial habitat, wildlife and recreational uses; promote infiltration and vegetative water use; and

    b. Decrease detrimental wildlife uses (such as beaver dams, goose overabundance) that damage water control facilities, shoreline vegetation, water quality or recreational facilities.

9. The City will manage and control noxious and invasive plant species as practical and work to increase awareness of the problem.

10. Cooperate with watersheds and other units of government to complete habitat and recreation corridor connections (greenways).

11. Continue to manage key conservation areas within the City. Coordinate efforts to protect rare and endangered species and areas of significant natural communities with the Minnesota Department of Natural Resources. Refer to the zoning map from the comprehensive plan for a reference of these areas.

12. Coordinate efforts with state, county and neighboring municipalities to enhance water based recreation to the extent practical.

5.5. Enhancement of Public Participation, Information, and Education

5.5.1. Goal

Increase public awareness, understanding and involvement in water and natural resource management issues.

5.5.2. Policies

1. The City will disseminate information to the public regarding water resources, groundwater, wetlands, native vegetation, buffers, wildlife habitat, litter control, pet wastes, recycling, trash disposal, leaf collection, grass clippings, lawn chemicals, and hazardous materials. Information may be distributed via the City's newsletter, City website, local newspapers, cable television or other appropriate methods.

2. The City will coordinate its education efforts with the local watershed districts, watershed management organizations, and Ramsey County to take advantage of efficiencies of scale where appropriate.

3. The City will continue to implement an education program. This program includes the following:

    a. Storm drain stenciling (contracted with Friends of the Mississippi River)

    b. Door hangers with information about protecting water resources (contracted with Friends of the Mississippi River)

    c. City Staff go to local schools to share information about protecting water resources

    d. City newsletters

    e. City website (http://www.ci.stpaul.mn.us/).

    f. Include informational brochure with storm sewer service utility charge mailing

4. The City will sponsor a city-wide parks cleanup day.

5.6. Public Ditch Systems

5.6.1. Goal

There are no public ditch systems owned by the City of St. Paul. The Beltline Interceptor, identified in Table 3.5-2 of the RWMWD Comprehensive Plan, was transferred to the RWMWD district in January 1, 1996.

5.7. Groundwater

5.7.1. Goal

Coordinate activities and/or manage surface water runoff to the degree necessary to meet requirements for groundwater protection or management as required by Ramsey County, Minnesota Pollution Control Agency, the Minnesota Department of Health, and the Department of Natural Resources.

5.7.2. Policies

1. Encourage groundwater recharge and cooperate with the watershed efforts to protect recharge areas from potential sources of contamination. Provide increased green space, native vegetation, and pond "dead" storage wherever possible and appropriate to allow for the infiltration of stormwater runoff and promote groundwater recharge.

2. The City will work cooperatively with Ramsey County to protect groundwater sources and recharge areas identified in the 2010 Ramsey County Groundwater Protection Plan[28].

3. The City will cooperate with state and regional agencies on ground water monitoring,

[28] https://www.ramseycounty.us/sites/default/files/2010%20groundwater%20plan%20update%20conservation.pdf

inventorying, wellhead protection efforts, and permitting programs.

4. The City will cooperate with the Department of Health and the Ramsey Conservation District to insure that all unsealed or improperly abandoned wells within the City are properly sealed. Technical requirements for the abandonment of these wells will be in conformance with the local and state regulations.

5. The City will coordinate with the watershed districts to evaluate the need and resources for a permanent groundwater quality monitoring program.

6. The City will maintain updated records of all known on-site septic systems and prohibits the installation of new individual septic systems or alterations, repairs or extensions of existing systems when connection can be made to the city sanitary system. The City will also continue to develop a management program and ordinance for individual sewage treatment systems (ISTS) that is consistent with MPCA Rules 7080 and Metropolitan Council policies.

7. The City will encourage the development of alternative stormwater management methods including rainwater reuse, vegetated swales and infiltration practices for stormwater projects, development, and redevelopment, provided these methods do not contaminate ground water.

5.8. Wetlands

5.8.1. Goal

The City will protect wetlands in conformance with the requirements of the Wetland Conservation Act of 1991, as amended. Achieve no net loss of wetlands, including acreage, functions, and values. Where practical, improve the functions, values, biological diversity, and acreage of existing wetlands.

5.8.2. Policies

1. The City is the local governmental unit (LGU) responsible for administering the Wetland Conservation Act (WCA) and rules. The City will protect and manage wetlands in conformance with WCA.

2. The City will seek opportunities to create new wetlands and restore previously impacted wetlands in cooperation with citizens, counties, and the state.

3. The City will encourage public and private landowners to maintain wetlands and open space areas for the benefit of wildlife.

4. Prior to issuance of any city grading or building permits, all development and redevelopment activities must comply with the Wetland Conservation Act.

5. When managing a wetland for the primary purpose of quality management and flood retention, detrimental effects to the other wetland functions and values such as wildlife habitat, species diversity, aesthetics, etc will be minimized to the extent practical and feasible.

6. The City will encourage buffers on private land to be implemented around storm ponds, lakes, wetlands, and streams upon new development or redevelopment.

7. A vegetated buffer strip with a minimum buffer width of 25-feet and an average width of 30-feet measured from the ordinary high water level of the watercourse or wetland is required adjacent to wetlands, lakes and natural water course.

8. Drainage and utility easements shall be dedicated over wetland buffer areas.

9. Runoff shall not be discharged directly into wetlands without pretreatment of the runoff.

10. The City will work with local watershed districts and watershed management organizations to streamline and coordinate the application and approval process for wetland permits.

5.9. Erosion and Sediment Control

5.9.1. Goal

Protect the capacity of the City's stormwater management system, prevent flooding, maintain water quality by preventing erosion and sedimentation from occurring, and correcting existing erosion and sedimentation problems.

5.9.2. Policies

1. The City of St. Paul is responsible for the review and enforcement of erosion and sediment controls for activities that require a grading and erosion control plan.
2. Erosion control must meet the requirements outlined in the Minnesota Pollution Control Agency's NPDES General Permit to Discharge Stormwater from Construction Sites[Error! Bookmark not defined.2].
3. The City's Inspectors will conduct erosion control inspections for construction projects.
4. Point discharges of stormwater to open channels or detention basins shall be constructed in a manner that minimizes erosion.
5. Effective energy dissipation devices should be provided at all conveyance system discharges to prevent bank, channel or shoreline erosion.
6. Design of stream bank stabilization and streambed control measures should consider unique or special site conditions, energy dissipation potential, adverse effects, preservation of natural processes and habitat, and aesthetics in addition to standard engineering and economic criteria.
7. The City will require any development or redevelopment to comply with the erosion control standards found in the City's Stormwater Ordinance included in Appendix C
8. The City will maintain its erosion and sediment control standards to be in conformance with the "Minnesota Urban Small Sites BMP Manual" (Metropolitan Council) and "Protecting Water Quality in Urban Areas"(MPCA). This Building Code contains information about erosion control requirements and is included in Appendix C.

9. It shall be the responsibility of the developer / contractor to keep streets and property adjacent to construction areas free from sediment carried by construction traffic at site entrances and access points, and from site runoff and blowing dust.
10. Acceptable erosion in drainageways is limited to that which causes no net degradation of the watercourse or destruction of properties adjacent to the watercourse.

5.10. NPDES Stormwater Permit

A full copy of the City's Stormwater Permit Annual Report can be obtained upon request; the document is included in this LSWMP by reference. The goals and policies of the Stormwater Permit are outlined below.

5.10.1. Goal

The City will continue to meet the goals of its current NPDES permit to fulfill the obligations of the permit to reduce the amount of sediment and pollution that enters surface and ground water from storm sewer systems to the maximum extent possible.

5.10.2. Policies

1. The City will continue to implement a water quality monitoring program per the NPDES permit.

2. The City will sweep all the City streets and alleys as outlined in the Stormwater Permit Annual Report. Street sweeping frequency ranges from three times per week to twice per year. A copy of the report is available from the St. Paul Public Works Department.

3. The City will continue to implement the City's Public Education Program. More information regarding the storm drain stenciling education program can be found in the Stormwater Permit Annual Report available at the St. Paul Public Works Department or contacting the Friends of the Mississippi River (FMR) citizens' organization.

4. The City will continue to implement an Asset Management system to have the data and system necessary to accurately determine the drainage area, land use, population, percent impervious surface, and the runoff coefficient for each of the City's storm sewer outfalls. This system is being jointly implemented with the St. Paul Regional Water Services.

5. The City will maintain a list of facilities that are issued NPDES permits by the MPCA and provide this list in the Stormwater Permit Annual Report.

6. The City will operate, maintain, and construct its storm sewer system in a manner to minimize the impacts on water quality of the receiving waters. The performance measures for this policy are outlined in the Stormwater Permit Annual Report.

7. The City will continue to monitor 20% of its storm sewer outfalls on an annual basis and provide erosion protection as necessary based on the outlet inspection results. Results of previous inspections are available in the Stormwater Permit Annual Report.

8. The City will continue to inspect its stormwater ponds on an annual basis and perform

maintenance as needed.

9. The City will continue to train employees on snow and ice control on streets in order to maintain safe streets in an economical way while protecting the environment.

10. The City will conduct an annual field screening of illicit discharges and improper disposal of materials into the storm sewer system.

11. The City will continue to implement its storm drain stenciling program with assistance from other organizations, such as the Friends of Mississippi River.

12. The City will continue its involvement with Metro Watershed Partners.

13. The City will continue to support Waterfest with the Ramsey-Washington Metro Watershed District.

14. The City will continue to support the Annual Spring Parks Clean Up.

5.11. Shared Stacked Green Infrastructure (SSGI) Design

5.11.1. Goal

Meet stormwater requirements while providing stormwater treatment, recreational space and improved air quality in an aesthetically pleasing environment.

5.11.2. Policies

1. SSGI must be implemented on a case-by-case basis, so projects must determine its feasibility early in development.

2. The EPA's final document[29] outlining the shared-stacked green infrastructure concept provides guidelines for implementing stormwater management in limited, urban space.

3. SSGI will be an approach considered when new roads or other public improvement corollary to private development will required water quality treatment or runoff control.

4. Maximizing runoff control and water quality treatment will be a priority considered during SSGI projects.

5. City staff will establish interdepartmental capacity to implement SSGI and District systems.

5.12. Financing

5.12.1. Goal

Minimize and fairly distribute public expenditures for plan implementation, with emphasis on using the City's stormwater utility to finance projects and

[29] West Side Flats Greenway Conceptual Green Infrastructure Design. https://www.epa.gov/sites/production/files/2015-10/documents/saint_paul_tech_assistance.pdf

collaborating/partnering with other entities.

5.12.2. Policies

- Use the City's Stormwater Utility Fund to pay for stormwater management projects and implementation activities.
- Use other funding sources including land sale proceeds, partner with the Watersheds, State Aid funds, grants, etc. to pay for the implementation activities, when available and appropriate.
- The City will use its Stormwater Utility Fund to pay for the public education and information programs.

SECTION 6

6. IMPLEMENTATION PROGRAM

6.1. Implementation Program Components

Table 6-1 contains a comprehensive list of the MS4 activities and projects, programs, and studies that make up the City of St. Paul's implementation program for the next 10 years (2018 through 2027). The program was developed by evaluating the requirements in the MS4 permit, reviewing existing information (**Section 2**), identifying potential and existing problems (**Section 4**), reviewing goals and policies (**Section 5**), and then assessing the need for programs, studies, maintenance, or projects. Costs were estimated, possible funding sources were identified, and a schedule was developed to complete the implementation activities. It is anticipated these tables will be updated/revised on a yearly basis.

6.2. Implementation Priorities

The implementation components listed in **Table 6-1** were prioritized to make the best use of available local funding, meet MS4 Permit requirements, address existing stormwater management problems, and prevent future stormwater management problems from occurring. **Table 6-1** identifies which activities are MS4 Permit Requirements, Annual Requirements, or Capital Projects/Programs/Studies. The City's implementation plan reflects its responsibility to protect the public health, safety, and general welfare of its citizens by addressing problems and issues that are specific to the City of St. Paul.

6.3. Financial Considerations

The City will use funds generated from its Stormwater Utility as the primary funding mechanism for its implementation program including; maintenance, repairs, capital projects, studies, etc. The City will continue to review the stormwater utility fee annually and adjust as needed. The City will also take advantage of grant or loan programs to offset project costs where appropriate and cost-effective.

6.4. Plan Revision and Amendments

The City may need to revise this Plan to keep it current. Any significant amendments that are made to the plan must be submitted to the CRWD, LMRWMO, MWMO, and RWMWD for review and approval before adoption by the City. Future changes will be submitted to the WDs and WMOs for their record, but not for review and approval. The City may amend this plan at any time in response to a petition by a resident or business. Written petitions for plan amendments must be submitted to the City Sewer Utility. The petition must state the reason for the requested amendment, and provide supporting information for the City to consider the request. The City may reject the petition, delay action on the petition until the next full plan revision, or accept the petition as an urgent issue that requires immediate amendment of the plan. The City of St. Paul may also revise/amend the plan in response to City-identified needs. This Plan is intended to be in effect for 10 years (implementation program outlines cost/activities for 15 years) per state statute. The Plan will be updated at that time, to the extent necessary.

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Comments
	TABLE 6.1													
	LOCAL WATER MANAGEMENT IMPLEMENTATION PLAN													
				Proposed Cost By Year[1]										
	CAPITAL IMPROVEMENT PROJECTS (CIP)													
1	Construct regional infiltration basins based on Volume Reduction Study, implement volume improvements	$4,500,000	Stormwater Utility, Grants, Watershed District Partnerships	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	$450,000	Cost dependent on outcome of study, assume 30,000 (verify) cu ft of storage will be required to offset street projects, 12.25 / cu ft
2	Annual replacement of storm sewer with road projects (includes remaining Como subwatershed)	$850,000	Stormwater Utility, Grants	$85,000	$85,000	$85,000	$85,000	$85,000	$85,000	$85,000	$85,000	$85,000	$85,000	
3	Coordinate park maintenance, bluff erosion, natural areas restoration, and lake management along the Mississippi River	$70,000	City Funding, Stormwater Utility, Grants	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000	
4	Partner in implementing projects identified in the Capitol Region Watershed District In-Lake TP Study. This study is currently underway.	TBD	CRWD											Cost depenent on outcome of study
5	Implement projects identified in the Battle Creek subwatershed feasibility study for TSS and E.coli. RWMWD WRAPS implementation table identifies this study to be complete in 2016/2017.	TBD	RWMWD, Grants, Stormwater Utility											Cost depenent on outcome of study
6	Assess options for inactivation of sediment release in Beaver Lake by 2020 and collaborate with Ramsey-Washington.	$80,000	RWMWD, Grants, Stormwater Utility		$40,000	$40,000								
7	Ravine stabilization by Cherokee Heights. The City of St. Paul recently entered into a joint powers agreement (JPA) with the City of West St. Paul and City of Mendota Heights to prepare construction plans and complete a project to rehabilitate the Cherokee Heights upper ravine.	$700,000	West St. Paul, Mendota Heights, LMRWMO Grants	$350,000	$350,000									
8	East Phalen Filtration WQ Project	$800,000	Stormwater Utility, RWMWD, Grants											
9	Update Dodd study, look at connector to West St. Paul in West Side Flats area. The City will look to partner with neighboring communities.	TBD	Grants, Stormwater Utility, Other Municipalities						x					No current study is underway.
10	Identify potential stormwater projects on the Ford site.	TBD	Grants, Stormwater Utility					x						Cost dependent on outcome of the study.
11	Identify projects from the Como-Park Regional Stormwater Master Plan for capital improvements to achieve TP reduction. This study is currently underway.	TBD	CRWD, Stormwater Utility, Grants, City Funding											

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	Proposed Cost By Year[1] 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Comments
12	Como Park Senior high school, partnership with public school district and CRWD. This project is nearing completion.	TBD	CRWD, Stormwater Utility, Grants, SSPS	x										
13	Como McMurray Field (Region Field). This project would include a potential partnership with CRWD, St. Paul Park Department, and St. Paul Public Works.	TBD	CRWD, Stormwater Utility, Grants, City Funding											Diversion installed. Concept study CRWD.
14	Sacket Pond infiltration feasibility options, partnership with RWMWD. Feasibility study nearing completion.	TBD	RWMWD, Stormwater Utility, Grants											
15	Provide funding support for projects that provide pollutant reduction to the Mississippi River	TBD	Grants, Stormwater Utility											Cost depenent on outcome of study. Projects will be identified over 10 years.
16	Towerside Innovation District - future projects will be developed in this area includeing the Dominion Weyerhaeuser Site/Phase 2 of the Sunrise Building and greening and habitat improvements around Kasota Ponds.	TBD	Grants, Stormwater Utility, MWMO											
17	Storm sewer tunnel rehabilitation	$48,000,000	Grants, Stormwater Utility	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	$4,800,000	
18	Partner with Ramsey-Washington Metro Watershed District to improve the PHAL-08 Pond. See RWMWD Watershed Management Plan and WRAPS report for additional detail.	$75,000	RWMWD, Stormwater Utility, Grants			$75,000								
19	Collaborate with RWMWD and Ramsey County on water management issues related to stormwater runoff from the Beltline Interceptor, Battle Creek, and Fish Creek subwatersheds.	$150,000	RWMWD, Stormwater Utility, Grants				$50,000			$50,000			$50,000	Identified in RWMWD's Watershed Management Plan
20	Complete projects City-wide to address flooding and stabilization issues	TBD	Grants, Stormwater Utility											

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	Proposed Cost By Year[1] 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Comments
OPERATIONS AND MAINTENANCE														
21	Continue street sweeping program per MPCA Storm Water Permit and City standards	$31,300,000	Stormwater Utility, City Funding	$2,900,000	$3,000,000	$3,100,000	$3,100,000	$3,200,000	$3,200,000	$3,200,000	$3,200,000	$3,200,000	$3,200,000	
22	Conduct Storm Sewer Maintenance. This includes cleaning, inspection, and repair of storm sewer, catch basins, and manholes, as well as BMP cleaning.	$13,500,000	Stormwater Utility	$1,200,000	$1,200,000	$1,250,000	$1,250,000	$1,300,000	$1,300,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	
23	Be an active participant in the activities of the local watershed districts and water management organizations	$400,000	Stormwater Utility	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	$40,000	
24	Provide review for all new development or redevelopment of sites within the City to assure the goals, policies, and objectives outlined in this plan are implemented. Includes cost for City staff as well as any consultant review time.	$800,000	Stormwater Utility, City Funding	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	$80,000	
25	Perform Local Government Unit (LGU) Role for Wetland Conservation Act	$100,000	Stormwater Utility	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	
26	Sponsor City-wide parks clean up day	$150,000	Stormwater Utility, City Funding	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	$15,000	
27	Coordinate with Ramsey County to continue to implement the household hazardous waste disposal program	$10,000	Stormwater Utility, City Funding	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	
28	Continue NPDES water quantity and quality monitoring program per the MPCA Stormwater Permit	$2,100,000	Stormwater Utility, CRWD	$200,000	$200,000	$200,000	$210,000	$215,000	$215,000	$215,000	$215,000	$215,000	$215,000	
29	Continue a public education program. Includes storm drain stenciling, Metro Clean Water Campaign, and Adopt a Storm Drain.	$805,000	Stormwater Utility	$75,000	$76,000	$78,000	$80,000	$81,000	$83,000	$83,000	$83,000	$83,000	$83,000	
30	Perform neighborhood cleanups throughout the City.	$873,000	Stormwater Utility, City Funding	$80,000	$83,000	$85,000	$87,000	$88,000	$90,000	$90,000	$90,000	$90,000	$90,000	

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	Proposed Cost By Year[1] 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Comments
31	Annually inspect City storm water ponds and remove sediment as needed	$2,445,000	Stormwater Utility	$230,000	$234,000	$239,000	$244,000	$248,000	$250,000	$250,000	$250,000	$250,000	$250,000	
32	Continue to support Waterfest with RWMWD	$50,000	Stormwater Utility, City Funding	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	
33	Continue development of the GIS storm sewer asset management system	$30,000	Stormwater Utility	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	
34	Manage and control noxious and invasive plant species and work to increase awareness of problems in and around stormwater ponds and wetlands	$50,000	Stormwater Utility, City Funding	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	
35	Chloride operations including equipment upgrade	$100,000	Stormwater Utility, City Funding	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	
Monitor and Study														
36	Provide a biennial evaluation for potential projects from the City's regional infiltration study.	$25,000	Stormwater Utility		$5,000		$5,000		$5,000		$5,000		$5,000	
37	Perform required MS4 activities including the following: -Identify improper/illicit discharges to the storm sewer system -Inventory/prioritize industrial discharge locations -Monitor 20% of storm sewer outfalls annually -Annual training to staff	$50,000	CRWD, RWMWD, Grants, Stormwater Utility	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	Proposed Cost By Year[1]										Comments
				2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	
38	Identify and target certain high-priority areas for watershed district, watershed management organizations, and private development redevelopment partnerships	$60,000	CRWD, RWMWD, Grants, Stormwater Utility			$30,000				$30,000				
39	Evaluate non-degradation/preservation project opportunities from the following: -Phalen Lake Strategic Management Plan -Beaver Lake Strategic Management Plan -Como Lake Strategic Management Plan -RWMWD WRAPs Study -Wakefield Lake TMDL	$40,000	Grants, Stormwater Utility, CRWD, RWMWD				$40,000							
40	Atlas 14 Analysis and Ordinance Revision for Chapter 52 of City Code	$30,000	Grants, Stormwater Utility	$30,000										
41	Study Performance of BMPs- collaborate with various partner agencies	TBD	MPCA, Watershed Districts, Other Grant Funding						x		x			Cost dependent on scope of the study.
42	Evaluate stormwater asset management program to assist in assessing stormwater BMP performance,maintenance prioritization and budgeting	$90,000	Grants, Stormwater Utility		$50,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	
43	Complete wetland management plan update which will include a wetland inventory and habitat assessment.	$30,000	Grants, Stormwater Utility, City Funding			$30,000								
44	Studies for West Side Flats drainage issues and the Ford Site	$100,000	Grants, Stormwater Utility, City Funding		$50,000			$50,000						

No.	Project Description	10 Year Total Cost Estimate [1,3]	Possible Funding Sources [2]	Proposed Cost By Year[1] 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	Comments
45	Evaluate and pursue permanent flood control options for Lowertown area.	$100,000	Grants, Stormwater Utility			$50,000	$50,000							
46	Coordinate with partner agencies on Willow Reserve water quality study	$35,000	CRWD					$35,000						
47	Evaluate H&H modeling updates for Atlas 14 rainfall data to better plan for City resiliency	$50,000	CRWD, RWMWD, Grants, Stormwater Utility			$50,000								
48	Evaluate the current Mississippi River Critical Area Plan and update with any rule revisions	$10,000	Stormwater Utility, Grants		$10,000									
49	Partner with the MWMO to complete a study of DNR waters that would be affected by the small watercourse appropriation requirement	$20,000	Stormwater Utility, Grants, MWMO			$20,000								
50	Review and discuss with watershed districts and watershed management organizations redevelopment plans and identify partnering opportunities	$18,000	CRWD, RWMWD, Grants, Stormwater Utility		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	
	TOTAL	$108,596,000		$10,581,000	$10,816,000	$10,770,000	$10,639,000	$10,740,000	$10,666,000	$10,941,000	$10,866,000	$10,861,000	$10,916,000	

[1] Cost estimates are preliminary and subject to review and revision as engineer's reports are completed and more information becomes available. Table reflects 2015 costs and does not account for inflation. Costs generally include labor, equipment, materials, and all other costs necessary to complete each activity. Some of the costs outlined above may be included in other operational costs budgeted by the City.

[2] Funding for stormwater program activities projected to come from following sources - Surface Water Management Fund, Developers Agreements, Grant Funds, General Operating Fund, or Special Assessments.

[3] Staff time is not included in the cost shown.

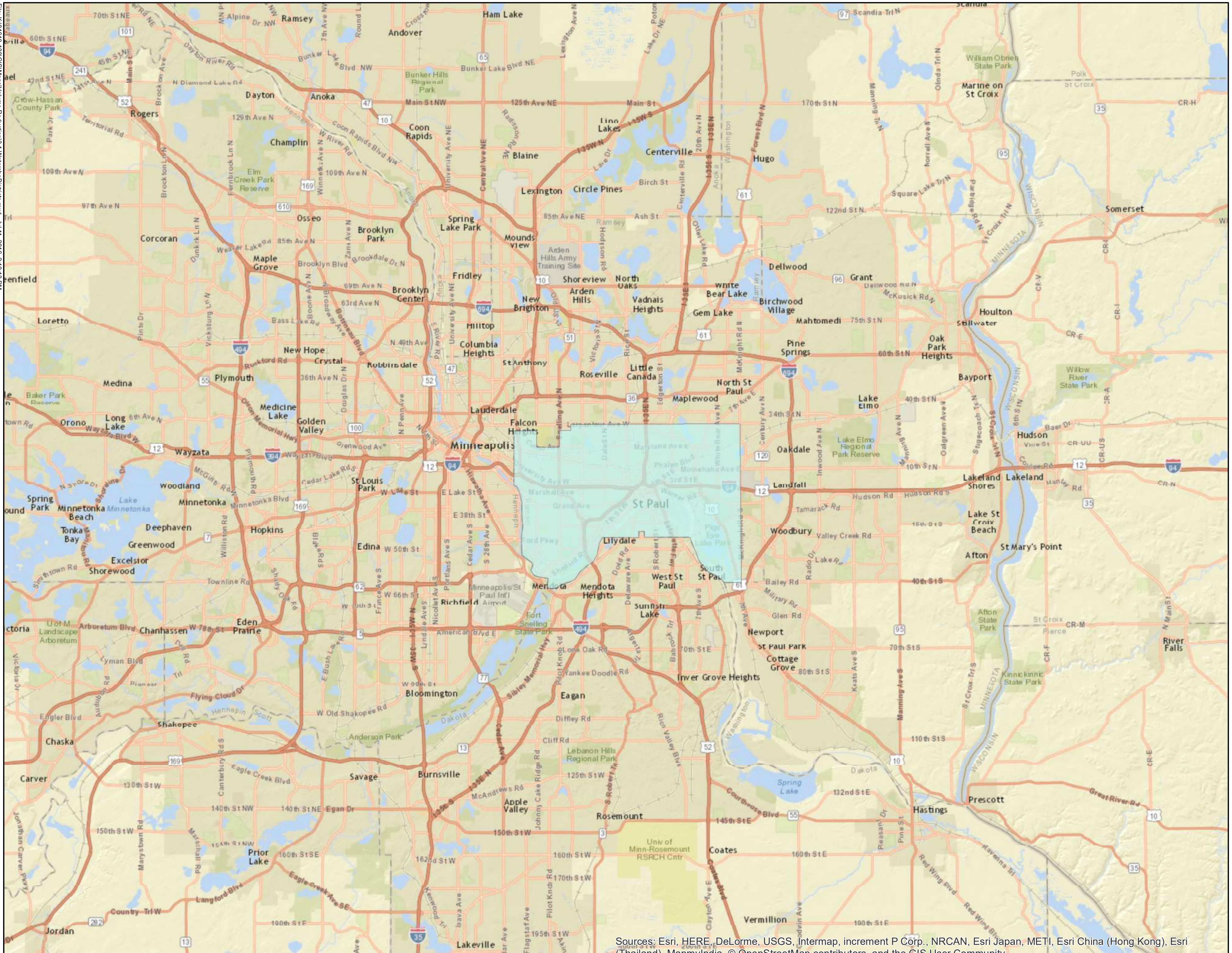
Appendix A

Figures

City of St. Paul

Surface Water Management Plan

Figure A1
Location Map



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SAINT PAUL
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N
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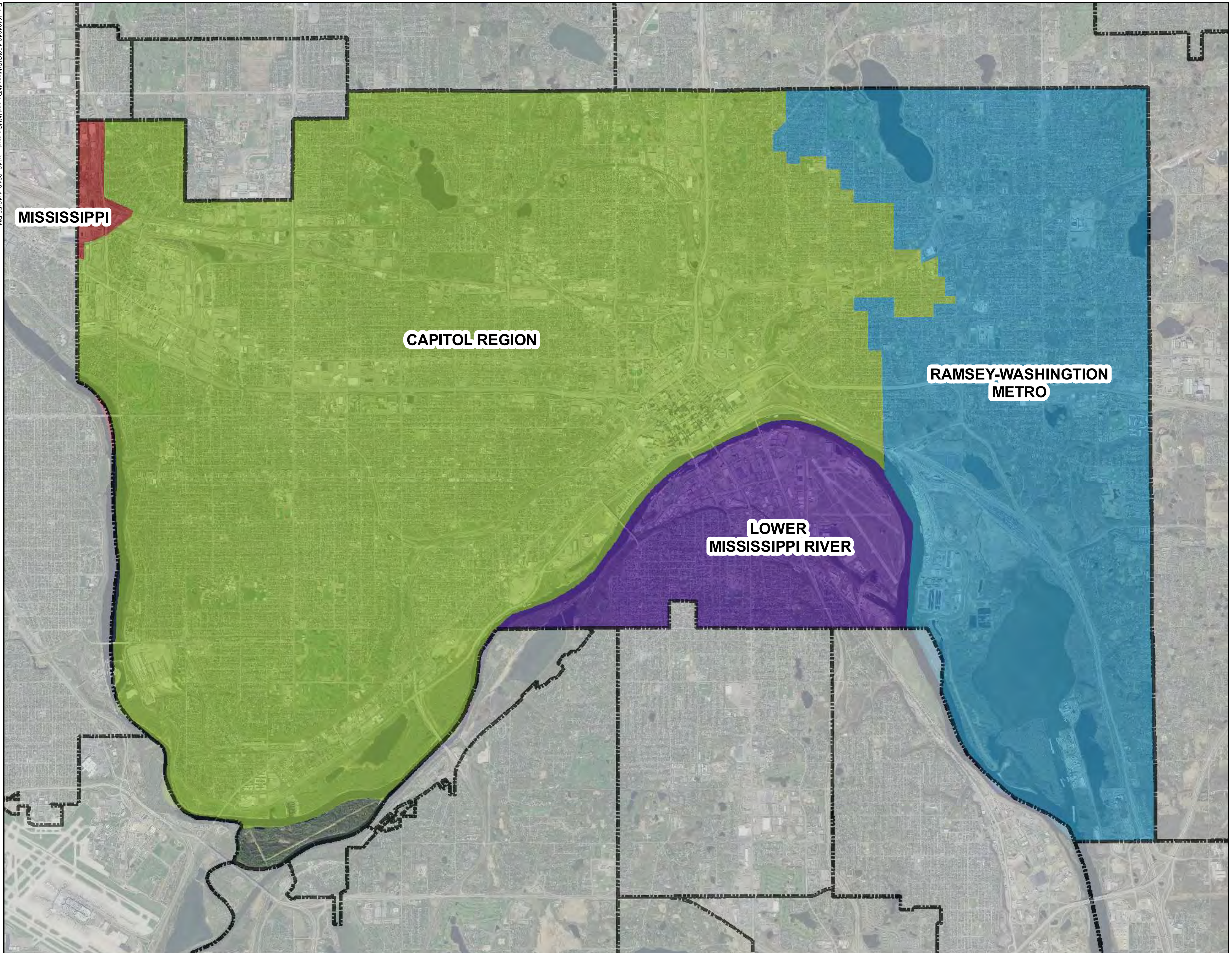
0 1 2 4 6 8
Miles

LEGEND

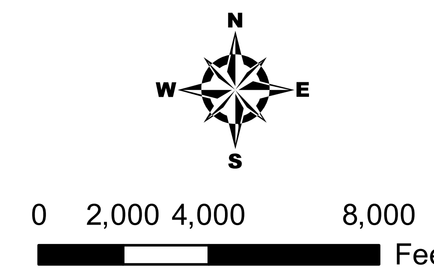
St. Paul

WSB & Associates, Inc.



City of St. Paul
Surface Water Management Plan

Figure A2
Watershed Districts/ WMOs



LEGEND

NAME

- CRWD
- LMRWMO
- MWMO
- RWMWD

City of St. Paul

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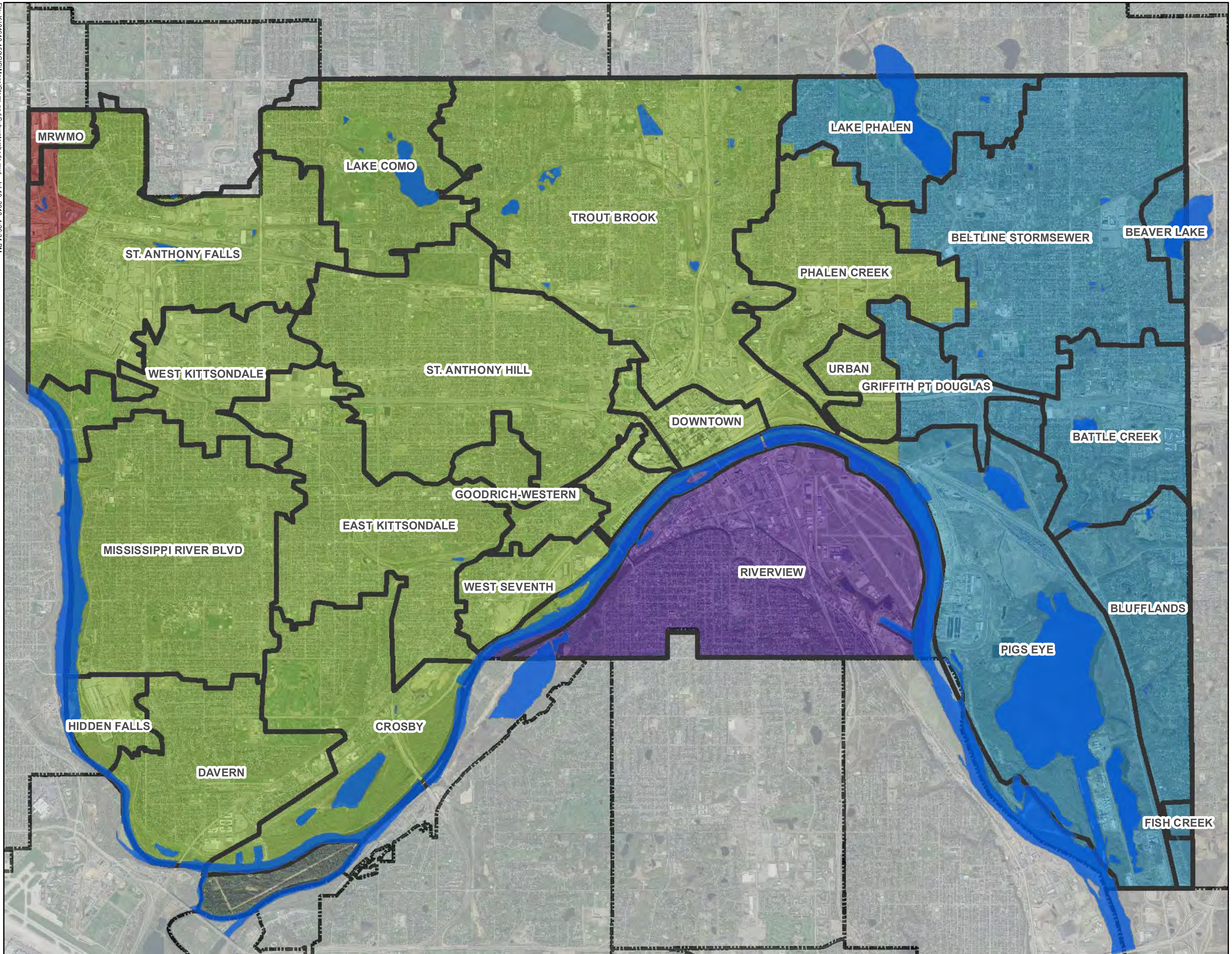
Figure A3
Subwatersheds



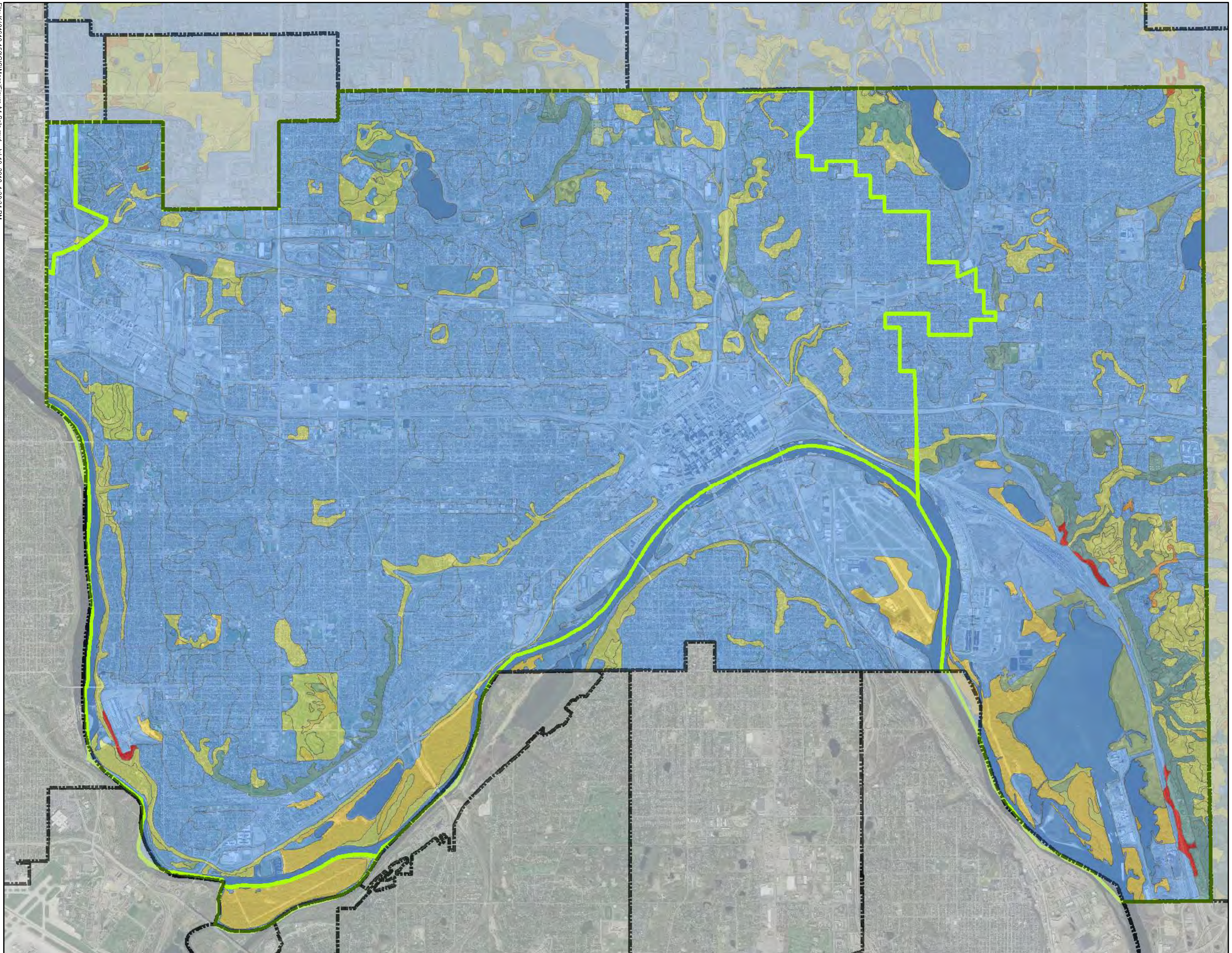
N
W E
S

0 2,000 4,000 8,000 Feet

LEGEND

- Major Subwatersheds
- CRWD
- LMRWMO
- MWMO
- RWMWD

WSB



City of St. Paul

Surface Water Management Plan

Figure A4
Hydrologic Soil Groups

0 2,000 4,000 8,000
Feet

LEGEND

Watershed Agency Boundaries

HSG

- Unclassified/Urban Soils
- A
- A/D
- B
- B/D
- C
- C/D
- D

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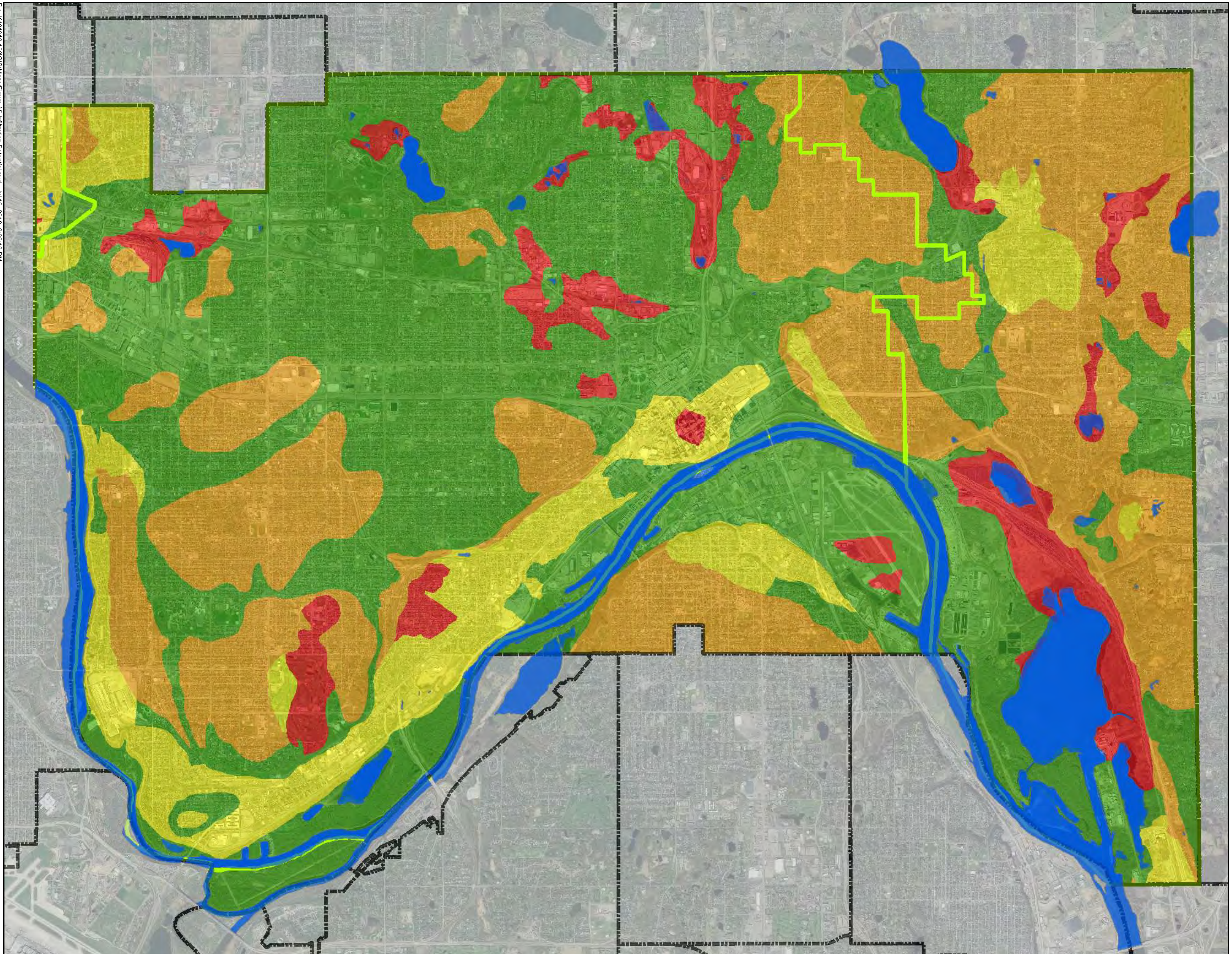

City of St. Paul

Surface Water Management Plan

SAINT PAUL

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Figure A5
Infiltration Potential

N
W E
S

0 2,000 4,000 8,000
Feet

LEGEND

Watershed Agency Boundaries

Infiltration Potential

- High
- Medium
- Low
- None
- Water

WSB

Notes

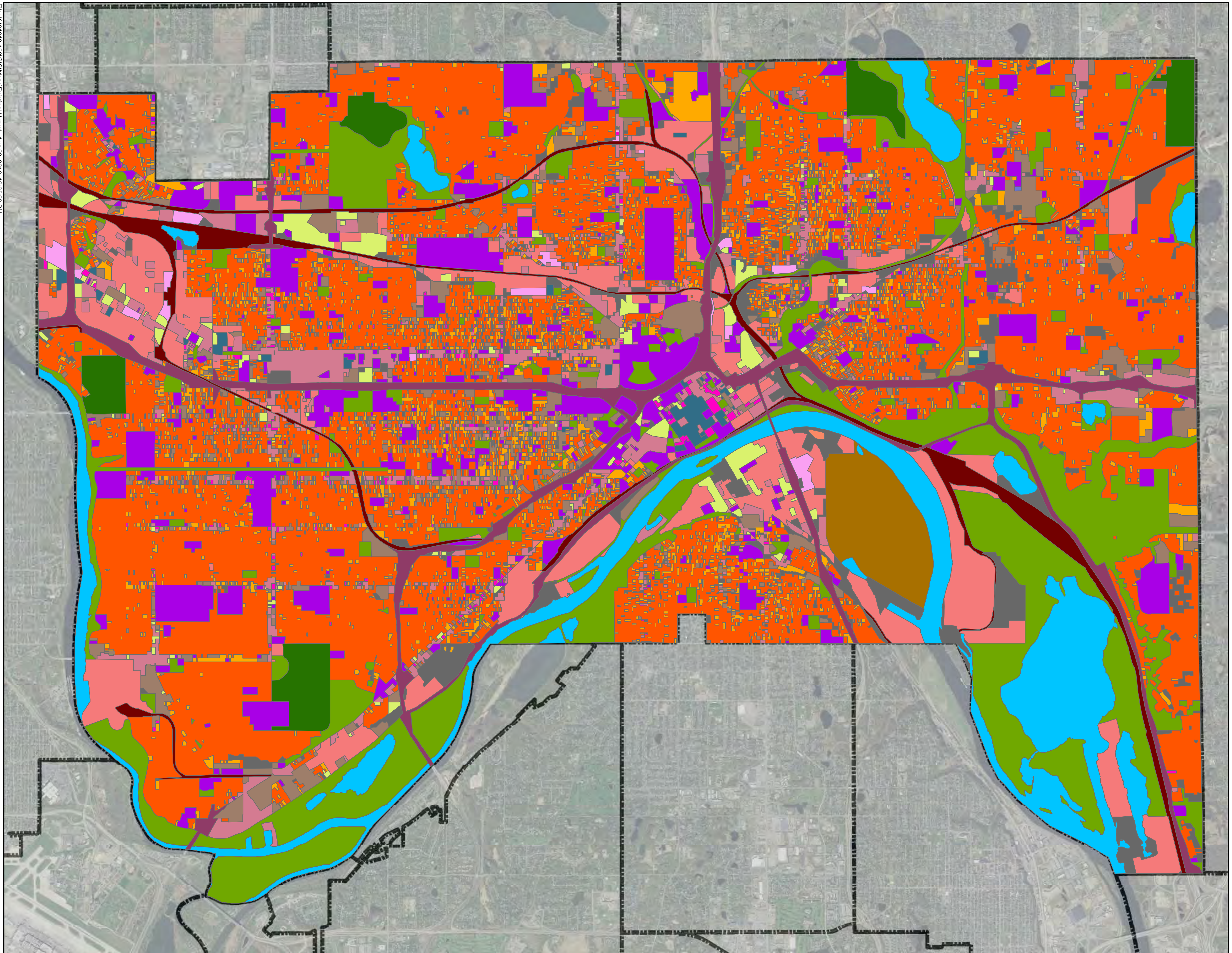
This data illustrates the level of confidence that subsurface infiltraiton BMPs will be effective based on surficial soils. This figure does not condider the risks of infiltrating over confining bedrock or groundwater. See report text for additional information.

City of St. Paul

Surface Water Management Plan

The Most Livable City in America

Figure A6
Existing Land Use



0 2,000 4,000 8,000 Feet

LEGEND

- Agricultural
- Airport
- Extractive
- Golf Course
- Industrial and Utility
- Institutitional
- Major Highway
- Mixed Use Commercial
- Mixed Use Industrial
- Mixed Use Residential
- Multifamily
- Office
- Open Water
- Park, Recreational, or Preserve
- Railway
- Retail and Other Commercial
- Single Family Attached
- Single Family Detached
- Undeveloped

N W E S

WSB & Associates, Inc.

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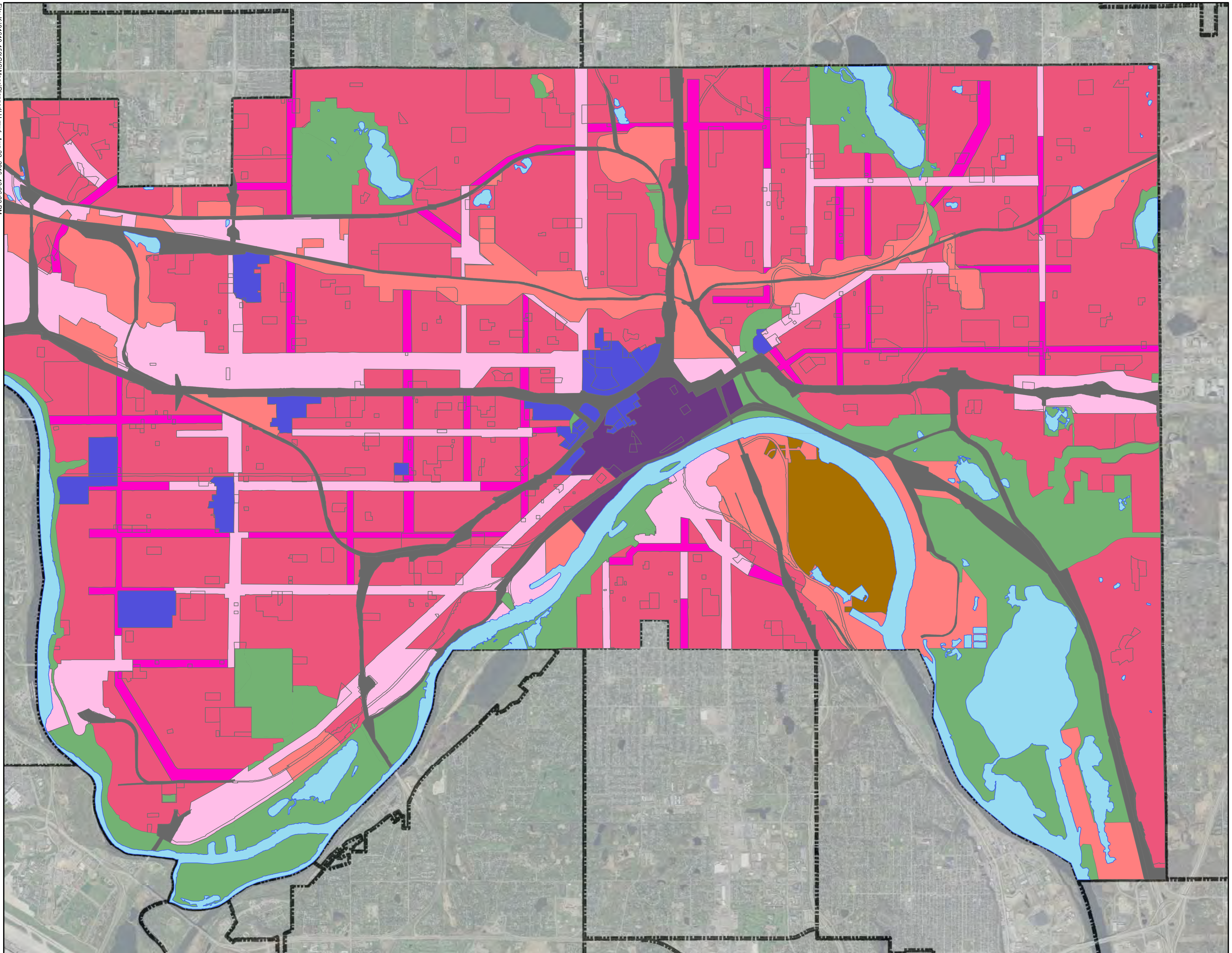

City of St. Paul

Surface Water Management Plan

SAINT PAUL
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Figure A7
Predicted Land Use by 2030

0 2,000 4,000 8,000
Feet

LEGEND

- Airport & Airport Property
- Commercial
- Downtown
- Established Neighborhoods
- Industrial
- Institutional
- Low Density Residential
- Major Institutional
- Major Parks & Open Space
- Mixed Use Corridor
- Multi-Family Residential
- Open Space
- Open Water
- Parks and Recreation
- Residential Corridor
- Single Family Residential
- Transportation
- Vehicular Right-of-Way
- Water

N
W E
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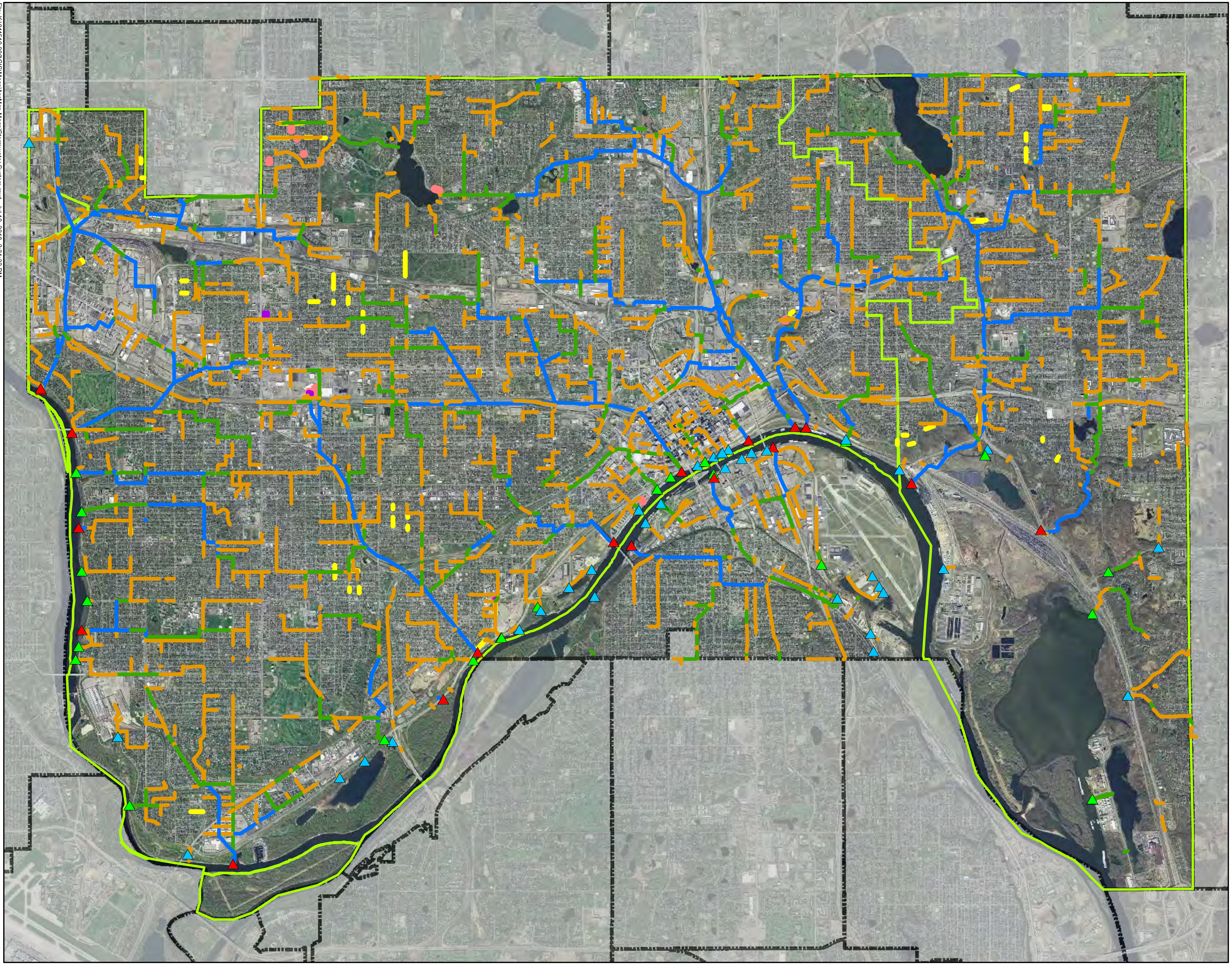
WSB
& Associates, Inc.



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City of St. Paul

SAINT PAUL
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Figure A8
Stormwater System

N
W E
S

0 2,000 4,000 8,000
Feet

LEGEND

Watershed Agency Boundaries
Raingarden/Infiltration Basin
Infiltration Trench
Pervious Pavement

Outfalls

30" - 48"
50" - 72"
> 72"

Storm Sewer Diameter

<48"
48-72"
>72"

WSB

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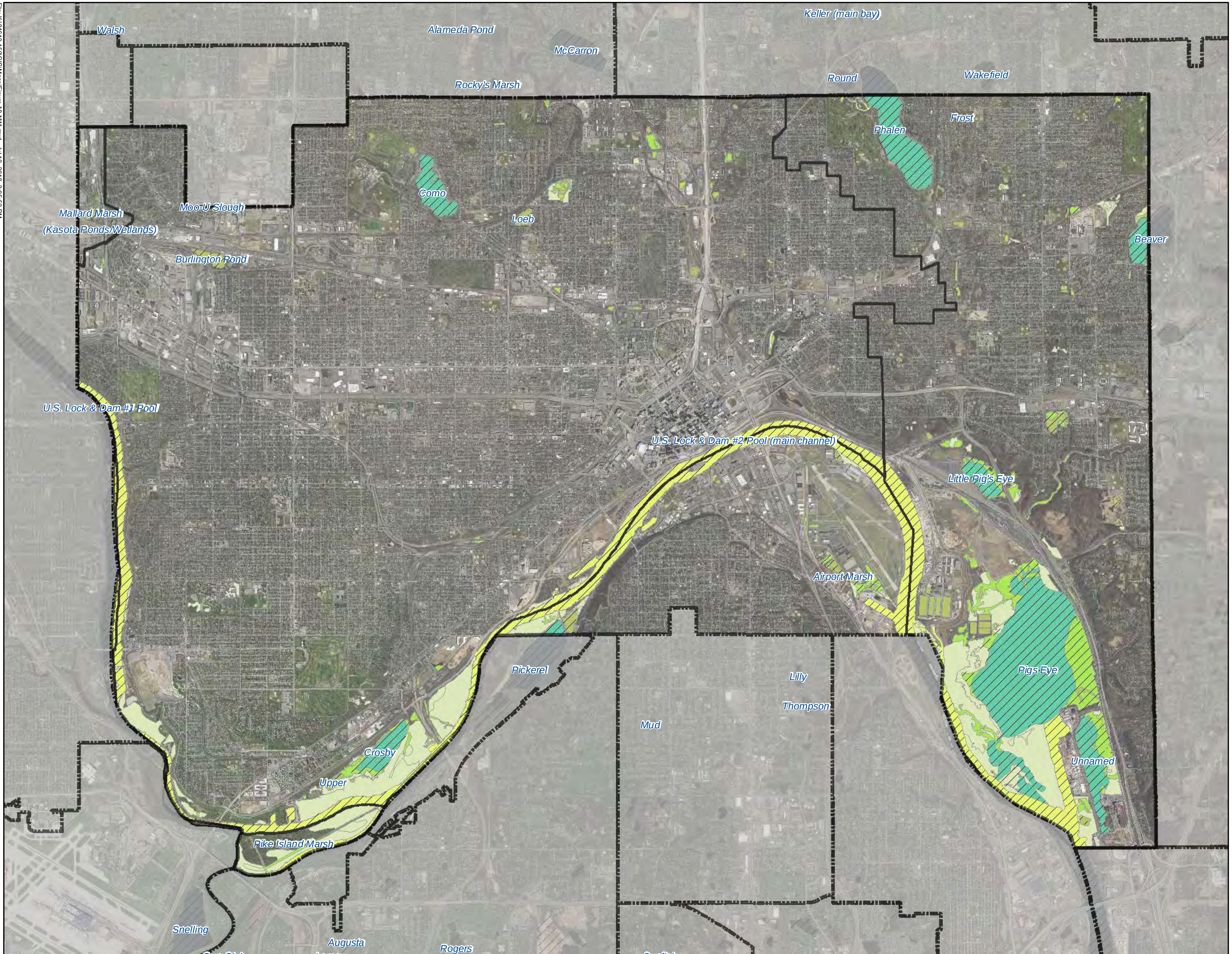

City of St. Paul

Surface Water Management Plan

SAINT PAUL
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Figure A9 National Wetland Inventory (NWI)

N W E S

0 2,000 4,000 8,000 Feet

LEGEND

Watershed Agency Boundaries

DNR Protected Waters

Type

Freshwater Emergent Wetland

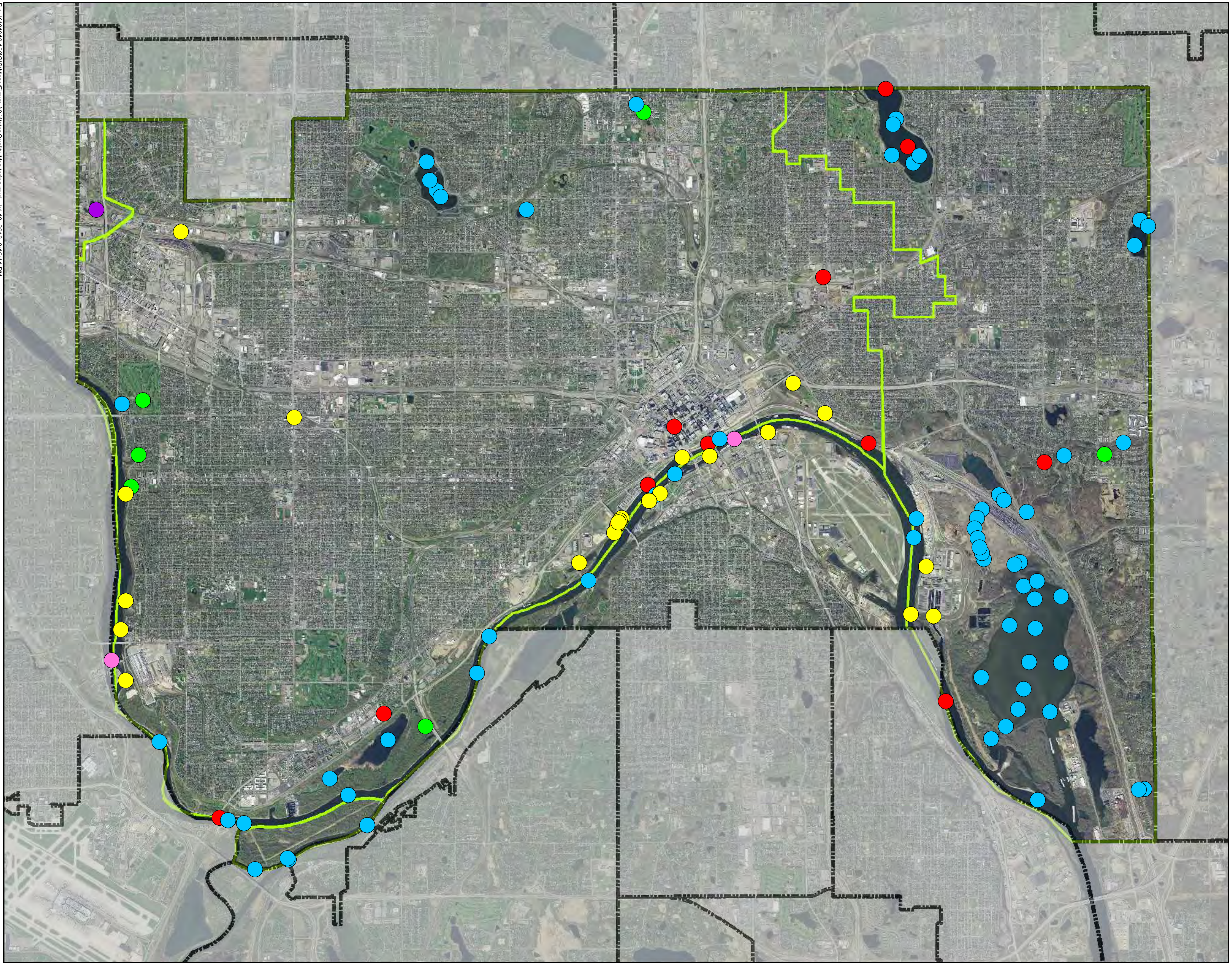
Freshwater Forested/Shrub Wetland

Freshwater Pond

Lake

Riverine

WSB



City of St. Paul

Surface Water Management Plan

Figure A10
Water Quality Monitoring Locations

N
W E
S

0 2,000 4,000 8,000
Feet

LEGEND

Watershed Agency Boundaries

ORGANIZATION

- MNDNR
- Met Council
- MPCA
- NPDES
- USEPA
- USGS
- MWMO

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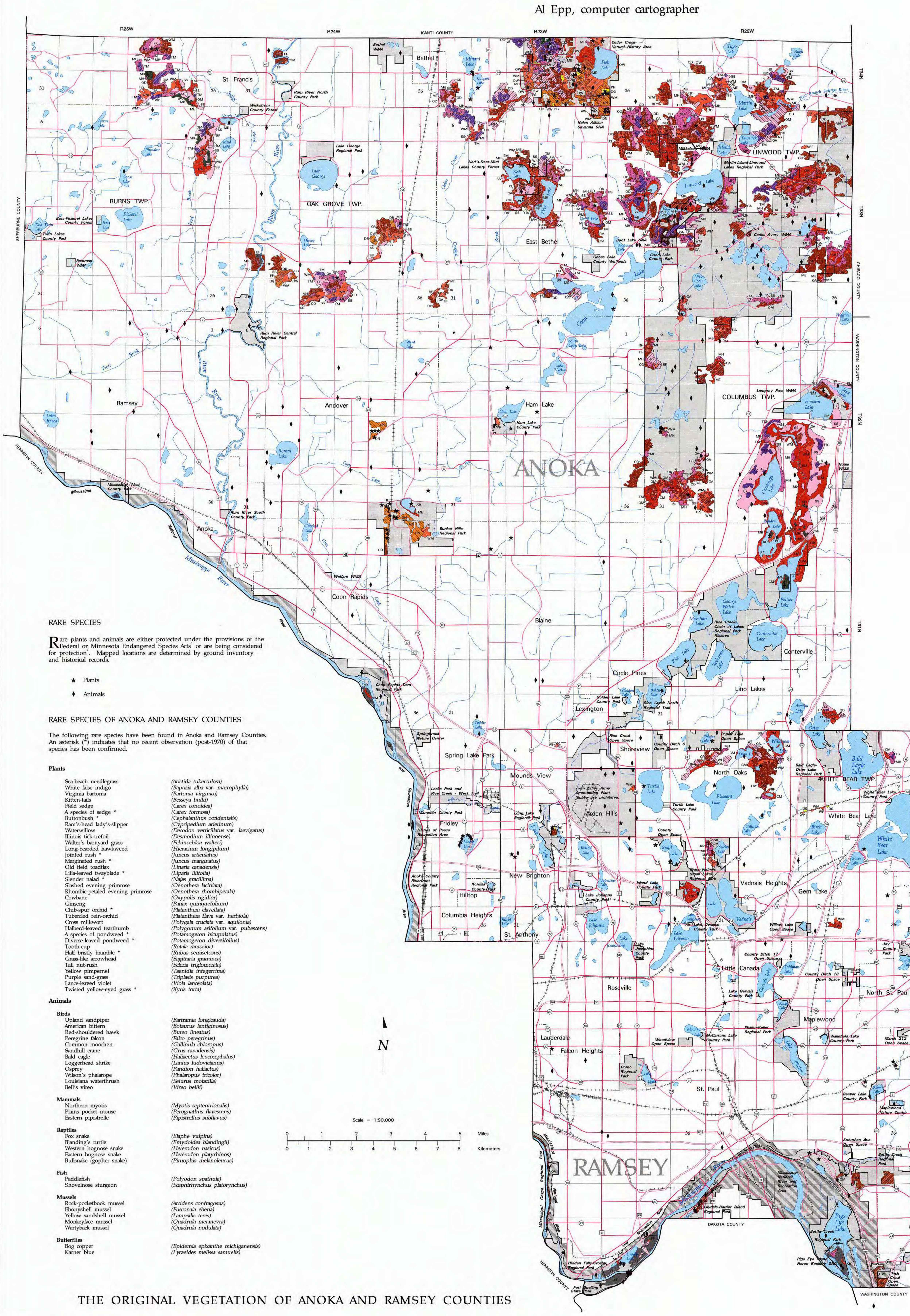
MINNESOTA COUNTY BIOLOGICAL SURVEY
Department of Natural Resources
Section of Wildlife
Natural Heritage and Nongame Wildlife Programs
500 Lafayette Road - Box 7, St. Paul, MN 55155
Phone (612) 296-3344

Figure A11 NATURAL COMMUNITIES AND RARE SPECIES OF ANOKA AND RAMSEY COUNTIES, MINNESOTA

by
Barbara Delaney, plant ecologist
Al Epp, computer cartographer



Natural communities are functional units of the natural landscape, classified and described by considering vegetation, hydrology, landform, soils, and natural disturbance regimes. The natural community types and subtypes on this map are classified primarily by vegetation and major habitat features. Areas of natural vegetation were located by air photo interpretation[1] and confirmed by field inventories conducted in 1989 through 1990[2]. The natural community type and subtype descriptions given below describe vegetation and habitat characteristics present in Anoka and Ramsey Counties[3]. Uncolored areas represent land where the natural communities have been seriously altered or destroyed by human activities such as farming, logging, draining, and development. Classification and inventory of natural communities is an ongoing effort of the Natural Heritage Program and the Minnesota County Biological Survey[4].

DESCRIPTION OF MAP UNITS

UPLAND FORESTS

DECIDUOUS FOREST

OD **Oak Forest - dry subtype** - dry forests on outwash sand or well-drained slopes; canopy dominated by northern pin oak *(Quercus ellipsoidalis)*, bur oak *(Quercus macrocarpa)*, or white oak *(Quercus alba)*; quaking aspen *(Populus tremuloides)* common at wetland margins; subcanopy either absent or composed of red maple *(Acer rubrum)*.

OM **Oak Forest - mesic subtype** - mesic forests on glacial till or moist slopes; canopy dominated by a variety of species including red oak *(Quercus rubra)*, basswood *(Tilia americana)*, bur oak, white oak, and northern pin oak; ironwood *(Ostrya virginiana)* in subcanopy.

OA **Oak Forest** - subtype not determined; either dry or mesic.

MB **Maple-Basswood Forest** - mesic forests on glacial till; canopy dominated by sugar maple *(Acer saccharum)*, basswood, red oak, and green ash *(Fraxinus pennsylvanica)*.

LH **Lowland Hardwood Forest** - wet-mesic forests on moist mineral soil above normal flood levels; canopy dominated by black ash *(Fraxinus nigra)*, green ash, basswood, bur oak, slippery elm *(Ulmus rubra)*, or quaking aspen; ground layer dominated by upland forest herbs such as lady fern *(Athyrium angustum)* or wild sarsaparilla *(Aralia nudicaulis)*.

CONIFEROUS FOREST

WF **White Pine Forest** - dry-mesic forests on outwash sand; canopy dominated by white pine *(Pinus strobus)*; subcanopy cover is sparse to patchy, composed of deciduous trees such as red oak, red maple, big-toothed aspen *(Populus grandidentata)*, or ironwood.

MIXED CONIFEROUS - DECIDUOUS FOREST

WH **White Pine-Hardwood Forest** - dry to dry-mesic forests on sandy outwash; canopy dominated by white pine and deciduous trees such as red oak, northern pin oak, and red maple; understory composition is similar to oak forests.

DECIDUOUS WOODLAND / SAVANNA

DECIDUOUS WOODLAND

AW **Aspen Woodland** - mesic to wet-mesic woodlands on level, low-lying areas; patchy canopy dominated by quaking aspen; common species include gray dogwood *(Cornus foemina* ssp. *racemosa)*, common blackberry *(Rubus allegheniensis)*, and sensitive fern *(Onoclea sensibilis)*.

OW **Oak Woodland-Brushland** - dry to dry-mesic woodlands; patchy canopy dominated by bur oak or northern pin oak; pronounced shrub layer dominated by American hazelnut *(Corylus americana)*, red raspberry *(Rubus strigosus)*, or choke cherry *(Prunus virginiana)*; scattered openings with prairie species.

DECIDUOUS SAVANNA

DR **Dry Oak Savanna - sand-gravel subtype** - dry to dry-mesic savannas on outwash sand or on sandy river terraces; bur oaks or northern pin oaks scattered or in groves; ground layer dominated by grasses and forbs typical of dry sand-gravel prairies.

DN **Dry Oak Savanna - barrens subtype** - dry savannas on dune formations; bur oaks and northern pin oaks scattered or in groves; ground layer dominated by dry prairie vegetation that is especially sparse on dune crests, dry slopes, and sand blowouts; characteristic species include sand reedgrass *(Calamovilfa longifolia)*, silky prairie-clover *(Petalostemon villosum)*, and false heather *(Hudsonia tomentosa)*.

PRAIRIE

UPLAND PRAIRIE

DG **Dry Prairie - sand-gravel subtype** - dry to dry-mesic prairie on sandy outwash or alluvium; common species include little bluestem *(Schizachyrium scoparium)*, porcupine grass *(Stipa spartea)*, rough blazing-star *(Liatris aspera)*, prairie violet *(Viola pedatifida)*, and large-flowered beard-tongue *(Penstemon grandiflorus)*.

FORESTED WETLANDS

HS **HARDWOOD SWAMP FOREST**

MH **Mixed Hardwood Swamp** - wet forests on organic soil; canopy any combination of paper birch *(Betula papyrifera)*, yellow birch *(Betula alleghaniensis)*, red maple, quaking aspen, or black ash.

MS **Black Ash Swamp** - wet forests on organic soil; canopy dominated by black ash with lesser amounts of paper birch, yellow birch, or red maple.

CONIFER SWAMP FOREST

TM **Tamarack Swamp - minerotrophic subtype** - wet forests on organic soil; canopy dominated by tamarack *(Larix laricina)* with red maple, paper birch, or black ash; common shrubs are speckled alder *(Alnus incana* ssp. *rugosa)*, winterberry *(Ilex verticillata)*, and poison sumac *(Rhus vernix)*.

TP **Tamarack Swamp - sphagnum subtype** - wet forests on organic soil; canopy dominated by tamarack; shrub layer dominated by leatherleaf *(Chamaedaphne calyculata)* and Labrador tea *(Ledum groenlandicum)* with a hummocky mat of sphagnum mosses *(Sphagnum* spp.*)* below.

TS **Tamarack Swamp** - subtype not determined; either minerotrophic or sphagnum.

WC **White Cedar Swamp** - wet forests on organic soil; canopy dominated by northern white cedar *(Thuja occidentalis)* with lesser amounts of black ash and yellow birch; common shrub and ground layer species are poison sumac, dwarf blackberry *(Rubus pubescens)*, and naked bishop's cap *(Mitella nuda)*.

FLOODPLAIN FOREST

FF **Floodplain Forest** - forests on seasonally flooded river bottoms; canopy dominated by silver maple *(Acer saccharinum)*, sometimes with bur oak, green ash, or cottonwood *(Populus deltoides)*.

SHRUB WETLANDS

SS **SHRUB SWAMP**

AS **Alder Swamp** - wet shrub community on organic soil; dominated by speckled alder; lake sedge *(Carex lacustris)* often common below.

WI **Willow Swamp** - wet shrub community on mineral or organic soil; dominated by willows *(Salix gracilis, S. bebbiana, and S. discolor)* and often with red-osier dogwood *(Cornus stolonifera)*.

OPEN WETLANDS

WET MEADOW / FEN

WP **Wet Prairie** - prairies on wet or seasonally-wet mineral or organic soil; common graminoids are big bluestem, prairie cordgrass *(Spartina pectinata)*, Hayden's sedge *(Carex haydenii)*, or blue-joint *(Calamagrostis canadensis)*; characteristic species include mountain-mint *(Pycnanthemum virginianum)*, yellow stargrass *(Hypoxis hirsuta)*, and Culver's root *(Veronicastrum virginicum)*.

WM **Wet Meadow** - open wetlands on mineral or organic soil in shallow basins or at lake or stream margins; dominated by tussock sedge *(Carex stricta)*, Hayden's sedge, lake sedge, or blue-joint; commonly with joe-pye-weed *(Eupatorium maculatum)*, meadowsweet *(Spiraea alba)*, and slender willow *(Salix gracilis)*.

RF **Rich Fen** - open wetlands on organic soil; dominated by wire-grass *(Carex lasiocarpa)* or tussock sedge; with marsh fern *(Thelypteris palustris)*, three-way sedge *(Dulichium arundinaceum)*, marsh cinquefoil *(Potentilla palustris)*, and little or no sphagnum moss.

PF **Poor Fen** - shallow peatlands with more or less continuous layer of sphagnum mosses; dominant vascular plants are wire-grass *(Carex lasiocarpa)* and leatherleaf; commonly with small cranberry *(Vaccinium oxycoccus)*.

EM **EMERGENT MARSH**

CM **Cattail Marsh** - open wetland of floating or rooted vegetation mats in shallow basins or at lake margins; dominated by broad-leaved cattail *(Typha latifolia)*.

ME **Mixed Emergent Marsh** - open wetland typically composed of vegetation rooted in mineral substrate at lake or stream margins; dominant species are often broad-leaved arrowhead *(Sagittaria latifolia)* or bulrushes *(Scirpus* spp.*)*.

RARE SPECIES

Rare plants and animals are either protected under the provisions of the Federal or Minnesota Endangered Species Acts[5] or are being considered for protection[2]. Mapped locations are determined by ground inventory and historical records.

★ Plants

♦ Animals

RARE SPECIES OF ANOKA AND RAMSEY COUNTIES

The following rare species have been found in Anoka and Ramsey Counties. An asterisk (*) indicates that no recent observation (post-1970) of that species has been confirmed.

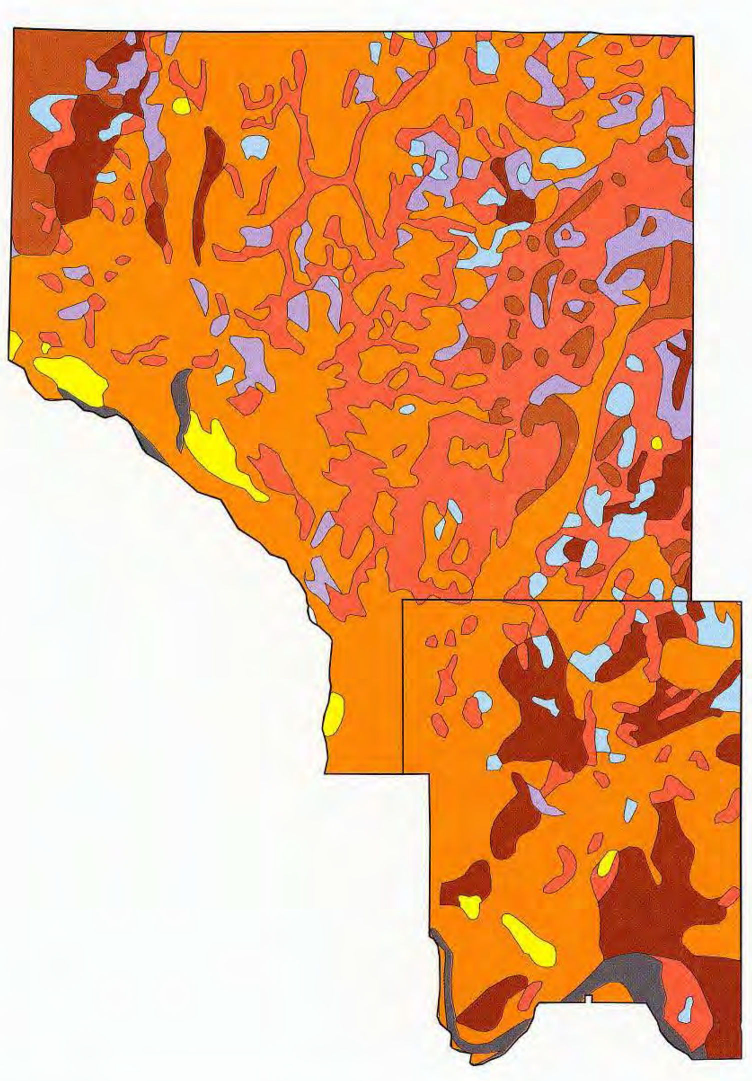
Plants

Sea-beach needlegrass	*(Aristida tuberculosa)*
White false indigo	*(Baptisia alba var. macrophylla)*
Virginia bartonia	*(Bartonia virginica)*
Kitten-tails	*(Besseya bullii)*
Field sedge	*(Carex conoidea)*
A species of sedge *	*(Carex formosa)*
Buttonbush *	*(Cephalanthus occidentalis)*
Ram's-head lady's-slipper	*(Cypripedium arietinum)*
Waterwillow	*(Decodon verticillatus var. laevigatus)*
Illinois tick-trefoil	*(Desmodium illinoense)*
Walter's barnyard grass	*(Echinochloa walteri)*
Long-bearded hawkweed	*(Hieracium longipilum)*
Jointed rush *	*(Juncus articulatus)*
Marginated rush *	*(Juncus marginatus)*
Old field toadflax	*(Linaria canadensis)*
Lilia-leaved twayblade *	*(Liparis lilifolia)*
Slender naiad *	*(Najas gracillima)*
Slashed evening primrose	*(Oenothera laciniata)*
Rhombic-petaled evening primrose	*(Oenothera rhombipetala)*
Cowbane	*(Oxypolis rigidior)*
Ginseng	*(Panax quinquefolium)*
Club-spur orchid *	*(Platanthera clavellata)*
Tubercled rein-orchid	*(Platanthera flava var. herbiola)*
Cross milkwort	*(Polygala cruciata var. aquilonia)*
Halberd-leaved tearthumb	*(Polygonum arifolium var. pubescens)*
A species of pondweed *	*(Potamogeton bicupulatus)*
Diverse-leaved pondweed *	*(Potamogeton diversifolius)*
Tooth-cup	*(Rotala ramosior)*
Half bristly bramble *	*(Rubus semisetosus)*
Grass-like arrowhead	*(Sagittaria graminea)*
Tall nut-rush	*(Scleria triglomerata)*
Yellow pimpernel	*(Taenidia integerrima)*
Purple sand-grass	*(Triplasis purpurea)*
Lance-leaved violet	*(Viola lanceolata)*
Twisted yellow-eyed grass *	*(Xyris torta)*

Animals

Birds	
Upland sandpiper	*(Bartramia longicauda)*
American bittern	*(Botaurus lentiginosus)*
Red-shouldered hawk	*(Buteo lineatus)*
Peregrine falcon	*(Falco peregrinus)*
Common moorhen	*(Gallinula chloropus)*
Sandhill crane	*(Grus canadensis)*
Bald eagle	*(Haliaeetus leucocephalus)*
Loggerhead shrike	*(Lanius ludovicianus)*
Osprey	*(Pandion haliaetus)*
Wilson's phalarope	*(Phalaropus tricolor)*
Louisiana waterthrush	*(Seiurus motacilla)*
Bell's vireo	*(Vireo bellii)*
Mammals	
Northern myotis	*(Myotis septentrionalis)*
Plains pocket mouse	*(Perognathus flavescens)*
Eastern pipistrelle	*(Pipistrellus subflavus)*
Reptiles	
Fox snake	*(Elaphe vulpina)*
Blanding's turtle	*(Emydoidea blandingii)*
Western hognose snake	*(Heterodon nasicus)*
Eastern hognose snake	*(Heterodon platyrhinos)*
Bullsnake (gopher snake)	*(Pituophis melanoleucus)*
Fish	
Paddlefish	*(Polyodon spathula)*
Shovelnose sturgeon	*(Scaphirhynchus platorynchus)*
Mussels	
Rock-pocketbook mussel	*(Arcidens confragosus)*
Ebonyshell mussel	*(Fusconaia ebena)*
Yellow sandshell mussel	*(Lampsilis teres)*
Monkeyface mussel	*(Quadrula metanevra)*
Wartyback mussel	*(Quadrula nodulata)*
Butterflies	
Bog copper	*(Epidemia epixanthe michiganensis)*
Karner blue	*(Lycaeides melissa samuelis)*

THE ORIGINAL VEGETATION OF ANOKA AND RAMSEY COUNTIES



The original vegetation of Anoka and Ramsey Counties is shown here as interpreted by Frances J. Marschner[1] from Public Land Survey Records with slight modifications of Marschner's map unit descriptions as appropriate for east-central Minnesota. Current natural community names[2] are given in parentheses as well as highly specialized natural communities that were not described by Marschner or by the early land surveyors.

DESCRIPTION OF MAP UNITS

HARDWOOD FORESTS

Big Woods - Bur oak, white oak, red oak, northern pin oak, elm, basswood, ash, maple, hornbeam, aspen, birch (Maple-Basswood Forest, Oak Forest - mesic subtype, White Pine-Hardwood Forest, Lowland Hardwood Forest).

River Bottom Forest - Elm, ash, cottonwood, boxelder, silver maple, willow, aspen, hackberry (Floodplain Forest).

BRUSHLAND

Brush Prairie - Grass and brush of oak and aspen (Oak Woodland-Brushland, Dry Oak Savanna).

Oak Openings and Barrens - Scattered trees and groves of oaks of scrubby form with some brush and thickets (Dry Oak Savanna; also includes many areas that have succeeded to Oak Woodland-Brushland or Oak Forest).

Aspen-Oak Land - Aspen, generally dense, and small in most places, with scattered oaks and a few elms, ash and basswood (Oak Forest, early successional stage).

GRASSLAND

Prairie - (Dry Prairie, Mesic Prairie).

Wet Prairies, Marshes and Sloughs - Marsh-grasses, flags, rushes, wild rice, with willow and alder-brush in places (Alder Swamp, Willow Swamp, Rich Fen, Wet Meadow, Emergent Marsh).

BOGS AND SWAMPS

Conifer Bogs and Swamps - Tamarack (Tamarack Swamp, White Cedar Swamp, Rich Fen, Poor Fen).

FOOTNOTES

1. Marschner, F.J. 1974. The original vegetation of Minnesota (map scale 1:500,000). USDA Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota (redraft of the original 1930 edition).

2. Minnesota Natural Heritage Program. 1993. Minnesota's native vegetation:; a key to natural communities. Version 1.5. Minnesota Department of Natural Resources, St. Paul, Minnesota. 111 pp.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Diagram showing how sections are numbered in a township

MISCELLANEOUS FEATURES[6]

Minor Civil Divisions

Managed Area Boundaries

Public Ownership within managed areas
WMA - State Wildlife Management Area
SNA - State Scientific and Natural Area

Private Ownership within managed areas

Primary Roads

Secondary Roads

Other Roads

Railroads

Streams

Lakes and Rivers

FOOTNOTES

1. Natural communities were interpreted from color infrared photography taken in October, 1985 (1:24,000; Metropolitan Council, St. Paul, Minnesota).

2. Data are available from the Minnesota Natural Heritage Information System, Department of Natural Resources, St. Paul, Minnesota. Phone (612) 296-3344.

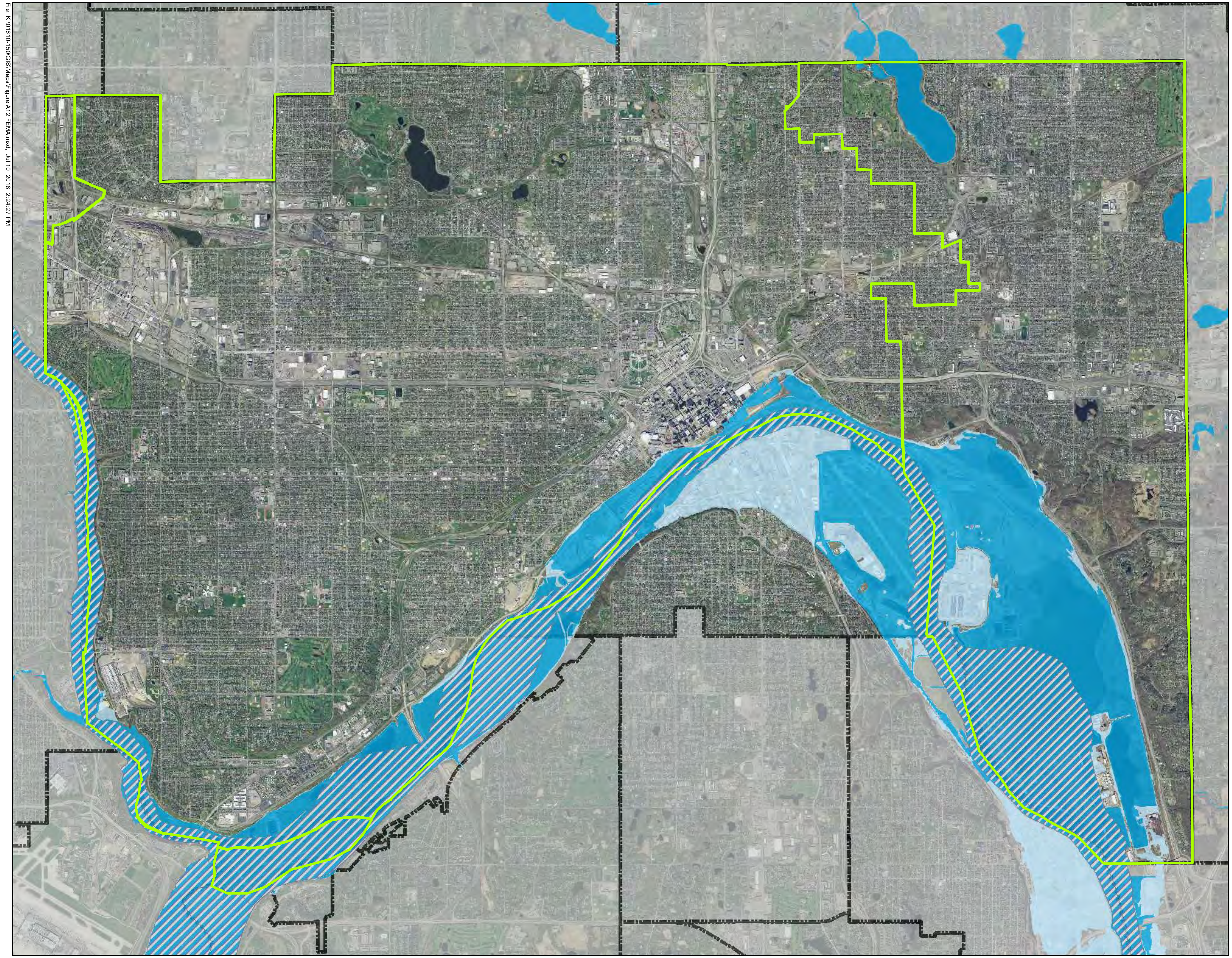
3. Wovcha, D.S., B.C. Delaney, and G.E. Nordquist. In press. Minnesota's St. Croix River Valley and Anoka Sandplain: a guide to native habitats. University of Minnesota Press, Minneapolis, Minnesota.

4. Minnesota Natural Heritage Program. 1993. Minnesota's native vegetation: a key to natural communities. Version 1.5. Minnesota Department of Natural Resources, St. Paul, Minnesota. 111 pp.

5. Federal and state legislation concerning endangered species is detailed in Coffin, B. and L. Pfannmuller, eds. 1988. Minnesota's endangered flora and fauna. University of Minnesota Press, Minneapolis, Minnesota. 473 pp.

6. Civil division, transportation, and water features data were obtained from the Department of Natural Resources, St. Paul, Minnesota. Managed area boundaries were obtained from the Minnesota Natural Heritage Program, Anoka County Parks, and Ramsey County Parks. Natural community boundaries and certain miscellaneous features were digitized from 1:24,000 U.S. Geological Survey topographic base maps. Land ownership within managed areas may not be clear where natural community map units are shown. Every effort was made to obtain current versions of these data, however, errors may exist on this map.

Funding for this project approved by the Minnesota Legislature with partial funding (M.L. 1991, Chapter 254, Art. 1, Sec. 14, subd. 9.d) as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund.



City of St. Paul

Surface Water Management Plan

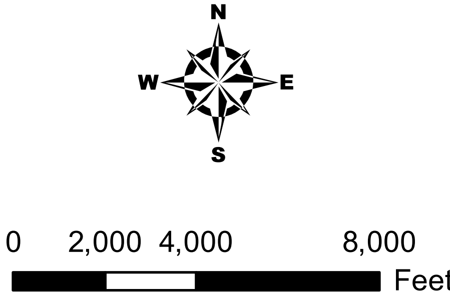
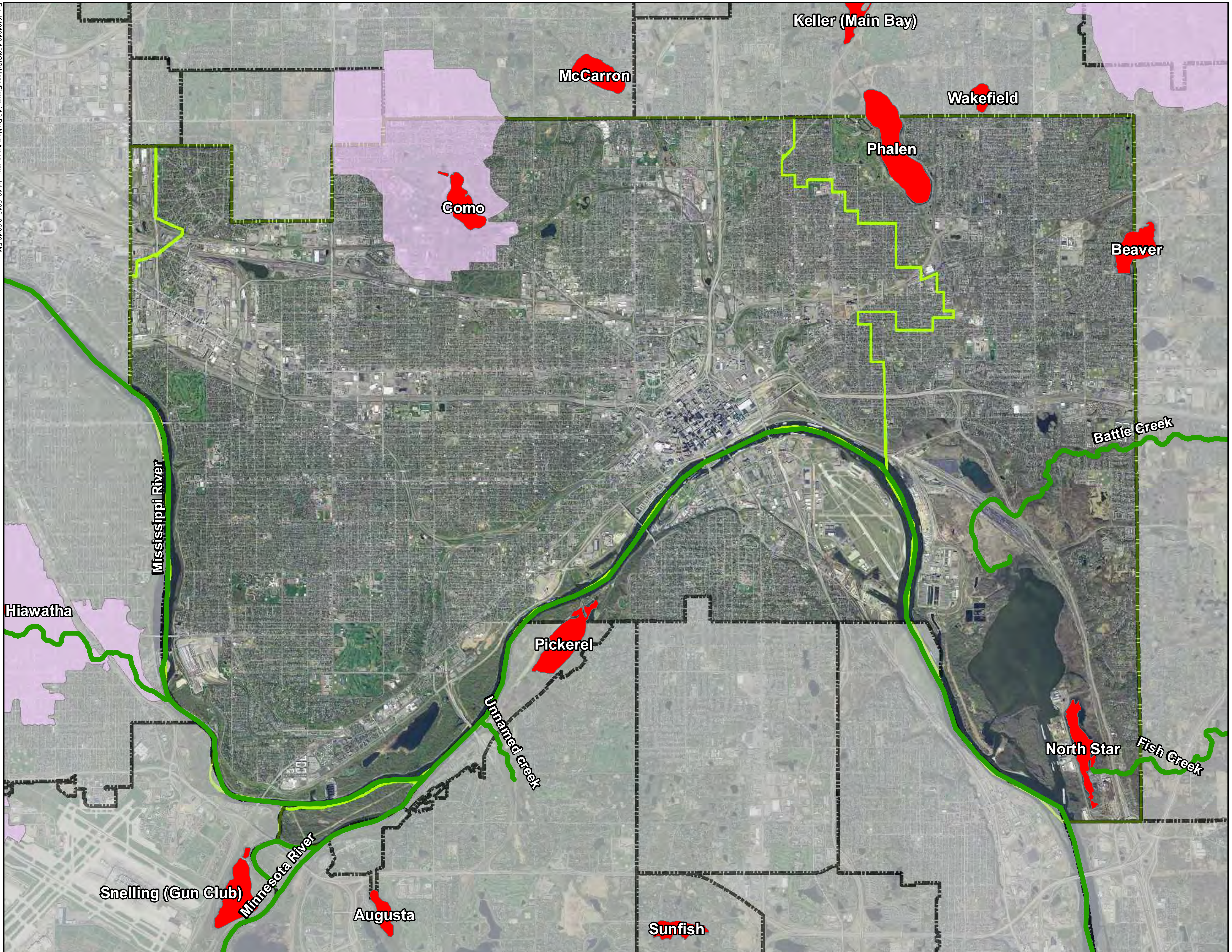


Figure A12 FEMA Floodplain

LEGEND

- Watershed Agency Boundaries
- Floodway
- 100 Year Floodplain
- 500 Year Floodplain

Figure A13 MRCCA Rulemaking Districts
St. Paul



City of St. Paul

Surface Water Management Plan

Figure A14 Impaired Water Bodies and WRAPS Study Areas

N W E S

0 2,000 4,000 8,000 Feet

LEGEND

- Impaired Streams
- Impaired Lakes
- WRAPS Boundaries
- Watershed Agency Boundaries

Appendix B

MPCA TMDLs

Twin Cities Metropolitan Area Chloride Management Plan

February 2016

wq-iw11-06ff

Acknowledgements

The development of this plan was accomplished through a partnership approach with several organizations across the metro and the state. Their contribution to this plan and commitment to the issue has allowed us to develop this comprehensive and strategic approach to reducing salt use while maintaining public needs.

American Public Works Association - Minnesota Chapter
Bassett Creek Watershed Management Commission
Board of Soil and Water Resources
Capitol Region Watershed District
City of Burnsville
City of Minneapolis
City of Plymouth
City of Shoreview
City of St. Paul
City of Waconia
Dakota County
East Metro Water Resource Education
Enviro Tech Services
Force America
Fortin Consulting
Freshwater Society
Friends of the Mississippi River
Hennepin County
LimnoTech
Metropolitan Council Environmental Services
Minneapolis Park and Recreation Board
Minnehaha Creek Watershed District
Minnesota Cities Stormwater Coalition
Minnesota Department of Health
Minnesota Department of Natural Resources
Minnesota Department of Transportation
Minnesota Pollution Control Agency
Mississippi Watershed Management Organization
National Park Service
Nine Mile Creek Watershed District
Prescription Landscape
Ramsey County
Ramsey-Washington Metro Watershed District
Rice Creek Watershed District
Riley Purgatory Bluff Creek Watershed District
Scott County
Scott County Watershed Management Organization
Three Rivers Park District
United States Geological Survey
University of Minnesota - Duluth
University of Minnesota - Twin Cities
University of Minnesota Extension

Table of Contents

Tables

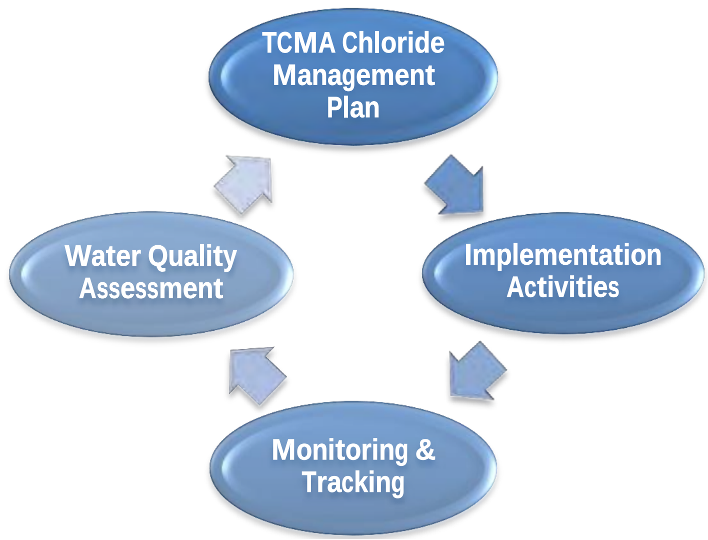
Figures

Acronyms

AUID	Assessment unit identification
BMP	Best management practice
BWSR	Board of Water and Soil Resources
CFR	Code of Federal Regulations
CMP	Chloride Management Plan
DNR	Minnesota Department of Natural Resources
EOC	Education and Outreach Committee
EPA	Environmental Protection Agency
EQuIS	Environmental Quality Information System
IPP	Industrial Pretreatment Program
KCl	Potassium chloride
LA	Load allocation
lbs	pounds
MCES	Metropolitan Council Environmental Services
mg/L	milligrams per liter
MCWD	Minnehaha Creek Watershed District
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MPRB	Minneapolis Park & Recreation Board
MS4	Municipal Separate Storm Sewer System
MWMO	Mississippi Watershed Management Organization
NaCl	Sodium Chloride
NMCWD	Nine Mile Creek Watershed District
NPDES	National Pollutant Discharge Elimination System
RO	Reverse osmosis
RWMWD	Ramsey-Washington Metro Watershed District
SWCD	Soil and Water Conservation District
TCMA	Twin Cities Metropolitan Area (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, Washington)
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WD	Watershed District
WLA	Wasteload allocation
WMAt	Winter Maintenance Assessment tool
WMO	Watershed Management Organization
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

What is the TCMA Chloride Management Plan?

The Minnesota Pollution Control Agency (MPCA) has worked with stakeholders in the Seven County Twin Cities Metropolitan Area (TCMA) to assess the level of chloride in water resources, including lakes, streams, wetlands and groundwater. There are two primary sources of chloride to the TCMA water resources: 1) salt applied to roads, parking lots and sidewalks for deicing; and 2) water softener brine discharges to municipal wastewater treatment plants (WWTPs). The MPCA and stakeholders also worked together to develop a plan to restore and protect waters impacted by chloride.



This Chloride Management Plan (CMP) incorporates **water quality assessment, source identification**, **implementation strategies**, **monitoring recommendations,** and **measurement and tracking of results** into a performance-based adaptive approach for the TCMA. The goal of this plan is to develop the framework to assist local partners in minimizing salt (chloride) use and provide safe and desirable conditions for the public.

The CMP is intended to characterize water resources across the TCMA and the overall impacts of chloride. As part of the CMP, waters not meeting state standards have been listed as impaired and Total Maximum Daily Loads (TMDLs) developed. However, water quality is not the only factor driving the need to reduce chloride entering TCMA waters. Improved practices for anti-icing and deicing roads, parking lots and sidewalks not only reduce chloride impacts on water quality, but they can also lead to long-term cost-savings as a result of purchasing less salt for winter maintenance and reduced impacts on vegetation and corrosion of infrastructure and vehicles. A key challenge in reducing salt usage is balancing the need for public safety with the growing expectation for clear, dry roads, parking lots, and sidewalks throughout the mix, severity, and duration of winter conditions in the TCMA. Notable efforts have already been made by the Minnesota Department of Transportation (MnDOT) and some TCMA cities, counties, and others to improve winter maintenance while reducing salt usage. This CMP is intended to learn from and build on these efforts. The CMP will guide and assist agencies, local governments, and other TCMA stakeholders in determining how best to restore and protect water resources impacted by elevated chloride levels while balancing the need for public safety, level of service considerations, as well as water softening needs. This CMP is not intended to resolve all issues. Rather, it provides understanding and guidance for management activities over the next 10 years. While this plan was developed to address chloride impacts specifically to waters in the TCMA, the restoration and protection goals, implementation strategies, and monitoring and tracking recommendations can be applied statewide.

The purpose, scope and audience for the CMP are presented on the next page.

Chloride Management Plan
Purpose - Scope - Audience

Purpose

- Highlight the impacts of chloride on TCMA water quality
- Develop an appreciation of the competing demands of level of service and reduced salt usage
- Set performance-based goals for restoration and protection
- Inform and guide implementation of improved winter maintenance practices and policy needs
- Demonstrate the success and economic benefits of improved practices

Scope

- Status and trends of chloride levels in lakes, wetlands, streams, and groundwater
- Sources of chloride
- Restoration and protection goals
- Implementation strategies to reduce chloride impacts
- Educational and training resources
- Continued monitoring, tracking and adaptive management

Audience

- Local working groups (local governments, watershed management groups, etc.)
- Winter maintenance groups (MnDOT, local governments, private applicators, commercial property owners, residents, etc.)
- Elected officials and policy-makers
- State agencies (MPCA, MnDOT, DNR, BWSR, etc.)

1. Background and Description

The TCMA includes 186 cities and townships and a population of approximately 3,000,000 people. It covers approximately 3,000 square miles with about one-third in urbanized areas. It is a vibrant and growing community. The area is fortunate to be home to nearly 1,000 lakes and wetlands, small streams and large rivers, as well as shallow and deep groundwater aquifers. These water resources hold high value to the community and visitors to the area.

Twin Cities 7-County Metropolitan Area (TCMA)

The Twin Cities receives approximately 54 inches of snow each year on average. The thousands of miles of streets and highways in the TCMA, along with parking lots and sidewalks, must be maintained to provide safe conditions throughout the winter. Winter maintenance of these surfaces currently relies heavily on the use of salt, primarily sodium chloride (NaCl), to prevent ice build-up and remove ice where it has formed. The chemical properties of NaCl make it effective at melting ice, but these properties also result in the chloride dissolving in water and persisting in the environment. The dissolved chloride moves with the melted snow and ice, largely during warm-up events, and ends up in the water resources. Salt applied in winter for deicing in urban areas is a major source of chloride to Minnesota surface waters and groundwater.

Residential water softener use is also a significant source of chloride. Residential water softeners use chloride to remove hardness, which is typically caused by high levels of calcium and/or magnesium. In areas with hard water, residential water softeners which use salt are common. The chloride from water softeners makes its way to the environment either through discharge to a septic system or by delivery to a municipal WWTP. Chloride is not removed from wastewater using conventional treatment methods. However, chloride can be removed from wastewater by using reverse osmosis (RO) technology, which is considered cost-prohibitive for an issue of this scale.

Elevated chloride concentrations have been found in waterbodies throughout the TCMA. At levels exceeding the WQS, chloride is toxic to aquatic life. Water quality samples from lakes, wetlands, streams and groundwater show increased chloride levels in urban areas across the state. While monitoring has only been conducted for about 10% of all the surface waterbodies in the TCMA, the available data indicates 39 waterbodies in the TCMA currently exceed chloride levels protective of the aquatic community. Two of these impaired waterbodies have approved TMDLs (Shingle Creek and Nine Mile Creek). These high concentrations call for immediate attention to the issue, the development of a plan to restore waters already impaired, and for protection of waters at risk of further degradation.

A Chloride Feasibility Study for the TCMA (Phase 1) was completed in December 2009. This study improved understanding of the extent, magnitude, and causes of chloride contamination of surface waters and explored options and strategies for addressing impacts. This project included extensive data analysis, a literature review, a telephone survey, and analysis of potential strategies for further research, public education, and potential regulation.

In 2010, the MPCA initiated the TCMA Chloride Project. It built on the previous work to improve and maintain water quality with respect to chloride for the TCMA. A robust stakeholder involvement process was undertaken to develop partnerships and gain insight into winter maintenance activities and other sources of chloride. This process allowed the stakeholders to assist in the development of the CMP and has generated the support of local partners. This effort consisted of over 115 participating stakeholders on seven teams; an inter-agency team (IAT) made up of state government agencies, a technical advisory committee (TAC) consisting of local stakeholders, a monitoring advisory group (MSG) with local and state water quality monitoring experts, an Education and Outreach Committee (EOC) that included local education specialists throughout the TCMA, a technical expert group (TechEx) which was comprised of winter maintenance professionals, and an implementation plan committee (IPC), which was a combination of all the teams.

The Problem with Too Much Chloride

Low levels of chloride can be found naturally in the TCMA lakes and streams and is essential for aquatic life to carry out a range of biological functions. However, high concentrations of chloride in the surrounding water harm aquatic life as a result of a disruption in the cellular process called osmosis which moves molecules, such as water, through cell membranes. Too much chloride in the surrounding water can cause water to leave the cell and also prohibit the transport of needed molecules into the cell. If elevated concentrations of chloride persist in the water, aquatic life such as fish, invertebrates, and even some plant species become stressed and/or die. The MPCA has adopted the United States Environmental Protection Agency's (EPA) recommended water quality criteria for chloride, which is designed to protect aquatic life from the harmful effects of excessive chloride. The allowable chloride concentration to protect for acute (short-term) exposure is 860 mg/L. The allowable chloride concentration to protect for chronic (long-term) exposure is 230 mg/L. These values were developed based on toxicity test results for a range of freshwater aquatic organisms. Short-term exposure (one hour or more) to concentrations greater than 860 mg/L or continued exposure (four days or more) to chloride concentrations greater than 230 mg/L can be expected to have detrimental effects on community structure, diversity, and productivity of aquatic life.

Increased chloride concentrations due to salt applied to paved surfaces in winter can also have indirect effects on biota. Additives and contaminants such as phosphorus, cyanide containing compounds, copper, and zinc may cause additional stress or accumulate to a potentially toxic level (Wenck 2009).

Impacts on water quality in lakes, wetlands and streams are not the only concern related to high levels of chloride in the environment. Chloride can affect groundwater and drinking water supplies, infrastructure, vehicles, plants, soil, pets, and wildlife. The Phase 1 Feasibility Study documented the results of a literature review on the impacts of chloride from salt. Research identifies the negative impacts that chloride has on the environment, whether from pavement salt sources or water softeners, but there are still many unknowns. Continued research will help us understand how chloride interacts with the environment and therefore, how to protect our water resources. Additional concerns associated with chloride in the environment, including an analysis of the estimated cost of those impacts, are discussed below.

Chloride is persistent in the environment

Once chloride is in water, the only known technology for its removal is RO through massive filtration plants, which is not economically feasible. This means that chloride will continue to accumulate in the environment over time. A study by the University of Minnesota (UMN) found that about 78% of salt applied in the TCMA for winter maintenance is either transported to groundwater or remains in the local lakes, and wetlands (Stefan et al. 2008).

Surface Water

Chloride concentrations in lakes, wetlands and streams in the TCMA, as well as in many cold climate states have been increasing (Novotny et al. 2007; Novotny at al. 2008). Thirty-nine lakes, wetlands, and stream reaches are impaired for aquatic life due to high concentrations of chloride in the TCMA according to the MPCA's 2014 Draft 303(d) List of Impaired Waters (MPCA 2014). Impacts on lakes include toxicity to aquatic life as well as the potential interruption of the vertical mixing (turnover) process.

It is difficult to put a financial value on the impacts of chloride impairments. However, the Adirondack Watershed Institute (Kelting and Laxson 2010) did a simulation of road salt impacts on surface waters and forests and showed a $2,320 per lane mile per year reduction in environmental value. If this value is applied to the 26,000 lane miles of roadways in the TCMA (Sander et al. 2007), the resulting estimate of economic impacts on surface waters and forests in the TCMA is roughly $60 million per year. On a cost per ton of salt basis, using 349,000 tons per year applied in the TCMA (Sander et al. 2007), the resulting reduction in environmental value is $172 per ton of salt. These are not actual out-of-pocket costs, but indicate the cost of the loss of environmental value.

Groundwater and drinking water

Groundwater is another important resource in Minnesota; about 75% of Minnesotans rely on groundwater for their drinking water supply (MPCA 2013). Groundwater also contributes flow to lakes, wetlands, and streams. Deicing salt application is resulting in higher chloride concentrations in groundwater. A recent MPCA study found that 30% of monitoring wells tested in shallow sand and gravel aquifers in the TCMA exceeded the state chronic standard for surface waters of 230 mg/L for chloride (MPCA 2013). The amount of sodium (a common component of salt) in drinking water is a human health concern, particularly for individuals on sodium restricted diets (EPA 2003; EPA 2014).

The cost of mitigating groundwater contamination is substantial. The EPA has set a Secondary Maximum Contaminant Level of 250 mg/L for chloride in drinking water, which is a guideline for protection based on taste (EPA 2014). According to a 1991 report, $10 million is spent nationally each year on mitigating impacts to groundwater from salt (Transportation Research Board 1991). The United States uses approximately 20 million tons of deicing salt per year (Anning and Flynn 2014). This equates to a cost of about $0.50/ton for mitigating groundwater impacts. A 1976 estimate (Murray and Ernst) was much higher, with a figure of $150 million per year for damages due to contamination of water supplies by deicing salt. This estimate includes more direct and indirect costs such as treating water, replacing wells, supplying bottled water, adding practices to prevent additional contamination, human health concerns, and property value damage. Using an estimate of 9 million tons of salt used in 1976, this equates to $16.67 per ton for damages to water supplies.

Lake Ecosystems

Chloride changes the density of water, which can negatively affect the seasonal mixing of lake waters (Novotny et al. 2008). Mixing increases oxygen levels required by aquatic life. Changes in mixing can also affect nutrient cycling processes, phytoplankton community composition and productivity, zooplankton community composition and phenology, and fish.

No value has been assigned to impacts on aquatic life due to chloride toxicity or impacts on lake ecosystems whose natural turnover is disrupted due to formation of a chemocline caused by salt. Prevention of turnover can result in anoxia in the bottom of lakes and potential death of aquatic biota (Michigan DOT 1993). Increased salinity can result in a loss of native plant species and invasion by invasive salt tolerant species such as Common Reed (*Phragmites australis*), Narrowleaf cattail (*Typha angustifolia*) and Eurasian watermilfoil (*Myriophyllum spicatum*) (Kelting and Laxson 2010). Salt can be toxic to fish at fairly high concentrations (Evans and Frick 2001).

Plants

Direct deicing salt splash can kill plants and trees along roadsides and plants can also be harmed by taking up salty water directly through their roots. When chloride flows into lakes, wetlands, and streams, it harms aquatic vegetation and can change the plant community structure.

Vitaliano estimated that the aesthetic damage to trees in the Adirondacks due to road salt was $75 per ton (1992). Research in the Adirondacks has shown that the application of deicers and abrasives on roads has severely changed the chemical and physical structure of soil along roads (Langen et al. 2006). The New York State Department of Transportation spent $10,000 per mile to replant and reestablish natural vegetation along a two-mile stretch of highway in the Adirondacks (NYSDOT Press Release 2008).

Soil

Soil along roadsides can be impacted by road salt (primarily the sodium) in a number of ways, including change in soil structure, effects on the nutrient balance, accelerated colloidal transport, mobilization of heavy metals, reduced hydraulic conductivity and permeability (Amundsen 2010; Michigan DOT 1993). These changes can lead to reduced plant growth. Soil structure changes also may result in increased erosion and sediment transport to surface waters (Kelting and Laxson 2010).

Pets and Wildlife

Pets may consume deicing materials by eating them directly, licking their paws, or by drinking snow melt and runoff, which can be harmful to pets. Exposure to deicing salt can cause pets to experience painful irritation, inflammation, and cracking of their feet pads. Some birds, like finches and house sparrows, have an increased risk of death if they ingest deicing salt. Deer and other large mammals consume the salt on roadsides and roadside ponds to fulfill their sodium needs, resulting in increased traffic incidents (Environment Canada 2001; Amundsen 2010). Exposure of amphibians to road salt can result in abnormalities, reduced growth, behavior changes, lower survival rates, and changes in community structure (Environment Canada 2001; Denoël et al. 2010; Karraker 2008; Collins and Russel 2009). Deicing salt may also cause a decline among populations of salt sensitive species, reducing natural diversity.

Infrastructure

Chloride corrodes road surfaces and bridges and damages reinforcing rods, increasing maintenance and repair costs. The costs associated with infrastructure are based on damage to infrastructure and maintenance and replacement costs associated with this damage. A study by economist Vitaliano, included an estimate of expenditures of an additional $332 per ton of salt per season for bridge maintenance (1992). One ton of road salt results in $1,460 in corrosion damage to bridges, and indirect costs may be much higher (Sohanghpurwala 2008). The total annual cost of bridge decks damages due to road salt was estimated at greater than $500 million nationwide (Murray and Ernst 1976). Costs would be substantially higher now.

In addition to damage to bridges, chloride deicers also damage concrete pavement, requiring higher maintenance costs. Vitaliano (1992) estimates an overall increase in roadway maintenance costs of over $600 per ton. This figure is believed to include the extra cost due to damage to bridges. Salt applied to pavement is also damaging to parking garages and underground utilities (Michigan DOT 1993).

Vehicle Corrosion

Deicing salt also accelerates rusting, causing damage to vehicle parts such as brake linings, frames, bumpers. Vitaliano (1992) estimated that vehicle depreciation due to corrosion from road salt results in a cost of $113 per ton of salt. Automobile manufacturers have improved corrosion resistance in cars since the 1992 study; however, measures to protect vehicles against corrosion cost auto manufacturers an estimated $4 billion each year, which is passed on to consumers (Adirondack Council 2009).

Cumulative Costs

Estimates of damage to infrastructure, automobiles, vegetation, human health and the environment due to road salt were found in the literature from several sources. They ranged from $803 to $3,341 per ton of road salt used.

Table 1 shows the overall range of the cost estimate with a low and high range as well as the estimated associated cost for the TCMA based on 349,000 tons of salt applied per season.

Table 1. TCMA Overall Cost Considerations

	Low Overall Estimate		High Overall Estimate	
Cost component	**Rate per ton of salt**	**Cost * (millions) per year**	**Rate per ton of salt**	**Cost * (millions) per year**
Material	$73	$25	$73	$25
Labor and equipment	$150	$52	$150	$52
Overall damages	$803	$280	$3,341	$1,166
Combined Cost	**$1,026**	**$358**	**$3,564**	**$1,243**

** Calculated using TCMA annual salt use of 349,000 tons/season*

The money saved from reducing damage to infrastructure, vehicles, plants, water supplies, and human health is much higher than that from the material and labor savings. At a 10% salt use reduction, annual savings in the TCMA for reduced material and applications costs plus reduced damages would amount to an estimated $36 million to $124 million each year. At a 70% salt use reduction, savings would amount to $251 to $870 million each year (Fortin 2014).

2. TCMA Chloride Conditions

Chloride data across the TCMA was compiled and assessed to support the development of the CMP. As part of the TCMA Chloride Project, the MPCA worked with local partners to develop and implement a chloride monitoring program. The objective of the monitoring program was to better inform an understanding of chloride conditions across the TCMA, including seasonality, trends over time, and the potential for high chloride concentrations in the deepest part of lakes. Seventy-four lakes, 27 streams, and eight storm sewers were monitored as part of this effort from 2010-2013. The Chloride Monitoring Guidance for Lakes and Chloride Monitoring Guidance for Streams and Stormsewers were developed by the MPCA and local experts from the TCMA Chloride MSG and can be found on the MPCA's TCMA Chloride Project website. The monitoring guidance provides recommendations on sample collection, times of the year to sample, as well as guidance for monitoring high risk waters. In addition to data collected in 2010-2013 following the TCMA Chloride Project monitoring program, chloride data from a host of other sources and timeframes were compiled. The data were collected by several local organizations including the MPCA, the United States Geological Survey (USGS), Capitol Region Watershed District (CRWD), Metropolitan Council Environmental Services (MCES), Minneapolis Park &

Recreation Board (MPRB), Minnehaha Creek Watershed District (MCWD), Mississippi Watershed Management Organization (MWMO), Ramsey County Environmental Services, Ramsey-Washington Metro Watershed District (RWMWD), Rice Creek Watershed District, Scott County Watershed Management Organization, and Three Rivers Park District. A large portion of the data were compiled and submitted to the State of Minnesota's Environmental Quality Information System database (EQuIS). All data collected by Metropolitan Council are available on their Environmental Information Management System (EIMS) database: es.metc.state.mn.us/eims, and data collected by USGS are available on their water-quality data for the Nation database: waterdata.usgs.gov/nwis/qw.

The impacts of climate change create uncertainty related to winter salt application and chloride levels in TCMA waters in the future. Predictions provided by the United States Global Change Research Program for the TCMA area include warmer winter temperatures by 5 - 6 degrees Fahrenheit, longer freeze-free seasons increasing by 20-30 days, greater winter precipitation, and the likelihood of more frequent extreme events (Kunkel et al. 2013). On the one hand, these predictions of climate change may result in reduced salt use. On the other hand, more frequent snow events, more extreme events, and potentially more frequent ice storms may result in greater needs for deicing roads. Continued monitoring of climate change and chloride concentrations in the TCMA waters, tracking of salt use on all paved surfaces, and an adaptive process will be needed to restore and protect the TCMA waters from chloride impairments with the prospects of a changing climate.

A STREAM, LAKE OR WETLAND IS IMPAIRED BY CHLORIDE IF:

Two or more samples exceed 230 mg/L within a three-year period;

Or,

One sample exceeds 860 mg/L.

The remainder of this section will present an overview of the assessments conducted based on the available data, including determinations of impairment, time and spatial trends in chloride concentrations, the TMDLs developed for impaired waters, and waters showing a high-risk for future impairment.

2.1 Condition Status

This section describes the current status of water resources within the TCMA with respect to applicable chloride criteria. The status of surface waters including lakes, wetlands and streams is presented first. The status of groundwater resources is presented second.

Surface Water

The MPCA's approach to determining whether or not a stream, lake, or wetland is impaired by chloride relies on an assessment of available data. The MPCA conducted an assessment for chloride in the TCMA waterbodies in 2013. Two or more exceedances of the chronic criterion of 230 mg/L within a three-year period are considered an impairment. One exceedance of the acute criterion of 860 mg/L is considered an impairment. The 2013 TCMA chloride assessment resulted in 29 new chloride impairments (6 streams, 19 lakes, and 4 wetlands) added to the 2014 draft impaired waters list, resulting in a total of 39 chloride impairments in the TCMA. Shingle Creek and Nine Mile Creek were previously listed as impaired with completed chloride TMDLs. Approximately 11% of the 340 waterbodies assessed were determined to be impaired. An additional 38 (11%) were classified as high risk and 11% did not have enough data. High risk was defined as a waterbody having one sample in the last 10 years that was within 10% of the chronic criteria (207 mg/L). An interactive map showing assessed, impaired, not impaired, and high risk waters is on the MPCA Chloride Project website (MPCA Chloride Project Website Map of Assessments and Impairments). The assessed lakes, wetlands, and streams are shown on Figure 1. The highest density of impairments is in the heavily urbanized area in Hennepin and Ramsey Counties, though three streams in the outlying suburban areas are also impaired by chloride. The chloride causing impairments in the streams in the outlying areas of the metro is largely effluent from the WWTPs, rather than deicing salt.

It is important to keep in mind that of the over 1,000 lakes, wetlands and streams in the TCMA, less than one-third had chloride data to make an assessment of impairment/attainment of water quality criteria. Also, of those waters with adequate data to make an assessment, only 30% were part of the TCMA Chloride Project monitoring program, which was developed to collect samples at critical times of the year and critical locations. As a result, data used to evaluate water quality conditions in waters not part of the TCMA Chloride Project monitoring program, may not have been representative of critical conditions. Critical times of the year for collecting chloride samples are typically during the winter snowmelt runoff (February through March) and during low flow periods, and critical areas for collecting chloride samples in a lake are near the bottom.

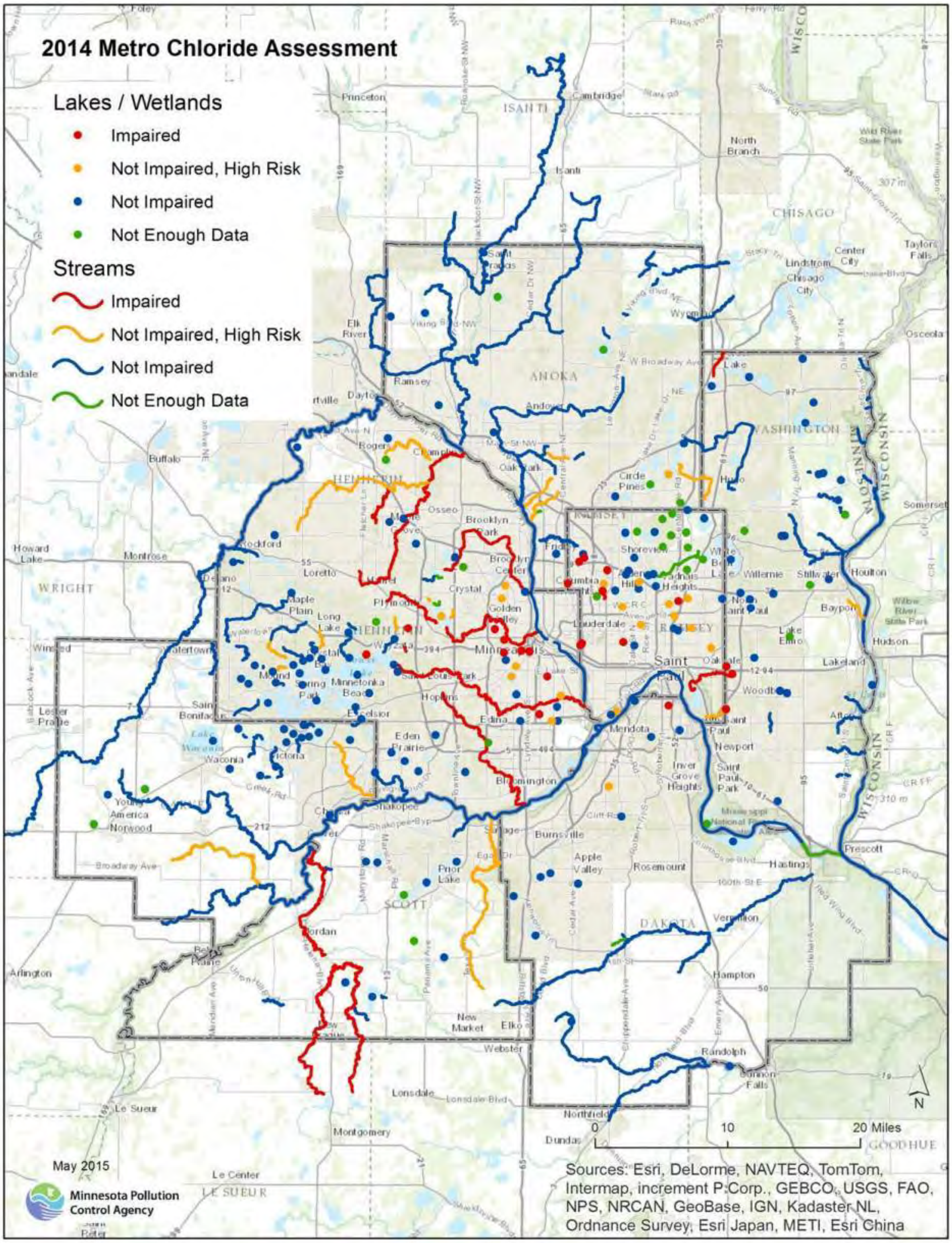


Figure 1. 2014 Chloride Assessment Results in the TCMA

The impaired lakes, wetlands, and streams were compared by the concentrations of chloride ranked from highest to lowest concentrations. These rankings are presented in Figure 2 and Figure 3. These figures are not a direct reflection of the 303(d) listing assessment; they are intended to make a relative comparison of the extent of impairment across impaired waters. The values presented in these figures were calculated by identifying the maximum chloride concentration measured in a waterbody on individual sampling days, then averaging all individual sampling day maximums that exceeded the standard of 230 mg/L from 2003-2013. These figures indicate the variability in one waterbody or watershed to the next by the severity of the impairment. These rankings can be used by chloride users to prioritize management activities by area. Since only a portion of the TCMA waters have chloride monitoring data, the rankings can also be used to determine specific areas that are close to impaired and high-risk watersheds for further monitoring and higher levels of management.

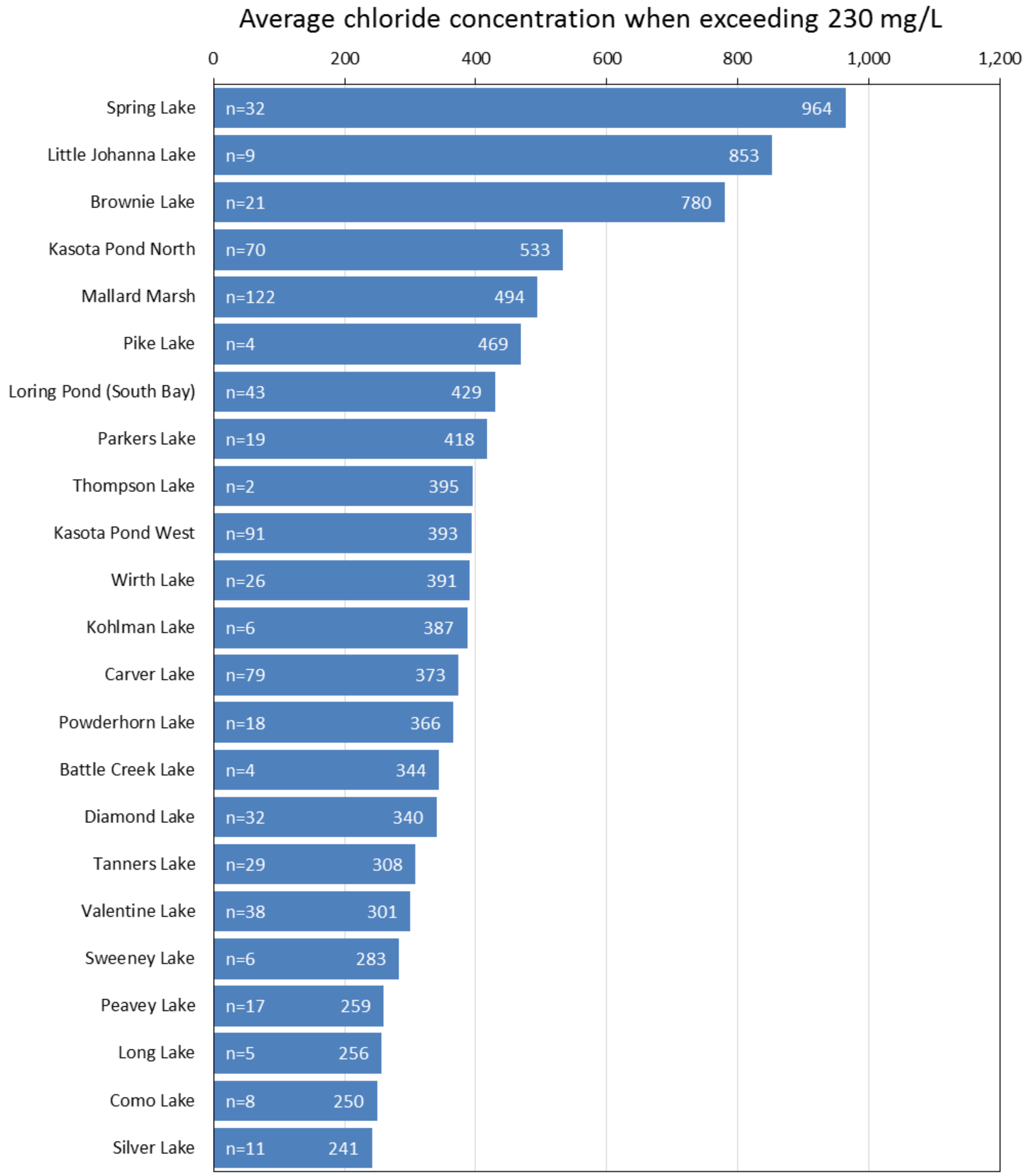


Figure 2. Comparison of Impaired Lakes and Wetlands in the TCMA
Data from 2003-2013; average chloride concentration of samples exceeding 230 mg/L; n is the number of days with samples exceeding 230 mg/L.

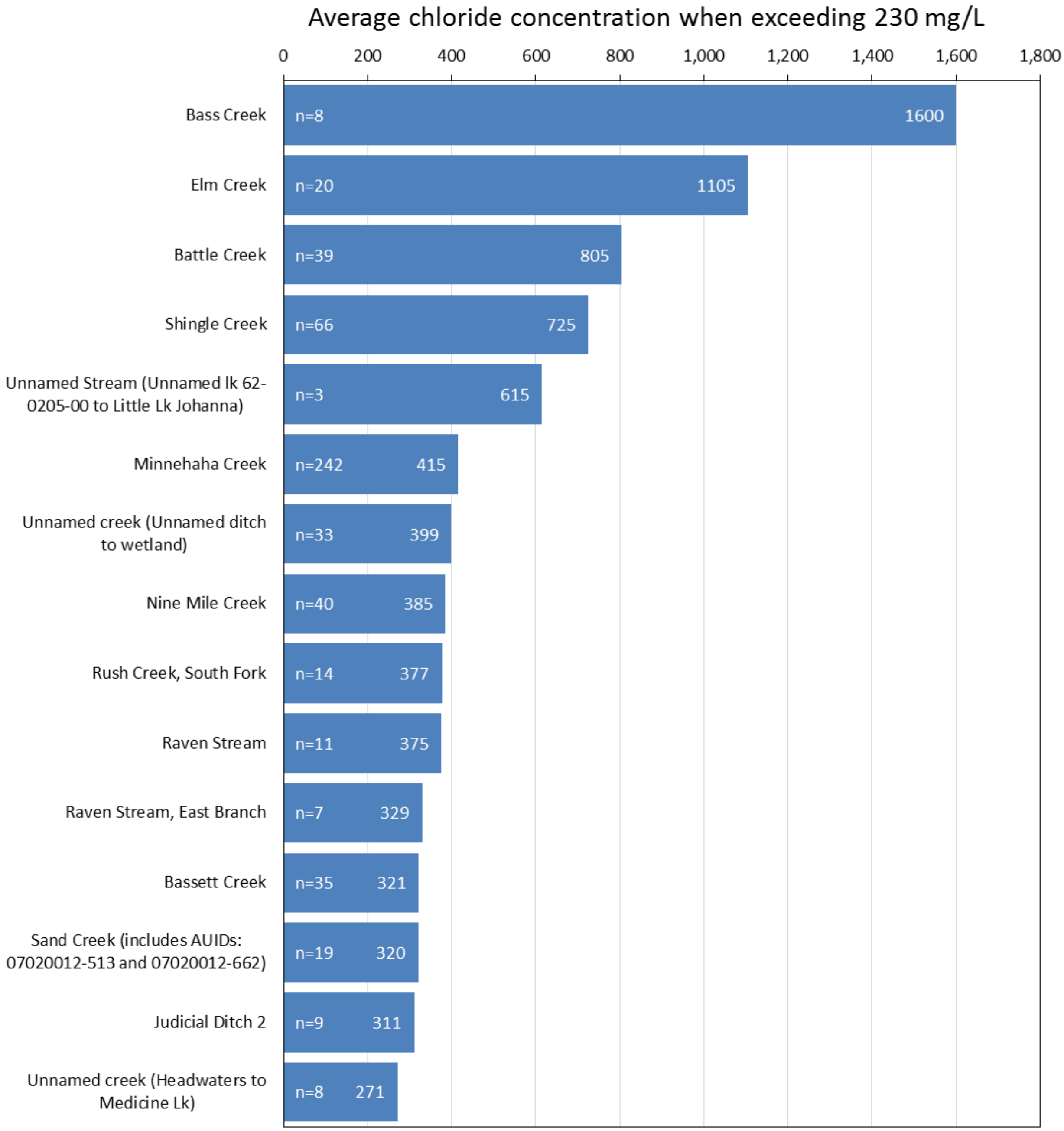


Figure 3. Comparison of Impaired Streams in the TCMA

Data from 2003-2013; average chloride concentration of samples exceeding 230 mg/L; n is the number of days with samples exceeding 230 mg/L.

Groundwater

Chloride concentrations in shallow groundwater are increasing, likely as a result of the application of deicing salt. This correlation is observed in a recent study by the MPCA, The Condition of Minnesota's Groundwater, 2007-2011, which found that chloride concentrations were higher in wells sampled in urban areas, where salt is more commonly applied in winter months, compared to wells sampled in areas that were undeveloped (Table 2).

Table 2. Average chloride concentrations in groundwater based on land use

Land Use	Chloride (mg/L)
Residential	45 mg/L
Commercial/Industrial	60 mg/L
Undeveloped	15 mg/L

The median chloride concentration in sand and gravel aquifers in the TCMA was 86 mg/L, compared to a median concentration of 17 mg/L in sand and gravel aquifers outside the TCMA. Twenty-seven percent of sand and gravel monitoring wells in the TCMA had chloride concentrations greater than 250 mg/L, the secondary maximum contaminant level set by the EPA (Figure 4). Very few monitoring wells outside the TCMA (about 1%) had chloride concentrations exceeding 250 mg/L.

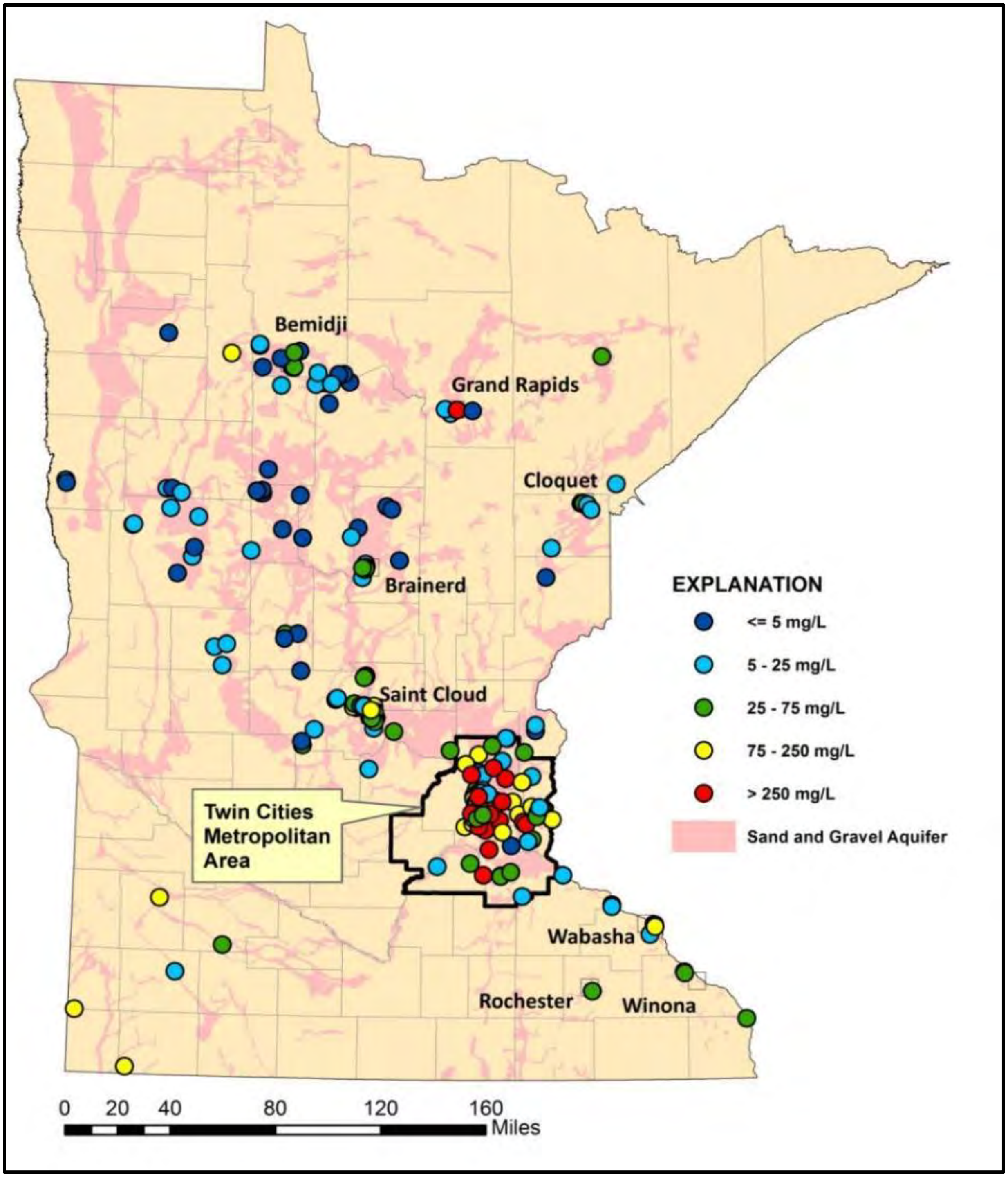


Figure 4. Chloride concentrations in ambient groundwater from the sand and gravel aquifers
Data from 2007-2011; figure taken from the MPCA's Ambient Groundwater Monitoring Network (MPCA 2013, p. 29).

2.2 Chloride Sources

Chloride enters the TCMA lakes, streams, wetlands, and groundwater from a variety of sources. The relative significance of each source of chloride is dependent on the watershed. For highly developed urban areas, winter maintenance activities are typically the primary source. In less developed areas where point source discharges exist, the municipal wastewater treatment facilities may be the primary source of chloride, which in most cases is due to water softening. A conceptual model diagram of the primary anthropogenic sources is shown in Figure 5. A chloride budget for the TCMA estimated that only 22%-30% of the chloride applied in the TCMA was exported out of the TCMA via streamflow in the Mississippi, Minnesota, and St. Croix Rivers (Stefan et al. 2008). Therefore, 70%-78% of the applied chloride remains in TCMA lakes, wetlands, and groundwater and it may also be stored in soil-water where infiltration is slow. Since chloride is an element and does not breakdown over time, the high percentage retained in the TCMA suggests that chloride will continue to accumulate and eventually make its way to the deep aquifers. This implies that, on average, chloride concentrations in the TCMA waterbodies are increasing with time. If the chloride loading remains steady, the concentrations will level out when equilibrium develops between loadings and transport out of the TCMA. By the same token, if loadings are reduced sufficiently and persistently, the chloride concentrations in the TCMA waterbodies will begin to decrease and will continue to decrease until a new equilibrium is reached. Each of these sources is briefly described below.

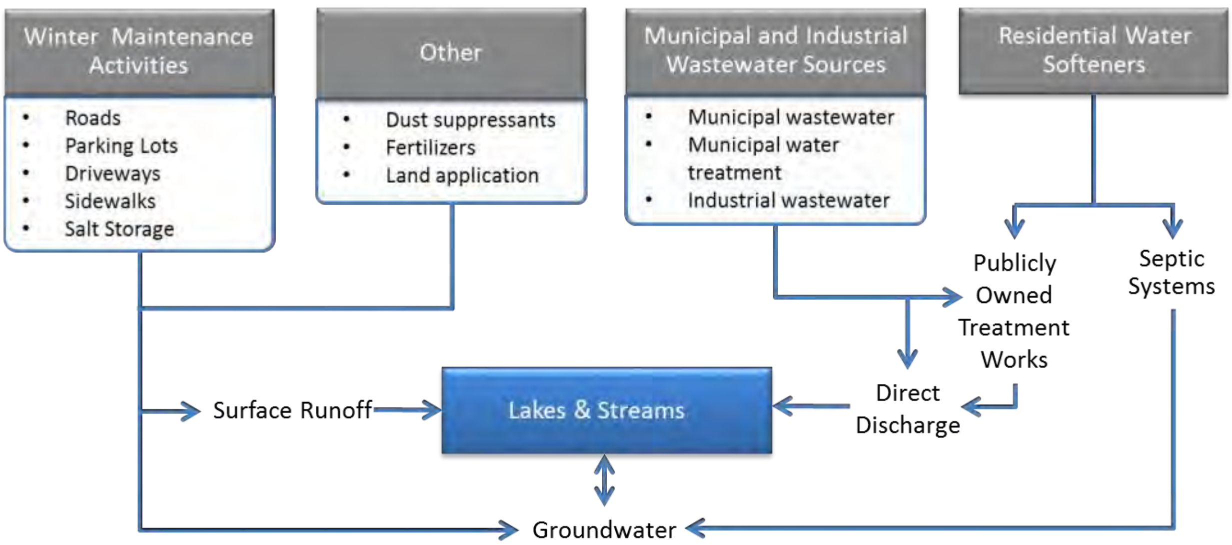


Figure 5. Conceptual model of anthropogenic sources of chloride and pathways

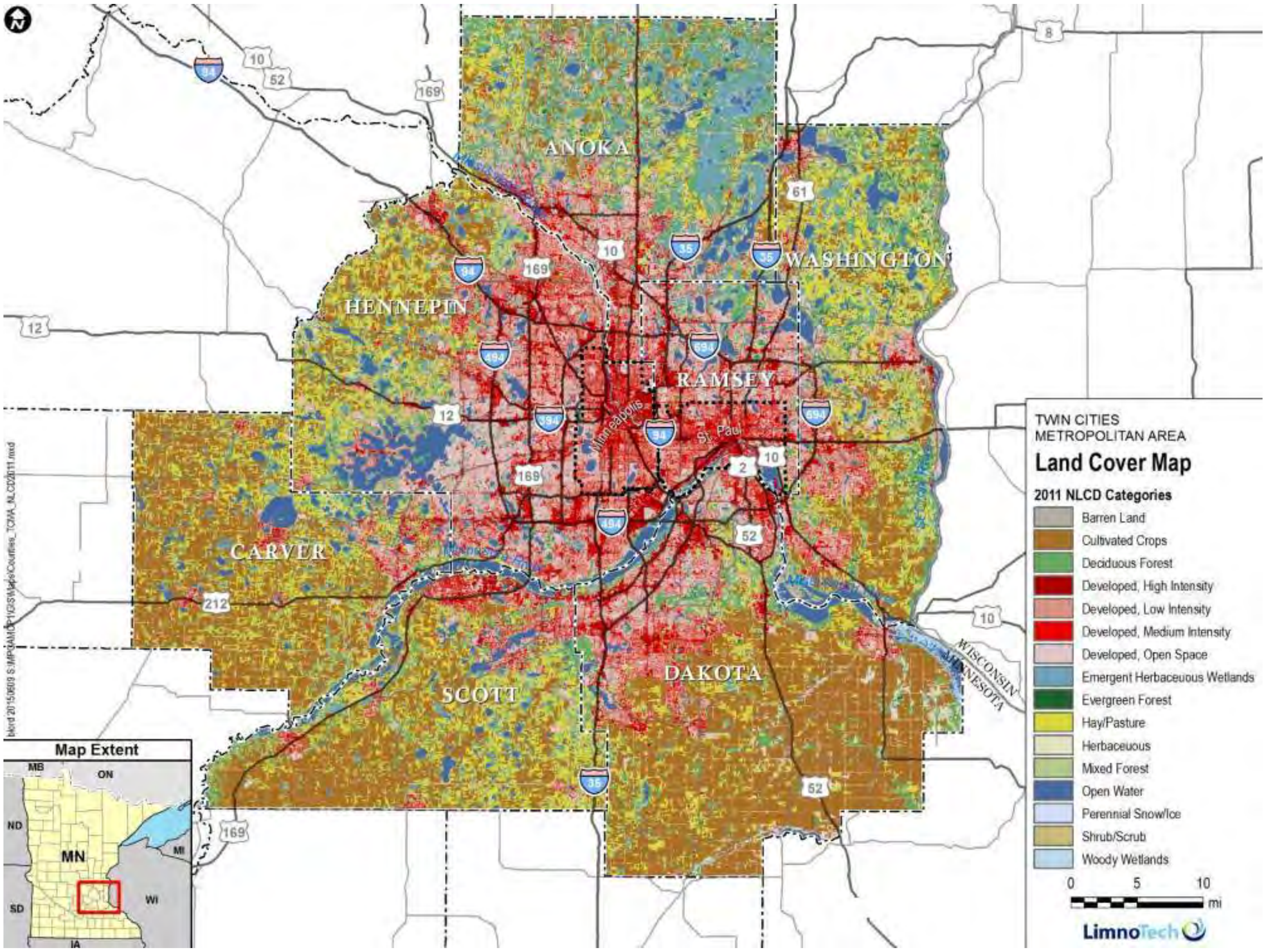


Figure 6. Land Use in the TCMA *(based on the National Land Cover Database from 2011)*

As shown in Figure 6, land use in the TCMA is largely urban in the core of Minneapolis and St. Paul with a transition to rural and agricultural moving outward through the suburbs. The primary source of chloride may shift locally depending on land use. Section 2.3 discusses the correlation of road density and chloride concentrations in surface waters.

Winter Maintenance Activities

Winter maintenance activities include snow and ice removal. Application of deicing and anti-icing chemicals, primarily salt, is common. Salt is applied to a variety of surfaces including roads, parking lots, driveways, and sidewalks. Runoff from salt storage facilities is another potential source of salt. The St. Anthony Falls Laboratory at the UMN developed an inventory of salt uses in the TCMA for a Minnesota Department of Transportation (MnDOT) Local Roads Research Board study (Sander et al. 2007). The inventory estimated the total amount of salt used for winter maintenance activities in the TCMA, based on purchasing records, to be 349,000 tons per year. Estimates of use by various entities are shown in Figure 7.

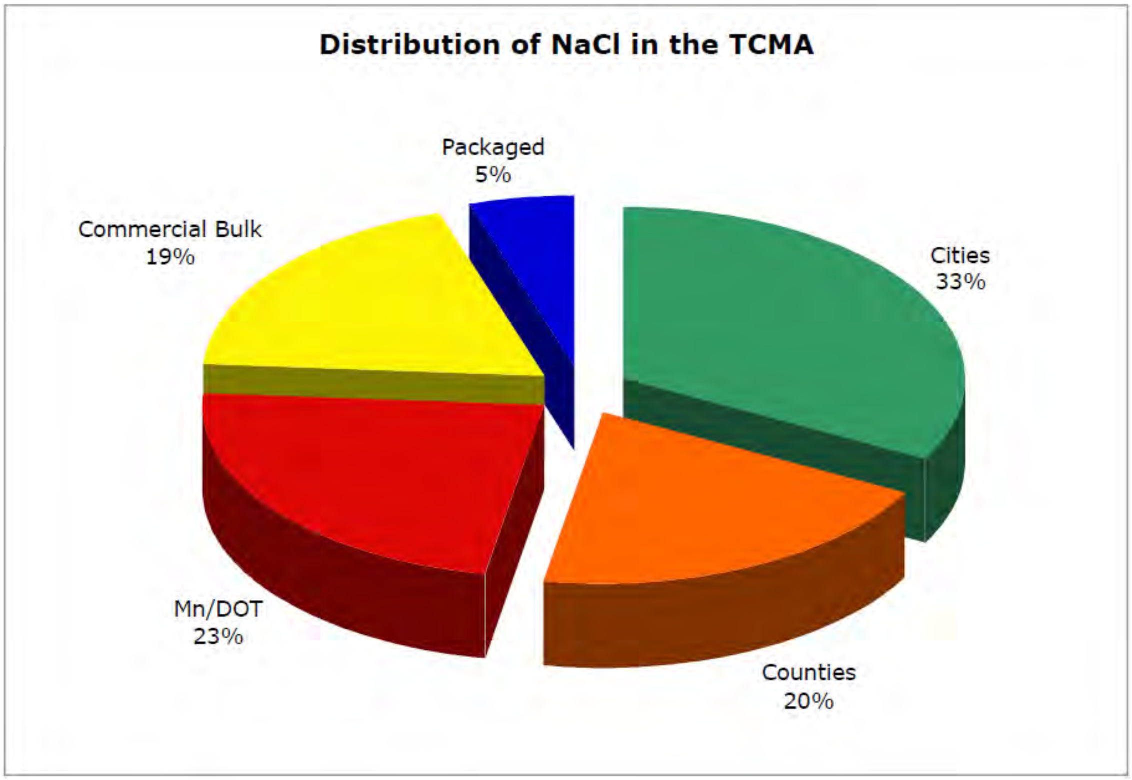


Figure 7. Distribution of NaCl in the TCMA (*Figure adapted from Sander et al., 2007)*

Salt sales data in the United States shows a dramatic increase in the amount of salt being purchased. Figure 8 below from the Salt Institute illustrates this increasing trend. Along with the increased use of salt, increasing levels of chloride in lakes, wetlands, and streams should be expected.

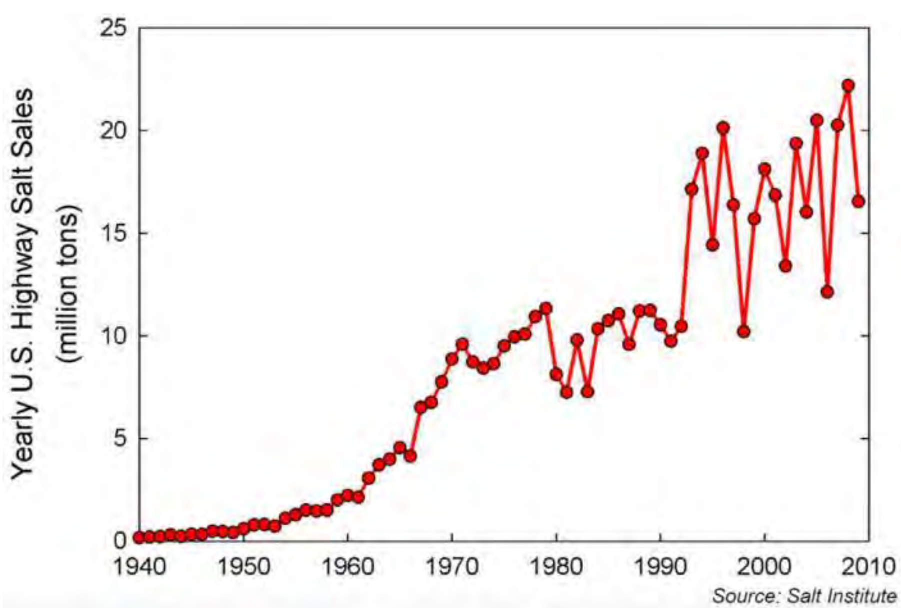


Figure 8. Road Salt Sales Trend in the United States

Roads

The TCMA is estimated to have over 26,000 lane miles of roadways (Sander et al. 2007). Application rates range from 3 to 35 tons of road salt, per lane mile, per year, based on the salt purchasing records and the number or lane miles of MnDot, counties, and cities in the TCMA (Wenck 2009)

A survey of municipal winter maintenance professionals in the TCMA, done by LimnoTech in 2013, found that typical application rates range from 100 - 600 pounds of salt applied per lane mile per event, which is consistent with previous evaluations of road salt application rates. However, rates can be much higher on hills, near intersections, and other ice problem areas. Higher speed roadways will typically have higher road salt application rates. Some events may require multiple passes of salt application and increase the application rate per event.

Commercial Parking Lots, Driveways, and Sidewalks

Commercial sources of deicing salt can vary greatly between different watersheds and includes salt applied to parking lots, driveways, and sidewalks on commercial property. The land owner or tenant may conduct winter maintenance activities, or winter maintenance may be contracted with private winter maintenance providers. Commercial sources are likely responsible for 10% and 20% of the total salt applied to paved surfaces in the TCMA (Wenck 2009). The MPCA and Fortin Consulting conducted research to validate and refine assumptions regarding commercial and private salt application rates specific to Minnesota (Fortin 2012a). There is a range of reported application rates, which is to be expected, because rates should vary based on temperature, type of snow event, surface to where material is applied, number of passes over an area during an event, and type of material used. Application rates of salt on parking lots are estimated to range from 0.1 to 1 ton per acre per event, and typically 6.4 tons per acre per year. For sidewalks, the application rate is estimated to range from 8 to 25 pounds per 1,000 square feet per event (0.2 to 0.5 tons per acre per event). More area specific residential and commercial estimates of chloride usage can be determined on a watershed basis by digitizing all of the residential and commercial impervious surfaces and multiplying by the estimated application rates.

Review of available information and additional research included application rates from across the United States' and Canada's snowbelt, with an emphasis on Minnesota specific data. It was determined that an average rate of 6.4 tons per acre per event is the appropriate application rate to expect on parking lots. As a percent of the total deicing salt usage, it is estimated that anywhere between 5% and 45% is used for commercial applications (parking lots, sidewalks, residential, private roads). The amount of chloride from commercial sources is variable, and is dependent on the characteristics of the watershed, including the amount of impervious area. Additional estimates of commercial salt use are presented below.

- The Nine Mile Creek Chloride TMDL report, used data on salt purchases from Sander et al. (2007) and Novotny et al. (2008), but weighted the data based on land use. It was determined that the relative contribution for commercial and packaged deicer in the Nine Nile Creek watershed was 38% of the total amount of road salt that is applied (Barr Engineering 2010).
- In the Shingle Creek TMDL, it was estimated that 7.5% of salt application was by commercial/private applicators. This figure was based on the estimates used in Canada. "Cheminfo (1999) estimated that commercial and industrial consumers represented

approximately 5 to 10% of the deicing salt market. In quantifying total deicing salt application in Canada, Environment Canada used the midpoint of these data (7.5%) to represent commercial and industrial salt application (Environment Canada 1999)." (Wenck 2006).

- Sander et al. (2007) estimated that the bulk deicing salt applied by commercial snow and ice control companies accounted for 19% of the total salt used in the TCMA, while packaged deicer for home and commercial use was estimated to account for 5% of the total in the TCMA.
- Novotny et al. (2008) used market share amounts from the USGS annual mineral reports and the market share report published annually from the Salt Institute. TCMA amounts were estimated based on national amounts combined with the commercial bulk (19%) and packaged (5%) deicer estimates for a total of 24%.
    - On a national basis, the Salt Institute estimated that 20% of bulk road salt purchases were by non-governmental entities.
    - The USGS estimated 13% of ice control salt is for commercial use.
- A chloride TMDL study in New Hampshire reported a chloride application rate of 5.7 to 6.4 tons per acre per year for parking lots and drives (Sassan and Kahl 2007). Parking lots were 47% of paved surfaces in the watershed and accounted for 36% of the chloride load. The study also estimated that 45% of salt was applied by private applicators.

Private Parking Lots, Driveways, and Sidewalks (residential)

Residential winter maintenance salt use has been estimated from purchasing records. Packaged deicer for home and commercial use is estimated to account for 5% of the total in the TCMA (Sander et al. 2007). See Figure 7.

A Sidewalk Salt Survey was conducted to qualitatively assess the use of sidewalk salt by the general public in the TCMA. The survey was disseminated by local partners including RWMWD, MCWD, and MnDOT. The survey was administered through an on-line Survey Monkey link on the MCWD website (www.minnehahacreek.org) from November 2011 through March 2012. The survey was completed by 606 people online and 148 completed a paper survey. Approximately 47% of the respondents lived in St. Paul or Minneapolis, and other respondents lived in surrounding cities including Woodbury, Richfield, Plymouth, and Maplewood. Although the survey sampled 754 residents, the results represent a small percentage of the TCMA population and are non-random/voluntary; therefore, the survey is not representative of all residents in the TCMA. However, the data provide valuable information on the use of sidewalk salt by TCMA residents.

The majority of residents that responded to the survey used sidewalk salt (57%), particularly on sidewalks and steps. Most people selected products based on performance in colder temperatures and environmental safety. The majority of respondents did not know how much sidewalk salt to use (59%), and if they did know, they determined how much to use based on the instructions on the packaging or used as little as possible. For complete results of the survey see Appendix C.

Municipal and Industrial Treatment Facilities

Municipal wastewater, backwash from municipal WWTPs, and industrial facilities with waste streams may contain chloride. The primary source of chloride in a municipal waste stream comes from water softeners. Many cities do not soften drinking water before it is distributed to residents. Many residents soften the water in their home with personal water softeners. The most common water softening systems use NaCl or potassium chloride (KCl). Salt that contaminates the groundwater can enter the sanitary sewer system through cracks and/or leaks in the pipes and pipe joints. Industrial facilities that discharge to the municipal wastewater collection system can be another source of chloride. Some industries have chloride in their discharge due to the products they produce or chemicals they use (Henningsgaard 2012).

Industrial facilities may discharge directly to surface waters following treatment or may discharge to a sanitary sewer system, which transports the wastewater to a wastewater treatment plant (WWTP) for further treatment prior to discharge to surface water. A range of industrial facilities discharge directly to waters that are already impaired by chloride, these include food processing facilities, manufacturing, pipeline terminals, biofuel facilities, and groundwater treatment systems. Discharges of chloride from municipal and industrial wastewater sources are covered by individual or general permits. Chloride data for wastewater and industrial sources is currently not widely available. However, chloride monitoring is being required for many facilities as permits are re-issued.

As part of the TMDL component of this project, several facilities were identified that likely discharge chloride within the impaired watershed. A table listing these facilities and their location is shown in Appendix A-3. There are likely additional facilities with the potential to contain chloride in their discharge; however, since they are not contributing to an impairment they were not evaluated at this time.

Residential Water Softeners

In areas with high hardness in the water supply, like the TCMA (See Figure 9), residential water softeners that use salt are common. Hardness is a measure of the calcium and magnesium carbonate concentration in water. Most water softeners use chloride ions to replace the calcium and magnesium ions. Chloride from this salt is delivered to the environment either through discharge to a septic system or by delivery to a WWTP. Septic systems become more prevalent in the rural areas outside of the TCMA urban core. The chloride that comes from septic systems enters the shallow groundwater or local streams through subsurface flow. Chloride loading from any individual home water softener is dependent on many variables and is specific to the individual homeowner’s water chemistry, water use, hardness preferences, and softener efficiency. Estimates of the amount of salt discharged from residential water softeners in the TCMA are not available at this time. However, where the primary source of household water is hard and it is not softened by municipal water utility, residential water softeners are the primary source of chloride to WWTPs. Figure 10 shows the hardness values of drinking water supply wells for the entire state of Minnesota. The Sand Creek watershed, located in Scott County of the TCMA, is an example where the primary source of chloride to surface waters is from water softening; chloride concentrations in WWTP effluent for three WWTPs located in the watershed average from 521 mg/L to 618 mg/L.

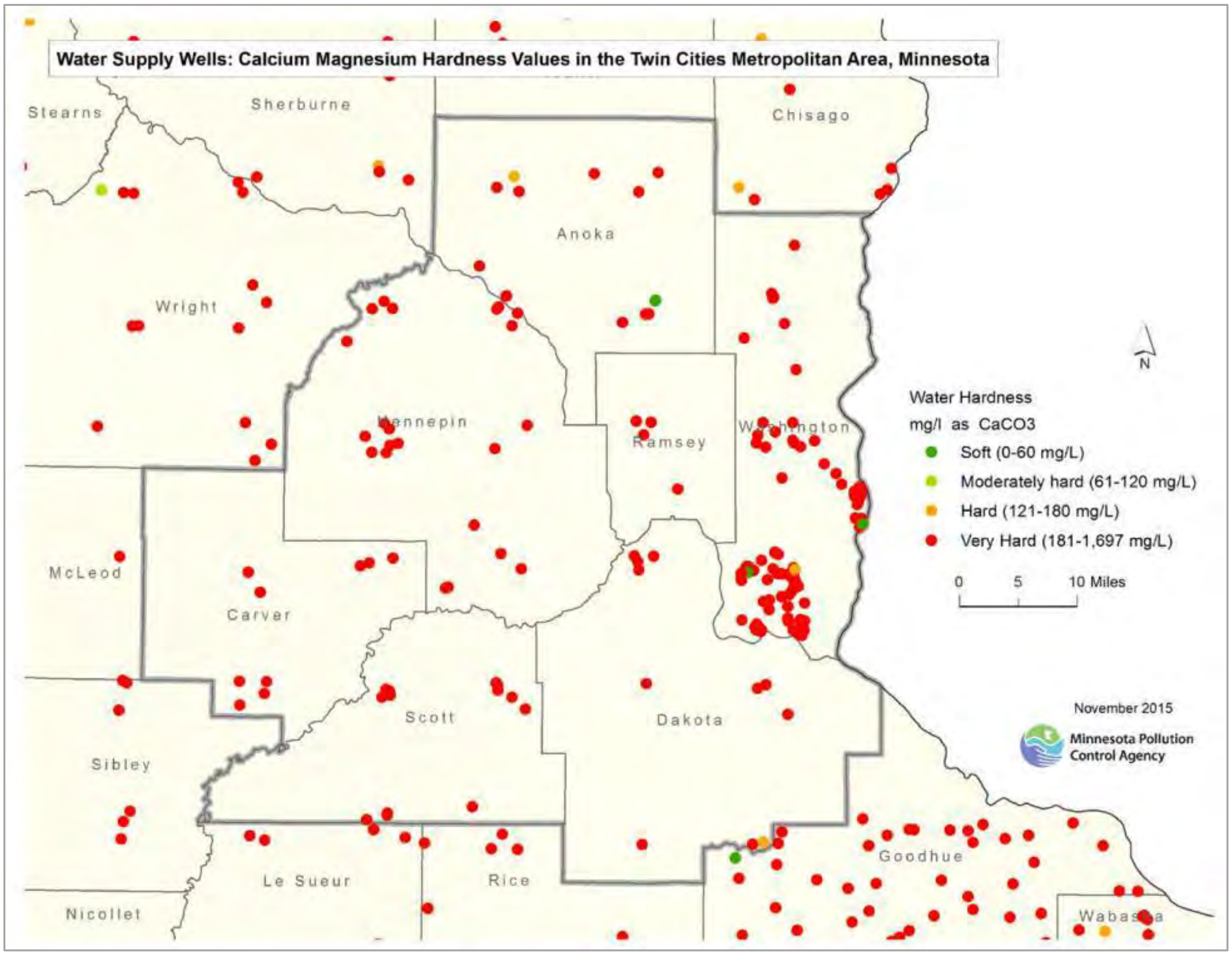


Figure 9. Hardness values of drinking water supply wells in the TCMA

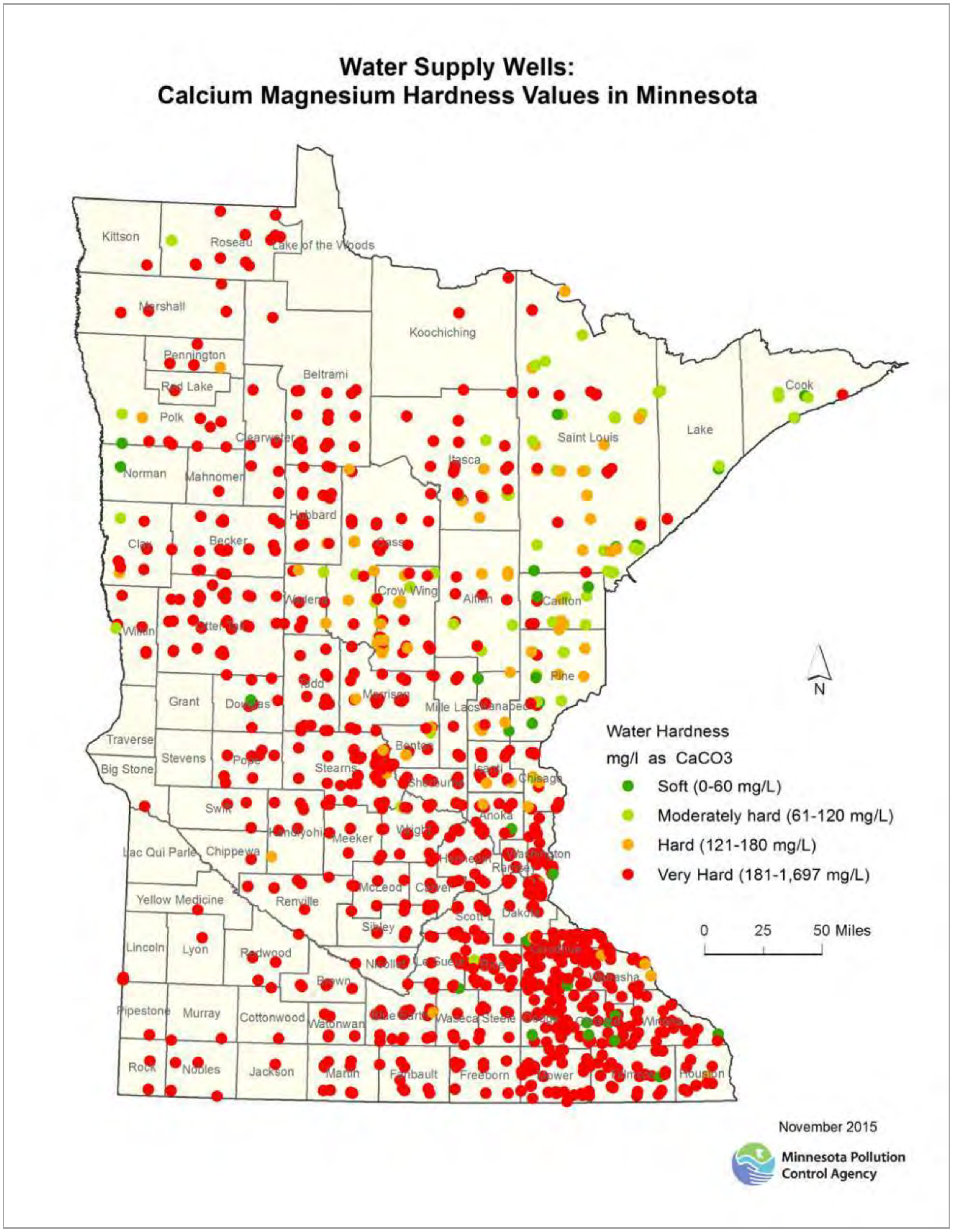


Figure 10. Hardness values of drinking water supply wells in Minnesota

Natural Background Sources of Chloride

Chloride occurs naturally in soil, rock, and mineral formations. Chloride is naturally present in Minnesota's groundwater due to the natural weathering of these formations. Glacial deposits from eroded igneous rocks and clay minerals with chloride ions attached are potential sources in the TCMA. Natural background levels of chloride in surface runoff and groundwater vary depending on the geology. The natural background concentration in small streams in the TCMA has been estimated to be 18.7 mg/L (Stefan et al. 2008). A natural background concentration for lakes has not been estimated; however, the natural background load from surface runoff to lakes was assumed to be at a concentration of 18.7 mg/L as well. This background concentration characterizes runoff that is not impacted by current or historical applications of anthropogenic sources of chloride. Concentrations of chloride in precipitation are estimated to be 0.1 mg/L to 0.2 mg/L (Chapra et al. 2009).

Agriculture

Agricultural crop land may be a small source of chloride to lakes and streams. Fertilizers and biosolids from food processing and publicly owned treatment works contain chloride. The application of fertilizers and biosolids on crop land can result in chlorides being transported to lakes and streams through surface runoff, as well as infiltration into shallow groundwater and subsequent transport to lakes and streams. KCl is the most commonly used fertilizer containing chloride. While not expected to be a significant source of chloride, estimates of the amount of chlorides in land applied fertilizers and biosolids in the TCMA are not available.

An on-going evaluation of agricultural drainage water quality done by North Dakota State University – Department of Agriculture and Biosystems Engineering indicates that chloride concentrations from agricultural drainage can range from 8.6 mg/L to 37.4 mg/L. [The results of this study have not been published].

Other Potential Sources

Sources of chloride to TCMA lakes, wetlands, and streams other than those discussed above exist, but are considered to be small. One such source of chloride is the use of dust suppressants on gravel roads and parking areas. Chloride is a common constituent found at high concentrations in dust suppressants. Landfill leachate has also been shown to contain elevated levels of chloride (Mullaney et al. 2009). The use of aluminum chloride for treatment of lake sediments or ferric chloride for treatment of stormwater are sources of chloride and should be avoided in waters and watersheds with chloride impairments.

2.3 Chloride Trends

This section of the CMP presents evaluations of chloride water quality conditions in the TCMA considering:

- Seasonal chloride trends in surface waters
- Long-term chloride trends
- Chloride trends within lakes
- Chloride relationships to watershed characteristics
- Chloride concentrations in stormwater
- Chloride relationships between surface and groundwater

This information is intended to help inform management decisions such as where and when to focus monitoring efforts and where to prioritize implementation activities.

Seasonal Chloride Trends in Surface Waters

Chloride data were evaluated for seasonal trends by looking at monthly chloride concentrations. Seasonal trends can help determine the cause of elevated chloride concentrations. Causes can be direct runoff from winter maintenance practices using chloride, groundwater inputs (primarily from infiltrated chloride containing deicers) during low flow, and WWTP inputs.

For the majority of impaired lakes, chloride concentrations were highest January through May. Figure 11 presents an example of the seasonal variability observed in Powderhorn Lake. Powderhorn Lake does not have a natural outlet and has little opportunity to flush chloride from the lake. For streams, chloride concentrations were highest December through April. Lakes tended to show less variation seasonally than streams, as would be expected due to the longer residence time and mixing that occurs in a lake.

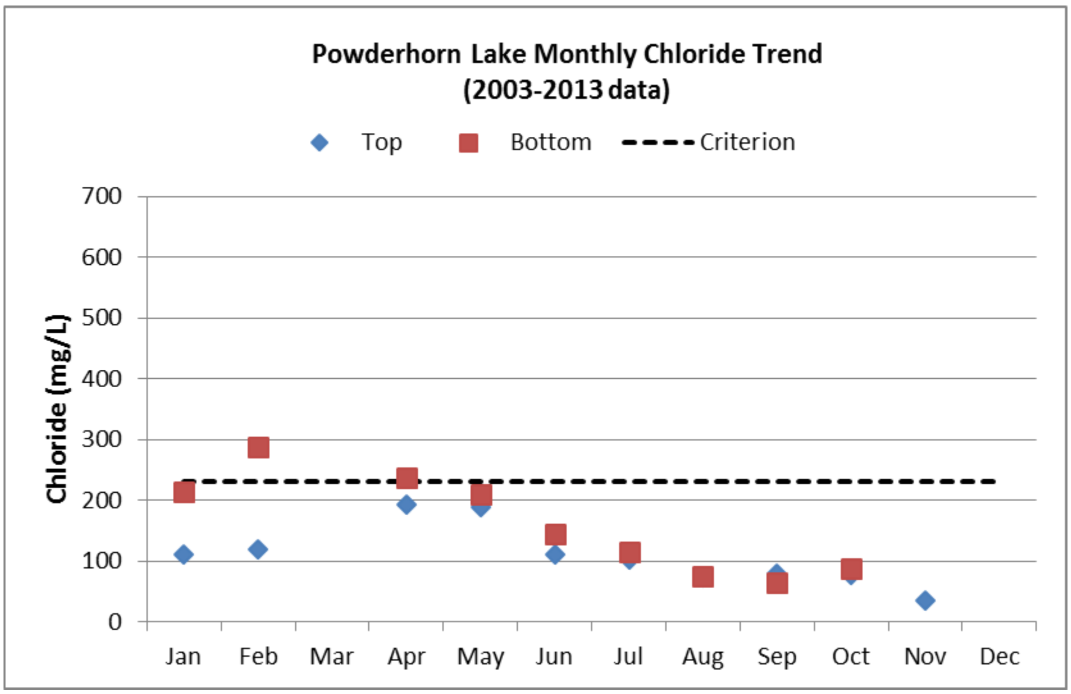


Figure 11. Monthly average chloride concentations in Powderhorn Lake

Figure 12 and Figure 13 present examples of the seasonal variability observed in Bassett Creek and Battle Creek, respectively.

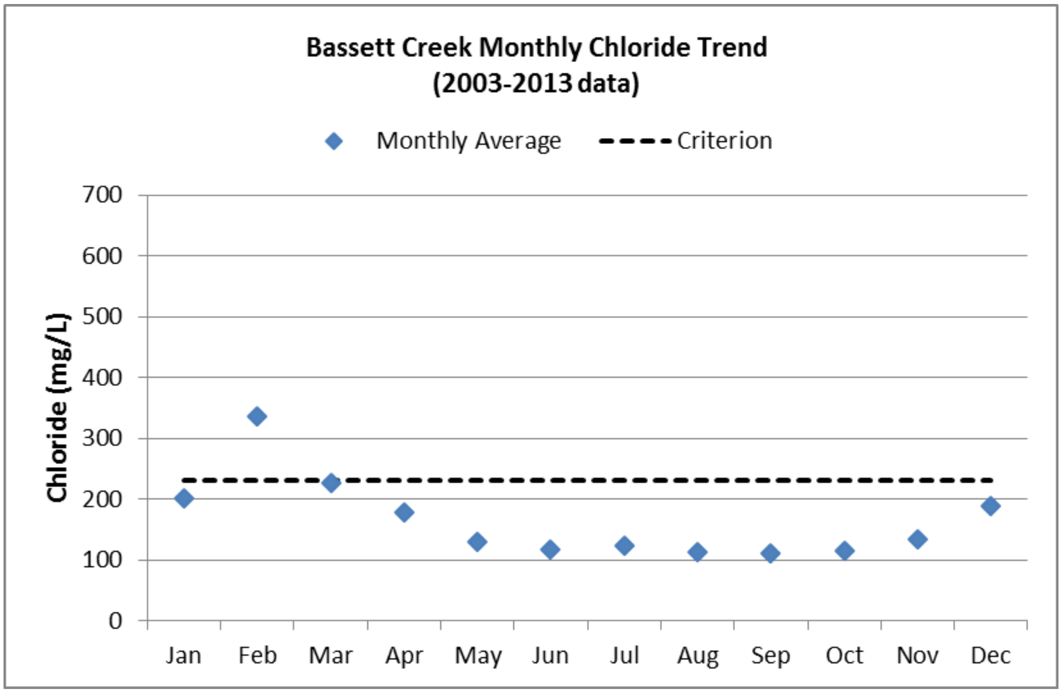


Figure 12. Monthly average chloride concentations in Bassett Creek

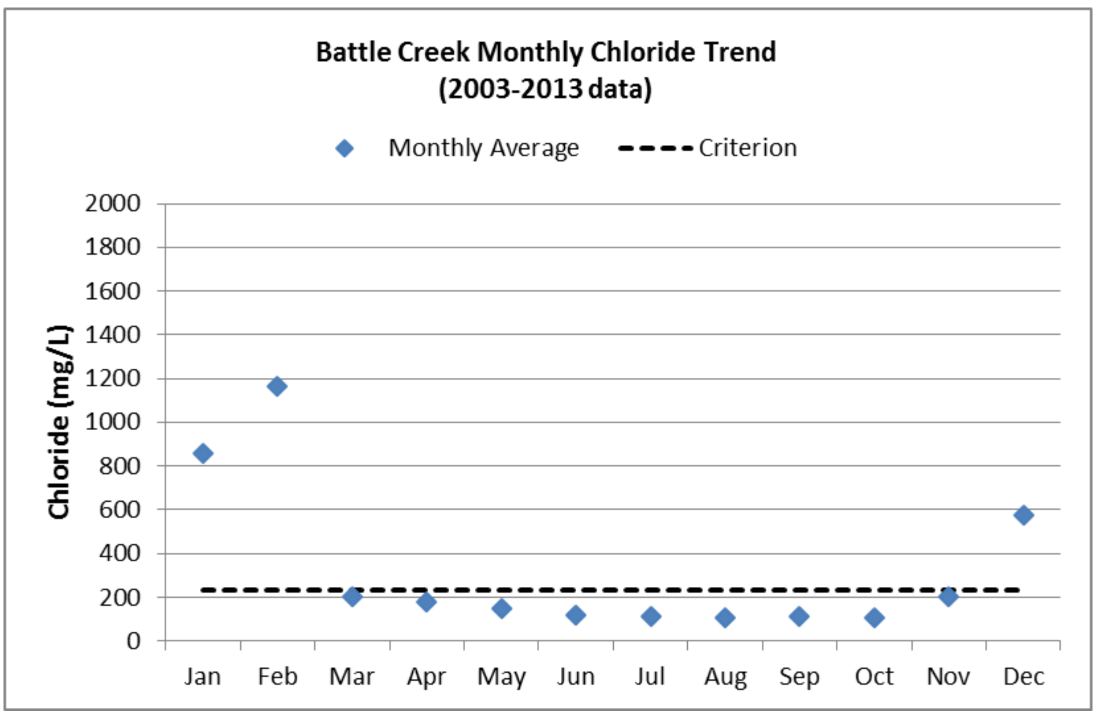


Figure 13. Monthly average chloride concentations in Battle Creek

There are some streams where chloride concentrations are influenced significantly by sources other than winter maintenance activities, such as WWTPs. These streams tended to show the highest chloride concentrations when flows were low. Low flows generally occur during winter months and dry summer months (July through September) when runoff is low. Sand Creek is an example and is shown in Figure 14. Chloride concentrations in Sand Creek were highest in late summer and winter and lowest in spring and early summer. Limited chloride data from the WWTPs discharging to Sand Creek confirm this as a significant source of chloride. Elm Creek is another stream that exhibits highest chloride concentrations in summer, as shown in Figure 15, but does not have the WWTPs contributing to the chloride concentration, indicating a different source is present that requires further investigation.

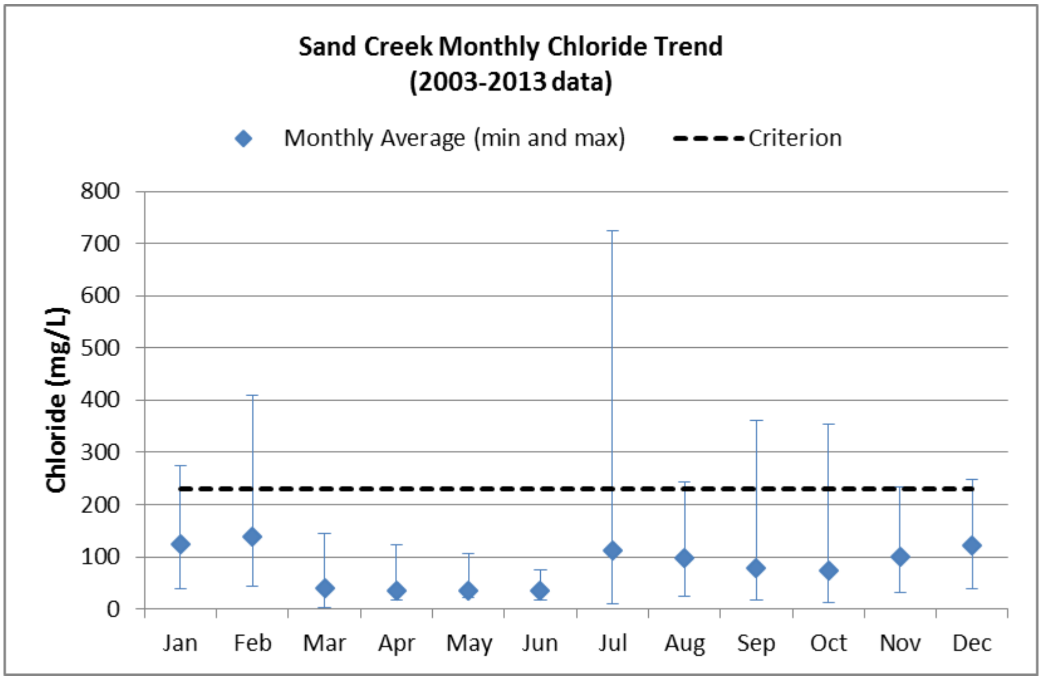


Figure 14. Monthly chloride concentrations (average, maximum, and minimum) in Sand Creek

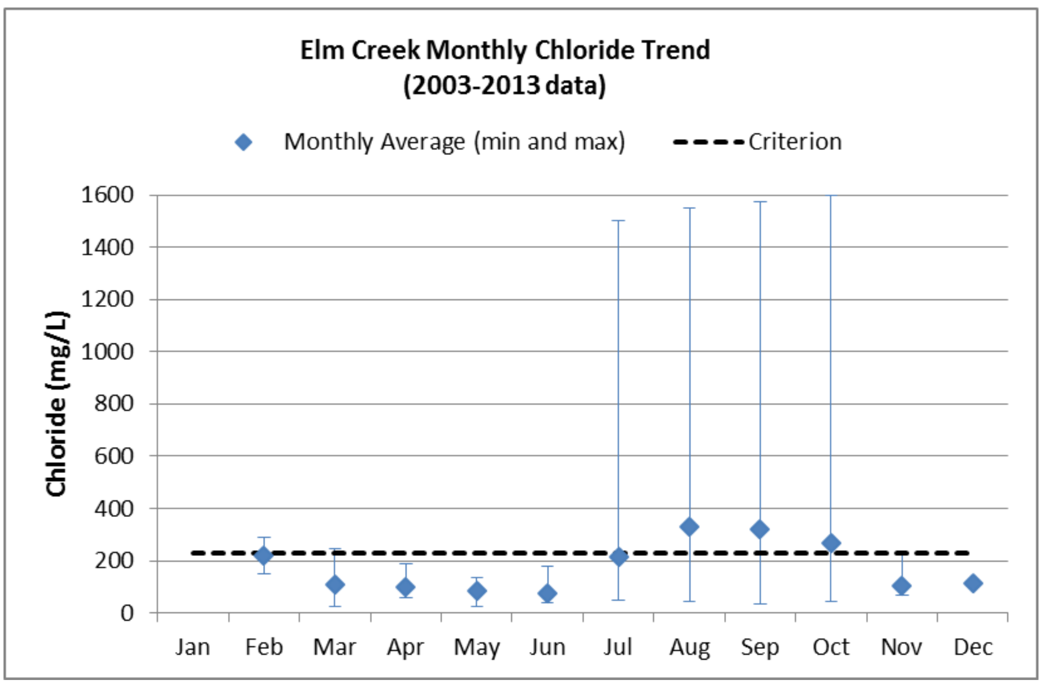


Figure 15. Monthly chloride concentrations (average, maximum, and minimum) in Elm Creek

Long-Term Chloride Trends

Long-term statistical trend analyses require a long, mostly continuous, monitoring record. Sufficient data were available in EQuIS to conduct long-term statistical trend analysis for 11 of the impaired lakes and 9 of the high risk lakes in the TCMA. Trends were determined using the Season Mann Kendall Trend Test with R Statistical Software and are presented in Table 3. Lakes with a minimum of 10 years of data were analyzed and only samples collected from the surface were used in the analyses. Fourteen lakes showed a significant ($p < 0.05$) increasing trend in chloride and eight lakes did not have a significant trend. Figure 16 shows an increasing trend in chloride concentration in Gervais Lake. The other lakes in Table 3 showed similar trends.

Table 3. Long-term chloride trends in lakes in the TCMA.
The Seasonal Mann-Kendall test indicates whether the chloride concentrations versus time are increasing (positive value) or decreasing (negative value). Red rows indicate a degrading trend for chloride.

Lake	Period	Percent change/year	Trend Description
Beaver	1984-2014	+2.42%	Increasing
Bennett	1984-2014	--	No trend
Calhoun	1991-2014	+1.74%	Increasing
Carver	2004-2014	--	No trend
Como	1984-2014	--	No trend
Gervais	1983-2014	+3.72%	Increasing
Hiawatha	1994-2014	--	No trend
Johanna	1988-2014	+3.37%	Increasing
Keller (Main Bay)	1983-2014	+3.85%	Increasing
Kholman	1983-2014	+3.62%	Increasing
Lake of the Isles	1991-2014	--	No trend
Loring	1995-2014	--	No trend
McCarron	1985-2014	+2.41%	Increasing
Powderhorn	1994-2014	--	No trend
Silver	1979-2014	+2.92%	Increasing
South Long Lake	1984-2014	+3.66%	Increasing
Spring	1995-2014	+4.34%	Increasing
Tanners	2004-2014	+3.63%	Increasing
Valentine	1990-2014	+5.56%	Increasing
Wabasso	1984-2014	+1.92%	Increasing
Wakefield	1984-2014	--	No trend
Wirth	1994-2014	+2.49%	Increasing

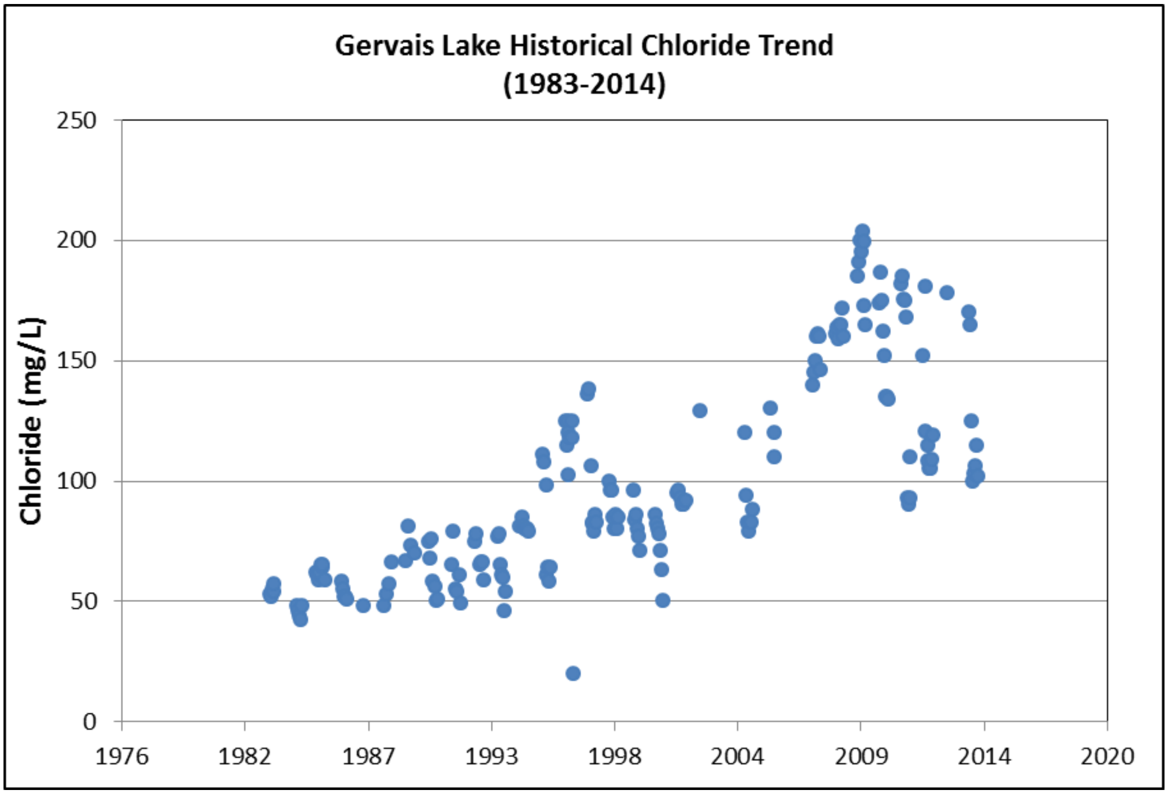


Figure 16. Increasing chloride concentration in surface samples in Gervais Lake from 1983-2014.

The Metropolitan Council is currently analyzing long-term trends in chloride concentrations for some of the streams in the metro area. The results of the analyses will be available on the Metropolitan Council's Stream Monitoring and Assessment webpage.

The Metropolitan Council 2013 Stream Water Quality Summary for the TCMA found that current chloride concentrations within the St. Croix, Minnesota, and Mississippi River basins are at levels higher than the 10-year average (2004-2013).

A multiple regression using both the year and the number of snowfall events in a winter season (precipitation equivalent > 0.01") as the independent variables showed the strongest potential to predict average winter chloride concentrations. Waterbodies with 10 years of data (2004-2013) and a relatively strong correlation over this period include Powderhorn Lake, Wirth Lake, Bassett Creek, and Nine Mile Creek. The results of the multiple regression analyses are presented in Table 3. The results show that average winter chloride concentrations are increasing between 9.7mg/L per year and 19.3 mg/L per year for these waters, though Bassett Creek did not exhibit a significant correlation to year. Average winter chloride concentrations increase between 2.9 mg/L and 7.9 mg/L for every additional snowfall event. Tests of significance for these correlations demonstrated that there is meaningful correlation, though the limited dataset of 10 years results in a fairly wide range in confidence intervals for the coefficients and intercepts.

Table 4. Results of Regression Analyses for Average Winter Chloride Concentrations (2004-2013)

Waterbody	Predicted winter average chloride (mg/L)	Yearly average increase (mg/L/yr)	Average increase per snowfall event (mg/L event)	R-square
Powderhorn Lake	10.5 * year + 2.9 * # of events -20,898	10.5	2.9	0.63
Wirth Lake	9.7 * year + 4.2 * # of events -19,422	9.7	4.2	0.50
Bassett Creek	4.8 * # of events +74	---	4.8	0.61
Nine Mile Creek	19.3 * year + 7.9 * # of events -38,815	19.3	7.9	0.67

Long term trends in groundwater chloride concentrations have also been evaluated (Figure 17). Chloride concentrations in the TCMA groundwater have increased in about one-third of the wells that had sufficient data for trend analysis (MPCA The Condition of Minnesota's Groundwater 2013). In some wells, chloride concentrations have increased by about 100 mg/L in the last 15-20 years. Most of the wells with increasing trends were shallow wells tapping the sand and gravel aquifers; however, increasing concentrations were also found in two deep wells in the TCMA. The high concentrations of chloride found in the shallow sand and gravel aquifers in the TCMA are likely a result of winter deicing materials (MPCA 2013).

Based on the chloride data and associated analyses, it is clear that chloride concentrations continue to increase in both the surface water and groundwater. The increasing trends in chloride concentrations indicate the need to take steps now to reduce chloride use.

Shallow groundwater will eventually either discharge to surface waters or move down to deeper aquifers that contain water that is used for Minnesota's drinking water supplies. If continued trends of increasing chloride in shallow groundwater persist, higher concentrations in deep aquifers will eventually occur, which could result in higher water treatment costs or restrict its use for drinking water supplies (MPCA 2013).

Upward trends in chloride concentrations were not just restricted to shallow wells that tapped the sand and gravel aquifers. Concentrations also significantly increased in two deep wells in the TCMA. One of these wells was 190 feet deep and tapped the Jordan aquifer in the vicinity of Cottage Grove. The other well was 72 feet deep and tapped a buried sand and gravel aquifer in Hennepin County. The Cl/Br ratios in both of these wells; 803 and 822, respectively; also was considerably greater than those expected in groundwater unaffected by human-caused contamination. In these two wells, chloride concentrations increased on average 1.8 mg/L each year. This translated into an increase of about 15-30 mg/L over approximately the past 15 years. Concentrations in the Jordan aquifer well increased from about 12 mg/L in 1999 to 41 mg/L in 2011, and concentrations in the buried sand and gravel aquifer wells increased from about 30 mg/L in 1996 to 46 mg/L in 2011 (MPCA 2013).

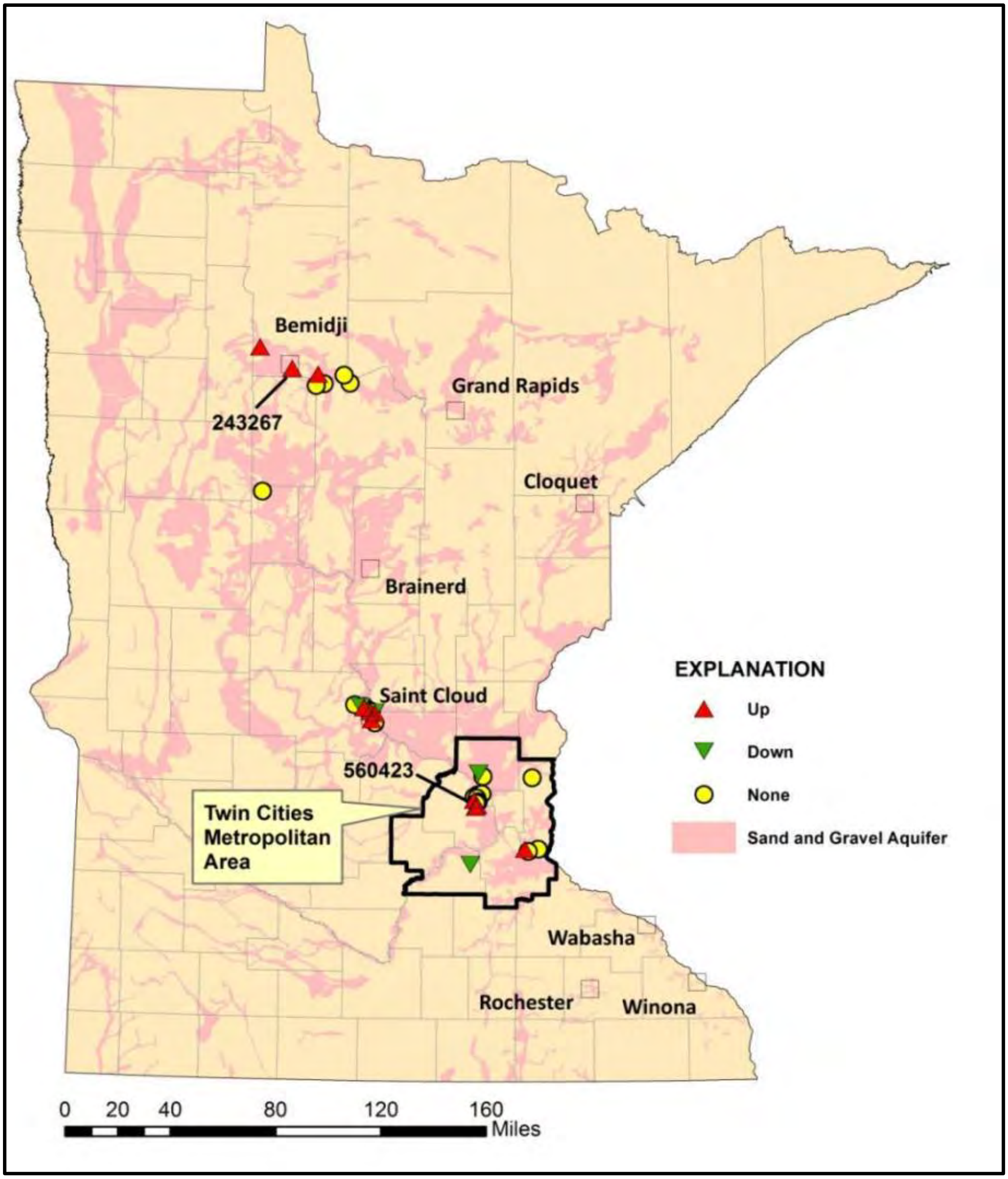


Figure 17. Chloride concentration trends in Minnesota's ambient groundwater

Data from 1987-2011; figure taken from the MPCAs Ambient Groundwater Monitoring Network and the US Geological Survey (MPCA 2013, p. 34).

Chloride Trends within Lakes

As chloride concentrations in water increase, the density of the water increases. Water that is denser will tend to collect at the bottom of a lake. As chloride concentrations increase, the differences between chloride concentrations in the bottom and top waters can become more pronounced. As these differences become greater, the normal mixing patterns of the lake can be inhibited and potentially stop all together (Novotny et al. 2008). Some lakes exhibit meromictic conditions or incomplete mixing and/or circulation, which can mean turn-over of the lake is limited, delayed, or non-existent. Mixing is an important process in a lake as it prevents reduced dissolved oxygen levels in the hypolimnion or lower level of the lake. Factors such as hydraulic residence time, fetch, groundwater inputs, colored fraction of dissolved organic carbon, and lake depth all influence the mixing conditions in a lake. Meromictic conditions are more likely to occur in lakes with higher depth to surface area ratios, as measured by the Osgood Index. High chloride concentrations in a lake may result in an increased risk of meromictic conditions. Brownie Lake and Spring Lake have been identified as being meromictic. The meromictic conditions in Brownie Lake may be due to alterations to the watershed and outlet that occurred prior to the practice of winter salt application.

A number of the monitored lakes had substantial differences in the chloride concentrations between the top and bottom of the water column. Brownie Lake exhibits this characteristic most dramatically, as shown in Figure 18. Peavey Lake, Powderhorn Lake, and Spring Lake also exhibit a clear pattern of higher chloride concentrations at depth as shown in Figure 19, Figure 20, and Figure 21 respectively.

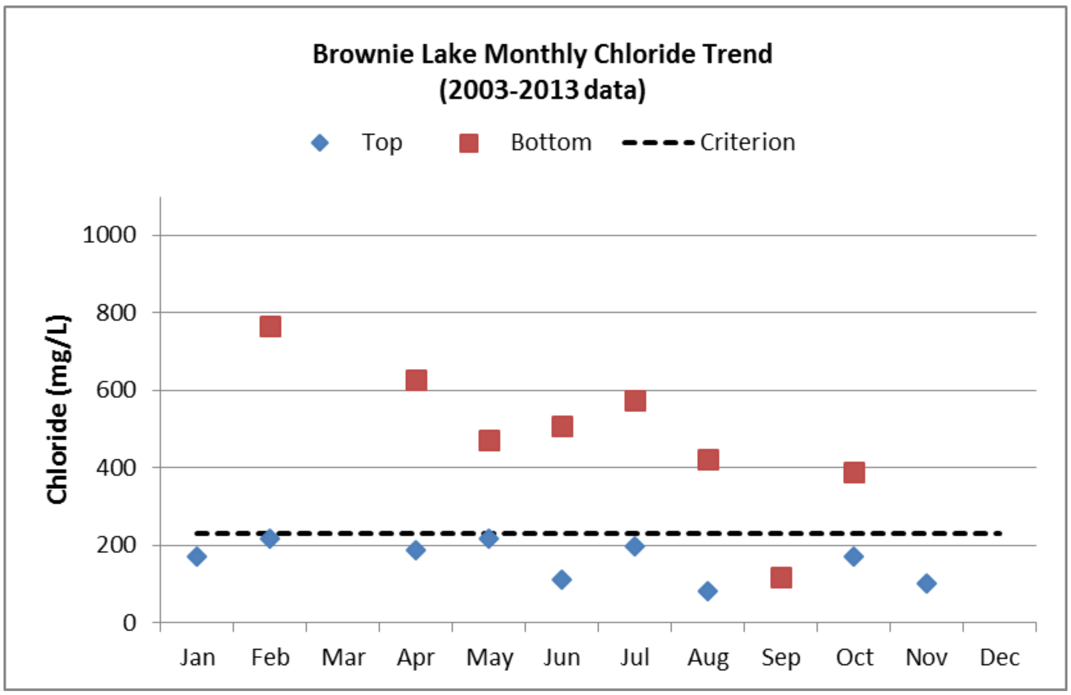


Figure 18. Average monthly chloride concentrations in top and bottom samples in Brownie Lake

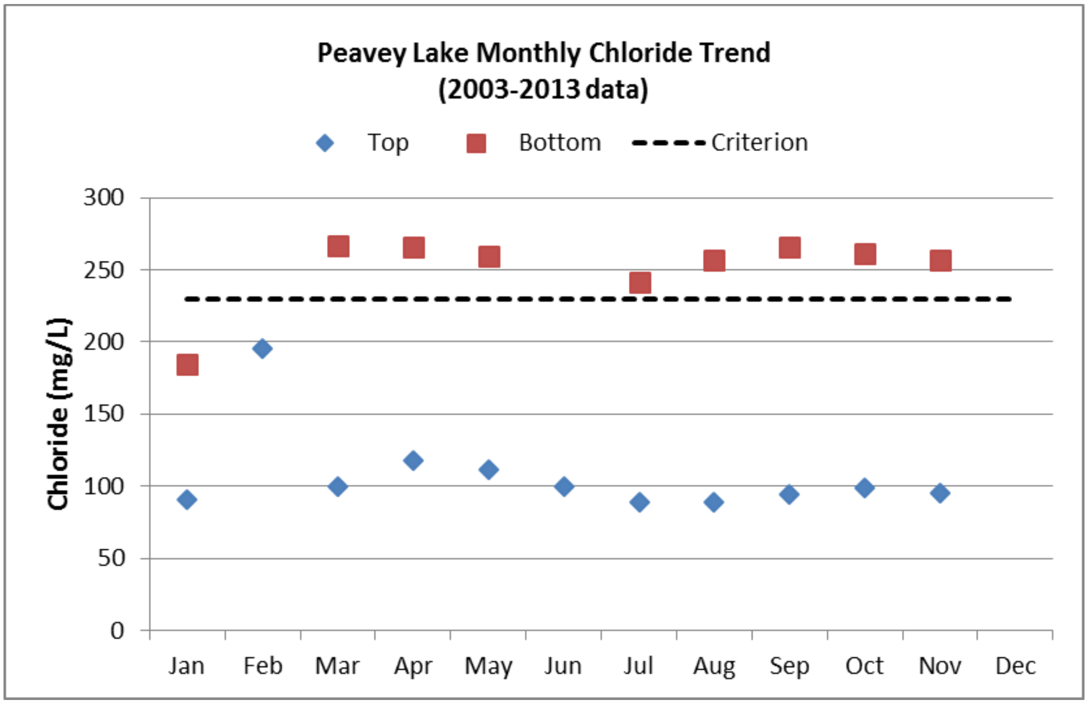


Figure 19. Average monthly chloride concentrations in top and bottom samples in Peavey Lake

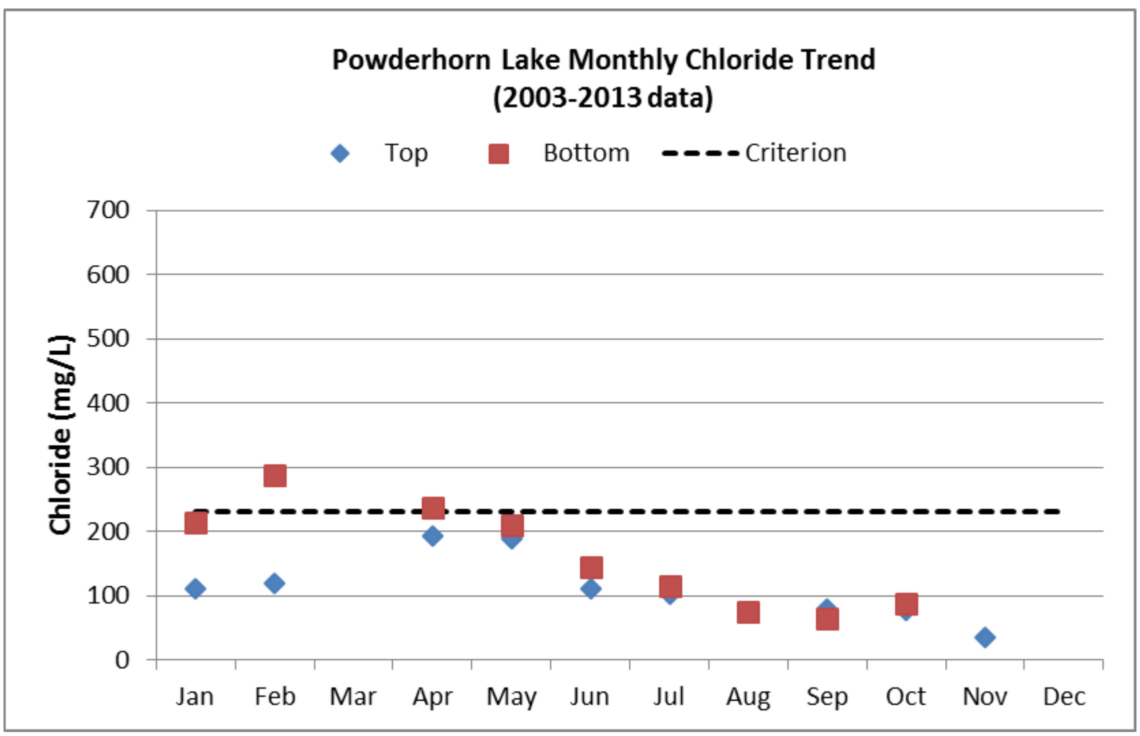


Figure 20. Average monthly chloride concentrations in top and bottom samples in Powderhorn Lake

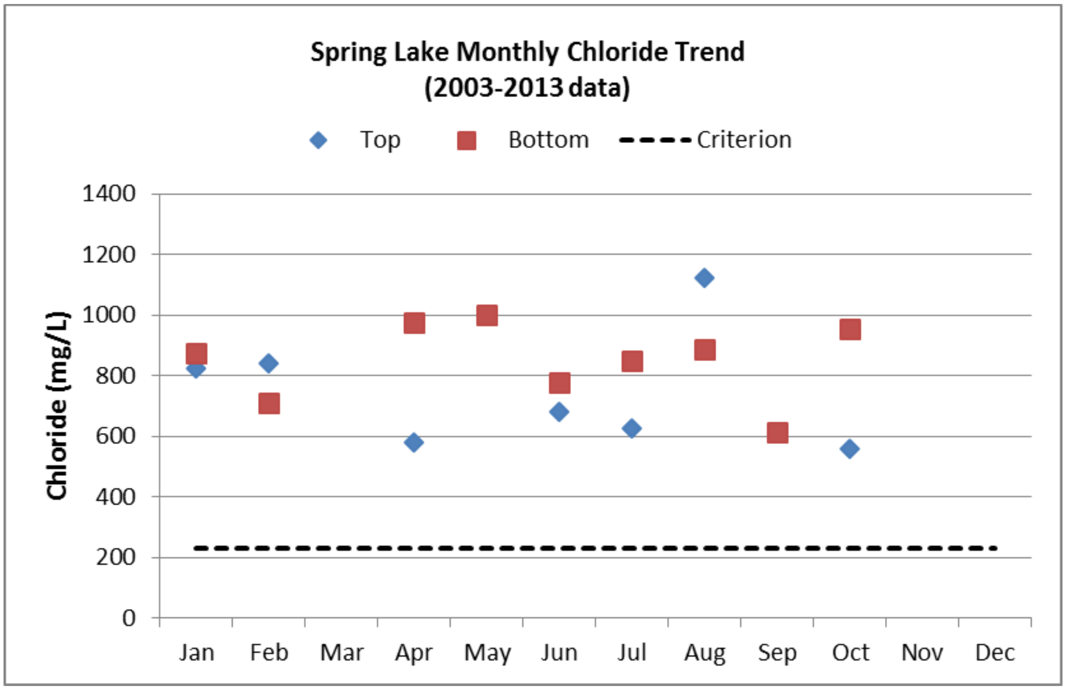


Figure 21. Average monthly chloride concentrations in top and bottom samples in Spring Lake

Chloride Relationships to Watershed and Waterbody Characteristics

Relationships were evaluated between the average winter chloride concentrations to watershed size, percent impervious surface, lake volume, and the lake Osgood Index. No strong relationships were identified with the exception of the Osgood Index and road density. The Osgood Index relates the mean depth of a lake to the surface area (Osgood Index = Mean Depth (m) ÷ Surface Area $(km^2)^{0.5}$). Lake chloride concentrations generally increase with increasing Osgood Index as shown in Figure 22. The Osgood Index may be used to prioritize monitoring efforts for lakes with no or limited data.

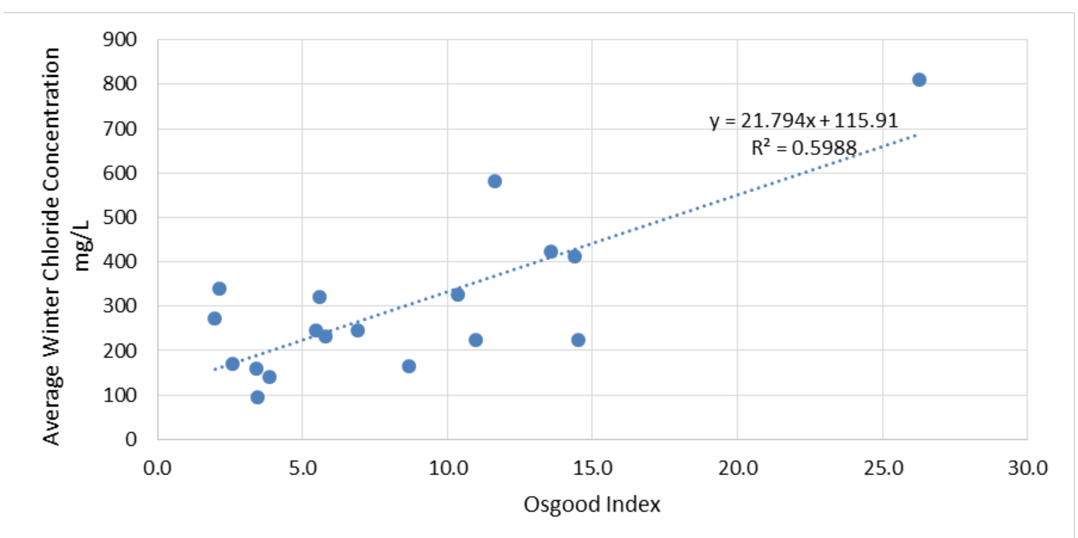


Figure 22. Winter chloride concentrations (November-March) in TCMA lakes versus Osgood Index

Salt applied to impervious surfaces as a deicer is considered a primary source of chloride to lakes and streams. Therefore, one might expect chloride concentrations to be correlated to the amount of impervious area in a watershed. Winter stream chloride concentrations were positively correlated with annual winter salt application (Figure 23). Watersheds with less than 15 tons per square mile of chloride varied in winter stream median chloride concentration ranging from 18 to 89 mg/L (Wenck 2009).

Road density was also positively correlated with median winter chloride concentrations. The deicing salt load was highly dependent on road density (Figure 24). Median winter chloride concentrations appear to increase with road densities greater than 25 lane miles per square mile (Wenck 2009). A road density map for the TCMA is presented in Figure 25.

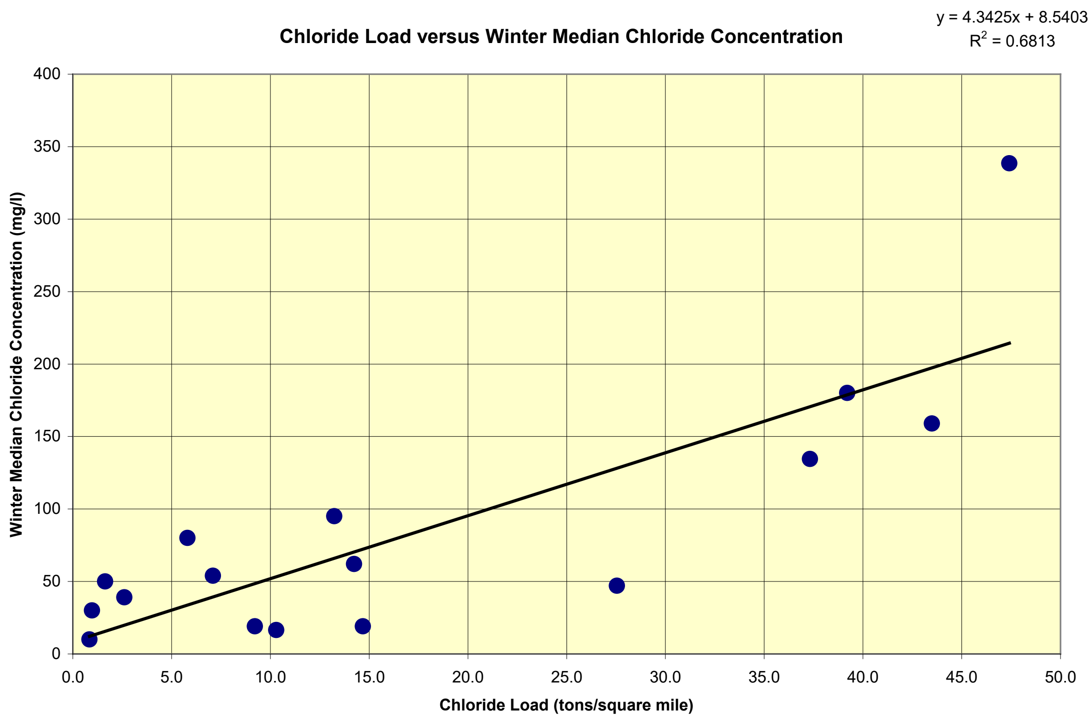


Figure 23. Relationship between road salt load and median winter stream chloride concentration *(Wenck 2009)*

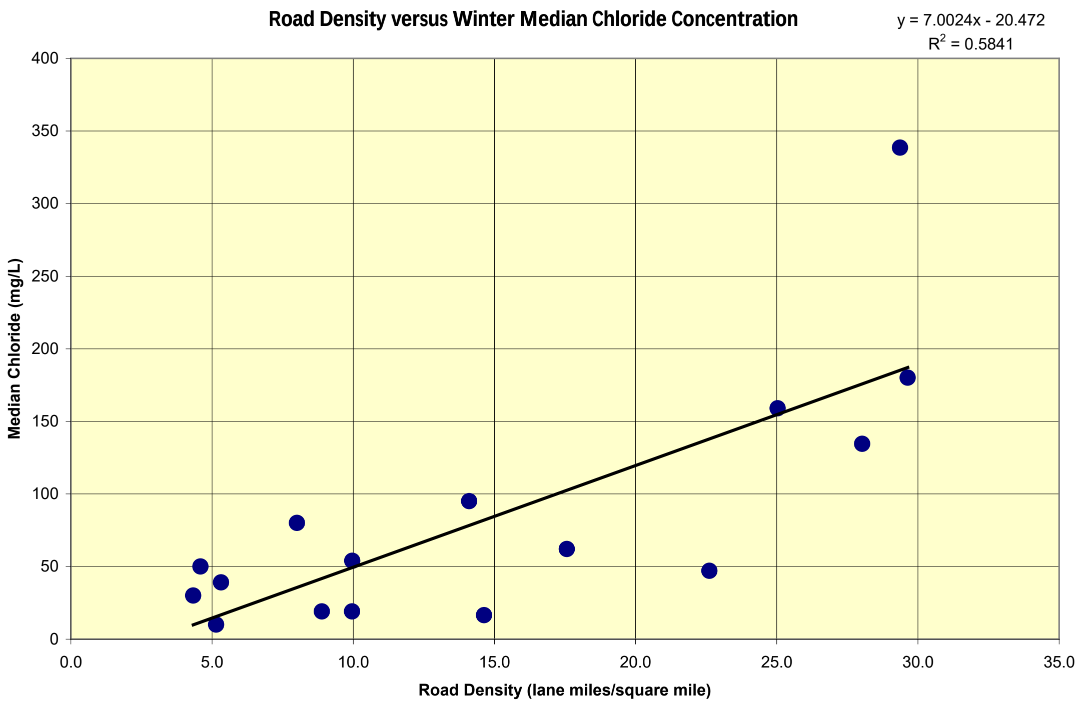


Figure 24. Relationship between road density and median winter chloride concentration

(Wenck, 2009)

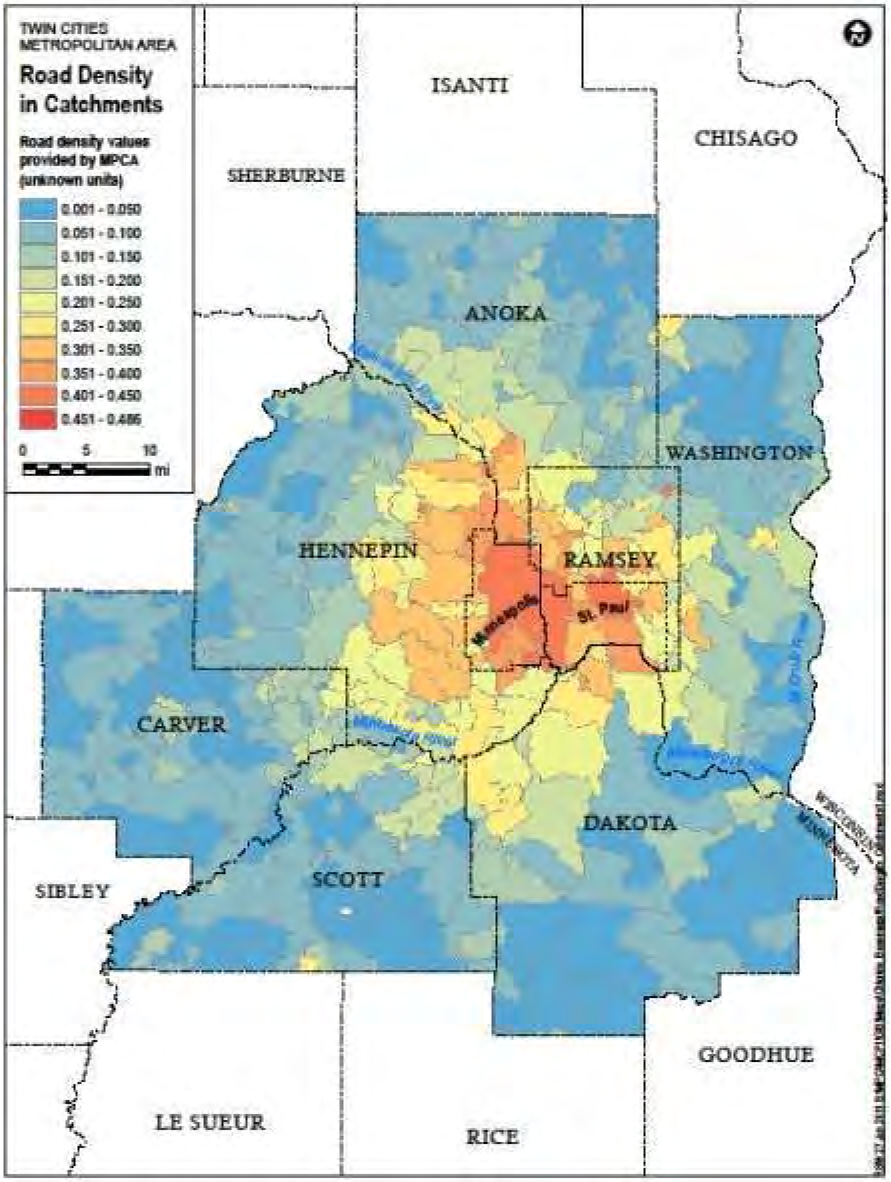


Figure 25. 2010 Road Density in the TCMA

(Road density from MPCA based on roads from MnDOT and catchment watersheds from DNR)

Chloride Concentrations in Stormwater

In comparison to chloride samples taken from lakes, wetlands, and streams, the area's stormwater runoff contains some of the highest chloride concentrations found in the TCMA. The data indicates a high degree of seasonal variability, which is a result of winter maintenance activities and the direct connection to impervious surfaces. Figure 26 shows storm sewer chloride data collected in the TCMA from 1980 through 2013. Sample set sizes ranged from 19 to 288 samples per month, for a total of 1,569 samples. The data indicate that high chloride concentrations are found during the winter maintenance season and increase as the winter season progresses with the peak occurring in February.

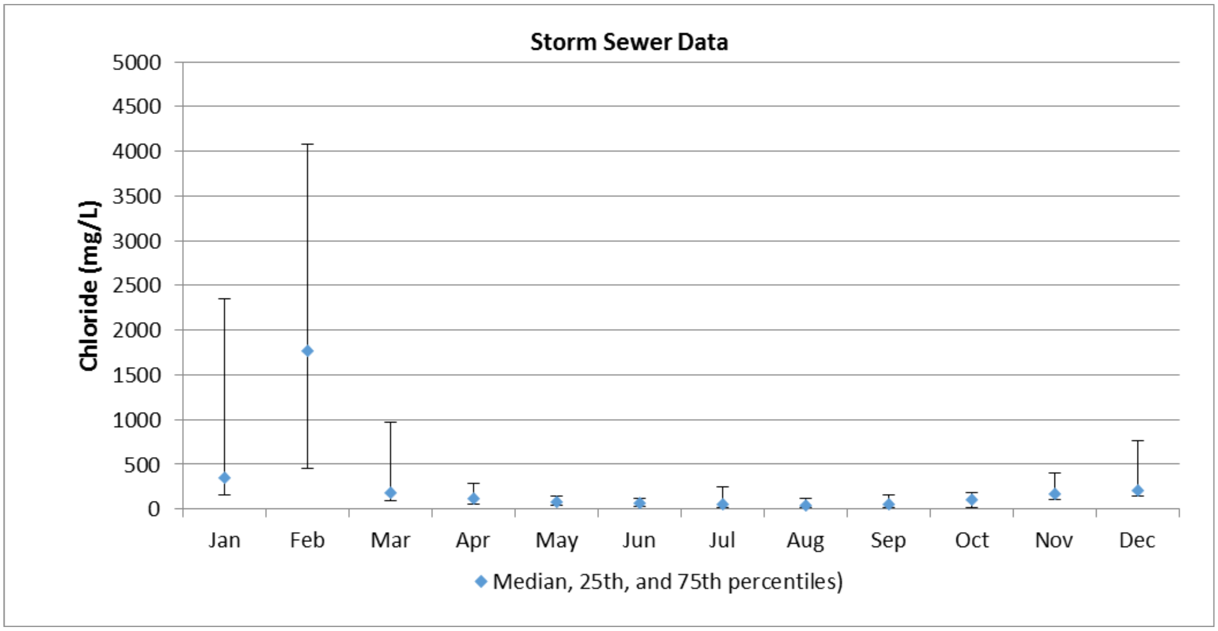


Figure 26. Storm sewer monthly chloride concentrations (*Data from TCMA between 1980-2013; median, 25th, and 75th percentiles*)

Chloride Relationships between Surface and Groundwater

Concentrations of chloride in shallow groundwater are increasing. Shallow groundwater contributes flow to lakes, wetlands, and streams. In the TCMA, average chloride concentrations in shallow monitoring wells located within watersheds that contain one or more impaired surface waters were higher (141 mg/L) compared to wells in watersheds without an impaired lake, stream, or wetland (48 mg/L) (Figure 27 and Figure 28).

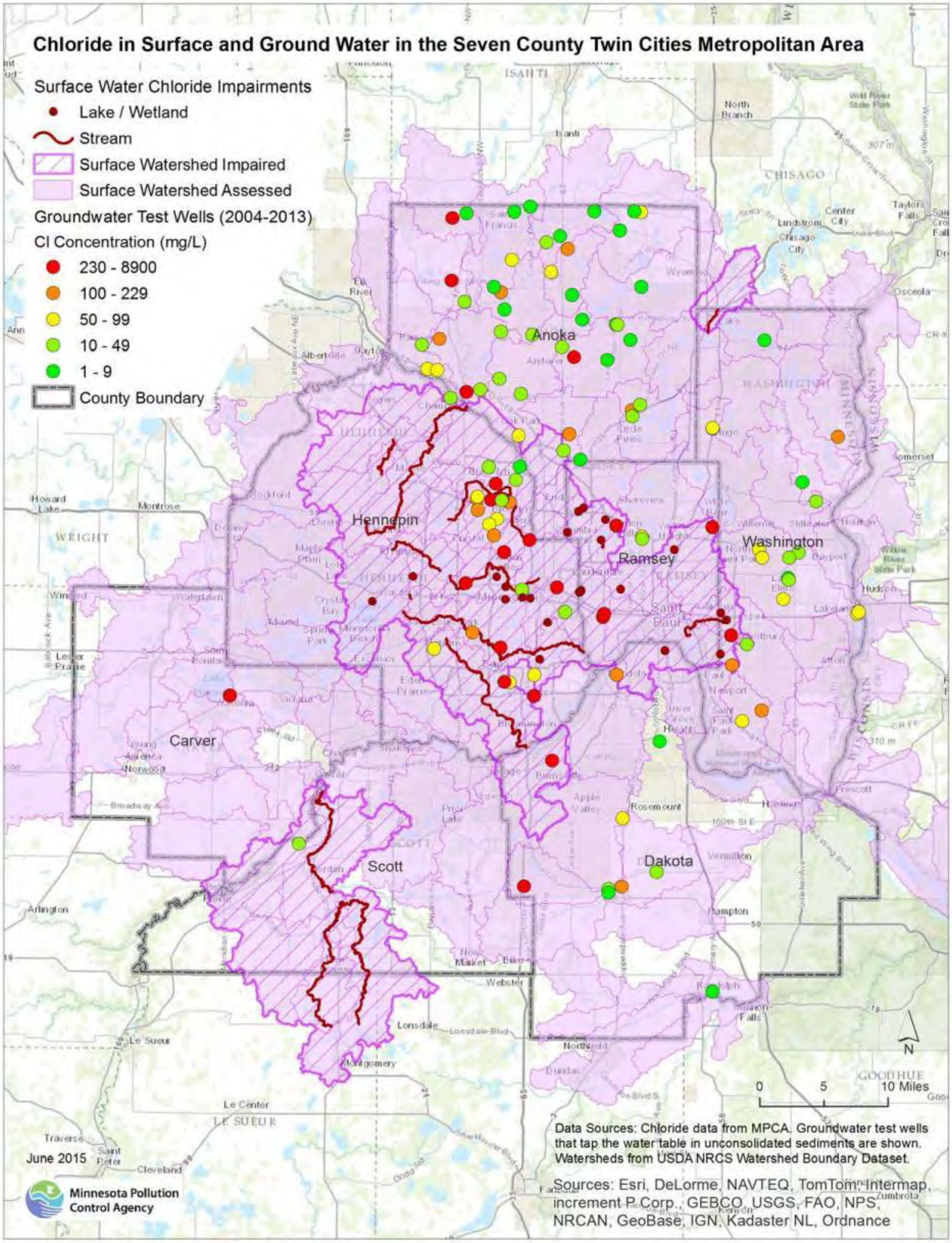


Figure 27. Chloride in Surface and Ground Water in the TCMA

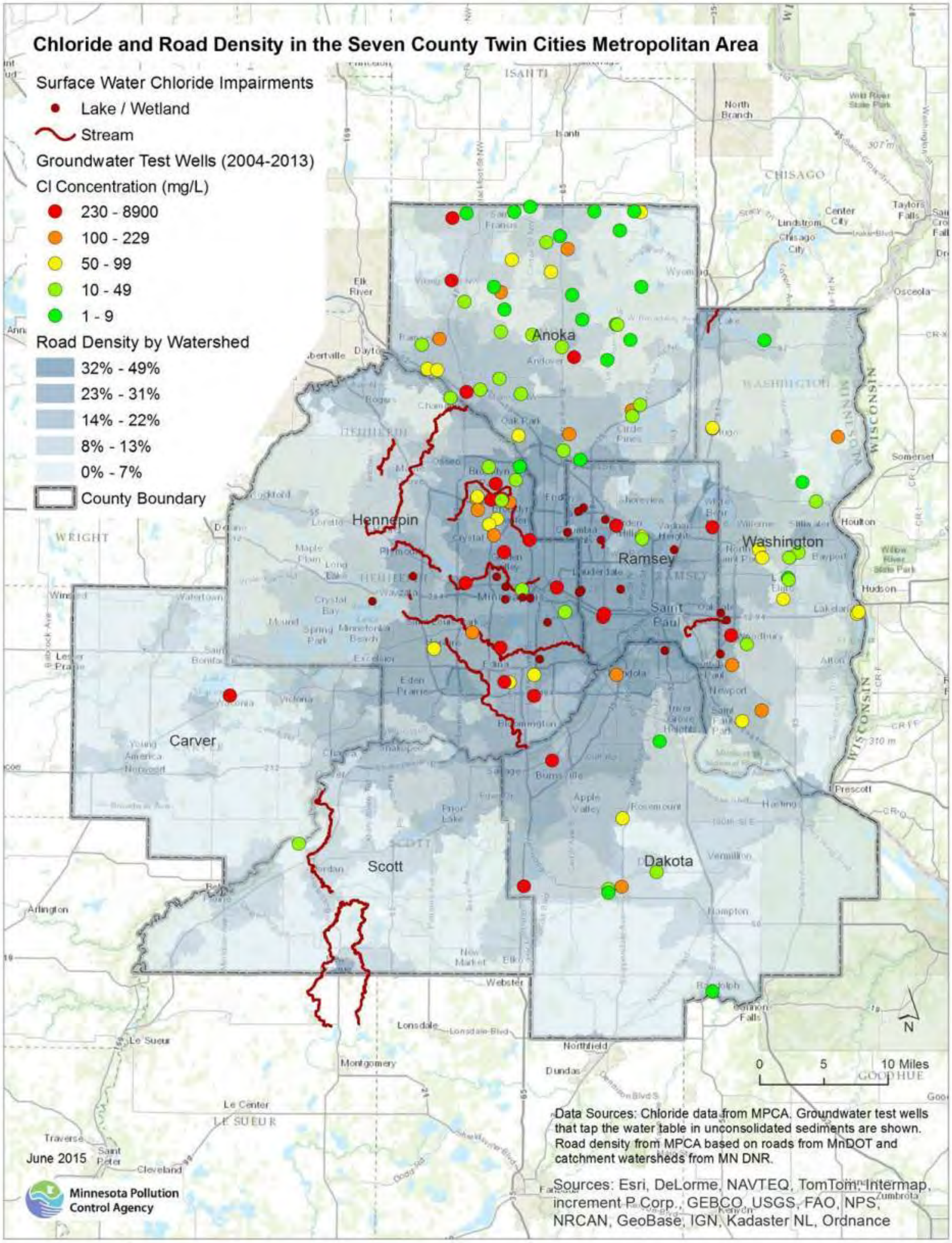


Figure 28. Chloride and Road Density in the TCMA

Several studies of streams in the Upper Midwest have found that higher chloride levels in shallow groundwater have, in part, contributed to an increase in concentration in streams during low flow conditions, when stream flow is dominated by groundwater inputs (Kelly 2008; Eyles et al. 2013; Corsi et al. 2015). This pattern of increased chloride concentrations during low flow conditions, typically during the summer months, is also evident in streams in the TCMA. Chloride concentrations exceeding the 230 mg/L standard have been observed in Bassett Creek in June and Shingle Creek in August. This issue is not isolated to the TCMA. For example, chloride levels in Miller Creek, a trout stream located in Duluth, have also consistently exceeded the 230 mg/L standard in July and August.

Eagle Creek is located in the city of Savage (Scott County) near the Highway 13/Highway 101 crossroads and is a Class 2A cold-water trout stream, meaning that it is a self-producing trout stream and is primarily fed by groundwater year round. Chloride concentrations have always been below the chronic chloride water quality standard of 230 mg/L; however, chloride concentrations have increased over time. The median chloride concentration in 2012 was 36 mg/L, which is more than twice the median concentration in 2001, 16 mg/L (Figure 29).

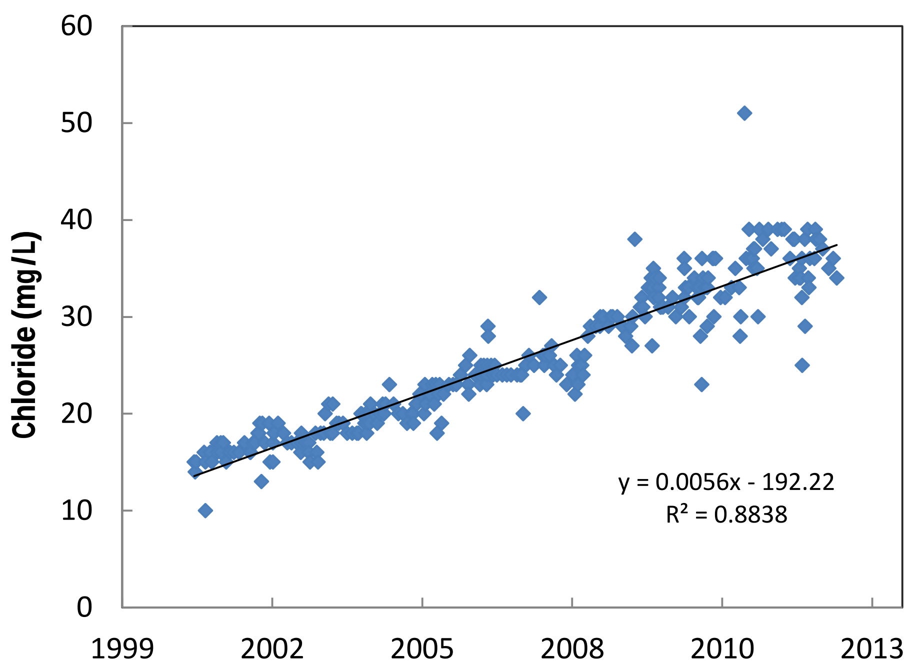


Figure 29. Increasing chloride concentrations in Eagle Creek from 2001-2012 (*Data collected by MCES)*

Shingle Creek, a tributary to the Mississippi River, is an urban stream that runs through Brooklyn Park, Brooklyn Center, and Minneapolis. The creek typically has numerous exceedances of the 230 mg/L standard each year, particularly during winter months. However, average chloride levels in the stream during summer months have also increased over time (Figure 28). The estimated increase in average summer (July through October) chloride concentration in Shingle Creek from 1996 to 2014 was 53 mg/L, based on a linear regression. The increased chloride concentrations in Eagle and Shingle Creek, and likely many other streams in the TCMA, suggest that chloride from deicing activities is infiltrating into shallow groundwater, resulting in elevated chloride concentrations in streams during summer baseflow conditions.

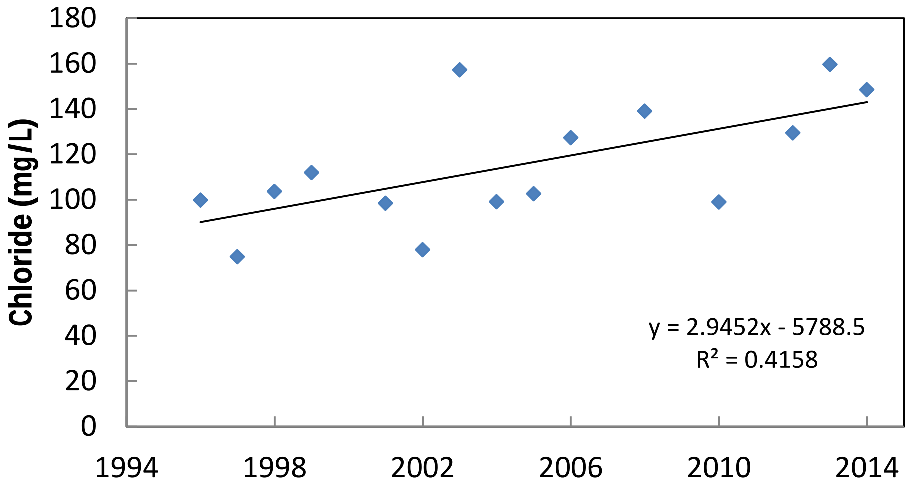


Figure 30. Average monthly chloride concentrations (July-October) in Shingle Creek from 1996-2014
(Data collected by the USGS at Queen Avenue in Minneapolis)

Similar to other studies (Kelly 2008; Eyles et al. 2013; Corsi et al. 2015), streams in the TCMA and greater Minnesota are experiencing high chloride concentrations during summer baseflow conditions. This trend is attributed to high chloride concentrations in shallow groundwater discharging to streams as baseflow.

Summary of Data Analysis

Based on the water quality data collected and the above data analyses, the following conclusions can be made:

1. Chloride use increased in the TCMA in the latter half of the 20th century, 1950-2000.
2. Levels of chloride are continuing to increase in both groundwater and surface waterbodies in the TCMA.
3. The highest chloride concentrations occur during snowmelt conditions during winter months and low flow periods in streams.
4. Chloride levels tend to be higher in the bottom of a lake versus the surface.
5. Chloride concentrations in TCMA waterbodies are positively correlated to road density in the contributing watersheds.
6. There are existing data gaps of chloride concentrations in TCMA waterbodies, as many have limited to no data and lack data that would represent critical conditions.
7. Winter maintenance activities in urban areas and WWTPs in rural areas tend to be the primary sources of chloride to TCMA waters.

2.4 TMDL Summary

The TMDLs were developed for each of the lakes, wetlands and streams in the TCMA impaired for chloride, with the exception of Shingle Creek and Nine Mile Creek which already have existing TMDLs. A TMDL quantifies the allowable pollutant loading to a lake, wetland, or stream that will result in water quality standards being attained. The water quality target for the TMDLs was set to the chronic water quality criterion for chloride of 230 mg/L. The total allowable load, or TMDL, is allocated to the various sources contributing chloride as well as consideration of a margin of safety and reserve capacity. Margin of safety is intended to account for uncertainty in the development of the TMDL. Reserve capacity is intended to set-aside a portion of the TMDL for future growth. For the TCMA chloride TMDLs, reserve capacity was set to zero assuming that any further development and additional impervious surfaces would be expected to have the same level of best management practices (BMPs) implemented for winter maintenance activities as for the remainder of the watershed. The complete details of the TMDL development are presented in the TCMA Chloride TMDL report (see Appendix A).

A total of 39 waterbodies are listed as impaired by chloride, and TMDLs for Shingle Creek and Nine Mile Creek have already been prepared under separate projects. A total of 37 TMDLs were completed as part of this project. Summaries of the TMDLs are presented in Table 4 for lakes and wetlands and Table 5 for streams.

Table 4: Summary of TMDL and Components for Impaired Lakes and Wetlands in the TCMA

Lake/Wetland	AUID	Watershed Area (ac)	TMDL and Components (all values in lbs/yr of chloride)					
			Loading Capacity (TMDL)	WLA		LA		Margin of Safety
				MS4 Categorical	Wastewater Sources[1]	Non-Permitted Aggregate	Natural Background	
Battle Creek Lake	82-0091-00	4,326	2,153,699	1,766,033	0	0	172,296	215,370
Brownie Lake	27-0038-00	452	341,418	279,963	0	0	27,313	34,142
Carver Lake	82-0166-00	2,242	1,071,123	878,321	0	0	85,690	107,112
Como Lake	62-0055-00	1,850	994,078	815,144	0	0	79,526	99,408
Diamond Lake	27-0022-00	744	486,017	398,534	0	0	38,881	48,602
Kasota Ponds North	62-0280-00	10	6,234	5,112	0	0	499	623
Kasota Ponds West	62-0281-00	6	5,742	4,708	0	0	459	574
Kohlman Lake	62-0006-00	7,533	4,839,183	3,106,733	1,050,484	0	303,096	378,870
Little Johanna Lake	62-0058-00	1,703	1,224,242	1,003,879	0	0	97,939	122,424
Loring Pond (South Bay)	27-0655-02	34	9,764	8,007	0	0	781	976
Mallard Marsh	62-0259-00	16	9,851	8,077	0	0	788	985
Parkers Lake	27-0107-00	1,064	1,431,262	528,161	787,163	0	51,528	64,410
Peavey Lake	27-0138-00	776	205,995	165,889	3,692	0	16,184	20,230
Pike Lake	62-0069-00	5,735	3,591,268	2,943,971	1,059	0	287,217	359,021
Powderhorn Lake	27-0014-00	332	218,588	179,242	0	0	17,487	21,859
Silver Lake	62-0083-00	655	370,011	303,409	0	0	29,601	37,001
South Long Lake	62-0067-02	114,785	26,334,624	21,534,261	4,030	0	2,106,448	2,633,059
Spring Lake	27-0654-00	39	15,600	12,792	0	0	1,248	1,560
Sweeney Lake	27-0035-01	2,439	1,456,271	1,194,142	0	0	116,502	145,627
Tanners Lake	82-0115-00	1,732	826,520	677,746	0	0	66,122	82,652
Thompson Lake	19-0048-00	178	134,340	110,159	0	0	10,747	13,434
Valentine Lake	62-0071-00	2,404	1,165,072	955,359	0	0	93,206	116,507
Wirth Lake	27-0037-00	426	1,095,000	897,900	0	0	87,600	109,500

[1] WLA=0 in the wastewater sources column means that there is no wastewater discharges in that watershed

Table 5. Summary of TMDL and Components for Impaired Streams in the TCMA

Stream	AUID	Watershed Area (ac)	TMDL and Components (all values in lbs/yr of chloride)					
			Loading Capacity (TMDL)	WLA		LA		Margin of Safety
				MS4 Categorical	Wastewater Sources[1]	Non-Permitted Aggregate	Natural Background	
Bass Creek	07010206-784	5,434	1,746,399	1,432,047	0	0	139,712	174,640
Bassett Creek	07010206-538	25,209	9,334,219	6,642,961	1,233,048	0	648,094	810,117
Battle Creek	07010206-592	7,246	2,328,721	1,909,551	0	0	186,298	232,872
Elm Creek	07010206-508	66,382	21,332,410	17,386,888	0	105,688	1,706,593	2,133,241
Judicial Ditch 2	07030005-525	1,587	510,115	418,294	0	0	40,809	51,011
Minnehaha Creek	07010206-539	109,151	35,997,083	28,679,140	1,004,128	0	2,806,140	3,507,675
Raven Stream	07020012-716	42,750	15,023,193	442,771	1,284,983	10,822,561	1,099,057	1,373,821
Raven Stream, East Branch	07020012-543	14,751	6,025,349	442,093	1,284,983	3,445,007	379,229	474,037
Rush Creek, South Fork	07010206-732	13,844	4,470,069	3,646,696	21,010	1,532	355,925	444,906
Sand Creek (South) - includes 07020012-662	07020012-513	175,578	59,480,179	4,402,547	3,056,425	41,864,932	4,513,900	5,642,375
Unnamed creek (Headwaters to Medicine Lk)	07010206-526	6,447	2,071,959	1,699,006	0	0	165,757	207,196
Unnamed creek (Unnamed ditch to wetland)	07010206-718	793	254,852	208,979	0	0	20,388	25,485
Unnamed Stream (Unnamed lk 62-0205-00 to Little Lk Johanna)	07010206-909	1,627	522,817	428,710	0	0	41,825	52,282

[1] WLA=0 in the wastewater sources column means that there is no wastewater discharges in that watershed

2.5 Protection of Surface and Groundwater

Protection is an opportunity to prevent waters from continued degradation which may result in impairment. Prevention or protection is often more easily accomplished than the restoration of an impaired waterbody. Protection efforts also may eliminate the need for additional permit and other regulatory requirements to reduce pollution. Successful protection efforts rely on understanding how current practices or conditions may be contributing to water quality conditions.

High Risk Surface Waters

Preventing a waterbody from being contaminated with chloride is easier and more cost effective than restoration. Chloride is a conservative ion and will not break down over time but rather it accumulates in waters. Therefore, efforts should be made to protect waters that show an increasing trend in chloride concentration or have been shown to have chloride concentrations approaching the water quality criteria. Lakes, wetlands, or streams with at least one sample within 10% of the chronic water quality standard within the last 10 years have been identified as a high risk waterbody (one exceedance of 207 mg/L chloride). Proactive actions to reduce chloride loads to these high risk waterbodies should be pursued. Proactive actions similar to actions listed for impaired waters should be explored to protect high risk waters. These waters are considered to be approaching the water quality standard and if no actions are taken, they will likely reach impairment status in the near future. The TCMA lakes and streams identified as being at high risk for potential chloride impairment are shown in Table 6 and Table 7, respectively.

It should be noted that there are potentially many more high risk waters in the TCMA that have not been identified because there is limited or no monitoring data available for those waters. For this reason, similar proactive approaches to chloride management should be taken to prevent chloride contamination.

All Surface Waters and Groundwater

In addition to the high risk waters listed above, protecting all surface waters and groundwater from further degradation due to chloride is important. By implementing salt reducing practices throughout the TCMA, both the need to restore those waters already impaired and also protect those waters not yet exceeding the standard are addressed. The practices necessary for protection of groundwater are the same as those for restoring and protecting surface waters. Through targeting and prioritization a starting point can be established. Management practices and BMPs used for impaired and high risk waters can be the same for all waterbodies and should provide the same level of protection and chloride reduction.

Table 6: High Risk Lakes in the TCMA

Lakes	AUID
Beaver Lake	62-0016-00
Bennett Lake	62-0048-00
Calhoun Lake	27-0031-00
Centerville Lake	02-0006-00
Crosby Lake	62-0047-00
Crystal Lake	27-0034-00
Fish Lake	19-0057-00
Gervais Lake	62-0007-00
Hiawatha Lake	27-0018-00
Johanna Lake	62-0078-00
Keller Lake (Main)	62-0010-02
Lake Of The Isles	27-0040-00
McCarron Lake	62-0054-00
Medicine Lake	27-0104-00
Ryan Lake	27-0058-00
Taft Lake	27-0683-00
Unnamed Lake	62-0278-00
Wabasso Lake	62-0082-00
Wakefield Lake	62-0011-00

Table 7: High Risk Streams in the TCMA

Streams	AUID
Bevens Creek	07020012-718
Bluff Creek	07020012-710
Classen Lake Creek	07010206-703
Clearwater Creek	07010206-519
County Ditch 17 (Spring Brook)	07010206-557
Credit River	07020012-517
Diamond Creek	07010206-525
Dutch Lake Outlet	07010206-678
Fish Creek	07010206-606
Painter Creek	07010206-700
Rush Creek	07010206-528
Unnamed Creek	07010206-704
Unnamed Creek	07010206-740
Unnamed Creek (Pleasure Ck)	07010206-594
Unnamed Stream (Perro Ck)	07030005-612
Unnamed Stream (Sand Ck)	07010206-744
Unnamed Stream (Trib To Long Lk) (Furgala Creek)	07030005-765
Unnamed Stream In Plymouth	07010206-738
Unnamed Stream Receiving Wtr From Medicine Lk	07010206-785

3. Prioritizing and Implementing Restoration and Protection

Reducing chloride at the source is needed throughout the entire TCMA, not only to restore already impacted waters but also to protect all water resources. There are multiple sources to consider, a variety of options to reduce chloride, and a large geographical area to address. This section is intended to provide guidance, resources, and information to assist in making the important decisions of the what, how and when for managing chloride. The available data indicates that surface waters and groundwater that exceed the state's chloride standards, as well as many lakes and streams that are considered to be at high risk for chloride impairment. Many lakes, streams, and wetlands have minimal or no data available, especially during critical times of the year, which makes it difficult to determine the current chloride status. Reductions in chloride loads not only benefit surface and groundwater quality, but may also reduce damage to infrastructure and vehicles due to corrosion, and reduce impacts to vegetation along roadways. Finally, improved winter maintenance practices that reduce salt usage also result in direct cost-savings to winter maintenance organizations and private applicators. Without making efforts to reduce chloride loads, the trend of increasing chloride concentrations in lakes, wetlands, streams, and groundwater is expected to continue and the cost-savings related to improved winter maintenance practices will be lost. Treating waters already contaminated by chloride through RO or distillation is impractical and cost-prohibitive.

Performance-Based Approach for Reducing Chloride

Deicing salt is currently the most common and preferred method for meeting the public's winter travel expectations. There is currently not an environmentally safe and cost-effective alternative that is effective at melting ice. Therefore, the continued use of salt as the predominant deicing agent for public safety in the TCMA is expected. Setting a specific chloride load reduction target for each individual winter maintenance chloride source is challenging, as is measuring actual chloride loads entering our surface and groundwater from deicing salt and other nonpoint sources in the TCMA. Therefore, priority should be put on improving winter maintenance practices to use only a minimal amount of salt, also referred to as Smart Salting, across the entire TCMA. With these considerations in mind, the implementation approach for achieving the TMDLs and protecting all waters in the TCMA is to focus on performance of improved winter maintenance practices as well as continuing to monitor trends in local waterbodies.

A standard approach to TMDL implementation is to translate the wasteload allocation (WLA) component of the TMDL directly to a numeric permit limit, which is typical for permitted facilities with monitoring requirements. In the case of urban stormwater regulated through a Municipal Separate Storm Sewer System (MS4) Permit, the WLA may be presented in the form of a percent reduction from a baseline condition. The specified percent reduction is then included in the MS4 Permit. With a performance-based approach, the numeric WLA is translated to a performance criterion. This can include the development and implementation of winter maintenance plan which identifies a desired level of the BMP implementation and a schedule for achieving specific implementation activities. Progress made towards those goals are documented and reported, along with annual estimates of salt usage and reductions achieved through BMPs implemented.

In cases where it is not feasible to calculate a numeric effluent limit, federal regulations allow for the use of the BMPs as effluent limits (40 CFR § 122.44(k)). Such a performance-based or BMP approach to compliance with WLAs is being taken by states to address the Chesapeake Bay TMDL for nutrients. The TMDL is being implemented through state Implementation Plans. Some states are taking a performance-based approach to addressing urban stormwater sources, requiring minimum levels of the BMP implementation rather than requiring specific levels of pollutant load reductions.

A performance-based approach will be tracked through documentation of existing winter maintenance practices, goals for implementing improved practices including schedules, and reporting on progress made. Entities may choose to use the Winter Maintenance Assessment tool (WMAt), which is a winter maintenance BMP tracking tool, to assess and document practices and set goals, or another approach of their choice. Entities should track progress and document efforts, including, to the extent possible, estimates of reduced salt usage as a result of improved practices. Entities that have achieved their goals for winter maintenance will have documented their practices in a winter maintenance plan. Entities that have already made significant progress in winter maintenance activities will be able to demonstrate this through their documentation of existing practices. This plan should be reviewed annually and evaluated against the latest knowledge and technologies available for winter maintenance.

The performance-based approach doesn't focus on specific numbers to meet, but rather on making progress through the use of BMPs. Progress is measured by degree of implementation and trends in ambient monitoring. In a traditional approach with numeric targets, progress would be measured by accounting for salt applied and comparing to the targets. The performance-based approach is intended to allow for flexibility in implementation and recognize the complexities involved with winter maintenance. Because the performance-based approach does not provide a specific numeric target, a limitation of the approach is that it is not definitive on when enough progress has been made. This can only be determined by continued ambient monitoring that demonstrates compliance with water quality standards.

3.1 Prioritization and Critical Areas

This plan has been developed for many different audiences. Organizations interested in reducing the amount of salt in waters should start with an effort to fully understand the problem and determine what role the organization plays in contributing, preventing, or remediating the growing trend of increased chloride in surface and groundwater.

Prioritization of efforts to reduce chloride may be based on current water quality conditions. Waters found to exceed the state standard and their contributing watersheds should be given top priority for chloride reduction efforts. Many waters are considered to be high risk, but do not exceed the standard at this time. These areas may be given second priority unless there are no known chloride impairments in the watershed, and then the high risk waters could be given highest priority.

Prioritization of reduction efforts may also be based on the relative size and impact of the source of chloride, such as prioritizing winter maintenance activities in areas with a high density of impervious surfaces, or putting emphasis on residential water softeners for those watersheds where wastewater treatment facilities are identified as a major contributor of chloride. There may also be other ways that are more appropriate for each organization to determine where to prioritize reduction efforts.

Critical areas have been identified where chloride reduction efforts are necessary to achieve water quality goals. Two strategies have been used based on the source of chloride to identify critical watershed. The first strategy identifies watersheds with road densities of 18% or greater to identify watershed where chloride concentrations are typically above water quality standards. Figure 31 depicts the critical watersheds statewide; Figure 32 highlights the critical watersheds in southern Minnesota; and Figure 33 shows the critical watershed in the norther part of Minnesota. An interactive map showing these critical areas is available on the MPCA Road Salt & Water Quality website. The second strategy used to identify critical areas for chloride reduction focuses on areas with drinking water supply wells with hard and very hard water. Figure 10 identifies areas across the state where the drinking water supply is considered hard or very hard therefore requiring softening treatment. Through these two strategies critical areas have been identified across the state where chloride loadings are to be expected high and therefore implementation efforts to reduce chloride should be focused. For the protection of surface and ground waters implementation is encouraged statewide.

Figure 31. Watershed with road densities 18% and greater in Minnesota

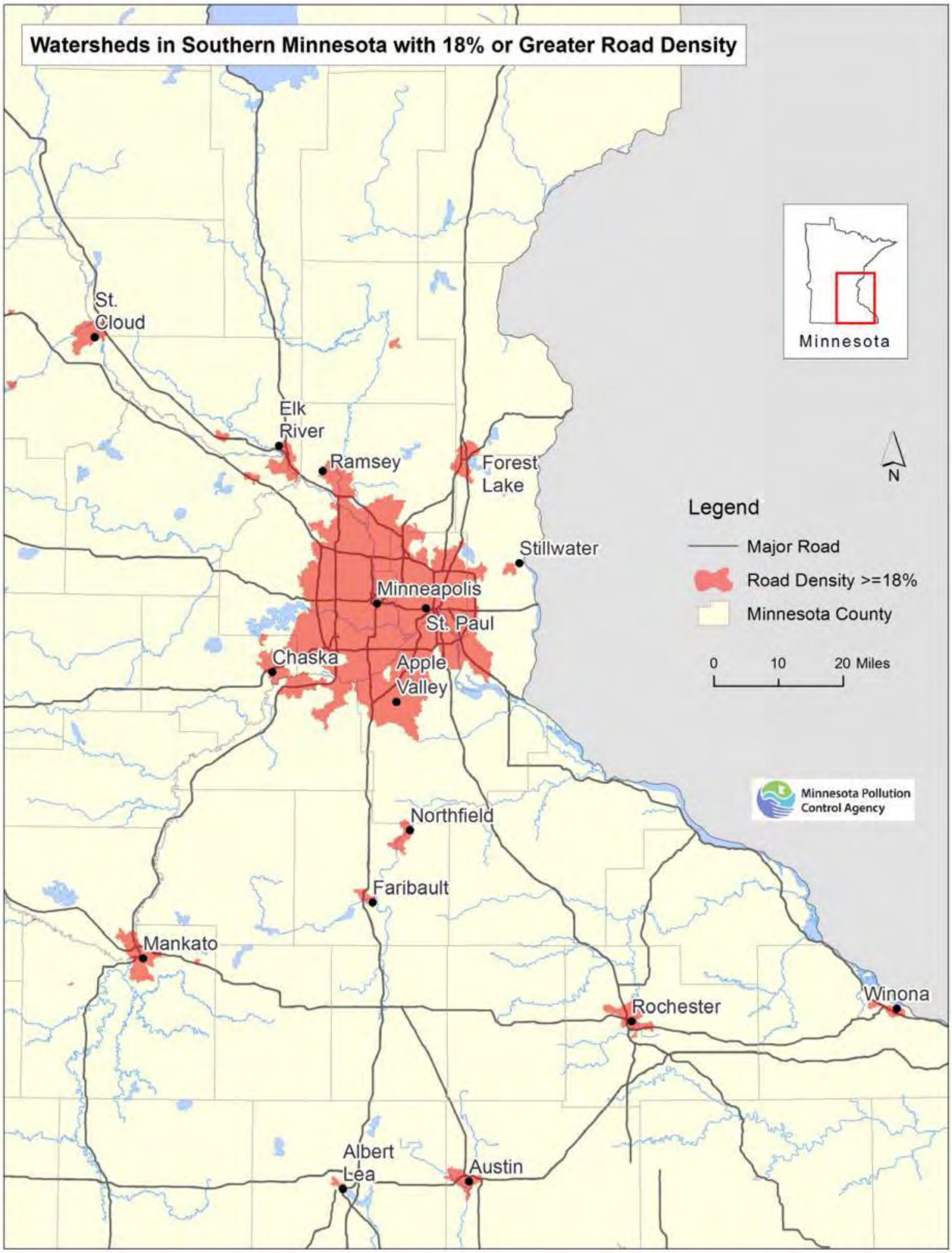


Figure 32. Watershed with road densities 18% and greater in southern Minnesota

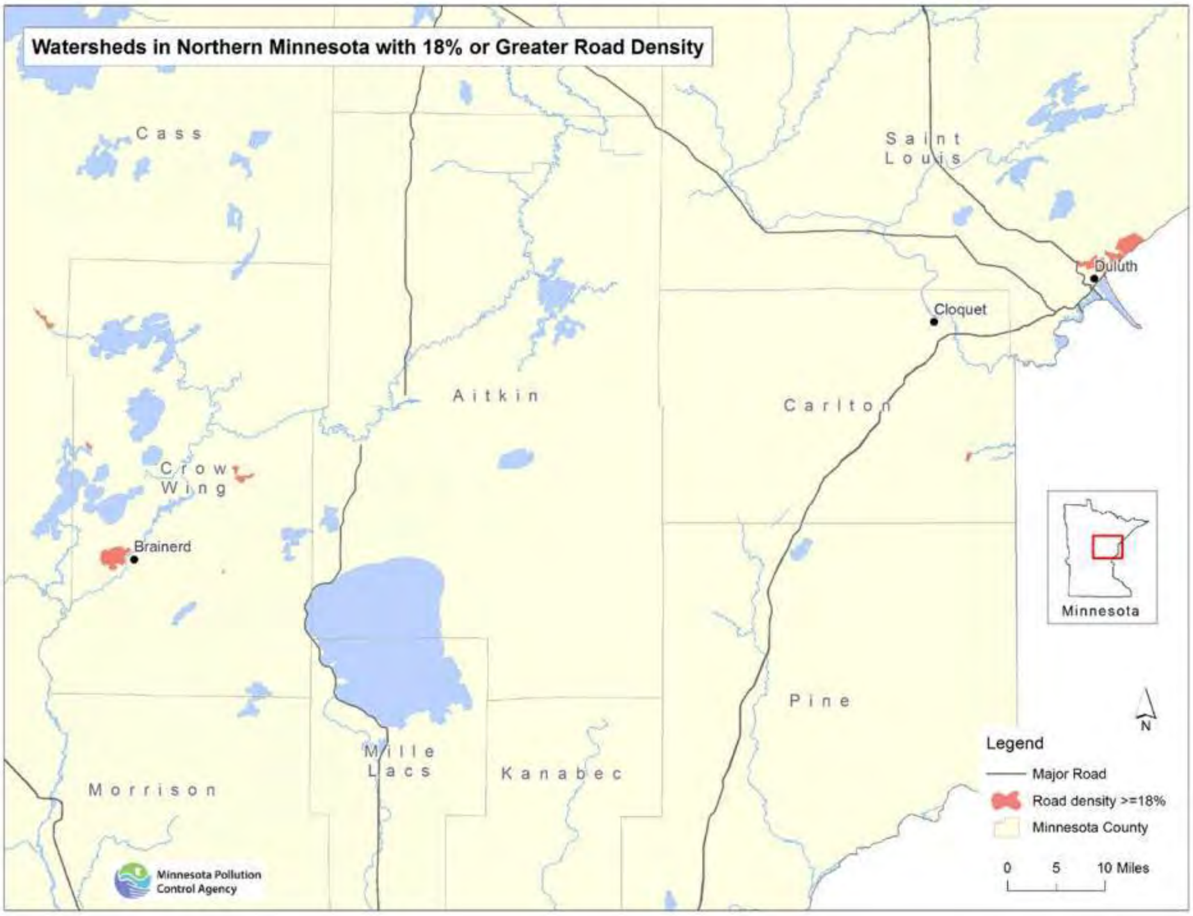


Figure 33. Watershed with road densities 18% and greater in northern Minnesota

3.2 Implementation Strategies

This section provides the overall framework for the implementation strategies that are necessary to protect and restore our water resources. These high-level strategies are intended for both protection and restoration and are described by audience. The next section will provide more detailed implementation activities for the various sources of chloride. The over-arching implementation strategy is a performance-based approach. This approach allows stakeholders and regulators flexibility in the type of BMPs and the timing of implementation, and allows individuals an opportunity to develop chloride management strategies that are practical for their individual situation. Success under the performance-based approach will be measured in terms of the BMPs implemented.

A tool called the WMAt has been developed by the MPCA and is available for use by winter maintenance professionals across the state. The WMAt can be used voluntarily to understand current practices, identify areas of improvement, and track progress. While optional, everyone involved in winter maintenance is highly encouraged to use the WMAt. The tool is intended to streamline and simplify implementation goals and strategies. The tool can also be used to compare practices with other entities and learn from each other in order to achieve the greatest chloride reductions while providing a high level of service. Utilization of this planning tool will allow the user to track their progress over time and show the results of their efforts. The tool can serve as both a reporting mechanism to understand the current practices and as a planning tool to understand future practices. The planning side of the tool will help understand the challenges and costs associated with improved practices.

The overall performance-based implementation strategy for the primary audiences and a suggested timeframe is presented in Table 8 with descriptive text following the figure. Secondary audiences are described at the end of this section and are not presented in a table.

Table 8. Performance-Based Chloride Reduction Strategies

TCMA CMP Performance-Based Implementation Audience	years 1-2	years 3-5	years 6-10	Beyond year 10
Winter Maintenance Leadership (state, county, city, schools, private): those not involved in day to day operations of maintenance crew.	- Review responsibilities - Develop policies - Assess the situation - Create goals - Set priorities - Implement changes - Use WMAt	- Follow plan - Share successes	- Re-assess operations - Revise goals - Continue to implement changes - Share successes	- Re-assess operations - Revise goals - Continue to implement changes - Share successes.
Winter Maintenance Professionals (state, county, city, schools, private): plow drivers, mechanics, supervisors of crew.	- Attend training - Keep an open mind towards change - Look for ways to make salt use more efficient - Use WMAt tool - Create list with the desired changes - Prioritize the action plan - Implement changes - Use less salt	- Follow plan - Eliminate poor practices - Share successes - Use less salt	- Re-assess operations - Adjust goals - Follow plan - Eliminate all poor practices - Share successes - Use less salt	- Re-assess operations - Revise goals - Continue to implement changes - Share successes - Use less salt
WMOs/WDs, Environmental Organizations and Institutions, and Educators	- Modify plan - Put salt education and outreach goals in the operating plans - Develop/modify grant program - Develop a cost share program - If there is an existing grant program, modify - Continue monitoring	- Implement plan - Educate	- Implement plan - Educate	- Review and revise the outreach plan - Continue to educate - Encourage testing of new technologies
Municipalities	- Create a plan - Start implementing the plan - Track progress - Use the WMAt - Prioritize actions - Continue monitoring	- Follow plan - Continue to improve practices - MS4s report progress to MPCA	- Review and revise plan - Continue to improve practices - MS4s report progress to MPCA	- Follow plan - Continue to improve practices - MS4s report progress to MPCA
Wastewater Treatment Plants and Industrial Dischargers	- Understand the sources - Create a plan to reduce and remove chloride - Monitor chloride in effluent	- Implement plan - Discharge less salt	- Continue implementing plan for lower salt discharge - Share successes - Discharge less salt	- Review and revise plan - Continue making progress - Discharge less salt
Water Treatment Facilities (water supply)	- Research to determine if centralized softening or individual softening would be a lower salt solution - Develop plan for minimal salt use in water distribution area.	- Implement plan	- Implement plan	- Continue to work towards lower salt solutions.
Citizens	- Follow recommendations - Use less salt - Encourage others to use less salt	- Reduce salt use - Encourage others to reduce salt use	- Reduce salt use - Encourage others to reduce salt use.	- Continue to reduce salt use.
MPCA	- Create and share the CMP for the TCMA - Create an internal plan to assist stakeholders - Continue monitoring chloride - Help various groups better understand the salt problem - Educate and promote lower salt solutions	- Support TCMA CMP - Follow internal chloride reduction plan	- Support TCMA CMP - Follow internal chloride reduction plan	- Determine if TCMA CMP was effective - Adjust as needed - Re-evaluate chloride reduction efforts
Policy Makers (city, county, state, other)	- Understand why we use salt - Understand what the options are for lower salt use	- Improve policy	- Improve policy	- Improve policy

Winter Maintenance Leadership (State, County, City, Schools & Private)

Winter maintenance leadership is the group responsible for hands-on efforts and operation management. This group includes the individuals in charge of the shop facilities, selling winter maintenance services, determining the type of pavement overlays, or organizing the “getting ready for winter” refresher training. This group does not include the plow drivers or their direct supervisors.

Winter maintenance leadership is a very diverse group that plays a variety of roles across many organizations. Their influence is significant and they have great potential to positively impact reductions in salt use. This group can advocate for change by understanding the economic benefits of salt reduction, including the direct cost savings as a result of using less salt.

Table 9 presents example activities and timelines for winter maintenance leadership to consider. Throughout implementation, goals and practices should be reviewed, assessed, and adaptively updated to reduce the use of chloride. Examples presented in this section include specific possible actions. However, these actions are intended to be examples and are not meant to put emphasis on the specific actions. Each entity will need to assess the most relevant and cost-effective actions to take in their situation to reduce salt loadings.

Table 9. Examples of Implementation Strategies for Winter Maintenance Leadership

Example Implementation Strategies Assessment Items	Goals	Actions
Does salt leave storage sites in ways not intended?	No salty runoff water from salt sheds.	Storage sheds 1, 2, 4 are ok. Re-grade floor of storage shed 3 so water that enters the shed stays in shed.
Do customers know that salt harms the environment and that improved practices are being implemented to reduce salt use yet provide great service?	Give all customers the opportunity to learn about efforts to reduce salt.	Meet or talk to all customers when bidding on work explaining approaches to winter maintenance and environmental protection (private contractors) or run cable TV infomercials about salt reduction reasons and strategies during November (municipal).
Do trucks contribute salt to the truck wash water?	Re-use 50% of winter truck wash water for brine making or have less salt on truck prior to entering the wash.	Install filter system to remove wash water oils and solids, install tank to capture wash water, integrate filtered wash water in brine making system or Install a truck cleaning station before the truck wash to encourage thorough truck emptying in an area where granular salt can be easily reclaimed.
Which organizations have been most successful in reducing salt and what are the lessons learned?	Identify outstanding success in areas of interest (i.e. storage buildings, contracts that don't bill by the ton, using non-traditional plow drivers to get 24 hour coverage).	Look at Clear Roads research, Snow and Ice Management Association (SIMA) research, APWA research, AASHTO research, attend the Freshwater Society's annual Road Salt Symposium and other winter maintenance conferences to identify the leaders. Talk to them directly.
Are lower salt use pavements being installed (permeable, heated, narrower)?	Find some sort of pavement surface that requires 20% less salt on it.	Install permeable asphalt in parking lot near "Smith" lake.
Is payment based on amount of salt applied?	Have a profitable contract without billing by the ton which encourages overuse of salt.	Look at SIMA website for example contracts that do not charge by volume.
Is concern over liability resulting in over applying salt?	See if other states have a law to reduce liability for private companies doing winter maintenance.	Encourage legislators to look at New Hampshire's law that limits liability of private contractors in winter maintenance.

EXAMPLE: YEARS 1-2

ÿ Better understand the impacts of salt on the environment and how organization may contribute.
ÿ Create a chart of items to investigate that may reduce salt use/waste. Consider creating a list of items to be assessed, including goals, actions, and priorities.
ÿ Visit the Snow and Ice Management Association website for example contracts that do not charge by volume.
ÿ Encourage legislators to look at New Hampshire's law that limits liability of private contractors in winter maintenance.

Watch a video: This video, produced by the MWMO and the UMN, is used to train seasonal and full-time property employees as well as business owners, front desk staff and anyone else who needs to control snow and ice in or near entrances and on sidewalks- https://www.youtube.com/watch?v=-xMt1kyzIcg

EXAMPLE: YEARS 3-5

ÿ Install truck cleaning station before truck wash and provide training for proper use.
ÿ Provide training for crew on how to monitor pavement temperatures, calibrate equipment, chose deicer's that will work best based on pavement temperatures.
ÿ Revise contracts to avoid billing by the ton and stay profitable, meet with them for ideas.
ÿ Educate customers about winter maintenance strategies.

EXAMPLE: YEARS 6-10

ÿ Re-grade floor of storage shed #3.
ÿ Install permeable asphalt in parking lot near "Smith" Lake.

Winter Maintenance Professionals (State, County, City, Schools, Parks, Private)

Winter maintenance professionals are responsible for performing outdoor, hands-on winter maintenance and those who supervise them. The primary duties include snow and ice removal from roads, sidewalks, parking lots, and trails, and applying a variety of deicers and abrasives. Some are part of emergency services and have exemption for laws that may cover weight restrictions on trucks or hours of consecutive work.

Winter maintenance professionals are employed by the public and private sectors, working for very small organizations to large organizations. Unusual hours and working in a variety of difficult winter weather conditions are typical in this industry. All of these professionals are under public scrutiny and receive comments about their work, because it directly and visibly impacts the public. There is a lot of pride within this sector as they are called on repeatedly, in the most difficult weather, to get the travelling public to their destinations safely.

The state, county, and city winter maintenance operations in the TCMA are under the extreme pressure of moving people safely on high volume, high speed roads, during all times of the day and night. Although their job is difficult, they often have the advantages of more sophisticated equipment, bigger support staff, less staff turn-over, and access to better and more frequent training than their private counterparts.

Private winter maintenance companies are very diverse and have a unique set of challenges. They often assume legal liability for “slip and falls” at their customer sites. They cannot bill clients when they attend training and have fewer incentives for training their crews. It can be difficult to locate this segment to invite them to Smart Salting trainings. The equipment used for small sites is less sophisticated and prone to over application of material. Their customers are spread out geographically, creating problems for proper and efficient storage and the transport of materials. Part-time seasonal workers fill many of the positions in these companies, which makes proper training an additional challenge for the employer.

The areas of maintenance vary greatly from seldom used sidewalks to the interstate. It ranges from concrete bridge decks to the marble steps of the capitol building. Each maintenance area has unique challenges that must be understood and mastered. The public generally does not understand or appreciate the difficulty of winter maintenance, and certainly does not understand the increasing challenges and changes coming to this industry as it moves towards conservative use of salt.

Maintenance professionals should become educated on the environmental impacts of salt and how their practices contribute to it. Maintenance professionals could attend training on lower salt use strategies, keep an open mind towards change, and look for ways to make salt use more efficient.

Operators could attend training and learn about changes that can be made on an individual basis. Many salt saving strategies do not need the cooperation of an entire agency; they can be incorporated into daily work. Other salt savings actions can be led by supervisors that will involve teamwork within the department, such as moving from manual controlled spreaders to computer controlled spreaders.

Supervisors may assess their current maintenance program using the WMAt, or other assessment techniques, to assess advanced, standard, and remedial practices. The remedial practices could be prioritized then followed by working towards improving good practices to make excellent practices.

Training opportunities, tools, and other resources for winter maintenance professionals can be found in Appendix D.

EXAMPLE: YEARS 1-2

- ÿ Clean out salt from truck thoroughly before washing truck.
- ÿ Reduce speed when applying salt.
- ÿ Avoid plowing off other's salt, communicate with other drivers.
- ÿ Bring extra salt back to the pile, do not use it up on the route if not needed.
- ÿ Add tanks to 5 trucks a year starting in 2017.
- ÿ Work out agreement to buy brine from neighboring agency.
- ÿ All supervisors will attend training.
- ÿ Speed up physical removal of snow by changing our call out policy to 2 inches of snow.
- ÿ Reduce speed of application on high speed roads to 30mph.
- ÿ Calibrate most equipment yearly.

EXAMPLE: YEARS 3-5

- ÿ Speed up physical removal of snow by changing call out policy to 1 inch of snow.
- ÿ Work out salt building agreement for salt storage with neighboring agency.
- ÿ Calibrate all equipment yearly.

EXAMPLE: YEARS 6-10

- ÿ Push snow across bridges and/or truck it away.
- ÿ Adjust to selecting the appropriate material for the pavement temperature all of the time.
- ÿ All personnel will attend training.

Watershed Management Organizations & Districts and Soil & Water Conservation Districts

The WMOs, WDs, and SWCDs play a significant role in the management of the TCMA waters and provide an opportunity to combine the goals and recommendations of the CMP into watershed plans. This important group, together with environmental organizations, agencies and educators are the key organizations to help increase awareness of the problem and encourage reduced salt use across the TCMA. Much of the changes in attitudes and environmental awareness has stemmed from this group of organizations. There are a wide range of possibilities for incorporating key elements of this CMP into watershed plans, as well as important roles that the WMO/WDs can take to help reduce salt use.

The WMOs/WDs/SWCDs play an important role in developing funding programs specifically for private entities, who may have limited funding options.

EXAMPLE: YEARS 1-2

- Partner with the MPCA to offer the Smart Salting winter maintenance training for local private and public winter maintenance professionals each winter.
- Educate 50% of constituents on the benefits of smart salt use.
- Create awareness about the environmental impacts of chloride through education, outreach, and other activities to local residents, applicators, elected officials and businesses.
- Monitor local surface waters for chloride concentrations to track trends, track progress and understand the movement of chloride through the watershed.
- Develop incentive based program for chloride reduction strategies.
- Host yearly workshops for local winter maintenance professionals to encourage the use of the WMAt and track progress of BMPs implemented.
- Provide a measuring cup type salt scooper to homeowners and small businesses at the point of sale of salt in order to raise awareness of the amount of salt they are using.

EXAMPLE: YEARS 3-5

- Educate 75% of constituents on the benefits of smart salt use.
- Offer grants to private and public winter maintenance organizations for upgrading equipment or implementing innovating practices.
- Implement a rebate program to residents to install on-demand water softeners and remove old, inefficient water softeners.
- Provide “free” advertising to private applicators who meet “smart salting” criteria.
- Encourage local businesses and public buildings to reduce salt use through improved insurance benefits and liability protection.
- Partner with local stakeholder on innovative projects to reduce chloride at the source and alternatives for de-icing and water softening.

EXAMPLE: YEARS 6-10

- Educate 100% of constituents on the benefits of smart salt use.
- Create model ordinances, educational materials, or incentives for the organization or others to use and/or adopt. For example:
  - Restrict the application of salt within a city to trained winter maintenance professionals.
  - Citizens are asked to prove their knowledge of salt impacts on the environment and sign a pledge to use less salt, in return for a stormwater fee credit.
  - Create consumer awareness materials available at participating stores (promoting the sales of shovels and snow blowers instead of ice melt).
  - Encourage hazardous household waste centers to accept ice-melt products.

Municipalities

Expectations for all municipalities will begin with an assessment of the existing winter maintenance practices and designing a plan to improve practices. The MS4s will have an additional requirement to report progress on the use of improved winter maintenance practices to the MPCA.

The purpose of this assessment is to determine where opportunities exist to make reductions in salt use. The information in the CMP may be used by municipalities to assess existing practices, specifically the assessment criteria in Appendix B. For a quicker and more thorough assessment, the online WMAt, currently under development, could be used. The WMAt designed to be an easy-to-use web-based tool. This tool will allow municipalities to evaluate their current winter maintenance program at a very detailed level and create a customized plan for implementing salt savings. The tool will allow an individual to assess their current practices and speculate on potential future practices to understand how to reduce the use of chlorides while still providing an acceptable level of service.

This tool is developed for winter maintenance professionals with a broad and detailed understanding of the winter maintenance operations. These professionals should conduct the assessment, then set and share the goals so that the organization can work to meet the goals.

Municipalities can choose to assess existing practices using any means. Municipalities should identify practices to improve winter maintenance activities, with priority on eliminating remedial or unacceptable practices. The implementation goal for each MS4 will be specific to the MS4.

Each municipality will have a unique implementation goal. Some municipalities have already made substantial improvements in practices and require minor effort to improve practices. For leading edge operations it is worthwhile to note the technology and tools for further reductions of salt use are constantly evolving and changing. Organizations currently demonstrating the best practices will still have to dedicate time and resources to stay current with the industry. Leading edge operations could consider sharing their experiences with other organizations that are attempting to lower salt use. For organizations that are just beginning reductions, it may be worthwhile to observe the operations and equipment of those who have already made progress on reducing salt. Networking with other operators could be part of the organization's plan. Organizations outside of Minnesota may also have valuable insights. Many municipalities in the Midwest and Canada have developed expertise in different areas of winter maintenance and are recognized by their peers across the nations.

EXAMPLE: YEARS 1-2

ÿ Educate civic leaders on the benefits to reducing chloride and its importance.

ÿ Partner with the MPCA to offer the Smart Salting winter maintenance training for local private winter maintenance professionals in the area each winter.

ÿ Educate 50% of constituents on the benefits of smart salt use.

ÿ Create awareness about the environmental impacts of chloride through education, outreach, and other activities to local residents, applicators, elected officials, and businesses.

ÿ Attend trainings, workshops, and events to learn about new technology and strategies for reduced salt use.

EXAMPLE: YEARS 3-5

ÿ Educate 75% of constituents on the benefits of smart salt use.

ÿ Recognize private winter maintenance organizations for upgrading equipment or implementing innovating practices.

ÿ Implement a rebate program to residents to install on-demand water softeners and remove old, inefficient water softeners.

ÿ Provide “free” advertising to private applicators who meet Smart Salting criteria.

ÿ Encourage local businesses and public buildings to reduce salt use through improved insurance benefits and liability protection.

ÿ Partner with state and local stakeholders on innovative projects to reduce chloride at the source.

EXAMPLE: YEARS 6-10

- ÿ Educate 100% of constituents on the benefits of smart salt use.
- ÿ Create model ordinances, educational materials, or incentives for the organization or others to use and/or adopt. For example:
  - o Restrict the application of salt within a city to trained winter maintenance professionals.
  - o Citizens are asked to prove their knowledge of salt problems in the water and sign a pledge to use less salt, in return for a stormwater fee credit.
  - o Create consumer awareness materials available at participating stores (promoting the sales of shovels and snow blowers instead of ice melt).
  - o Encourage hazardous household waste centers to accept ice-melt products.

Wastewater Treatment Facilities and Industrial Dischargers

This section addresses municipal and industrial WWTPs that either create saline water in their operations or receive saline water and discharge it. The concentration of chloride present in the waste stream will vary for every facility and is dependent on the source of chloride. The major source of chloride to municipal WWTP is from residential water softeners (>90% in some municipalities).

If WWTPs effluent chloride concentrations demonstrate a reasonable potential to exceed 230 mg/L, the MPCA will work with the permitted entity to include appropriate permit conditions, including monitoring requirements, compliance schedules, and possible effluent limits. If a permitted facility receives a chloride limit they will be required to identify sources of chloride.

For municipal wastewater facilities, technologies capable of removing chloride from wastewater are either cost-prohibitive, technologically infeasible, or a mix of the two. The RO and evaporation of the resulting brine is the most viable option for removal of chloride at the WWTP. The MPCA analyzed the cost and implementation concerns of using RO treatment and evaporation to remove chloride for WWTPs in 2012 (Henningsgaard 2012), which is also summarized in Section 3.6. Based on the assessment, RO treatment and evaporation are cost prohibitive and pose significant implementation concerns.

The most feasible option for reducing chloride loading to the WWTPs is upstream source reduction. The two primary sources of chloride to WWTPs are industrial users and residential water softeners. If a facility has a chloride limit or would like to voluntarily reduce chloride, WWTPs should work through their Industrial Pretreatment Program (IPP) to identify significant users who may be contributing chloride. The WWTPs can review existing data from industrial users or can require industrial users to collect chloride data. If industrial users are identified as a significant source of chloride, the WWTP can work with the industrial user through the IPP to develop and implement a plan to reduce chloride loads.

Water Softeners

One option for municipalities includes the potential of providing lime or membrane water softening at the water treatment plant (WTP) in an attempt to eliminate water softening at individual residences. This option assumes that all WTP users would be connected to city drinking water and would have taken their water softener offline. Water softening at the WTP has the potential to be more cost efficient than individual residential water softening for many users.

The MPCA supports any effort to reduce chloride loading to the WWTPs, including encouraging residential users to switch to high efficiency ion exchange softeners. However, the MPCA does not believe that switching residents to high efficiency softeners will automatically allow a WWTP to come into compliance with chloride permit limits. The MPCA is developing a guidance document that will provide WWTPs chloride source reduction methods, treatment alternatives, and permitting strategies that will help WWTPs to come into compliance with the chloride water quality standard. The following steps will help to reduce the amount of salt being discharged to a WWTP:

- Know the hardness level of local water supply.
- Consider whether a water softener is needed and avoid the ongoing expenses if it isn't. Test water for hardness. Typically water hardness greater than 120 mg/L $CaCO_3$ needs to be softened. See the University of Kentucky's Guidance: Hard Water- To Soften or Not to Soften for more information.
- Do not over soften. Program the water softener to obtain an optimal level of hardness.
- Uninstall an old timed softener and replace it with a new demand softener. A new demand softener could be optimized to minimize backwashing and the newer model would have a more efficient ion exchange resin.
- If using a timer-based softener, set to recharge at the lowest effective rate and turn it off when on vacation.
- Install a bypass so landscape irrigation water is not softened.
- Consider alternatives to salt-based water softeners.
- Move to centralized water softening using lime rather than salt

Homeowners with water softeners with an on-site septic system, salt reduction strategies should also be taken. Chlorides in on-site septic systems will infiltrate to groundwater and may result in elevated levels of chloride in groundwater which can impact water supplies as well as groundwater recharge of lakes, streams, and wetlands.

For direct dischargers of industrial wastewater, the individual permittee will need to work with the MPCA to develop and implement a plan to reduce chloride if effluent concentrations have reasonable potential to exceed 230 mg/L. Each industrial discharger will have unique circumstances and will need to consider whether source reduction, treatment, or another approach would be most effective in their specific situation.

EXAMPLE: YEARS 1-2

- ÿ Monitor chloride in effluent and review past monitoring reports for chloride concentrations.
- ÿ Evaluate chloride data and determine if reasonable potential to exceed 230 mg/L exist.
- ÿ If potential to exceed 230 mg/L work with MPCA permit staff and create a plan to reduce upstream chloride sources.

EXAMPLE: YEARS 3-5

- ÿ Identify goals for chloride reductions.
- ÿ Develop a compliance schedule if chloride limits are established through NPDES permit.
- ÿ Educate industrial dischargers on the importance of reducing chloride in waste streams.
- ÿ Educate residents in cities that pre-soften water that they do not need water softeners.

EXAMPLE: YEARS 6-10

- ÿ Work with water softening companies to offer a trade-in program to upgrade to high efficiency residential water softeners.
- ÿ Offer a credit to a city or industrial discharger for reducing chloride concentrations in wastewater.
- ÿ Work with municipality to install municipal lime softening at the WTP.

Water Treatment Facilities (Water Supply)

This sector draws water from groundwater or surface water sources and tests and treats it before distributing it to residents. Municipalities that soften the water before it is distributed to households or municipalities that are considering this, care should be taken to minimize salt use and salt waste. Assess the need for soft water in the area and look for non-salt approaches such as lime softening. Consider the mass balance of how much salt is used by individual water softeners versus centralized water softening. However, users may be unaware the water from the municipality is softened or may be accustomed to having a residential softener leading to double softening. Municipalities can also evaluate how high saline water is disposed of in the cleaning and flushing process.

EXAMPLE: YEARS 1-2

ÿ Assess hardness level of water and need for softening.
ÿ Determine if non-chloride source softening is a viable option.
ÿ Survey homeowners on the use of residential water softening.
ÿ Educate customers on water conservation and the benefits related to chloride reduction.

EXAMPLE: YEARS 3-5

ÿ Encourage residents to install high efficiency water softeners.
ÿ Encourage home by-pass of soft water for irrigation and drinking water. Create cost share program to encourage plumbing changes needed to accommodate this.
ÿ For those with RO systems, explore ways to capture RO waste water which is saline and route to water softener.

EXAMPLE: YEARS 6-10

- Reuse salt from cleaning municipal water softening equipment.
- Use non-chloride techniques for softening source water.

Citizens

This group includes everyone living or working in the TCMA. Each person contributes to the attitudes and practices that have created a high and steadily growing volume of salt to be used each year. In order to reverse this situation each person must contribute to changing attitudes and practices that are more sustainable and require less salt. The list of actions that this group can take is extensive. Citizens form public policy, set the expectations that our maintenance crews must live up to, and use salt on their own property such as water softening and salting their sidewalks in the winter. Engaging the citizenry in the TCMA offers the best chance to get salt use under control.

There are many ways to reduce salt use while maintaining high safety standards. Below are a few simple steps that residents can take to help reduce the amount of chloride entering waters. More ideas are listed on the MPCA's website.

Citizens can look for ways to reduce salt use. Every teaspoon of salt reduction prevents five gallons of water from being polluted. Small changes can have big results. Typically the biggest salt uses are sidewalk/driveway/steps (winter maintenance) salt and water softeners, with the outdoor use for winter maintenance being the largest use.

Winter Safety:

- Support local and state winter maintenance crews in their efforts to reduce their salt use.
- Work together with local government, businesses, schools, churches, and non-profits to find ways to reduce salt use in the community.
- Inform and educate local and state policy makers on the importance of this issue.
- Shovel. The more snow and ice removed manually, the less salt is needed and the more effective it can be. Whether through shoveling, blowing, plowing or scraping, getting out early and keep up with the storm. Salt may not be needed.
- Do not apply salt to areas that have not been shoveled.
- Generally speaking, sidewalk salts work better when it is warmer. Below 15°F is too cold for salt as most salts stop working at this pavement temperature. Use sand instead for traction, but remember that sand does not melt ice. If melting snow or ice look for opportunities when the sun is shining or the temperatures are warming, which will be more effective with less salt.
- Slow down. Drive for the conditions and make sure to give plow drivers plenty of space to do their work. Consider purchasing winter (snow) tires.

- Be patient. If the salt is not visible on the road doesn't mean it hasn't been applied. These products take time to work. Allow more time for trips to account for driving at a slower speed.
- More salt does not mean more melting. Use less than 4 pounds of salt per 1,000 square feet (an average parking space is about 150 square feet). One pound of salt is approximately a heaping 12-ounce coffee mug. Consider purchasing a hand-held spreader to apply a consistent amount.
- Sweep up extra salt and sand. If salt or sand is visible on dry pavement it is no longer doing any work and will be washed away. Reuse this salt or sand somewhere else.
- Research the products. Choose the right one for the conditions. Salts are used because they are able to decrease the freezing point of water. Whatever product selected, know the temperature it stops working.
- There are no labeling laws for bags of deicers. Therefore the information on the bag may be accurate or misleading; it may contain a list of all ingredients, a partial list, or no ingredient list. See the MPCA salt & water quality website for information on common deicers and the practical melting ranges.
- Watch a video. This video, produced by the MWMO, provides tips to homeowners about more environmentally friendly snow and ice removal: Improved Winter Maintenance: Good Choices for Clean Water.
- Read and pass along Nine Mile Creek Watershed District's (NMCWD) brochure about residential snow and ice care: Residential snow and ice care (NMCWD)

Water Softening:

- Use a high efficiency water softener.
- Avoid using softened water for irrigation or drinking water.
- Do not use a water softener if source water is already softened by the WWTP.

Minnesota Pollution Control Agency

The MPCA will continue to provide support to stakeholders to address chloride impacts on surface water and groundwater resources, as resources allow. The MPCA will continue to monitor lakes, streams, and groundwater for chloride, in cooperation with the TCMA partners, to track progress and better understand water quality trends. The MPCA recognizes the importance of the MPCA Smart Salting (S2) training program and will continue to support and improve the training as new technologies and resources are available. The MPCA will also continue providing necessary technical assistance, resources, tools including supporting and hosting the WMAt, to its permitees, stakeholders and local partners, and to facilitate forums discussing progress of implementation of the CMP and adaptive management strategies in the TCMA as resources are available.

EXAMPLE: YEARS 1-2

- Explore ways to support a sustainable MPCA Smart Salting Program.
- Host, support and update the WMAt on the MPCA website.
- Continue to monitor lakes, rivers, and groundwater for chloride.
- Solicit assistance in statewide chloride monitoring through partnerships and grant programs.
- Participate in the Freshwater Society's annual Road Salt Symposium.
- Update website with educational information on lower salt use for citizens.
- Support and provide access to the "Salt Dilemma" display at various events and venues.
- Provide technical assistance to permitee for reducing chloride.

EXAMPLE: YEARS 3-5

- Continue to monitor lakes, rivers, and groundwater for chloride.
- Continue to update impaired waters list with waterbodies exceeding the state's chloride standard.
- Participate in the Freshwater Society's annual Road Salt Symposium.
- Support and provide access to the "Salt Dilemma" display at various events and venues.
- Continue to provide technical assistance to permittees for reducing chloride and fulfilling permit requirements for Chloride TMDLs.
- Integrate chloride reduction opportunities into other MPCA programs.
- Include chloride reduction as a priority at the MPCA where possible.

EXAMPLE: YEARS 6-10

- ÿ Continue to monitor lakes, rivers, and groundwater for chloride.
- ÿ Continue to update impaired waters list with waterbodies exceeding the state's chloride standard.
- ÿ Continue to support the implementation of the TCMA CMP.
- ÿ Support and provide access to the "Salt Dilemma" display at various events and venues.
- ÿ Continue to provide technical assistance to permittees for reducing chloride.

Policy Makers

State, county, city policy makers, and those that make policy to govern other entities have an important role to play in chloride management. Policy is the tool that helps speed up behavior change in areas where behavior change is not progressing or progressing fast enough. One of the challenges facing policy makers is that they may not fully understand the environmental impacts of salt. In order to enable policy makers to be more active in this area, information about the environmental impacts of salt and awareness of the existing voluntarily efforts to improve salt reductions is necessary. There are many policies and actions that can be considered to assist with reducing salt use.

EXAMPLE: YEARS 1-2

- ÿ Better understand environmental impacts of salt use and ways the constituents contribute.
- ÿ Understand options for reducing chloride use.
- ÿ Support the implementation of the CMP.
- ÿ Develop a limited liability law to protect private contractors from being sued if they are following BMPs under the Smart Salting (S2) training, similar to New Hampshire. Fear of law-suits often drives over application of salt.
- ÿ Create an ordinance for city that all salt and salt/sand piles must be stored indoors and on an impermeable surface.

EXAMPLE: YEARS 3-5

- ÿ Require statewide certification of salt applicators similar to the Department of Agriculture's pesticide applicator certification program.
- ÿ Require all new construction to have irrigation water and drinking water plumbed so as to not pass through the water softening.
- ÿ Require water softeners that recharge by the time of day and not by the salinity of water be banned from sale.
- ÿ Provide funding to various state agencies to support local implementation of salt reduction practices.
- ÿ Discuss lower levels of service with constituents.

EXAMPLE: YEARS 6-10

- ÿ Develop labeling laws for deicers sold in MN so ingredients are listed along with practical. melting range. Also should include warning about the environmental impacts of using the material.
- ÿ Policies should be reviewed to determine effectiveness in chloride reductions.
- ÿ Work with other policy makers to understand the most effective policies.

Secondary Audiences

This group includes those that have a smaller, but important, role in reducing the amount of salt entering surface and ground water.

Those awarding maintenance contracts

The property manager or contracts department for any organization hiring winter maintenance services should consider requiring those bidding on work to have successfully completed the MPCA Smart Salting training. When crews are on-site conducting maintenance work a high percentage (to be determined by contracts department) should have successfully completed the training within the past five years. Here are things to consider when negotiating a contract for winter maintenance services:

- Have all contracted and landlord winter maintenance workers applying salt attend the MPCA Smart Salting training.

- Charge for level of service (i.e., hourly, event-based or seasonally), not per pound of product.
- Develop a Snow and Ice Policy and set clear expectations (see Smart Salting training website for example policies).
- Clean up accidentally spilled piles of salt.
- Use mechanical methods of snow and ice removal (plow, shovel, brush, blow) prior to using any chemical control – capabilities needed.
- If using sand, conduct year-around sweeping to remove any excess product applied in winter.
- Record what and how much product is applied for each event.
- Calibrate all equipment at least annually and document the results.
- Use salt (NaCl) only if pavement temperature is above 15 degrees Fahrenheit.
- Find ways to wet salt – 30% less material can be used, it works faster and stays in place Show progress towards lower application rates based on the MPCA's training program.

Some example language to consider:

> *Snow plowing and deicing of parking lots will be done in a manner similar to guidelines provided under both the Minnesota Pollution Control Agency and the Minnesota Department of Transportation "Winter Parking Lot and Sidewalk Maintenance" manual provided to LESSOR.*
>
> *LESSOR shall request LESSOR'S vendor to attend Smart Salting training offered by the Minnesota Pollution Control Agency. The following link provides information about the Minnesota Pollution Control Agency's Road Salt Education Program:*
> http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_information

Grant-giving organizations

Ensure that grant opportunities are available for protection and restoration of surface and ground waters for chloride. Consider ways to ensure a simple application process and equal access to funds for non-traditional source reduction (pollution prevention) projects addressing chloride. Possible areas include:

- Research or implementation of reduced-salt strategies to winter maintenance.
- Research or implementation of lower or no salt pavement strategies.
- Citizen involvement on environmental impacts and solutions.
- Research or implementation of changing winter driver behavior and expectations.
- Research high efficiency residential water softening and non-chloride options.
- Re-using waste stream products for deicing.
- Research or implementation of urban design solutions that reduce salt use. (Examples: parking ramps/covered parking as an alternative to vast parking lots. Skyways or covered walkways. Transit-oriented development so people have alternatives to driving.)

Driver Education Programs and Department of Driver and Vehicle Services

For all new drivers, those getting additional licenses such as commercial or motorcycle licenses, and those moving into Minnesota, consider educating about winter tires, appropriate winter driving, and the environmental impacts of salt. Include training on winter driving, the temperature range at which salt does not work, how bridge decks and ramps freeze before the roads, and other tips for safe winter driving. Teach drivers to respect the plowing operations and take pressure off of public works departments for instantly cleared surfaces. Send information with driver license renewals to current drivers on tips for winter driving.

Pavement designers, researchers, engineers

Become educated on the issues with high-salt-use surfaces and the impacts to water resources. Look for opportunities to invent, test, and implement lower-salt-use pavement surfaces. This includes sidewalks, parking lots, roads, bridges, ramps, trails, parking ramps, steps or other highly salted surfaces in the winter months. Possible areas include, but are not limited to:

- Permeable surfaces
- Flexible surfaces
- Heated surfaces
- Different color or texture of surfaces
- Smaller surfaces
- Pavement overlays

Water experts in most any field including limnologists, hydrologists, biologists, chemists

Understand the impacts of chloride to water resources and the pathways it takes to get there. Look for opportunities to invent, test, and implement techniques to prevent salt from entering water resources after application or for strategies to mitigate for it. Problem areas to consider include:

- Recovering salt after application to paved surfaces
- Options for treating chloride in stormwater ponds
- Research the impacts of infiltration into ground water versus surface flow to surface waters
- Options for mitigating chloride already present in surface waters
- Capturing and reusing salt water (truck wash, runoff, waste water discharge)

Agriculture

The primary source of chloride from agricultural lands in the TCMA is from fertilizers and land application of food processing waste and biosolids from municipal sewage treatment. Excessive chloride concentrations on agricultural lands can be harmful to crop growth in addition to contributing to elevated levels of chloride in surface runoff and groundwater infiltration. Conservation practices and nutrient management not only protect water resources, but can save farmers money. Development and implementation of nutrient management plans could potentially be conducted for agricultural lands. Conservation practices and nutrient management planning information and guidance can be found at the Minnesota Department of Agriculture website.

Other State Organizations

The Minnesota Department of Health (MDH) should continue to monitor chloride in drinking water, as resources allow. The Metropolitan Council may continue to monitor chloride in lakes, wetlands, streams, and groundwater, as well as chloride in wastewater discharges in the TCMA. The Minnesota Department of Natural Resources (DNR) could continue to monitor chloride impacts on aquatic life, plants, and animals. The Board of Water and Soil Resources (BWSR) will continue to administer grant programs to protect, enhance, and restore water quality in lakes, rivers, and streams in addition to protecting groundwater and drinking water sources from degradation, as resources allow.

The MnDOT should continue to provide in-house training and leadership throughout the state in an effort to enable the implementation of effective chloride reducing BMPs. This includes research on innovative technology and passing the knowledge on to others.

The Minnesota Department of Agriculture could potentially work with farmers to develop nutrient management plans, which include methods to reduce chloride-based fertilizers.

3.3 Chloride Reduction Strategy

Implementation Strategies: Traditional Framework

Chloride management is a challenging issue in Minnesota and requires a balance between public safety and the environment. In addition to the balance, chloride management is complex since every winter event is different. The different events can be a result of the type of precipitation, temperature, longevity of the event, timing of the event, etc. In addition to variations in each event, winter seasons can be highly variable from year to year.

Snow and ice maintenance practices vary between road authorities and private applicators. Training, equipment, available resources, client expectations, and political pressure all factor into the amount of deicer being applied.

There is no single BMP that can cost-effectively remove snow and ice and maintain an appropriate level of service for all of the various situations. Chloride management can only be achieved through implementation of an array of different BMPs. The BMPs vary by effectiveness in reducing chloride application and cost of implementing the BMP.

The CMP includes an arsenal of BMPs, which give chloride applicators multiple ways to reduce chloride. This provides BMPs that can be used by high-use/high-experience entities all the way down to low-use/low-experience entities. A wide range of BMPs also allows greater flexibility in the timing and extent of implementation of BMPs.

Traditional BMP strategies can be implemented by chloride applicators. The primary recommended strategies include, but are not limited to:

1. Shift from granular products to liquid products
2. Improved physical snow and ice removal
3. Snow and ice pavement bond prevention
4. Training for maintenance professionals
5. Education for the public and elected officials

These strategies are centered on the continued use of chloride containing products in the most efficient and effective manner possible. This approach assumes maintaining the same level of service. There are several industry shifts that are needed to reduce salt waste. These changes are applicable to all winter maintenance areas in which a high level of service is expected: roads, parking lots, and sidewalks.

Implementing the strategies above will lower salt use, but it may not be reduced enough to protect or restore all water resources.

As part of the stakeholder process to develop the CMP, a TechEx was developed and consists of hands-on salt applicators and suppliers. The TechEx was engaged to better understand the state of the practice and the BMPs available to the winter maintenance industry. The TechEx provided valuable information on specific BMPs that are currently being used by various entities and the benefits of implementing these salt reducing BMPs. This team has been instrumental in the development of the WMAt that will assist winter maintenance organizations in developing their own customized salt reduction plan. Their knowledge, experience, and dedication to using smart salting techniques has been utilized to create this first ever comprehensive evaluation of all available chloride BMPs. Utilization of this planning tool will allow the user to track progress over time and show the results of the efforts.

The tool can serve as both a reporting mechanism to understand the current practices and as a planning tool to understand future practices. The planning part of the tool will help the user understand the challenges and costs associated with improved practices. The WMAt provides a more detailed and comprehensive list of the BMPs available to winter maintenance professionals.

A few salt saving BMPs for winter maintenance programs

While the preferred and most effective approach for developing a chloride reduction plan for individual winter maintenance programs is to utilize the WMAt, here are a few BMPs that have been proven to reduce salt use.

1. Calibrate all equipment regularly (both liquid and granular systems).
2. Integrate liquids (avoid applying dry material).
3. Develop a Winter Maintenance Policy/Plan and share it with supervisors, crew, and customers.
4. Provide state-of-the-art Smart Salting training, education, and professional development for all who work in the industry.
5. Store salt indoors and on an impermeable pad.
6. Anti-icing before events to reduce bonding of snow to pavement.
7. Use ground speed controllers.
8. Upgrade to equipment that can deliver low application rates.
9. Select products that will work well given the pavement temperatures and conditions.
10. Select application rates based on road temperatures and trends, the product used cycle time and other factors.
11. Start mechanical removal as soon as possible and keep at it throughout the storm.
12. Use a variety of methods to reduce bounce and scatter of salt
    - Reduce speed
    - Higher liquid to granular ratio
    - Lower spinner elevation
    - Chutes or skirts
    - Reduced spinner speed
    - Target center of road.
13. Refine application rates charts and continually test lower rates.

These BMPs may not be practical for all winter maintenance programs and should not be considered the best or only options for salt reducing activities, but rather a list of BMPs that many programs have already begun implementing and are seeing reduced salt use as a result. To determine the activities appropriate for each organization please visit the MPCA's Stormwater Manual to utilize the WMAt.

The MnDOT is a leader in winter maintenance related research in the state. Research reports and technical summaries on the latest research can be found on the MnDOT Research Services website.

Implementation Strategies: Non-Traditional Framework

The continued use of chloride containing deicing materials to provide safe winter conditions may not be a sustainable long-term solution. Therefore, considering practices that fall outside the current and common methods for winter maintenance are worth evaluating. When evaluating non-traditional methods, it is important to consider the environmental impacts of the methods.

Non-traditional approaches require public acceptance in terms of costs, expectations, and changes in behavior. Implementation of these practices will require a combination of messaging to the public which includes discussion of the potentially significant costs to individuals and government. Five of the main areas where change may be considered include:

1) Adopt a lower level of service for roadways, parking lots, and/or sidewalks during snow and ice conditions.

In this scenario, the public would be given a lower level of service on the roadways, parking lots, and/or sidewalks. Physical removal of snow would likely remain the same but the salting would diminish. There are many ways in which winter maintenance professionals could change their level of service. For example, roads could be salted less frequently or perhaps less of the road could be salted. Instead of roads free of ice and snow from shoulder to shoulder, the melted zone could be reduced, perhaps to the middle of the drive lane. Salting could be restricted to critical areas such as intersections, ramps, hills, and high speed roads. Road salt would still be used, but to a lesser extent.

Winter speed limits – alter the speed limits to match the driving conditions during winter storm events or super cold weather times when black ice is present. The MnDOT currently uses a managed traffic lane approach for dealing with high traffic volumes and congestion on the interstate system within the TCMA. It provides a way for the MnDOT to suggest a speed that will reduce braking and further congestion. This same approach could be utilized to manage the expectations of drivers in terms of speed during snow and ice conditions. The temporary winter speed limit approach has been taken in several states including Illinois, Pennsylvania, Colorado, Maine, and Oregon.

- *Primary challenges:* Changing the public's behavior and would require acceptance from the public. The cost of longer commute times and less safe travel conditions in winter months are unknown with this approach however. This would affect non-motorized commuters as well (i.e. pedestrians and bicyclists).
- *Benefits:* Potential to immediately reduce the amount of chloride entering our waters and would save money in salt purchases. This strategy would be easy to implement from a technical perspective but challenging to implement without political and public support.

2) Alternative pavement types and urban design

In this scenario, government transportation agencies and private industry would adopt different forms of pavement that can be kept clear with less or without the use of salt. This could include various forms of heated roadways, new types of improved traction surfaces, surfaces constructed with internal anti-icing features, solar roadways which could generate heat as well as electricity, permeable pavements, and flexible pavements. Narrower roadways may also allow for less application of deicing material.

Urban design methods such as parking ramps and covered parking, skyways or covered walkways, porous paving, public transit, transit-oriented development, and higher density development may also help to reduce impervious surfaces, reduce impervious surfaces requiring deicing, and reduce the overall chloride use.

- *Primary challenges:* would require large-scale public funding, and substantial rework of existing roadways. May result in much higher direct costs making its adoption less desirable and practical. This would be difficult to implement on a large scale due to funds, but may be feasible at a smaller, watershed scale. This approach may take a significant amount of time to convert traditional roads to high performance roads. It will be important to educate entities on permeable pavements and the importance in reducing chloride application since the runoff from permeable pavement surfaces will enter the groundwater.
- *Benefits:* No drastic change in the public expectations for winter travel conditions. Could implement as infrastructure is redeveloped. Would allow for treatment of other pollutants as well.

3) Driver behavior changes

Use of winter tires or other types of tires with improved traction could be required. This might possibly reduce the expectations for a high level of service, and any salt savings would need to be linked to this secondary step of diminished road melting. There remain concerns that driver behavior would not change enough to allow less salt use. Some types of tires have been associated with increased road wear and subsequent pollution, and Minn. Stat. 169.72, prohibits studded tires. The challenge with this approach lies again with public acceptance and driver education on how to safely use winter tires. There would also be a direct cost to consumers and the enforcement of such a requirement. Increased maintenance to roads would likely be an indirect cost associated with this approach, which the resulting salt savings would be modest at best.

Work with large employers to establish a work from home policy during snow events for employees who have suitable jobs. Possibly this will reduce traffic enough during critical times to allow maintenance to be more effective with less salt.

- *Primary challenge:* need for widespread changes from the public. Likely indirect cost passed onto consumers. Safety concerns. Increase damage to roads.
- *Benefits:* would allow for easier continued reduction in salt use.

4) Non-chloride deicers

There is a fairly wide variety of other chemicals that can be used for anti-icing and/or deicing, chemicals which do not contain chloride. However, there are significant environmental concerns with most of the existing alterative products. In general the toxicity of non-chloride based deicers is often more severe to surface water organisms in the short term as the chemicals breakdown. There are fewer long-term concerns with non-chloride deicers, which should be evaluated against the long-term permanency with chloride. Of the four strategies, this may be the easiest to implement, but the environmental impacts of these alternatives are the highest of the options listed and needs to be better understood.

- *Primary challenge:* in general, the costs of alternative products that work as well at melting ice are more expensive than chloride containing products. The environmental consequences of alternative products are relatively unknown.
- *Benefits:* no requirement for public acceptance or changes in behavior. Easy to begin implementing and only requires minor adaptations from maintenance professionals to understand how to effectively and appropriately use these new chemicals.

See MnDOT's Transportation Research Synthesis Report: Chloride Free Snow and Ice Control Material for further information on non-chloride deicers and other non-traditional strategies such as permeable pavement, reducing road widths, solar, and others.

5) Snow melting equipment

Snow melting equipment may be a viable solution in some cases. However, the costs, practicalities, and other environmental consequences of snow melting equipment should be explored further before implementing this method.

Training and Professional Development Opportunities

- MPCA Level I Smart Salting Training – Snow and Ice Control Best Practices
  - This training program is aimed at high level BMPs for private applicators and for city, county and state winter maintenance professionals. There are two classes offered:
    - Winter Parking Lot and Sidewalk Maintenance with reduced environmental impacts. The parking lot and sidewalk training manual is given to each participant.
    - Winter Road maintenance with reduced environmental impacts. The Field Handbook for snowplow operators is given to each participant.
    - The training schedule for the MPCA Smart Salting trainings can be found at http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_information
- MPCA Level II Smart Salting Training
  - This program is currently being developed and is intended to provide a higher level of training for more experienced winter maintenance professionals.
  - The training will provide winter maintenance professionals an opportunity to learn how to utilize the WMAt.
- Minnesota Local Technical Assistance Program (LTAP)
  - Snow and Ice Control Material Application
    - This training is aimed at determining proper application rates during various conditions in order to use salt and sand effectively and efficiently.
  - Snowplow Salt and Sander Controller Calibration Hands-on Workshop

    - § This workshop is aimed at calibrating salt and sander controllers. Attendees receive hands-on calibration instruction.
- Freshwater Society's Annual Road Salt Symposium
    - o The symposium brings together environmental and transportation professionals to learn about the latest research on the environmental impacts of road salt and innovations that are helping overcome the problems. Environmental leadership awards are presented to local organizations that are making progress in reducing salt.
- American Public Works Association (APWA)
    - o Offer training at APWA meetings and conferences: http://www.apwa.net/topics/education-and-training
        - List of those certified by the MPCA Smart Salting trainings can be found at: http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_certificate_holders
- Small site Smart Salting training video and homeowner Smart Salting training video can be found at https://www.pca.state.mn.us/water/educational-resources .

More training and professional development opportunities can be found in Appendix D.

MS4 Permit Implications/Strategies/Reporting

One of the challenges for public road authorities is the variability in road types, conditions, and meeting driver expectations. Each municipality is faced with unique challenges and circumstances that will play a role in determining the specific BMPs implemented. Development of winter maintenance policies/plans that are proactive and aim to minimize salt use is a critical first step for all winter maintenance programs to begin implementing the BMPs in an effective and strategic way. Training and regular professional development for all applicators is another key strategy to allow winter maintenance programs to reduce overall chloride use while providing an appropriate level of service.

Municipalities in the TCMA make up the most significant portion of salt applicators and would be expected to take on the majority of the BMP activities for reducing chloride. Those municipalities with a National Pollutant Discharge Elimination System (NPDES) Permit with the MPCA in a chloride impaired watershed will be required to report progress on the implementation of the salt reducing BMPs beginning after issuance of the next Phase 2 MS4 permit, which is expected to occur in 2019. The Phase 1 MS4s, (St. Paul and Minneapolis) will be asked to report their progress in 2016.

The WMAt is a valuable resource to MS4s in terms of prioritizing and implementing the BMPs. Use of the WMAt is not a requirement but will allow each MS4 to determine their own priorities that may be based on cost, location, ease of acceptance, or other important factors unique to the MS4's particular situation. The WMAt provides the specific BMPs related to all areas of winter maintenance to aid in the development in a detailed plan that meets the unique conditions of each individual program and can be prioritized and implemented according specific needs and constraints.

Another valuable resource for public road authorities is their peer group. Several public road authorities have improved practices, significantly reduced chloride use, and have recognized cost savings by implementing BMPs. These success stories, when shared between entities can be a great way to demonstrate specifically how chloride reductions have been successfully achieved. Case studies describing some of these local success stories and specific areas of improvement are discussed below in Section 3.5.

The MS4 reporting will consist of discussion of the BMPs that have already been implemented and the BMPs that are planned, including a timeline for implementation. Further information on reporting requirements can be found on the MPCA MS4 program website.

Private (Commercial, Industrial, Residential)

A major challenge in the overall reduction of chloride use in the TCMA is getting private applicators to reduce chloride usage. There are five primary hurdles related to this effort:

1. Liability concerns for applicators and property owners
2. Education and training for applicators, including cost
3. Contracting practices and incentives for applicators
4. Diversity in personnel experience
5. Private companies often are excluded from grant opportunities

Two potential approaches to educating/training private applicators include a required training approach and a voluntary training approach, both discussed further below. A required training assumes that an ordinance or other regulatory mechanism is adopted by a governing body that requires training. A voluntary approach assumes that there is no ordinance or regulatory mechanism in place.

Potential Required Training Approach: for watersheds with chloride impairments (or suggested reductions)

1. Implement a state-wide Smart Salting certification program.
2. Watersheds to require the MPCA Smart Salting training for anyone performing professional level winter maintenance in the watershed.
3. Cities within those watersheds create an ordinance requiring Smart Salting training certification to work in their cities.
4. Cities ask commercial property owners in their city to become trained. They award contracts only to certified applicators.
5. All government organizations (state/counties/parks/schools/cities) to hire only Smart Salting certified contractors to maintain government properties.
6. The MPCA, watersheds, and cities all help advertise the training.

Voluntary Training Approach:

1. The MPCA to continue offering Smart Salting training.
    a. Increase the number of classes
    b. Expand locations of classes
    c. Incorporate alternative methods for certification (e.g., Webinars)
    d. Increase advertising about the availability and importance of being “certified” winter maintenance professionals
2. Watershed organizations and cities host and advertise classes in their area.
3. Ask cities/watersheds to host and advertise Smart Salting training classes in their area.

4. Improve communications with contractors by advertising training and following the research recommendations:
    a. Email
    b. Mail
    c. Websites (the MPCA, watersheds, cities)
    d. In-person at trainings, seminars, and conferences (both winter and summer maintenance)
    e. Via other professional organizations (MNLA was commonly referenced)
    f. Posting in newsletters of other professional organizations
    g. Telephone

The winter maintenance industry has changed since the MPCA Smart Salting training program started in 2006. The training itself has also changed. By making the training valid for a fixed number of years, this will encourage on-going awareness of the winter maintenance BMPs, keep the industry current with regulations, and strengthen communication between maintenance organizations and strengthen communication between the environment and maintenance. For optimal success these considerations should be made:

- Have training valid for a fixed number of years.
- Notify training participants when certification expires.
- Inform training participants that names/companies will be removed from the MPCA Smart. Salting certification list when expiration occurs.
- Provide a schedule for upcoming trainings.

In addition to education, legislation that limits liability for private applicators that are certified under the Smart Salting training program would enable them to use less deicer without fear of litigation. An important aspect to a statute like this is requiring training in order to maintain an appropriate level of service. The State of New Hampshire passed a new law, RSA 489-C effective November 1, 2013, which limits the liability of business owners who contract for snowplowing and deicing as long as the applicator is certified through the New Hampshire Green SnowPro Program. The entire law can be found at: www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-L-489-C.htm.

Feedback from stakeholders in Minnesota has indicated that many of the private applicators over-apply salt because of concerns about litigation. A law similar to New Hampshire's RSA 489-C could change salt application behaviors of private applicators by limiting their liability.

In some cases, compensation for winter maintenance is based on the amount of salt used, which can incentivize over-application of salt. In this case, a boilerplate should be developed and performance based contract for private entities to use when contracting for winter maintenance services. Performance based contracting methods and the boilerplate contract could be part of the education and training programs for private applicators.

Homeowners and Small Business Owners

A clear message on why reducing chloride is important for the environment, important for saving money, and how to effectively apply chloride will be the key to changing salt application behaviors by homeowners and small businesses. This messaging should be carried out by various state and local governmental entities in order to reach a broad range of people in the TCMA.

Nine Mile Creek approached this by providing a measuring cup type salt scooper to homeowners and small businesses in order to raise awareness of the amount of salt they are using. Homeowners currently not using salt should be encouraged to continue without salt. See detailed survey results in Appendix C and Section 3.4 for additional information on public education.

3.4 Citizen Attitudes and Practices

The average Minnesotan values having clean, healthy water resources. The same Minnesotans value safe driving conditions on roads and bridges. These two public goods are in direct conflict and create a serious dilemma for local government and businesses. Driving in difficult winter road conditions is a problem that directly impacts daily life for nearly all members of the public. It is immediately recognized and felt. Conversely, the problem of chloride pollution causing permanent damage to local waters is something that must be imagined and may not be felt until much later. Extreme public pressure is often brought to bear on local officials to address the immediate problem of icy roads, in spite of the long-term consequences of permanent damage to water resources that will have severe and wide impacts.

When confronted with this dilemma, most citizens will acknowledge this challenge needs to be resolved. However, the expectation is this is government's problem to solve. This dynamic – the government must solve this problem, while the public simply observes – is at the root of this challenge. Changing this expectation is needed to change the over use of chloride to manage winter roads, parking lots, and sidewalks.

The question is how?

Traditional information and education campaigns are important tools in raising awareness about chloride impairments in lakes, rivers, and groundwater. However, if the goal is to create long-term, sustainable change in the practices surrounding the use of salt and other chloride products (e.g., sidewalk deicers, water softening agents) additional strategies will be needed. Research shows that education may be effective in altering some citizens' behaviors for the short-term, but these changes are not likely to be widespread or sustained unless they are coupled with organizing strategies that provide supportive structures for citizen collaboration and public action (Dietz and Stern 2002).

In order to ensure that a new mindset and social norm are achieved around winter road expectations and the use of chloride, a long-term approach to organizing stakeholders will be needed. Changing attitudes will require significant, long-term, and small-scale organizing of homeowners to work in partnership with WDs, WMOs, lake associations, and neighborhood organizations. These community-based organizations are best poised to deliver outreach and programs.

Outreach and education programs remove the barrier of lack of information and encourage people to make changes in their day-to-day practices. However, research has found that there are often other barriers that keep people from changing their existing practices. One effective strategy for overcoming these barriers is to couple information with relationship-building and collaboration support systems in small-scale settings. Community associations, civic groups, and lake associations that already organize neighbors around the issue of water quality can expand their learning and strategies to include addressing chloride pollution. The trusting relationships that develop in these contexts and citizens openness to learn and act, increases the possibility they will consider new information and assistance.

Trusted local leaders delivering information will likely have greater impact than blanket media campaigns, fact sheets, or other educational materials. This approach can be especially effective when coupled with an effort to develop a sense of citizenship and common good while addressing water quality as part of an overall outreach and organizing strategy. Inspiring citizenship and caring for the common good and community, is showing promise in sparking interest in participation.

Development and implementation of public education and involvement is critical and necessary to the success of chloride management in the TCMA. Based on feedback from stakeholders, a multi-agency approach to public education and involvement is needed to reach a large and diverse group of salt applicators with a range of motivations related to salt application. Public education and involvement can be accomplished through multiple venues such as mainstream news media, social media, permanent and variable message signs, elementary and high school education, and other resources aimed at reaching the general public. The MPCA road salt and water quality website maintains a list of available educational resources: https://www.pca.state.mn.us/water/educational-resources. Educational resources for educators and citizens are also available in Appendix D.

Changes in personal practices and attitudes can be the most challenging and time consuming and require short- and long-term strategies. Current winter driving expectations is a result of decades of increasing road salt use and improvements to the level of service. The improved level of service has allowed the traveling public to drive faster with greater confidence during snow and ice events. A long-term strategy is needed to reverse this expectation. Education of young drivers could be an important starting point in changing driver behaviors to expect a lower level of service during snow and ice events.

As part of the TCMA Chloride Project, an education committee was created to identify the principal audiences for winter maintenance education and discuss potential opportunities and strategies to increase awareness about salt use and associated water quality issues. The EOC included state and local education specialists from the MPCA, counties, the UMN, The Freshwater Society, WDs, WMOs, conservation districts, and MnDOT which met four times over the duration of the TCMA Chloride Project.

The following is a summary of recommendations provided by the EOC and other stakeholders. These recommendations should be considered by professionals in relevant organizations and roles. In addition to the great information and recommendations gathered from local education specialists, there is a need for government and citizens to collaborate to make effective policy choices for reducing salt use.

Strategies for Education and Outreach

- Share winter maintenance success stories that reflect people who have made positive and measurable changes. Create a recognition award program to acknowledge organizations that have made efforts to improve winter maintenance practices.
- Share Smart Salting training for Small Sites, and Improved Winter Maintenance: Good Choices for Clean Water videos.
- Provide information on hiring certified winter maintenance contractors to condominium associations, townhouse developments, etc. The NMCWD (ninemilecreek.org) created “Hiring a Snow Removal Service” brochure.
- Develop seasonal salt messages for radio public service announcements.

- Create targeted messaging such as information wheels or videos for gas stations, home improvement stores, hardware stores, and other stores that sell deicers; create winter maintenance tips for products, like shovels.
- Create a system for the public to report excessive salt use. The system could be used to notify users of excessive use reports.
- Incorporate education on chloride into pre-existing community events (e.g., National Night Out) as much as possible, rather than expecting the public to attend a separate event about road salt.

Winter Maintenance Training

- Provide Smart Salting training for school maintenance and grounds directors. The NMCWD developed Winter Maintenance on School Grounds Workshop to train building and grounds directors on proper winter maintenance techniques for entrances, sidewalks, and parking lots.
- Provide training for private applicators and offer it at events such as the Northern Green Expo.
- Develop and implement a train-the-trainer and/or mentorship program. Provide opportunities for winter maintenance professionals to share changed practices and lessons learned at expos, trainings, etc.
- Create and implement a program similar to the Canadian program "Smart about Salt": www.smartaboutsalt.com. A similar program would allow schools, apartment complexes, condominiums, government, commercial properties, etc. to become certified. Benefits are cited as quality for insurance premium discounts and stormwater credits offered to certified sites within certain municipalities.

Strategies for Recruiting for Training

- Include a letter or a link to a short online video with the training brochure explaining the importance of the training and include a list of example BMPs.
- Prioritize recruiting individuals who perform winter maintenance activities on large parking lots, such as malls, hospitals, universities, etc. that drain to waterbodies.
- Promote trainings at events such as the Northern Green Expo, and at non-environmental events to target different audiences. Adjust emphasis and message (e.g., cost savings, habitat, etc.) depending on event and audience.
- Recruit individuals who have received funding for past projects (e.g., rain gardens) and/or individuals that have applied for permits for construction activities.

Legislative Strategies

- Create an ordinance for the city's legislative and administrative code that addresses certification of winter maintenance applicators, similar to the Lawn Fertilizer and Pesticide Application code.
- Introduce legislation that provides protection for slip and fall lawsuits for private applicators that are certified through the Smart Salting training program.
- Require all commercial applicators to receive the MPCA's Smart Salting training. Provide training remotely through webinars for applicators outside the TCMA.
- Apply a salt tax to annual vehicle registrations that could be used to implement salt reduction strategies.

Demonstration Projects

Demonstration projects can be used to test the organizing approaches for building partnerships between citizens and government or property owners to work together to solve the challenge of chloride use and water resource impairments. The demonstrations will likely be most successful where community capacity around environmental issues exists. Local leaders should be supported to experiment with building partnerships across sectors to co-develop strategies for chloride reductions by municipalities, businesses, and households. The demonstrations can employ pre- and post-evaluation to determine whether the approach achieves meaningful outcomes over time. The outcomes will determine whether the efforts should expand past the pilot stage. If defined outcomes are significant, the plan should be developed to scale to metro-wide and beyond application.

3.5 Success Stories

Reductions in the use of deicing salt are possible through smart salt use and adoption of winter maintenance BMPs. Many winter maintenance organizations have already begun implementing salt reduction practices across the state. Examples of local efforts to implement smart salting strategies are included in this section to provide ideas that may work for other winter maintenance programs and to highlight the great work already being done.

Maintenance Decision Support System and Automatic Vehicle Location -- MNDOT

Curt Pape presented this information at the 2012 Road Salt Symposium.

The Automated Vehicle Location (AVL) uses GPS equipment to track where and how much salt is applied. The Maintenance Decision Support System (MDSS) is used in conjunction with the AVL will use multiple factors to decide when, where, and how the salt should be applied. The average savings achieved through the use of the MDSS and AVL is 53%.

Example

Over 11 ice and snow events, a total of 71,745 tons of salt was applied at a total cost of $4,356.351. Using the projected average savings from implementing MDSS and AVL of 53%, the total savings would be approximately $2,308,866, which would also prevent over 38,000 tons of salt from entering lakes, streams, wetlands, and groundwater.

Dakota County

This information was taken from the *Dakota County Smart Salting training KAP Study Report* (Eckman et al. 2011).

The snowplow drivers in Dakota County, Minnesota, attended the MPCA sponsored Smart Salting training course presented by Fortin Consulting and the Minnesota LTAP in 2008. To test the effectiveness and impact of the course, a knowledge, attitudes and practices (KAP) was administered to these drivers before the course to establish how the snowplow drivers approached the job. After two winter seasons, approximately 14 months after the initial training, the same KAP test was administered again to measure any change. Steps were taken to maintain confidentiality of the respondent and to insure the same people were compared. Seasonal and temporary employees were not used in the comparison.

Results

In September 2008, the results of the survey showed that Dakota County plow drivers had good general knowledge and good practices, but they were in need of some improvement. While the drivers were aware of the county's winter maintenance policy, the independent judgement factor was a little more difficult. For example, only 60% agreed they "minimize the use of deicers during a snow storm." Although this type of information is useful, the goal was to evaluate how effective the training was to actually make a difference in all three facets of knowledge, attitudes, and practice.

The follow up survey in November 2010 showed mixed results. Most importantly, some of the significant improvements were under knowledge and practices.

Question	2008 Response (Yes)	2010 Response (Yes)	+/- percentage change
I minimize the use of deicers during a snow storm	60%	96%	+36%
During calibration I have set the computer speedometer to match my trucks speedometer.	40%	73%	+33%
I use an application rate chart to determine the amount of salt/sand to apply	35%	76%	+41%
I avoid using road salt when pavement temperature is below 15 degrees F	27%	88%	+60%
I document my winter maintenance actions	73%	69%	-4%
The policy encourages plowing before two inches of snow accumulation	92%	84%	-8%
Equipment is calibrated for each type of deicing material used	92%	88%	-4%
I have ground-speed controlled sanders-the auger is installed and working	84%	77%	-7%
I plow before applying deicers to minimize the dilution of the chemical	96%	92%	-4%
I avoid salt/sand mixes	72%	68%	-4%

The areas that showed declines were areas that either additional training or clearer policies could produce better outcomes. The majority of the questions indicate there has been a positive shift in knowledge, attitudes, and practices since attending training. In addition to the KAP survey, the amount of actual salt has been reduced to further underscore the success of the training. The county used an average of 405 tons of salt per snow event in 2007, the winter season before attending the training. Post training, the county reduced their usage by about 50 tons per event to 355 tons of salt per snow event. This reduction correlates to about 40 million gallons of freshwater protected from chloride contamination per snow event.

Scott County

This information was supplied by Scott County.

The past practice of Scott County was to use a mixture of 1:1 sand and salt that was applied with uncalibrated spreaders. No policy or guidelines were in place for mixture ratios or spread rates.

The county started a training program for the supervisors and operators to familiarize them with the effectiveness of salt depending on pavement and air temperatures. After attending the training, treated salt was added to the county's material options. Each plow truck was supplied with information about the route, how many lane miles, and tables for each material and its spread rate based on the temperature.

It took several events to convince the members of the team of the effectiveness. There was not an instant buy-in from the drivers, but after several events, most of the drivers were impressed with the results using the treated salt. During the course of 8 to 10 events, the usage of the sand and salt declined. The winter maintenance teams stopped using the sand/salt mixture, although small cities and townships continued to purchase the sand/salt mixture from Scott County.

Results

By implementing the new practices and policies, the drivers found a single load, or less, was enough to treat the route. Anecdotally, the drivers reported the usual practice would be to apply three or four truckloads of the sand/salt mixture in a single event. The County estimates that 1,500 to 2,000 pounds of the sand/salt mixture was applied per mile lane each event. After the change, the usage dropped to about 424 pounds per lane mile per event. The savings of over 1,000 pounds per lane mile paid for the increased costs of the treated salt. This correlates to a 25-30% reduction of chloride entering lakes, streams, wetlands, and groundwater. Scott County maintenance believes this is the most economical and environmentally sound approach available.

St. Louis County Public Works Department

St. Louis County began working on reducing salt contamination by erecting dome buildings and coverall type buildings where they store their salt and sand. This has been accomplished by the county alone and through partnerships with Net Lake Indian Reservations, Hibbing, Ely, and the state. They now have all of their salt and sand supplies covered. Hibbing, Pike Lake, and Ely have built-in storm water drainage ponds to stop runoff into lakes and streams.

In 2008, trucks with calibration technologies were purchased to make the application of materials more precise. They will continue to purchase trucks with this technology. In addition to this technology, the newest trucks in the fleet have pre-wetting equipment and GPS/AVL technology. Forty-six trucks purchased prior to 2008 have been retrofitted with the calibrated controls and pre-wetting equipment. Plans to add the GPS/AVL have been made, depending on available funds. St. Louis County has expanded their salt brine making capabilities to five additional facilities by partnering with MnDOT to share capabilities in Hibbing and Pike Lake.

Expectations

St. Louis County currently uses approximately 19,265 tons of salt each year and 67,440 cubic yards of sand, at a cost of around $1,207,338 and $202,320 respectively. Through the addition of new equipment and implementation of better practices, St. Louis County projects they will reduce their salt use by as much as 45%. The projected monetary savings is $634,346 per year. The environmental savings is the prevention of 8,669 tons of salt from entering the environment, and saving 7 billion gallons of freshwater. By reducing the application of the less effective sand/salt mixture, St. Louis County will be responsible for reducing 30,348 cubic yards of sand from entering the rivers and streams.

City of Cottage Grove

Cottage Grove saw a significant decline in salt usage after attending training. Their usages for the past few years, per event have declined steadily.

- 2009/2010 = 1,987 tons of salt used (71 tons/event)
- 2010/2011 = 2,083 tons of salt used (75.9 tons/event)
- 2011/2012 = 1,320 tons of salt used (57 tons/event)
- 2012/2013 = 3,019 tons of salt used (67.1 tons/event)

Results

The City realized a savings of 694 tons of salt for the 2011-2012 winter season. This translates into a savings of $40,000 in one season.

City of Eagan

This information was gathered from Tom Struve’s presentation notes, 2011.

The city of Eagan discontinued mixing sand and salt in the 2005-2006 winter season. Without dropping the level of service to residents, the city was able to eliminate a five year average purchase of safety grit. The elimination of the 3,249 tons of grit led to a 65% reduction in spring street sweeping hours. This elimination saved Eagan $70,000 per year.

In 2008, Eagan began using EPOKE winter chemical application technology. This enabled the city to use a precise chemical application of up to 90 gallons of brine per one ton of salt and realize immediate improvements. Also, the addition of AVL allows snowplow drivers to inform the police of the location of cars remaining on the streets during snow emergencies. The police receive a map by 8:00AM showing the exact location of the cars, which makes the mechanical removal of snow much more efficient and effective for the snowplow drivers.

The city of Eagan implemented additional practices including: pre-wetting material at the spinner; using salt brine to 10-15 degrees and substituting magnesium chloride when the temperature falls below 10 degrees; limited uses of Clear Lane for severely cold temperatures; and, managers directing the lane mile calibrated application rates. Eagan still has a stockpile of sand, which they rarely apply. Most importantly, Eagan has the buy-in of the operations staff, which has been very important for their success.

Despite the new practices, the level of service that Eagan provides for residents remains high. The residents have high expectations for winter road maintenance and Eagan has been able to make changes to reduce salt use, while also meeting the expectations of the community.

City of Minnetonka

The winter maintenance operators and managers for the city of Minnetonka are committed to the need to reduce salt to protect the environment. This city delivers high service and the residents expect excellent service. Minnetonka Public Works maintains 254 centerline miles of streets which includes 562 cul-de-sacs. During full scale snow events of 2 inches or greater, 20 plow trucks, 2 loaders, and 7 pickups are mobilized to perform snow removal.

Prior to the 2010-2011 winter season, Minnetonka installed a Cargill Accubrine automated brine production system. The system can blend up to two other products with the brine produced to aid in temperature suppression of the brine when needed. There are five 6,500 - gallon tanks to store the finished products or purchased additives. The City currently uses a corrosion inhibited 32% calcium chloride to pre-wet salt when temperatures are below 15 degrees F. Outside agencies, including Hennepin County and neighboring cities, purchase brine for use. The brine is used to pre-wet the salt before it is applied to the road and for anti-icing prior to a snow event.

Prior to snow events, Minnetonka uses a 2,000 gallon tanker truck and a truck with a 900 gallon tank that are used to pretreat the highest volume streets with brine at a rate of 30-35 gallons per lane mile. The fleet is currently being retrofitted with new technology: pre-wetting equipment, on spot chains, Force America data, and AVL.

All 20 plow trucks and 1 spare truck in the snow fleet are equipped with ground speed controllers to accurately apply and track salt used. The trucks are also equipped with brine tanks so that the salt that is discharged from the trucks is treated with brine at a rate of 10 gallons per ton of salt.

The City subscribes to a web-based weather service that provides a 48-hour weather forecast which is updated every hour. Information provided includes air and pavement temperature, wind speed, dew point, snow and ice accumulation totals and rates/hour, when the precipitation will start and stop, and also provides recommendations for salt and liquid application rates. This information supports decisions for properly staffed crews for the event, application of anti-icing liquid, and the application of the correct liquid for pre-wetting the salt. City staff can compare information from around the state with regards to road temperatures, wind speed, and radar to see how an approaching storm will affect Minnetonka operations.

The AVL is used on all mobile snow equipment to track vehicle location and salt application. A real-time, citywide map shows progress of snow removal operations and allows movement of plows around the City to address any missed areas or areas that are running behind schedule. The system will also send an email notification if an error occurs with a salt controller on a truck. Depending on the status of the plowing and storm, staff determines whether to bring the truck in for repair. Even if in an error state, the controller is able to track salt application provided the spreader is functioning. Four trucks are equipped with air and road temperature sensors which are monitored through the AVL system.

Results

The city of Minnetonka has achieved its goal set by the Nine Mile Creek Watershed during the 2010-2011 season. They reduced application of salt to 4.2 tons per mile from 7.022 tons per mile. This was a reduction of 180% during a normal season.

Minnetonka is focused on improving the use of liquids. For the 2012-2013 winter season, the trucks averaged 3.5 gallons/ton of brine for pre-wet and the city realized that the nozzles were not calibrated for the gravity application system. The nozzles are now calibrated along with the salt controllers before winter and the average for 2014-2015 increased to 6.2 gallons/ton. This is still below the 10 gallons/ton rate the trucks are calibrated for but it is improving.

Norwood Young America

This information was provided by Freshwater Society, 2014 Environmental Leadership Award on February 6, 2014.

In 2009, Norwood Young America city employee's attended an ice and snow workshop where they learned the importance of calibrating equipment. In 2010 staff attended another workshop on snow and ice control practices. After training, the city purchased tanks for pre-wetting salt. Through the implementation of recommended practices and attending the Smart Salting training, the city was able to reduce their salt usage by almost half in 2010. On average, the city had been using about 600 tons of salt per year.

After training, the city averaged 350 tons per year, saving $17,500. This success has encouraged the city to continue to improve their operations and practices.

City of Plymouth

The city of Plymouth began implementing salt reduction practices in 1996 by implementing the use of brine. At first, brine was used on a limited basis, but expanded through 2004. The city began implementing anti-icing and expanded its application by purchasing a 1,300 gallon tank in 2007. The AVL technology was added to the vehicles in 2009 to track the routes and salt application. The city continues to improve, and in 2014 purchased its most recent 1,300 gallon brine tank for anti-icing.

Results

As with many municipalities, it is difficult to track the reductions with absolute certainty. The City has experienced growth in excess of 30% since the mid-nineties. Granular salt use has been decreased by 40% despite this growth. Despite the 40% reduction in granular salt, it should be noted that there is still salt applied in the form of brine for anti-icing. The City estimates that the overall reduction, since the mid-1990s, is approximately 25%

City of Prior Lake

The information provided below is based on information provided by the city of Prior Lake for the 2010 American Public Works Association Excellence in Snow and Ice Control awards ceremony. The city of Prior Lake maintains approximately 100 center lane miles of street with 10 maintenance personnel and one supervisor.

Starting in 2003, Prior Lake implemented a winter maintenance program which includes:

- Staff education and development
- Anti-icing before events to reduce removal time
- Pre-wetting to deliver salt more efficiently at lower concentrations
- Upgraded controllers and sanders that allow flexibility for precise applications Pre-mixed chemical storage that allows on-site storage of three ready- to-use mixes and bulk storage of critical ingredients
- Liquid mixing and transfer equipment

Education

The staff buy-in and support was critical to the success of this program. Education was important for this; they started with supervisor training and researched other programs. Various training programs were attended or used including: LTAP, CTAP, Manual of Practice for an Effective Anti-icing Program, APWA Anti-icing/RWIS CD, AASHTO Clear Roads CD Series, and attending an APWA Snow Conference.

Since 2003 to 2011, the City invested about $250,000 in the program, including a $50,000 building addition. They recognized that the right equipment is the key to providing the flexibility to apply the right chemicals, in the appropriate amounts by the most efficient method.

Chemicals and Storage

Depending on conditions, Prior Lake keeps pre-mixed chemicals ready for use and bulk materials on hand. This allows the City to pre-mix and modify operations depending on weather conditions. Using the best available weather data for preparation and monitoring actual ground temperatures during operations is critical.

- Bulk materials include brine, beet juice, magnesium or calcium chloride, and molasses
- Pre-mixes include liquids for anti-icing and pre-wetting above and below 15 degrees

Application Equipment

Equipment upgrades can be phased in over time. Prior Lake took seven years to fully upgrade the fleet. The new 5100/6100 controllers and new sanders can apply pre-wet material at rates down to 85 pounds per lane mile. Liquid application units can also apply at below 100 pounds per lane mile rates. Upgraded equipment includes:

- Controllers
- Salt Sanders
- Evaluate plow configuration to further optimize
- On-board liquids

Liquid anti-icing operations increased removal efficiency. The City found that applications are effective for 7-14 days after application, depending on the type of mixture and conditions. Equipment was also used for a liquid-only route with deicing application rates of less than 100 pounds per lane mile.

Efficient truck design and equipment including Elliptical Box, 200 gallons of Liquid Storage, Falls Salt Special Material Applicator, Force America 6100 Controller, and bed tarp allows for more efficiency with application rates of pre-wet salt as low as 85 pounds per lane mile.

Results

Prior Lake had a reduction of average application rates from 500 pounds per lane mile of salt in 2005 lane to 200-250 pounds per lane mile using pre-wet salt in 2010.

- Added an all liquid route with application rates equivalent to 100 pounds per lane mile or less.
- Observed chloride level reduction in controlled watershed of 20 – 40 mg/l with all liquid program
- Reduced staff time for snow removal and maintenance
- Overall salt use reduced 42% since 2005 even with an additional 7% increase in mileage maintained.
- Minimum estimated savings per snow removal event $2,000 (salt, labor, equipment).
- Maintained safety and increased level of service.

Future Plans

- No chemical application routes, blade cutting edge technology advances
- Pre-wet application rates of 100 pounds per lane mile
- Expand liquid only routes
- High Priority Chloride Reduction Zones designations

Rice Creek Watershed Cities

This information was taken from the Six Cities Chloride Reduction Project. (http://www.ricecreek.org/vertical/sites/%7BF68A5205-A996-4208-96B5-2C7263C03AA9%7D/uploads/Road_Salt_Reduction_5-17-13.pdf)

The city of Centerville, after attending a winter maintenance workshop, collaborated with Lino Lakes, Hugo, Circle Pines, Lexington, and Columbus to purchase shared anti-icing equipment and to train the staff to use BMPs. The coalition was able to successfully apply for a Rice Creek County Watershed grant of $65,000 to offset the costs. The new anti-icing equipment was used to apply liquid salt brine to 245 miles of paved roadways before the winter storms to reduce the need to apply salt during and after the storm. The training provided to the operators, reinforced the need to apply enough salt for public safety, but to avoid applying unnecessary amounts to pollute. The coalition plans on using the savings on materials to continue to fund the operational costs and program maintenance.

Results

In the 2012-2013 winter season, the six participating cities reduced their salt use by 528 tons, or a 32% reduction based on the previous monitoring data. The six cities saved a combined total of $26,400 in a single winter, based on a conservative cost estimate of $50/ton of salt.

City of Richfield

The information provided below is based on information presented at the awards ceremony at the 2013 Road Salt Symposium (Freshwater Society 2013).

In 2009, the NMCWD began a TMDL Analysis and Report process for the chloride impairment identified for the Nine Mile Creek. By 2010, they had prepared a draft TMDL report that called for a 62% reduction of salt application by the NMCWD MS4 cities, including Richfield. Along with other agencies, Richfield's reaction to the reduction was the requirement was not only unreasonable, but impossible. They believed that public safety would be compromised and that the goal was too far to take seriously. However, the City eventually came to accept that they had to make efforts toward reducing salt usage.

The City Engineer learned that the NMCWD was working with Fortin Consulting and the LTAP to offer the free MPCA Winter Maintenance Certification Training. After attending the training the City Engineer found the training to be excellent. The entire snowplow operations staff was immediately enrolled in the next available training and all of the snowplow operators that plow parking lots have attended the MPCA Winter Parking Lot and Sidewalk Maintenance Training.

Despite the pride and effort that Richfield's winter maintenance staff has in their work, the training showed them many ways to improve their operations. The education, along with the dedication of the staff, created a sense of urgency to change their practices and make the needed improvements. The changes needed were relatively small and simple to implement quickly

Richfield's salt application process changes were:

- Calibrating all sanders every year
- Applying salt to the crown of the road only
- Determining application rates by road temperatures/weather conditions
- Using alternative materials for low road temperatures
- Adjusting policies for minor arterial roads

These small changes reduced the amount of salt applied to roads by over 50%. It is projected this will improve over time, bringing the city closer to the TMDL of 62%. The Richfield operators have traditionally taken great pride in their work; the additional training provided them with the understanding of the importance of reducing salt for the environment and not just cost savings shown below.

- 2010-2011--$30,000* in salt because of the trained crew, calibrated equipment, and correct application rates
- 2011-2012--$70,000* saved in salt; new addition was adding the pre-wet product, "Ice Slicer"
- 2012-2013—no savings (many more ice events than the previous years)
- 2013-2014—no savings (many more ice events than the previous years)
- 2015-2016—the operations superintendent expects to see savings compared to previous practices

*The cost savings were based on the 2009-2010 price of salt.

City of Shoreview

This information was supplied from the city of Shoreview in 2015.

In 2006, the city of Shoreview stopped using a mixture of sand and salt and began using straight salt. This was the beginning of a continuous effort to reduce chloride.

Shoreview's applicators and their supervisors each attend the annual "Snow and Ice Control Best Practices" training and are certified through the MPCA. The crew attends an annual meeting to discuss and review procedures and conservation methods. The operators are trained and allowed to make adjustments based on conditions and the pavement temperatures. The MPCA materials, guidelines, and BMPs have been successfully used throughout this effort.

A snow event begins with the city's crew monitoring the surface temperature and road conditions. This information is critical to following their BMPs and application guidelines. This practice allows for preparation for the storm and the application of anti-icing to reduce the ice that requires treatment during and after the storm.

The goal of the anti-icing procedure is to apply calcium chloride to at least 28 lane miles of roadway before the storm to reduce the buildup of ice and allow for cleaner plowing. All of the city's trucks are equipped with state-of-the-art spreading controls, pre-wetting tanks, and pavement sensors to ensure that each truck is calibrated and efficient. The use of the pre-wetting calcium chloride reduces the need for rock salt and minimizes the loss of salt from bounce or vehicle distribution. Pre-wetting allows the salt to be effective at lower temperatures.

Results

The three-year average salt use for 2006-2008 was 786 tons and in the period of 2009-2011 the average amount of salt used dropped to 437 tons. The reduction continued during 2012-2014 to 444 tons. Although the tons of salt appear to increase, there were more snow and ice events during the 2012-2014 period. The total reduction of salt since 2006 is approximately 44%. The cost savings for 2014 is estimated at approximately $24,468.

City of St. Paul

This information was provided by Freshwater Society, 2014 Environmental Leadership Award on February 6, 2014.

St. Paul Street Maintenance has changed and updated its snow maintenance practices and equipment to reduce salt, increase driver safety and improve the service level. The city created its first Snow Plan in 2011 through the collaboration of the maintenance staff.

The following equipment has been upgraded:

- In 2011, the decision was made to make salt reduction a priority when selecting equipment
- The salting equipment was upgraded with electronic controls—95% of the city's trucks were equipped with electronic spreader controls (90% increase)
- Trucks were upgraded with pre-wetting systems over two years (50% increase)
- All trucks with electronic controls were equipped with AVL to monitor and correct salt usage
- All trucks are calibrated before the season

Between 2012-2013, the following training was completed:

- By 2012, 95%, and by 2013, 99% of the staff and leadership had successfully completed the MPCA Winter Maintenance Certification training
- In 2012, six supervisors successfully completed the APWA Winter Maintenance Supervisor Certification training. Three more were certified in 2013.
- The vendor performed small group training for 92 workers and supervisors
- In 2013, 170 employees attended a two-day snow operations training program

Results

The city has had an average salt reduction of 30% per event over the past five years. The purchase of salt was reduced over the five years from 24,000 tons to 16,000 tons.

City of Waconia

The information provided below is based on information presented at the awards ceremony at the 2013 Road Salt Symposium (Freshwater Society 2013). The city of Waconia Public Services Department completes winter maintenance activities on 56 street center lane miles, portions of 14 miles of concrete sidewalk and 13 miles of bituminous trails.
Prior to the winter season, City staff attends an annual winter preparations meeting. They review the Winter Maintenance Policy, route assignments; discuss material use, and the service level expectations. All spreaders are calibrated for liquid and solid material applications. Calibration charts are prepared and placed in each vehicle for user review.

In 2010, the staff updated their 1999 “Snow and Ice Policy” to a “Winter Maintenance Policy.” The document title expresses a different, proactive approach to events. In the past, the city had a reactive approach to storms. The City changed from a 1:1 sand/salt mixture to straight salt and liquid anti-icing practices. Additional items reflected in the policy included:

- Service level expectations for streets, sidewalks, trails, parking lots, and downtown snow removal
- Additional ordinances reflecting policy guidelines
- Right-of-Way uses, including mailbox placements
- Description of operation commencement, use of air and pavement temperatures, and anti-icing practices
- Tips on resident snow storage, or maintaining a “snow pocket,” for driveway cleaning

By implementing calibration and equipment changes, the staff has been able to reduce materials rates of salt per-pound by 70%. Using pre-wetting practices and saving material by application rates based on weather and pavement conditions have saved $1.80 per-lane-mile and a yearly savings of $8,600.

As part of the winter maintenance practices for sidewalks and trails, the staff took the initiative to switch from hand-applied and truck-applied chloride products to liquid applications only. The staff conducts anti-icing and deicing activities as needed on sidewalks and trails leading to substantial savings. The staff obtained a “Local Operational Research Assistance Program” grant for $5,000. The research found a savings of 70% for activities related to recreational critical areas through the use of liquids for trails and sidewalks

University of Minnesota, Twin Cities

The information provided below is based on information presented at the awards ceremony at the 2007 Road Salt Symposium (Freshwater Society 2007) and updated by Doug Lauer, a Landcare Supervisor with the University. The UMN Twin Cities Campus made changes to their winter maintenance program starting the winter of 2006. They began making their own salt brine and anti-icing and adopted several other salt reduction BMPs. The resulting reductions for each winter maintenance material are listed below in Table 10.

Table 10: UMN – Twin Cities Campus – Winter Maintenance Improvements

Material	Tons/Year Used (1997-2005)	Tons/Year Used (2006-2008)	Tons/Year Used (2008-2014)	Reduction	Notes
Rock Salt	775	262		40%	
Ice Melt ($MgCl_2$)	131	64		51%	Changed from $MgCl_2$ to $CaCl_2$ in 2008
Ice Melt ($CaCl_2$)	131 ($MgCl_2$)		59	55%	
Sand	1965	20		99%	

In addition to salt reductions, they invested about $10,000 in new and saved $55,000 the first year the BMPs were implemented. The UMN used an average of 1,965 tons of sand from 1997-2005; in 2006 to 2008, it was reduced to 18 tons. This is a 99% reduction. Between 2009 and 2014, the UMN used an average of 21 tons of sand in this five year period, showing a continuing decline.

The UMN continues to use brine to treat before the storm, as indicated in Table 10. The staff is aggressive with mechanical removal using blades and brooms. A change was made from magnesium chloride to calcium chloride because it mixes better with sodium and doesn't clog their equipment when changing products. The product contains less corrosive beet juice.

Joe's Lawn & Snow

Joe's Lawn and Snow is a small lawn and winter maintenance company located in the TCMA. The following information was provided by Joe Mather, owner.

Joe's Lawn and Snow plows and treats both sidewalks and parking lots. Prior to attending the MPCA Winter Maintenance Certification class, the staff relied on manufacturer recommended application rates and best judgment for application rates. Joe Mather attended the certification class in the winter of 2013-2014 and sent four employees. Joe and his staff were able to implement the practices learned in the first year.

Practices implemented included:

- Purchased new spreader
- Calibrated equipment
- Made a bowl to catch any excess salt at spinner and reuse
- Adjusted the spreader to even the spread and prevent salt piles
- Reduced application rates
- Tested the results of application rates and continued to refine
- Purchased hand-held and truck mounted temperature sensors
- Used temperature to help determine rates and materials
- Identified drainage patterns and appropriate snow storage areas before the season
- Used sediment traps to contain solids in runoff and subsequently cleaned out manholes
- Experimented with anti-icing using liquids and plans to continue experimenting

Results

These changes, implemented for the last half of the 2013-2014 season, resulted in a reduction of salt by about 50% and did not reduce the level of service. Based on the 2014 cost of salt per ton, this saved Joe's Lawn and Snow $770 in material costs.

3.6 Cost Considerations and Funding Opportunities

The potential costs of reducing chloride loads and potential funding opportunities s are discussed.

Winter Salt (applied to Roads, Parking Lots, and Sidewalks)

The assessment of costs and economic benefits associated with chloride uses and its impacts is complex. One thing is certain, removing chloride from impaired lakes, wetlands, and streams through RO or distillation is impractical and cost-prohibitive; therefore, prevention or source control is the logical approach.

Application of salt in winter months is currently the most commonly used method of maintaining safe roads, parking lots, and sidewalks. The economic benefit of safe travel is hard to measure. Economic benefits also from reduced work-loss time. The various economic impacts and benefits are shown in Figure 34 and discussed briefly below. Though salt is one means of reducing accidents and work-loss time resulting from winter weather other means are available. Slower speed limits during snow events are one such option.

The economic impact of salt use goes beyond the environmental and includes costs associated with damage to transportation infrastructure, vehicle corrosion, and vegetation damage (Fortin 2014).

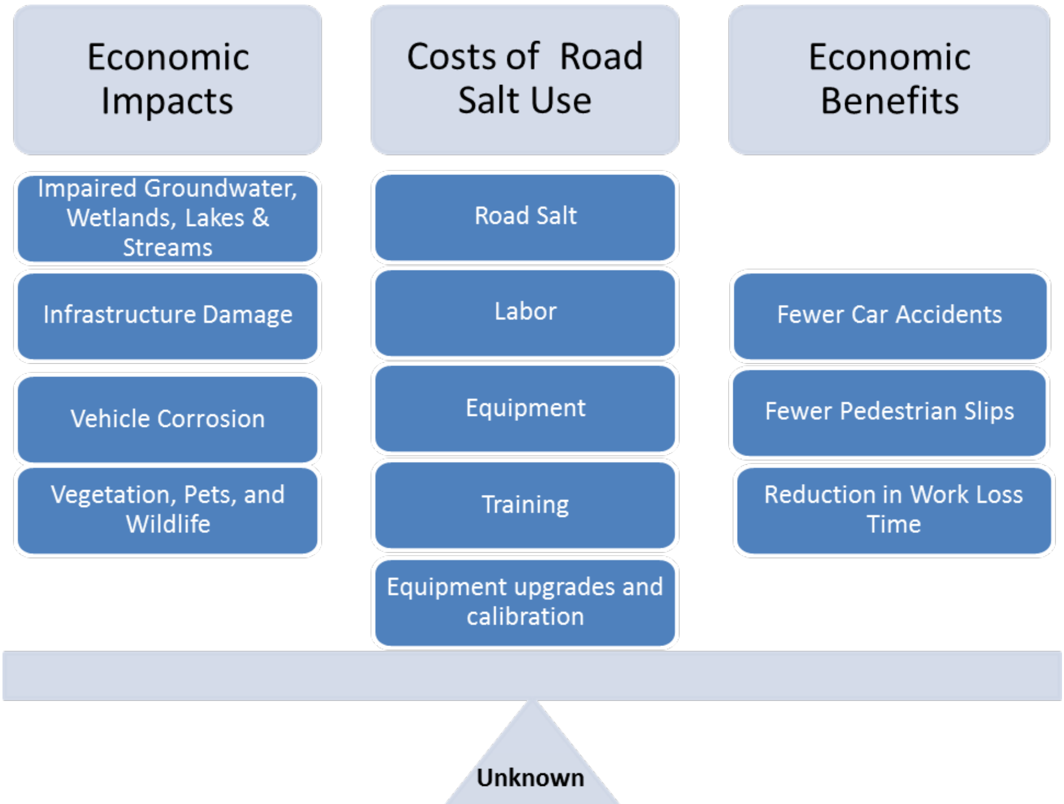


Figure 34. Cost Considerations Related to Salt Use

Efficient winter maintenance practices can reduce salt use without lowering the level of service. The improved practices are intended to maintain a consistent level of service in terms of safe roads, parking lots, and sidewalks with lower salt use. Implementation of improved winter maintenance activities may come with an initial investment cost to address training, new equipment, and public outreach. However, as a result of reduced salt usage, a cost savings is expected based on information provided by several local winter maintenance organizations. A net cost-savings has been shown by many organizations who have tracked cost before and after the implementation of winter maintenance BMPs. Table 9 provides examples of tracked cost savings associated with the implementation of various salt reducing BMPs by local winter maintenance organizations. Detailed descriptions of these cost savings examples can be found in section 3.5 of the CMP. The cost estimates provided in Table 11 reflect implementation of a variety of BMPs with multiple activities applied simultaneously. The information provided in Table 9 is not intended to be a reflection of cost for any one practice but rather an overall estimate. Each organization will implement practices that are most appropriate for their individual operations and there is not a one-size-fits-all approach when it comes to winter maintenance; therefore, the costs will vary greatly across organizations.

Table 11. Examples of Municipal and Private Cost Savings

Entity	Implementation Period	Main Actions Implemented	Salt Reduction	Cost Savings
University of Minnesota, Twin Cities	Start 2006	Began making salt brine and anti-icing and adopted several other salt reduction BMPs.	48%	New equipment cost $10,000 $55,000 cost savings first year
City of Waconia	Start 2010	Switch from 1:1 sand:salt to straight salt & liquid anti-icing; calibration; equipment changes; use of air and pavement temperatures.	70%	$8,600 yearly cost savings ($1.80 per lane-mile)
City of Prior Lake	2003-2010	Upgrade to precision controllers & sanders; anti-icing & pre-wetting; use of ground temperatures, best available weather data; on-site pre-mix liquid & bulk-ingredient storage, mixing & transfer equipment; staff education.	42%	$2,000 per event estimated cost savings; 20 – 40 mg/L decrease in receiving-water chloride (liquid app-only watershed)
City of Richfield	Start 2010	All-staff Training*; yearly sander calibration; use of low-pavement-temp de-icers; road crown-only application; minor-arterial-road policy adjustments.	> 50%	$30,000: 2010-2011 $70,000: 2011-2012
Rice Creek Watershed District Cities	2012-2013	Staff training; purchased shared anti-icing equipment	32%	$26,400 in one winter
City of Cottage Grove	2011-2012	Staff training	Not available	$40,000 in one winter
City of Shoreview	Start 2006	Stopped using a salt/sand mixture and moved on with straight salt; set up all its large plow trucks with state of the art salt spreading controls, pre-wetting tanks and controls and pavement sensors; use of calcium chloride in the pre-wetting tanks reduced the amount of rock salt as well; all applicators and supervisors annually attend *Training; crews attend an annual snowplow meeting to review procedures and talk about salt use and conservation methods; trucks set up for anti-icing main roads with calcium chloride.	44% since 2006	$24,468 in 2014

City of Eagan	Start 2005	Moved from a 50/50 salt/sand mix to straight salt; eliminated purchase of safety grit; EPOKE winter chemical application technology; use AVL; pre-wet at spinner.	Not availab le	$70,000 annual savings
Joe's Lawn & Snow, Minneapolis	Start 2013-2014	Owner & staff Training*; purchase of new spreader, temperature sensors; equipment calibration; use of temperature data; on-going experimentation.	50%	$770 estimated cost savings in 2014 Expected to use 20 tons, only use 9 tons

* Training - MPCA Smart Salting Training (All entities described above have attending the MPCA Smart Salting Training.)

Municipal Waste Water (primarily from Water Softening)

The cost for point source dischargers to remove chloride from their wastestream is very high and is cost prohibitive for most facilities. Below is an estimate of the cost to treat effluent from a WWTP (Henningsgaard 2012):

An estimate for the total cost is $4-$5.25 million:

- Fine filtration - $1.5 million per million gallons treated
- RO - $1-$2.25 million per million gallons treated
- Evaporation technology prior to landfill – $1.5 million per million gallons treated

Annualized cost for construction (assuming 20 year term at a market rate of 2.25%) is between $250,568 and $328,871 per year.

Annual Operation and Maintenance costs:

- Fine filtration – $0.01 to $0.15 per 1,000 gallons treatment
- RO - $2,200 per million gallons treatment
- Evaporator fuel - $10,000 to $12,000 per month

Based on specifics from each community, this cost could be considered to have "substantial and widespread economic and social impact" (40 CFR 131.10 (g) (6)) and could be justification for a variance that would not require this type of expensive treatment. There is no reasonable (environmental and economic) way to dispose of the highly concentrated sludge produced by RO treatment.

The high cost of end-of-pipe treatment for chloride and the high cost and difficulty of final disposal of the brine makes source reduction is a critical element to wastewater treatment of chloride-containing waste streams. In most municipal situations, a major source of chloride is water softeners. The NaCl or KCl is commonly used in the softening process at the WTP and in residential or commercial softeners.

Funding Opportunities

There are available sources of money to offset some of the costs of implementing practices that reduce chloride from entering surface and groundwater. Several programs, listed below, have web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program and funding requirements.

On November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution to:

- *protect drinking water sources;*
- *protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;*
- *preserve arts and cultural heritage;*
- *support parks and trails;*
- *and protect, enhance, and restore lakes, rivers, streams, and groundwater.*

The Clean Water, Land, and Legacy Fund has several grant and loan programs that can be used for implementation of the BMPs, education and outreach, and WWTP modifications. The various programs and sponsoring agencies related to clean water funding and others are:

- Agriculture BMP Loan Program (Minnesota Department of Agriculture)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- TMDL Grant Program (Minnesota Public Facilities Authority)
- Wastewater and storm water financial assistance (MPCA)

The WDs and WMOs may have individual grant opportunities for implementation of the BMPs and education and outreach activities.

The Minnesota Local Road Research Board's Local Operational Research Assistance (OPERA) Program helps develop innovations in the construction and maintenance operations of local government transportation organizations and share those ideas statewide. The OPERA program encourages maintenance employees from all cities and counties to get involved in operational or hands-on research. The program funds projects up to $10,000 through an annual request-for-proposal process. (www.mnltap.umn.edu/about/programs/opera/).

Implementation of the BMPs for this project can sometimes require purchasing and/or upgrading equipment, which does not necessarily fit nicely into the conventional grant and loan programs. Some work will need to be done with the funding agencies in order to make grants and loans available for equipment purchase and/or upgrades.

The Water Environment Research Foundation (WERF) funds water quality research that is funded through a competitive process. Apply for grants for research related projects at: www.werf.org.

There are several grant and loan programs through the federal government for education and outreach and purchasing equipment and implementation of the BMPs. A list of federal grant programs can be found at: water.epa.gov/grants_funding/.

4. Monitoring, Tracking, Reporting, and Adaptive Management

Addressing the issue of the environmental impacts of chloride in the TCMA is a long-term endeavor. Water quality improvements may take time to observe, due to historical loadings, groundwater inputs, variable residence times, and other complicating factors. Continued monitoring of the TCMA lakes, wetlands, and streams for chloride is critical, along with documenting changes in winter maintenance activities, point source discharges, and water softener usage. Continued water quality monitoring along with improved source tracking will allow adaptive management and inform the future steps to restore and protect the TCMA waters. This CMP is intended to be revisited and revised within 10 years based on improved understanding. The update of the CMP will also include new waterbodies that are identified as impaired by chloride.

4.1 Water Quality Monitoring

Addressing the issue of chloride impacts on the environment in the TCMA is a long-term endeavor and it may take some time before water quality improvements are seen due to historical loadings, groundwater inputs, variable residence times and other complicating factors. Therefore, continued monitoring of the TCMA lakes, wetlands, and streams for chloride is critical as well as the need to document changes in winter maintenance activities, wastewater source discharges, and water softener usage. Continued water quality monitoring, along with improved understanding of the sources of chloride will allow adaptive management to take place and inform future steps needed to restore and protect TCMA waters. The CMP is intended to be revisited within 10 years and revised based on improved understanding.

There are a number of organizations across the TCMA that monitor water quality or partner with others to conduct monitoring. In addition the MPCA, Metropolitan Council and the USGS also collect data throughout the TCMA. Incorporating the recommendations below into existing local water monitoring programs will provide valuable data to assist with tracking progress and meeting water quality goals. Monitoring should take place at the existing sites for consistency and comparison purposes. However, since monitoring activities are lead at the local level it will be dependent on available resources and local priorities. We encourage local monitoring data be shared with MPCA by routinely submitting data to the MPCA's water quality database, EQuIS. The monitoring that MPCA conducts across the state follows the 10-year monitoring strategy as described in Minnesota's Water Quality Monitoring Strategy report.

The MPCA has worked with the MSG to develop monitoring guidelines for lakes, streams, wetlands and storm sewers. Monitoring guidance documents are available on the MPCA TCMA chloride project website. The key components of continued monitoring to support the implementation of the CMP include:

- Collect samples during the critical periods for elevated chloride concentrations: January through May for lakes and December through April for streams. However, always put safety first when assessing conditions for collection of samples through the ice.
- Analysis of chloride should also be included in typical summer season sampling. Analysis for chloride is relatively inexpensive and should be included if the effort is being made to collect samples for analysis of other parameters.

- In lakes with potential for stratification collect a bottom sample and surface sample.
- Maintain consistency in sampling. Chloride concentrations may vary from year-to-year depending on the winter conditions. Assessment of long-term trends will have greater confidence with consistent, yearly datasets.
- Collect a matching conductivity reading with each sample taken for chloride analysis.
- Expand the sampling program to additional lakes, streams, and wetlands as resources allow. Many waterbodies in the TCMA have not been sampled sufficiently to make a reliable assessment of potential impairment by chloride.

High Risk Monitoring Recommendations

The MPCA has developed specific guidance for monitoring of the TCMA waters not currently impaired but showing a high risk of impairment. The chronic standard of 230 mg/L for chloride concentration applies as a four-day time average. In practice, impairment is often judged from monthly sampling results when these show a clear pattern of prolonged concentrations exceeding the standard. Weekly or twice-weekly sampling would provide the basis for a clear determination. Long-term sampling at such high frequencies is unreasonably expensive in most cases. Therefore, the MPCA suggests the following guidance for additional monitoring of high risk waters:

1. Identify dates or periods of past chloride concentrations that were either:
    a. Exceedances (exceeded the chronic chloride standard), and
    b. High occurrences, defining high as less than, but within, 10% of the chronic standard (thus >207 mg/L)
2. Select a four-week period centered on each such date or period, and for each:
    a. Sample for chloride weekly, always on the same day of the week
    b. Sample at the same depth or depths as in past sampling
3. If an electrical conductivity meter is available, take and record a matching conductivity reading with each lab sample taken:
    a. matching = from the same primary sample that provides the lab subsample, if the primary sample is a sufficiently larger volume than the laboratory bottle used; or otherwise
    b. matching = same location and depth as the lab sample
4. Possible expanded effort:
    a. Monitor twice weekly rather than once, always on the same days of the week (e.g., Mon and Thu) including, as resources permit:
        i. Chloride sample and conductivity measurement if possible
        ii. Chloride sample only if lacking conductivity meter
        iii. Conductivity measurement only on the increased frequency if laboratory costs limit sampling but a meter is available

To clarify, sampling for chloride at least weekly during the selected four-week period(s) is the necessary minimum effort for ensuring the value of this additional monitoring; conductivity measurements alone will not suffice at present. This could change in the future if a reliable and accurate relationship between chloride and conductivity is developed for an individual waterbody or for an area including the waterbody.

Impaired Monitoring Recommendations (Tracking Progress)

In order to assess high risk waters and waters without data, the MPCA recommends monitoring waters already identified as impaired for chloride less frequently. It is recommended that efforts focus on collecting samples during critical periods. For instance, if the impairment is a result of winter maintenance activities, chloride sampling should be conducted during January through May for lakes and wetlands, and December through April for streams. If the impairment is caused by effluent with high chloride concentrations from WWTPs, monitoring during low-flow periods in the streams should be targeted. If long-term monitoring data has already been collected, less frequent monitoring during critical conditions (monthly or twice monthly) is recommended. If monitoring efforts are limited by costs and a site-specific chloride-conductivity relationship has been established, the MPCA recommends collecting conductivity measurements during the critical period to track progress.

General Monitoring Recommendations for Waters without Data

At a minimum, collect monthly chloride and conductivity data for waters without data during the critical period. If possible, expand the effort to weekly sampling during the critical period, and include chloride in typical summer season sampling efforts. For lakes with a potential for stratification, collect a bottom and a surface chloride sample. If it is determined that these waters meet the high risk criteria, the MPCA recommends following the monitoring guidelines for high risk waters.

4.2 Tracking and Reporting Implementation Efforts

Measuring water quality in the TCMA and monitoring chloride loads in the lakes, wetlands, and streams is critical to understanding progress toward the ultimate goal of restored and protected lakes, wetlands, and streams. However, these types of measurements alone will not be sufficient to demonstrate the progress made in implementing individual salt reduction efforts and accomplishments taking place throughout the TCMA to reduce chloride. Tracking of implementation activities is needed to assess the related benefits to water quality, take credit for making progress, and identify areas where additional effort is needed.

The approach to tracking implementation efforts will vary by the source type. The WMAt will be an option available to any winter maintenance group and will support a consistent approach to tracking and reporting winter maintenance activities.

Treatment facilities holding an NPDES Permit will be required by permit to monitor for chloride for an initial term. If the effluent shows no reasonable potential to contribute to or cause violations of the chloride criteria, monitoring requirements may be dropped. For facilities where monitoring shows elevated chloride concentrations, the MPCA will work with the individual facility to determine a course for reducing chloride loads. Where residential water softeners are a major contributor to elevated chloride concentrations, educational and outreach efforts and implementation of water softener buy-back programs should be documented.

4.3 Adaptive Management

Implementation of a TCMA CMP, which includes 186 cities and townships and seven counties as well as colleges, universities, private industries, commercial property owners, school districts, private homeowners, and others, can only be accomplished by maintaining flexibility and adaptability within the overall approach. It should be understood that the water quality goals and chloride loads presented in this plan are estimates based on the best available science.

Adaptive management is an approach that allows implementation to proceed in the face of potentially large uncertainties. Adaption allows the implementation plan to be adjusted in response to information gained from future monitoring data and new or improved understanding of related issues. The adaptive implementation process begins with initial actions that have a relatively high degree of certainty associated with their water quality outcome. Future actions are then based on continued monitoring of the TCMA water resources and an assessment of the response to the actions taken.

The TCMA CMP is a prime candidate for an adaptive implementation process for a number of reasons. First, the scale, complexity, and variability of chloride sources within the area make a traditional implementation plan (i.e., one that identifies the specific implementation activities required to attain the TMDL) impractical. Second, there will likely be a time lag between reduction of external loads and the response of the system, and there will be year-to-year variability in the monitoring results. Finally, the TMDLs focused on the problem of high chloride loads and its current sources. However, restoration and protection of the TCMA water resources will require a planning framework that recognizes potential future threats such as changing deicing products, driver expectations, climate change, and population increases. For these reasons, implementation of the TCMA CMP will be conducted within an adaptive framework. The primary steps in the adaptive management framework are presented in Figure 30. Measurement and evaluation of progress in early years of implementation will be critical to success.

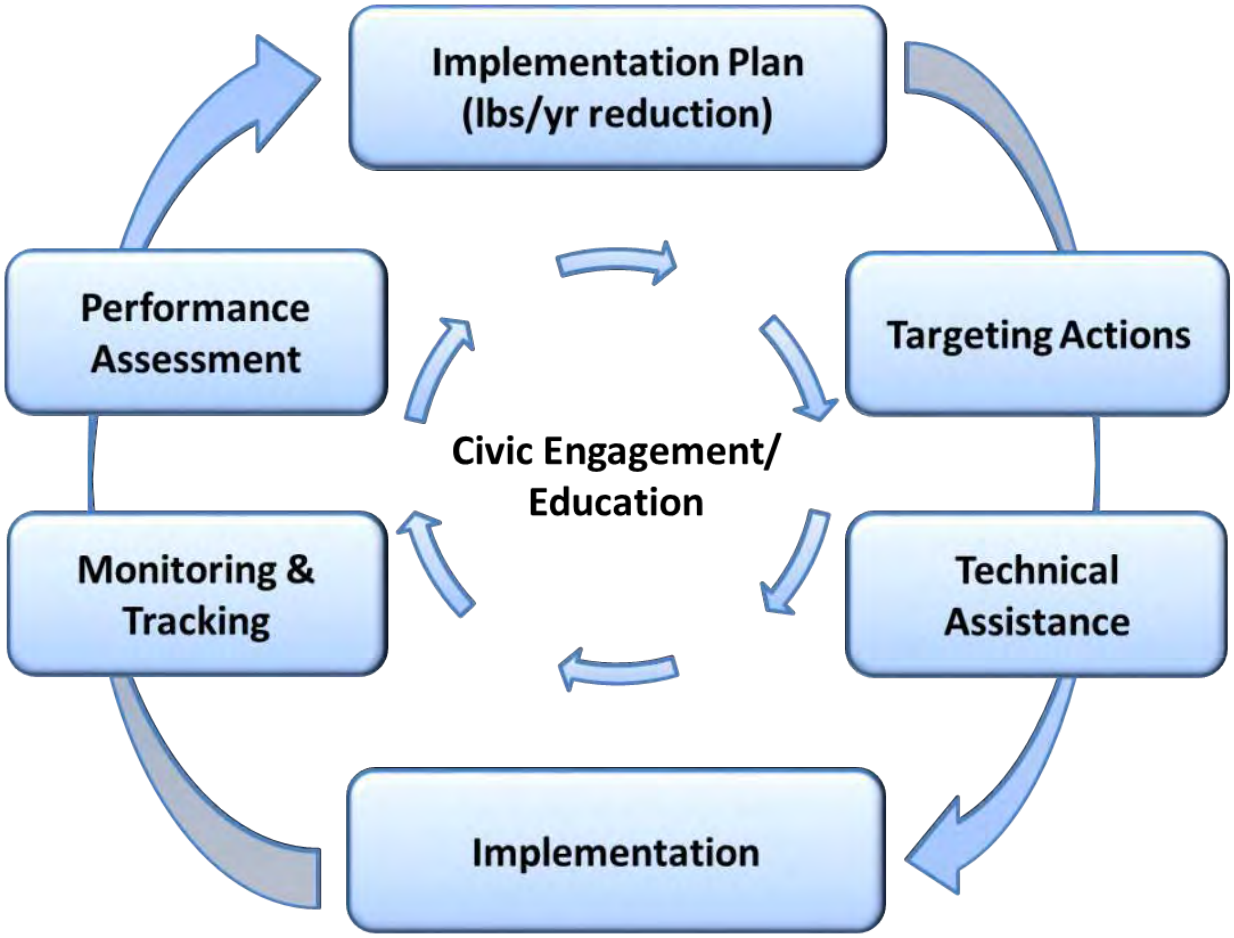


Figure 35. Adaptive Management Framework
Adapted from Washington County Conservation District

5. Research Needs

There are still many areas related to chloride where additional research and information may help to inform management decisions. There are 12 main areas that would benefit from additional information.

1. **Chloride reductions when implementing the BMPs**. The WMAt is the first ever, exhaustive resource of all known salt saving BMPs. The reduction potential for each BMP is largely unknown. The WMAt is limited by available research, in how much of a reduction that can be attained by improving each individual practice. More research is needed on many BMPs to understand how much salt can be saved when the BMP is implemented. The tool contains a list of over 200 BMPs, most of which would benefit from reduction potential research.
    a. For example, an estimated 17% of salt is lost by storing salt/sand pile uncovered over the winter. By implementing the recommended BMP of storing salt/sand pile indoor, there is an estimated 17% reduction potential for that pile
    b. For example, no information is available on the percent salt savings attained from increasing liquid to granular ratio from 8 gallons per ton to 50 gallons per ton. This information may help decision makers select those BMPs that achieve the greatest chloride reduction.

2. **Water softening options.** More information is needed on the effectiveness of various water softening systems at reducing chloride and the relative cost for each. The current available options for possibly reducing chloride from this source includes: converting old home water softening to on-demand softeners; eliminating home softeners with a centralized lime softening; and converting to non-chloride water conditioning in home systems. Developing a better understanding of the cost associated with such conversions would also aid in proper decision-making. Information on potential chloride reductions resulting from a more informed public would be beneficial. This would include a public that knows untreated hardness level, understands reasonably acceptable hardness levels for home use, and sets the water softeners appropriately.
3. **Environmental impacts of non-chloride deicers.** There are many alternative deicers that do not contain chloride; however, all have negative environmental impacts. A thorough review of all practical alternatives that exist with detailed information on the short-term and long-term environmental impacts and how it compares to chloride containing deicers in effectiveness and environmental impacts would allow more informed. Currently research about short term environmental impacts has been done on a variety of chloride and non-chloride deicers by the Clear Roads research consortium.
4. **Citizen attitudes and practices around the use of chloride.** Demonstration projects can be used to test the organizing approaches for building partnerships between citizens and government or property owners to work together to solve the challenge of chloride use and water resource impairments. The demonstrations will likely be most successful where community capacity around environmental issues exists. Local leaders should be supported to experiment with building partnerships across sectors to co-develop strategies for chloride reductions by municipalities, businesses, and households. The demonstrations can employ pre- and post-evaluation to determine whether the approach achieves meaningful outcomes over time. The outcomes will determine whether the efforts should expand past the pilot stage. If defined outcomes are significant, the plan should be developed to scale to metro-wide and beyond application.
5. **Effectively educate the public about environmental impacts of salt use and how they can help reduce it.** Research is needed for the most effective way to educate the public to make changes. A multi-agency approach is needed to reach the greatest public audience.
6. **Will the traditional salt savings steps recommended in this plan be enough**? If all the TCMA maintenance organization use the WMAt and show their practices are dominated by excellent practices, the information will show if these traditional BMPs will reduce salt enough to make the practices sustainable. It is difficult to project when, or if, this will occur. It is important to monitor the progress of the industry and compare to the water monitoring results. If there is a high compliance with traditional BMPs it will illustrate the effectiveness and demonstrate whether there can be a sustainable ecosystem and the use of salt for winter maintenance. This answer would be of high importance for all dealing with the same situation.
7. **Pavement alternatives.** Additional research should be done to understand pavement types and emerging pavement technologies that could reduce chloride usage while providing an adequate level of service.

8. **Water experts.** Research is needed to better understand how to capture chloride before it enters the water and how to remove it once it enters our surface water or ground water. Special attention should be directed toward preserving the food chain living in surface water systems when considering filtration methods for removing chloride from lakes, rivers, and wetlands.

9. **Reuse.** An evaluation of the feasibility of re-using wastewater with chloride for winter maintenance should be conducted, including brine from RO processes. As part of this evaluation, an understanding of the other chemicals present in the wastewater will be important in determining the feasibility of re-using wastewater.

10. **Non-chloride and reduced chloride.** The MnDOT has evaluated many different options for deicing, but some may need additional research into the effectiveness. Information can be found at "Chloride Free Snow and Ice Control Material."

11. **Septic Systems**. More research into septic systems and the amount of chloride loading to the groundwater needs to be better understood as well as other contributors of chloride to groundwater.

12. **Climate Change.** Additional research is needed to understand how climate change will affect precipitation patterns and temperatures and their effects on chloride. Precipitation and temperature could cause increases or decreases in chloride application. However, increased or decreased precipitation could also affect the amount of runoff available for dilution and flushing of chloride.

6. Stakeholder and Public Involvement Process

A robust stakeholder involvement process was undertaken to develop partnerships and gain insight into winter maintenance activities and municipal wastewater plants as a source of chloride. This process began in early 2010, and has continued throughout the project allowing the stakeholders to assist in the development of the TCMA CMP and the TMDL and has generated the support of local partners and created a common understanding of the challenges with balancing water quality and public safety. This effort consisted of over 115 participating stakeholders on seven teams over five years; an IAT, a TAC, a MSG, an IPC, an EOC, and Technical Experts (TechEx). Meeting information and stakeholder team membership lists are available at: http://www.pca.state.mn.us/programs/roadsalt.html.

The IAT members included water resources experts from the MPCA, MnDOT, BWSR, MDH, USGS, MCES, and the DNR. This team provided high-level oversight, support, and guidance for the project and became involved in the project during the initial feasibility study in 2009. The Committee met three times from 2010 through 2014.

The TAC members included representatives from the MPCA, MnDOT, St. Paul, Minneapolis, Shoreview, Burnsville, Plymouth, Capitol Region WD, Ramsey-Washington WD, Bassett Creek WMC, Mississippi WMO, Nine Mile Creek WD, Scott County WMO, Minnehaha Creek WD, Rice Creek WD and the APWA. This team was responsible for providing review, guidance, and support for the technical aspects of the project. Committee meetings were held seven times from 2010 through 2014. In addition to the in-person meetings, regular updates, and gathering of input and feedback on draft documents occurred over email.

The MSG was created to provide detailed technical guidance and support regarding the water quality monitoring aspects of the project. The team not only developed monitoring guidance for chloride but also partnered with MPCA to collect additional chloride data across the TCMA to inform the TCMA CMP and TMDL. This team consisted of local and state water quality experts from the MPCA, DNR, USGS, MCES, Minneapolis Park and Recreation Board, Three Rivers Park District, Ramsey County, Capitol Region WD, Ramsey-Washington WD, Rice Creek WD, Minnehaha Creek WD, and Mississippi WMO. The Committee met four times from 2010 through 2013.

The EOC included local education specialist throughout the TCMA representing WDs, WMOs, counties, Freshwater Society, UMN Extension, East Metro Water Resource Education Program, and the MnDOT. This team was created to provide insight, direction, and to share information and resources to develop the strategies and needs of educating and engaging the public and stakeholders. The team met four times from 2011 through 2014.

A TechEx was formed to assist in the development of the WMAt. The team included hands on leaders in the winter maintenance industry from the MnDOT, cities, counties, and private companies. This team was instrumental in developing the vision and technical details of the WMAt. This group met several times; however, much of the review, feedback, and expertise were shared electronically.

The IPC consisted of representatives from all other teams and other interested stakeholders. This team's primary responsibility was to provide oversight and guidance on the development of the TCMA CMP. This group also received updates on the development of the TMDL and other project information. Meetings were held three times from 2012 through 2014.

In addition to the involvement of the stakeholders on the seven project teams, there were many other meetings, events, and conferences over the five-year span of the project to share progress and results. This included:

- annual presentations at the Freshwater Society's Road Salt Symposium since 2010
- presentations at the Minnesota Water Resources conference in 2010 and 2014
- participation in the EPA's Stormwater Pollution Prevention Webinar in 2013
- presenting at the Minnesota Street Superintendent's Association meeting in 2014
- participation in the Mississippi River Forum in 2015
- attendance at numerous local meetings and events to discuss project

Two special outreach meetings were held specifically for the TCMA Chloride project. The first one was the Sand Creek Community Meeting, which was held in Jordan, Minnesota on July 30, 2014, to discuss the draft TMDL results. City, township, county representatives, and WWTP operators within the Sand and Raven Creek watersheds were invited to the meeting. Fourteen stakeholders attended the meeting. The second meeting was the Chloride Extravaganza held in St. Paul, Minnesota on April 28, 2015. Over 250 permitted and key stakeholders in the TCMA were invited to hear presentations from the various MPCA staff regarding the water quality conditions of chloride in the TCMA, results of the draft TMDL, and have discussion regarding implementation of the TMCA CMP and TMDL. About 100 stakeholders participated in the event.

Aside from collaborating, engaging, and informing local stakeholders about the TCMA Chloride project, additional efforts were made to increase the public's awareness about the environmental impacts of chloride. The primary and most effective efforts included the development of a new MPCA webpage with information and tips for the public to reduce salt use and protect water quality. A short YouTube video was created discussing the environmental concerns about deicing salt and the effort underway to develop a plan for a collaborative and effective chloride reduction strategy. A large interactive display was designed, built, and shared with the public at the Minnesota State Fair since 2012, and is available to local partners for local educational events. Finally, in 2010, the MPCA began generating press releases at the start of every winter that discusses the impacts of deicing salt on water resources and highlights new information, reports, or data available.

The official public comment period for the CMP and TMDL was held from August 3, 2015, through September 3, 2015. Eleven letters were received during the public comment period.

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Appendix A – TCMA Chloride Total Maximum Daily Loads (TMDLs)

[see TMDL report]

Appendix B – Winter Maintenance Assessment tool (WMAt)

There are thousands of miles of streets and highways in Minnesota, along with parking lots and sidewalks that must be maintained to provide safe conditions throughout the winter. Winter maintenance of these surfaces currently relies heavily on the use of salt, primarily NaCl, to prevent ice build-up and remove ice where it has formed.

In response to the increase in chloride concentrations from winter maintenance activities in area lakes, streams, wetlands, and groundwater, Minnesota state agencies, local municipalities, and experts across the TCMA have partnered to create a CMP to effectively manage salt use to protect our water resources in a responsible and strategic approach.

As part of the TCMA CMP development, the first of its kind, WMAt has been developed as a resource of all known salt saving BMPs. The WMAt is a web-based tool that can be used to assist public and private winter maintenance organizations in determining where opportunities exist to improve practices, make reductions in salt use and track progress.

The WMAt contains a list of roughly 180 BMPs that allows agencies and companies to complete an assessment of their current winter maintenance practices and speculate on potential future practices to understand how to reduce the use of chlorides, while still providing an acceptable level of service. Utilization of this planning tool will allow the user to track their progress over time and show the results of their efforts. It also can predict salt savings and associated cost savings (with a low degree of accuracy at this point) based on the industry's current salt savings research.

Finally, once an assessment has been completed, a report can be generated summarizing current practices as "remedial", "best" and "advanced" identifying areas for future improvement. The report is an excellent and convenient tool for winter maintenance managers to use to communicate winter maintenance operations to residents, clients or elected officials.

For those users who prefer not to do an online assessment, Appendix B offers a snapshot of the Best Practices contained in the tool at the given time (when this management plan was finalized). This appendix will soon be out-of-sync with the WMAt tool as the WMAt tool will be refined during testing and implementation to reflect the current and best practices in the industry. It is not our intent to keep Appendix B up-to-date with the WMAt. For the latest recommendations, please use the online tool.

Questions are generally grouped to address practices in the following six categories:

1. Before winter activities
2. Before the storm activities
3. Accuracy
4. Efficiency
5. Reduce waste
6. After winter activities

The WMAt assessment questions and general scoring of responses, from "remedial" or "unacceptable" to "advanced" or "best" are included in the following pages.

Before Winter Activities

Do you have a written winter maintenance policy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Does the crew understand the winter maintenance policy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Some of them
- Yes
- Not applicable

Do you try to communicate your winter maintenance policy to your customers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Some of them
- Yes
- Not applicable

Do supervisors compare crew actions to salt application guidelines?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

How often is your policy reviewed and updated?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Less than once a year
- Each year
- Not applicable

Does the crew document their actions?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Yes, on paper or through an automatic tracking system

Do most buildings you maintain drain onto salted surfaces?

Applies to: Parking Lots, Sidewalks

Unacceptable	Best
· Yes	· No

Are appropriate people notified of drainage problems?

Applies to: Parking Lots, Sidewalks

Unacceptable	Best
· No	· Yes · We are the property managers

Are culverts, storm drains, curb cuts inspected and cleared of debris/obstacles prior to first snow event?

Applies to: Low Speed Roads, Parking Lots

Unacceptable		Best
· No	· Some of them · Meets MPCA MS4 stormwater permit (at least 20%)	· All of them

· Not applicable

Is anti-icing equipment ready for use before first salting event?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable	Best
· No	· Yes

· Not applicable

Are pre-wet systems ready for use before first salting event?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable	Best
· No	· Yes

· Not applicable

Is your liquid deicer ready for use before first salting event?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable	Best
· No	· Yes

· Not applicable

Are spill shields installed prior to first storm?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No, never use spill shields; salt leaks out of truck
- No, most spill shields installed after first snow event
- Yes
- No, don't need spill shields; salt does not leak out of truck

Do you use snow fences?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Have used them in the past and are increasing our amount

Do you use weather prediction systems better than the TV news?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Yes, and including pavement temperature

Do you test each batch of your liquids?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Do not use liquids
- Always

How often are crew and supervisors trained on conservative use of salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Crew is trained occasionally
- Most of the crew is trained each year
- Entire crew is trained each year

Do crew and supervisors understand the long-term impacts of salt on our waters?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes, most of the crew
- Yes, everyone

Do supervisors participate in or attend training with crew?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Yes

How do you rate your operators' willingness to change?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- Low
- Medium
- High

How do you rate your managers or supervisors willingness to change?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- Low
- Medium
- High

Do you educate your customers about salt, the environment and what you are doing to be pro-active?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Some
- Yes

Are lakes, rivers, wetlands, well-heads marked on route maps?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Yes

Are trouble areas documented on each route?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Yes

How well do operators work together within your organization?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- Poorly
- Ok
- Excellent

How well do you communicate with neighboring organizations?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- Poorly
- Ok
- Excellent

Do you use the optimal equipment for the route?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Most of the time
- Yes

Do most plow operators have regular routes?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Yes

Do you actively promote lower speed, safer customer behavior during winter?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Always
- We reduce speed limits when necessary

Do you actively promote proper storage in your community? (beyond your operations i.e. private contractors)
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Yes

Are you changing any salted maintenance areas to non-salted areas?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Are you changing any salted maintenance areas to reduce salt areas? (textured for traction, dark colored, crowned, sloped, covered, sub base influence for warmth, chip seal, pavement overlay, etc.)
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

What percentage of your salted parking lots/sidewalks are designed for reduced salt use? (textured for traction, dark colored, crowned, covered, sub base influence for warmth, chip seal, pavement overlay, …)
Data entry question
Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- Enter %

What percentage of your salted roads are designed for reduced salt use? (textured for traction, dark colored, crowned, covered, sub base influence for warmth, chip seal, pavement overlay, …)
Data entry question
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Enter %

How fast do you need melted surfaces?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Faster than in the past, using more salt
- Same as in the past using more salt
- Slower than in the past, using more salt
- Faster than in the past, using the same amount of salt
- Same as in the past using the same amount of salt
- Slower than in the past, using the same amount of salt
- Faster than in the past, using less salt
- Same as in the past using less salt
- Slower than in the past, using less salt

What % of your salted roads must be snow/ice free?

Data entry question

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Enter %

What % of your salted parking lot/sidewalks must be snow/ice free?

Data entry question

Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- Enter %

Is there a change in your service area?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Lane miles/acres increasing
- No change
- Line miles/acres decreasing

Do you provide different levels of service?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Same level of service for everything
- Different levels of service for different areas

Does most of your crew meet their level of service targets?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Exceed level of service
- Below level of service
- Meet level of service

Does your crew know the level of service required for their maintenance areas?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Some of them
- Yes

Before the Storm Activities

Where do you anti-ice?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- None of the areas we salt
- Some of the areas where we salt
- All areas where we salt

When do you anti-ice? (i.e. apply liquids before the storm)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- On a regular schedule no matter how much residual salt
- Never
- On a regular schedule, if not adequate salt on surface
- Before predicted frost or snow

How do you treat frost?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Apply granular salt after frost is formed
- Apply liquids after frost is formed
- Anti-ice to prevent frost
- Do nothing

Our anti-icing systems are primarily:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Anti-ice with granular products
- Gravity glow, open loop system, flow rate depends on your speed
- By pump, open loop system, flow depends on your speed and how much pressure is in your tank
- Not applicable
- Electronic controls, closed loop system, ground speed system

Do you have any automated anti-icing systems built into your pavement surfaces?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Have you made changes to reduce loss of anti-icing liquids from airflow?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
· No	· Yes some of our fleet has modifications	· Yes all of our anti-icing fleet has modifications such as: spray skirts, spray flaps, long tubes to lower discharge point, and/or lower boom

· Not applicable

What is the first step you take with slush that will refreeze?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
· Ignore it · Salt it		· Remove it (shovel, plow, etc.)

For roads, what do you do with a light snow (> 1" for event)?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
· Without plowing, salt or sand it if needed	· Remove it and salt · Nothing	· Remove it (salt only if needed) · Anti-icing takes care of it

What do you do with a 2 inch snow?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
· Without plowing, salt or sand it if needed · Nothing	· Remove it and salt	· Remove it (salt only if needed)

For parking lots, what do you do with a light snow (> 1" for event)?

Applies to: Parking Lots

Unacceptable		Best
· Without plowing, salt or sand it if needed	· Remove it and salt · Nothing	· Remove it (salt only if needed) · Anti-icing takes care of it

When we have compaction, our "primary tool" is to:

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- Salt/sand mix

- Salt it
- Sand it
- Liquid salt to get underneath bond
- Other

- Scrape it
- Leave it

Are you optimizing mechanical removal to reduce use of chemical?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No

- Sometimes

- Yes, never put salt on unplowed, unshoveled surfaces

Do you have good equipment for effective snow removal?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No

- More good than bad equipment

- Yes

How do you plow and apply salt?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Plow and apply on each lane as you go

- Clear entire road, then have separate salting pass
- Plow 2 lanes then apply salt to middle

How do you salt when plowing in tandem?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Most plow tricks salt; nothing done to prevent loss of salt from plowing

- Most plow trucks salt; reduce salt loss by using spreaders on the left, turning spinners off, or using chutes. Two pass operation

- Plow in tandem salting is done later
- Most plow trucks salt; reduce salt loss by using spreaders on the left, turning spinners off, or using chutes. One pass operation

- Not applicable

How do you manage routes that overlap?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Plow or salt on other peoples routes without being asked
- Avoid plowing or salting on other peoples routes unless there is communication

For sidewalks, are you clearing before salting?

Applies to: Sidewalks

Unacceptable → **Best**

- No
- Yes, if there is more than 1 inch of snow
- Yes, unless there is compaction
- Yes

Do you have the ability to plow continuously throughout the storm?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Snow removal is only at end of storm
- Sometimes
- Yes

Is your response to snow events the same during weekday hours and weekend/evening hours?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Yes

Accuracy

How often do you calibrate spreaders?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- New equipment only
- Most equipment every other year
- Never
- Most equipment early
- All equipment yearly
- All equipment yearly, plus if equipment changes or something looks wrong

How many anti-icing systems (liquid only spreaders) do you calibrate?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- Less than half
- Don't have any
- More than half
- All

How many liquid pre-wet systems do you calibrate? (Pre-wet refers to a system that discharges liquids onto granular products)

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable ***Best***

- Less than half
- Don't have any
- More than half
- All

How many granular salting trucks do you calibrate? (including trucks from your active fleet that deliver sand/salt mix)

Data entry question

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable ***Best***

- No
- Some, enter #
- Yes (for all)

Do you calibrate your "gator" or small vehicle granular spreaders?

Data entry question

Applies to: Sidewalks

Unacceptable ***Best***

- No
- Some, enter values
- Yes (for all)
- Not applicable

Do you calibrate your push granular spreaders?

Data entry question

Applies to: Sidewalks

Unacceptable ***Best***

- No
- Some, specify #
- Yes
- Not applicable

What percent of your fleet is set up for liquids (of the trucks that apply salt)?

Applies to: Sidewalks

Unacceptable ***Best***

- 0 – 49%
- 50 – 79%
- 80 – 100%

Where are your manual spreader control calibration charts? (Manual spreader controls are controls that you adjust like a knob or gate opening and do not automatically change the discharge rate to match the speed at which you are applying)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· Not with the equipment	· Often with the equipment	· Always with the equipment and a back-up copy in the office · No manual spreader controls

For manual spreader controls, do your operators know how to read the calibration card?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· No	· Have all electronic controls, so don't need cards	· Yes

Do your operators know how to read your salt application rate charts?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· Don't have charts	· No, supervisors read the charts and assign rates · Don't have charts, use strictly MDSS for guidance	· Yes

What materials do you calibrate for?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· Don't calibrate	· For most commonly used product(s)	· For every product used

What guidance do you give to your crew for hand spreading?

Applies to: Sidewalks

Unacceptable → ***Best***

Unacceptable		Best
· Have a scoop in bucket with no instructions · Chicken feed with no instructions	· Have a line on spreader indicating fill line for each site · Have a hand spreader in bucket of salt instead of scoop · Crew has a picture of ideal spread pattern	· Amount of deicer is calculated each time based on square footage and pavement temp

For roads, what is your most common anti-icing rate for straight salt brine? (Straight salt brine is water and rock salt. No other ingredients)

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → ***Best***

- Don't use liquids
- More than 50 gallons per lane mile
- Don't use straight salt brine
- 50 gallons or less per lane mile

For parking lots/sidewalks, what is your most common anti-icing rate for straight salt brine?

Applies to: Parking Lots, Sidewalks

Unacceptable → ***Best***

- Don't use liquids
- More than 0.8 gallons per 1000 square feet
- Don't use straight salt bine
- 0.8 gallons or less per 1000 square feet

Do you have more than one type of liquid to choose from (for anti-icing or deicing)?

Applies to: Parking Lots, Sidewalks

Unacceptable → ***Best***

- No
- Don't use liquids
- Yes

For parking lots/sidewalks, what is your most common anti-icing rate for straight magnesium or calcium chloride liquid?

Applies to: Parking Lots, Sidewalks

Unacceptable → ***Best***

- Don't use liquids
- More than 0.4 gallons per 1000 square feet (18 gal. per acre)
- Don't use straight magnesium or calcium chloride
- Less than 0.4 gallons per 1000 square feet (28 gal. per acre)

For roads, what is your most common anti-icing rate for straight magnesium or calcium chloride liquid?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → ***Best***

- Don't use liquids
- More than 25 gallons per mile
- Don't use straight magnesium or calcium chloride
- 25 gallons or less per mile

Who determines (granular and/or liquid) application rates?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		***Best***
• We make our own application rate chart. Rates are higher than MN field handbook for snowplow operators • Application rate charts are not used	• We make our own application rate chart. The rates are higher than MN field handbook for snowplow operators or the MN parking lot and sidewalk manual but much less than we used to use • MDSS preprogrammed system with rates higher than MN field handbook for snowplow operators	• MDSS preprogramed system with rates similar to MN field handbook for snowplow operators. Truck suggests the rates • We use MN field handbook for snowplow operators • We use MN parking lot and sidewalk manual application rate chart • We make our own application rate chart comparable to the MN field handbook for snowplow operators or the MN parking lot and sidewalk manual

Are your application rates based on pavement temps?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable	***Best***
• No • Don't have application rate charts	• Yes

Do most of your operators follow application rate recommendations? (MDSS, supervisor, or chart)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		***Best***
• No • Don't know	• Half of the time	• Yes

How do you select your application rate?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Operator in charge: generally disregards charts and makes own decisions
- Supervisor in charge: generally disregards charts and makes own decisions
- Application rate charts are used but not based on pavement temperatures

- MDSS in charge: MDSS information is for general conditions not specific to operators route, operator follows MDSS advice
- Operator in charge: has application rate chart, pavement temperatures are from a remote source
- Supervisor in charge: dictate to the crew appropriate application rates based on general pavement temperatures

- MDSS in charge: MDSS uses information from individual truck sensors to suggest rates based on conditions specific to operators' route, operator follows MDSS advice
- Operator in charge: application rate charts and pavement sensor with operator, operator selects appropriate rates from supervisors chart

How many of each type of spreader controls do you have? (active fleet only)

Data entry question

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Manual, enter #
- Electronic controls (closed loop), enter #
- Electronic controls (MDSS), enter #

For manual controllers, when salting at different speeds how often does your crew change spreader settings?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- Rarely
- Half of the time
- Most of the time
- Have all computer controls

Where do you get your Maintenance Decision Support System (MDSS) advice?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → ***Best***

- From remote site sending general guidance to the trucks
- From each truck's sensors that monitors the real-time situation as the truck is being driven

- Not applicable

How is the blast button set?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- 600 lbs
- 700 lbs
- 800 lbs
- 900 lbs
- 1000 lbs
- 1100 lbs
- 1200 lbs
- 1300 lbs
- 1400 lbs

- 400 lbs
- 500 lbs

- 300 lbs

- Don’t have it

How accurate are your salt use numbers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Low: estimate at end of year
- Not applicable: we don’t keep track

- Medium: estimate and record after each shift

- High: AVL, scale in and out, PreCise MRM, etc.

- None: we don’t use salt

Efficiency

Do you use a sand/salt mix as your primary deicer?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Yes

- No

How much salt is mixed into your winter sand?

Data entry question

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Salt in mix greater than 10%

- Salt in mix equal or less than 10%

- Not applicable

Pre-wet is mixing salt and liquid at the truck, when you increase the amount of liquid, do you change your granular application rate?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No, use same application rate
- Yes, increase application rate
- Don't pre-wet
- Yes, decrease application rate

Are you working to increase liquid and decrease granular use across your entire operations?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

For parking lots and sidewalks, what % of the time do you use the below methods?

Data entry question

Applies to: Parking Lots and Sidewalks

Unacceptable → **Best**

- Dry salt
- Sand/salt mix
- 7 – 15 gal/ton
- 4 – 6 gal/ton (i.e. pretreated stockpile)
- Other
- Straight liquid
- Slurry >30 gal/ton
- 16 – 30 gal/ton

For roads, what % of the time do you use the below methods?

Data entry question

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Dry salt
- Sand/salt mix
- 7 – 15 gal/ton
- 4 – 6 gal/ton (i.e. pretreated stockpile)
- Other
- Straight liquid
- Slurry >30 gal/ton
- 16 – 30 gal/ton

Are you using liquids for deicing (during or after the storm)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Do you stir your storage tanks to insure proper mix?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Don't use liquids
- Don't have storage tanks
- Yes

Do you understand the practical pavement temperature range of your deicers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

We select the appropriate material for the pavement temperature:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Don't adjust our product selection based on pavement temps
- Don't know
- Most of the time
- Always

When pavement temps are below 15 degrees how often do you use dry rock salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- All of the time
- Don't know
- Half of the time
- Rarely or never

For extremely cold, below zero pavement temperatures

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- We use the best we have, but it's not very effective below 0 $^{\circ}$ F
- We use products that work better than salt or brine (e.g. potassium acetate, super slurry)
- We use nothing
- We use sand

If ice/snow isn't melting after plowing and salting:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- We use more of the same deicer
- We wait to allow more time for the salt to work before reapplying
- We switch deicers to a product that will work faster or work at colder temps
- If pavement temps are no longer appropriate for our deicer to work, we switch to sand

We buy:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• One deicer and use it for everything (e.g., rock salt)		• A selection of deicers so we have options

Reduce waste

What is the most common way you store your salt in the winter?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Pile tarped but not strictly maintained • Salt pile uncovered • Salt is purchased in small packages stored outdoors without additional protections	• Pile tarped and strictly maintained • Salt is purchased in small packages stored outdoors on tarped floor and covered	• Salt pile located indoors or in container • Salt is purchased in small packages store indoors

Do you prevent moisture from entering your salt shed(s)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Poor quality buildings	• Ok quality buildings or a mix of good and bad	• All good quality buildings with doors • All good quality buildings with no doors and salt protected from the opening

• Don't have sheds

Do your snow piles melt into your salt or salt/sand piles?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Sometimes		• No

• We don't have bulk salt or salt/sand piles

Any leaching out of your storage area? (one way to tell if you have leaching from your storage areas is if there are dried rivers of salt leading away from your shed)

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
• Sometimes		• No

What is under your salt pile?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Salt stored on absorbent surface (grass, gravel, cracked asphalt, etc.)
- Salt stored on hard surface (concrete, asphalt, storage containers, etc.)
- Salt stored on hard waterproof surface with concave base "birdbath shaped floor" and with a waterproof membrane, slope toward containment tank
- Don't have a bulk salt pile

Do you overfill your salt sheds?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Yes
- Rarely
- No
- Don't have sheds

How do you cover your salt/sand blended pile in the summer?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Summer salt/sand pile uncovered or poorly tarped
- Summer salt/sand pile tarped and properly secured
- Summer salt/sand pile indoors
- No sand/salt pile in the summer

How do you cover your salt/sand blended pile in the winter?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Winter salt/sand pile uncovered or poorly tarped
- Winter salt/sand pile tarped and properly secured
- Winter salt/sand pile indoors
- No sand/salt pile in the winter

What is your supporting surface for storing bagged salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Bagged salt stored on grass/gravel
- Bagged salt stored on tarp
- Bagged salt stored on concrete/asphalt
- Don't use bagged salt

What is under your salt/sand mix storage pile?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Sand/salt stored on absorbent surface (grass, gravel, cracked asphalt, etc.)
- Sand/salt stored on hard surface (concrete, asphalt, storage containers, etc.)
- Sand/salt stored on hard waterproof surface with concave base "birdbath shaped floor" and with a waterproof membrane, slope toward containment tank
- Don't have a bulk sand/salt pile

Do you prevent moisture from getting into your bags or buckets of deicers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Yes
- Don't use bagged salt

Do you receive salt shipments indoors or outdoors? (Can they drive into your building to unload?)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Receive shipments outdoors, leave outdoors
- Receive shipments outdoors, but move material indoors with poor cleanup
- Receive shipments outdoors, but move material indoors with good clean up
- Receive shipments indoors
- Don't have salt pile

Do you restrict delivery of deicers while it is raining or snowing?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- No, we may receive shipments in the rain/snow, but only allow tarped loads

Yes

How do you store your salt pile in the summer?

Applies to: Universal Parking Lots, Sidewalks

Unacceptable → **Best**

- Use up salt so none is left at the end of the season
- Summer salt pile outdoor and uncovered or poorly tarped
- Summer salt pile outdoor, tarped and properly secured

- Don't have a salt pile, buy bags
- Give away or sell leftover salt at the end of the season
- Store inside

How do you store your liquids?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Single wall tank
- Do not use liquids

- Single wall tank with a secondary container with a volume smaller than tank capacity

- Single wall tank with a secondary container with a volume equal or greater than tank capacity
- Double wall tank
- Double wall tank and secondary containment area

Are your spreaders covered during sidewalk/trail application?

Applies to: Sidewalks

Unacceptable → **Best**

- Spreaders uncovered

- Spreaders covered

Are your trucks tarped during application?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No

- Half of the time

- Yes

How is salt transferred to and from storage facilities?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Transfer truck with uncovered loads

- Transfer truck with covered loads

- Not applicable – we don't move our salt around

Where is the bulk salt loading area for the trucks?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Outdoors

- Indoors

- Don't use bulk salt

Do you overfill trucks?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- Yes
- Sometimes
- No

Do you overfill spreaders?

Applies to: Sidewalks

Unacceptable → **Best**

- Yes
- Sometimes
- No

What sort of bucket is used to load trucks?

Applies to: Parking Lots

Unacceptable → **Best**

- Loader bucket bigger than truck bed
- Clam shell bucket
- Regular loader bucket smaller than truck bucket

Are my trucks easy to unload?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No
- Yes

What is done with left over material at the end of shifts?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Used at the end of the shift if not needed
- Kept in the truck at the end of the shift
- Brought back to the pile at end of the shift

What do you do with leftover opened bags of salt?

Applies to: Sidewalks

Unacceptable → **Best**

- Use it up
- Not applicable
- Bring it back

What is done with leftover liquids?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Use it all during the shift, leftovers are rare
- Don’t use liquids
- Left in truck/spreader
- Brought back to the main tank

Is there enough time to unload at the end of storm?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Not enough time for thorough unloading of trucks
- Allow ample time for unloading of trucks

Which tools/equipment do you use to unload (when you are done with your route)?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- None
- Shakers, vibrators, raise the box, clean the auger or corners with a tool, elliptical boxes, run auger/conveyor

When salting low speed roads, the spinner is usually…

Applies to: Low Speed Roads

Unacceptable → **Best**

- On high
- On medium
- On low
- Off

When salting high speed roads, the spinner is usually…

Applies to: Low Speed Roads

Unacceptable → **Best**

- On medium or high
- On low
- Off

How do you apply granular salt to sidewalks?

Applies to: Sidewalks

Unacceptable → **Best**

- Broadcast spreader without shield
- Broadcast spreader with shield on one side
- Broadcast spreader with shields on two sides
- Drop spreader

Do you restrict the output of your push spreaders?

Applies to: Sidewalks

Unacceptable		Best
• No	• Do not use push spreader	• Yes, by restricting the amount of salt you give to the person applying • Yes, by blocking the spreader from delivering at high rates • Yes, by following our policy to only use low settings

Where on the road do you place the salt?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
• Entire drive lane	• Spread pattern in center (of 24-foot pavement)	• Narrow windrow on center line or super-elevation of road

What granular spread pattern is used on parking lots?

Applies to: Parking Lots

Unacceptable		Best
• Entire parking lot	• Drive lanes • Areas of high use	• Strategic plan with customer to minimize salt use

How do you salt intersections?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
• Blast button • Much higher rate than you were using on the road (may change spinner speed to spread wider)	• Slightly higher rate than you were using on the road (may change spinner speed to spread wider)	• Same rate you were using on the road (may change spinner speed to spread wider)

What anti-icing liquid spread patterns are used on roads and parking lots?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
• Fan	• Don't use liquids	• Streamer

What anti-icing liquid spread patterns are used on sidewalks?

Applies to: Sidewalks

Unacceptable → **Best**

- Fan
- Fan spray at super low rates
- Don't use liquids
- Streamer

What areas do you salt on sidewalks, parking lots, and low-speed roads?

Applies to: Low Speed Roads, Parking Lots, Sidewalks

Unacceptable → **Best**

- All surfaces
- Strategic spots

What areas do you salt on high-speed roads?

Applies to: High Speed Roads

Unacceptable → **Best**

- All surfaces
- Strategic spots

What method is most frequently used to open frozen drains/culverts?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Leave them blocked
- Salt
- Not applicable
- Mechanical
- High pressure water or stream

How often is the outdoor loading area swept back into the pile?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Rarely
- After each storm
- Continuous during winter operations
- Not applicable
- All indoor loading areas

How often do you wash your trucks?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- After each salting shift
- After the storm
- Less frequently than after each storm

How much salt is left in the truck when it goes into the wash?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- 100 lbs of salt washed out of box and sander
- 50 lbs of salt washed out of box and sander
- 25 lbs of salt washed out of sander
- Reuse wash water for brine system
- Do not wash trucks

What equipment is most commonly used to help keep salt on the road (not on shoulder/ ditch)?

Applies to: High Speed Roads

Unacceptable		Best
· Standard spinner	· Spinner with holes · Skirt	· Chute · Zero velocity · Lower spinner

Does salt commonly leave the truck through cracks, gaps, or when forget to turn off auger/conveyor (not salt lost over the top)?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
· Yes		· No

Where is the discharge of the truck located?

Applies to: High Speed Roads

Unacceptable		Best
· On right side of truck	· On left side of truck · In the center	· Chute on the left, spinner on the right side of the truck · Dual spinner

How man V-boxes and dump trucks do you have in your fleet?

Data entry question

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
	· Dump truck, enter #	· V-box, enter #

How do your trucks dispense salt?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
	· Auger · Conveyer without speed control · Other	· Conveyer · Slurry auger

What is the lowest application rate you can deliver with an even spread pattern?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
· Don't know · More than 200 lbs per mile (500 lbs per acre)	· 100 to 200 lbs per mile (300 to 500 lbs per acre)	· Less than 100 lbs per mile (300 lbs per acre)

Are most sidewalk spreaders able to deliver 10 pounds per 1000 square feet with an even spread pattern?

Applies to: Sidewalks

Unacceptable → **Best**

- Don't know
- No
- Yes

When you hand spread granular salt what is your most common method?

Applies to: Sidewalks

Unacceptable → **Best**

- Scoop delivery
- Pour from bag
- Shaker
- Scoop with fill mark and square footage guidance
- Other
- Not applicable
- Hand spreader

When salting parking lots, where are the spreader controls located?

Applies to: Parking Lots

Unacceptable → **Best**

- Controls not near operator while spreading
- Most controls near operator while spreading
- All controls near operator while spreading

When salting sidewalks/trails, where are the spreader controls located?

Applies to: Sidewalks

Unacceptable → **Best**

- Controls not near operator while spreading
- Most controls near operator while spreading
- All controls near operator while spreading

The discharge of deicing liquids (not anti-icing) are mostly:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Don't use deicing liquids
- Gravity or pump controlled without flow meter
- Pump controlled, closed loop

For parking lot deicing: Are the salt spreader settings marked? (so you know how much salt will be used at each setting)

Applies to: Parking Lots

Unacceptable → **Best**

- Gate opening with no setting on dial, hash marks on number to select
- Some settings marked and selected
- All settings marked and selectable

For sidewalk deicing, are the salt spreader settings marked? (so you know how much salt will be used at each setting)

Applies to: Sidewalks

Unacceptable		**Best**
• No settings selectable	• Some settings marked and selected	• All settings marked and selectable

At what speed do you spread salt on roads?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		**Best**
• 40 – 50 mph	• 30 – 39 mph	• 23 – 29 mph • 22 mph or less

How much salt do you apply on roads while it is snowing?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		**Best**
• Salt continuously during the event, applying roughly the same amount of salt on each pass	• Salt continuously during event, apply half the amount of salt during each pass as we do on the pass after the event	• Salt continuously during event, apply 1/4 the amount of salt during each pass as we do on the pass after the event

How much salt do you apply on parking lots while it is snowing?

Applies to: Parking Lots

Unacceptable		**Best**
• Salt continuously during the event, applying roughly the same amount of salt on each pass	• Salt continuously during event, apply half the amount of salt during each pass as we do on the pass after the event	• Salt continuously during event, apply 1/4 the amount of salt during each pass as we do on the pass after the event • No salt applied during the storm; salting occurs after the storm

How long after the storm until you apply salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		**Best**
• Apply deicer immediately regardless of surface temperatures	• Apply deicer immediately if we have a deicer that works for the pavement temperature • Apply sand immediately if we do not have a deicer that works for the pavement temperature	• Wait for improved surface temperatures where less salt is needed

After the storm, do you apply salt to areas that are both clear and icy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

Unacceptable:
- Yes

Best:
- No

Who salts the overlap stretches of routes?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

Unacceptable:
- Anyone driving over another's routes

Best:
- Only one route can apply to overlap stretch, unless communication between drivers

Does the last pass of the day get more salt?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

Unacceptable:
- Yes
- It depends on if I have salt left in my truck

Best:
- No

After winter activities

How do you dispose of truck wash water?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

Unacceptable:
- Dispose of wash water in storm sewer (goes to lake, river, pond)
- Dispose of wash water on landscape

Middle:
- Dispose of wash water in sanitary sewer (does to treatment plant)

Best:
- Remove salt from truck wash water, keep salt water, discharge clean water
- Remove salt from truck wash water, keep salt water, reuse water

Where does most of your storage runoff water go?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

Unacceptable:
- Allow runoff into storm sewer
- Allow runoff onto landscape
- Allow runoff into pond with connections to either surface or ground water systems

Middle:
- Allow runoff into pond with no connections to other surface or ground water systems
- Collect runoff and bring to sanitary sewer
- Direct runoff into sanitary sewer

Best:
- Collect runoff from storage area and reuse in brine system

Do you encourage research and development: to catch/filter salt before it enters our water, surfaces that do not need salt, ways to melt without chemicals?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Do you desalinize (remove salt) from any ponds, lakes, or rivers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Encouraging others to remove salt from river, stream, creek
- Yes

Do you desalinize (remove salt) from ground water sources?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Encouraging others to remove salt from ground water
- Yes

Do you require private contractors or businesses applying salt in your city to be certified by MPCA training program (or other training/certification programs that encourage low salt use)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Do you host low impact Smart Salting training for others? (people not in your organization)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Do you feel you have the necessary equipment, materials, and knowledge to use less salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

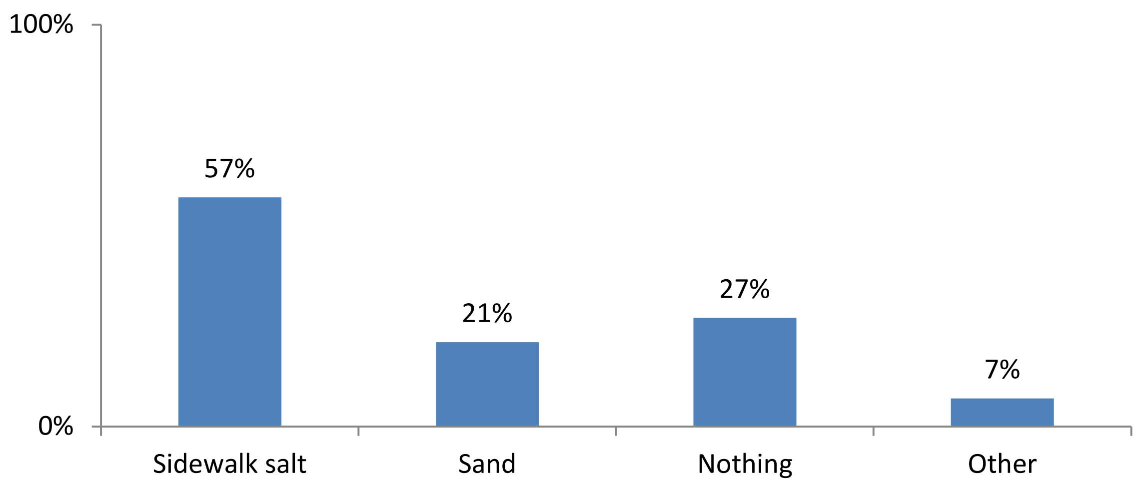
Unacceptable → **Best**

- No
- Some of the above
- Yes

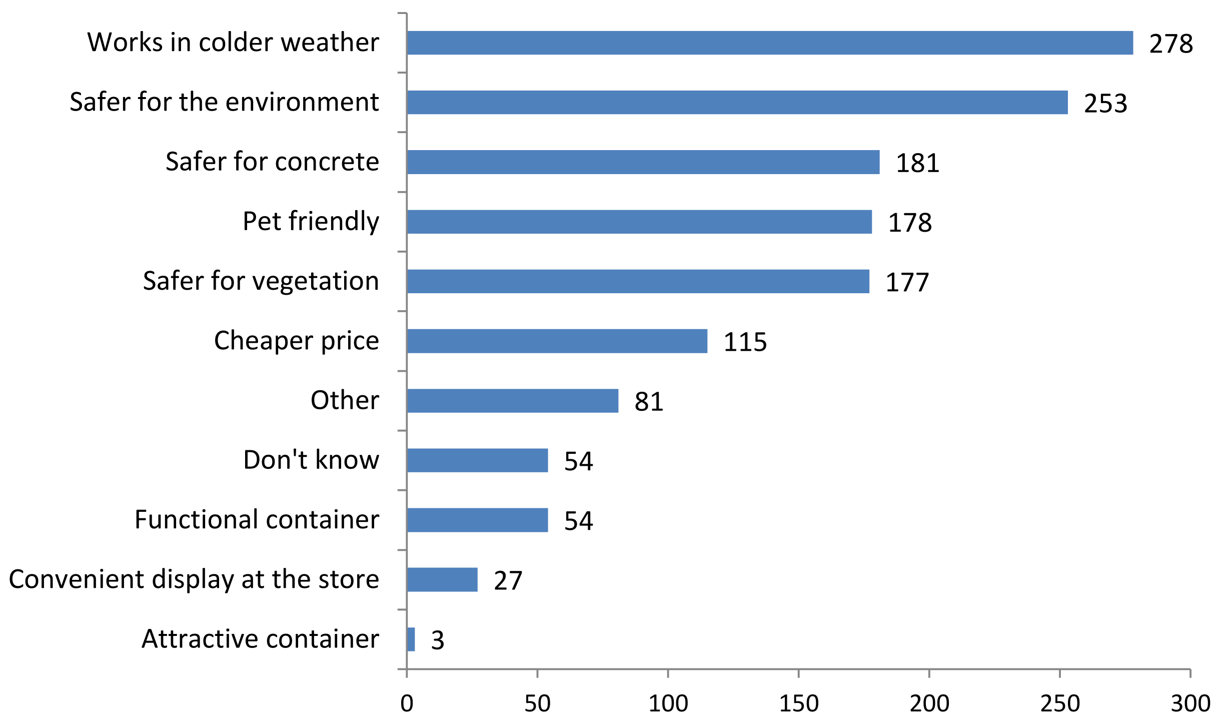
Appendix C – Sidewalk Survey Results

Below is a summary of results of the Sidewalk Survey that was completed by 754 residents in the TCMA from November 2011 through March 2012.

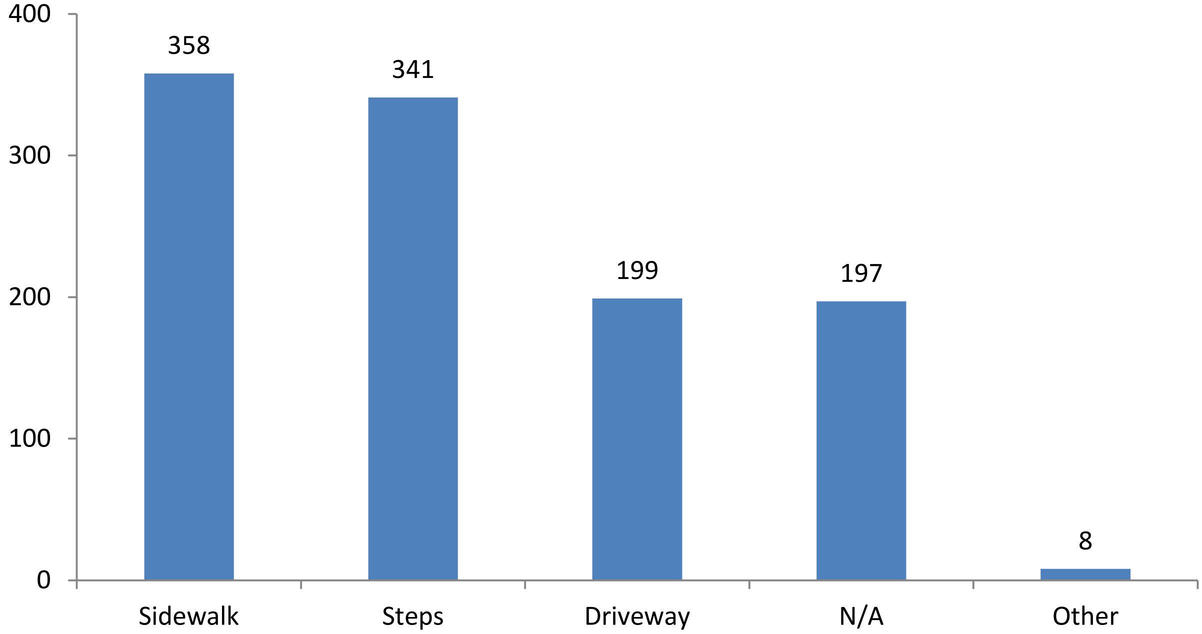
Question 1. What product do you most commonly apply to your icy areas?



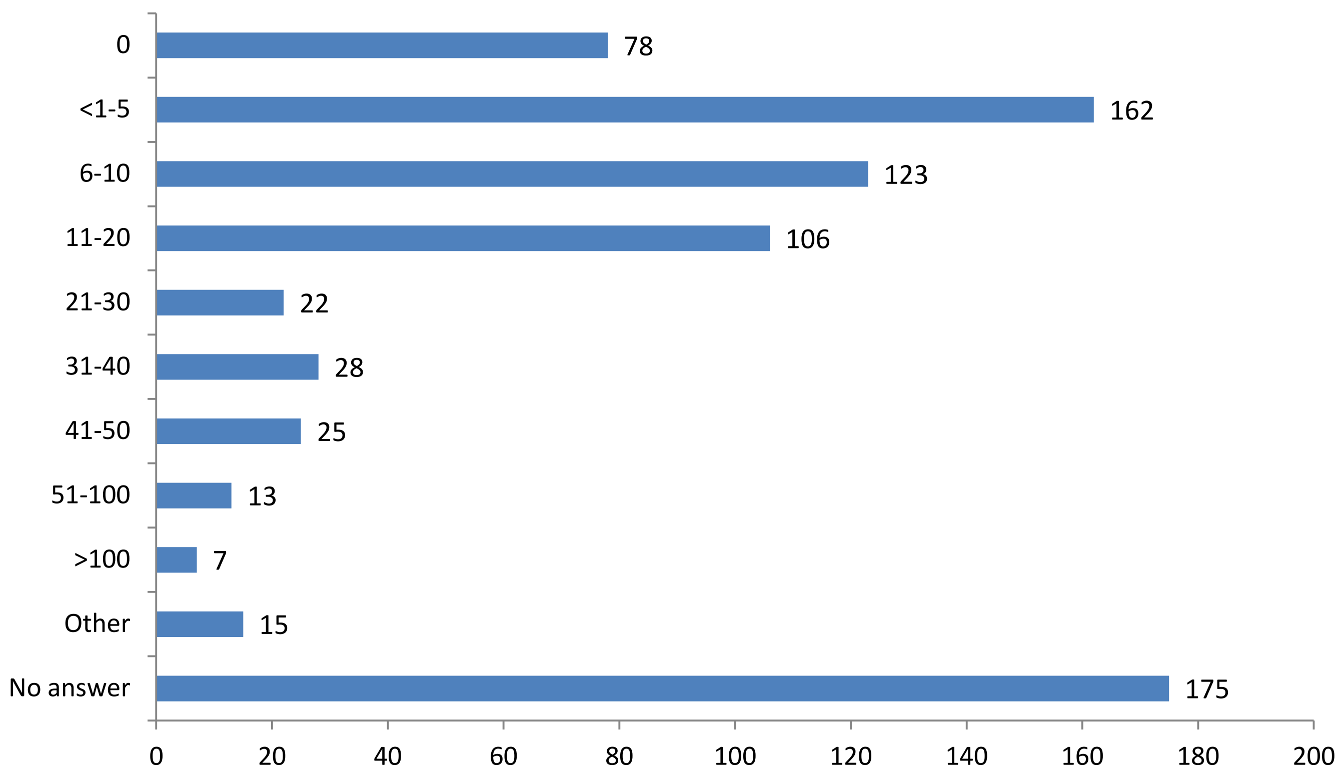
Question 2. Why did you choose that product?



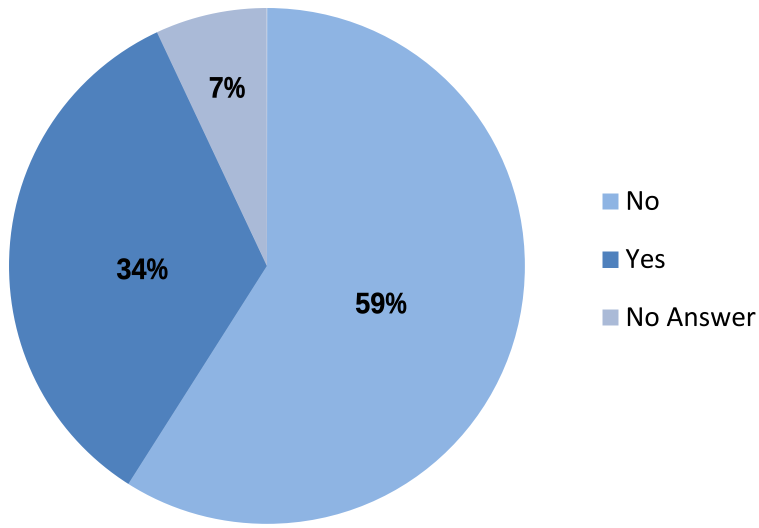
Question 3. Where do you most often apply sidewalk salt?



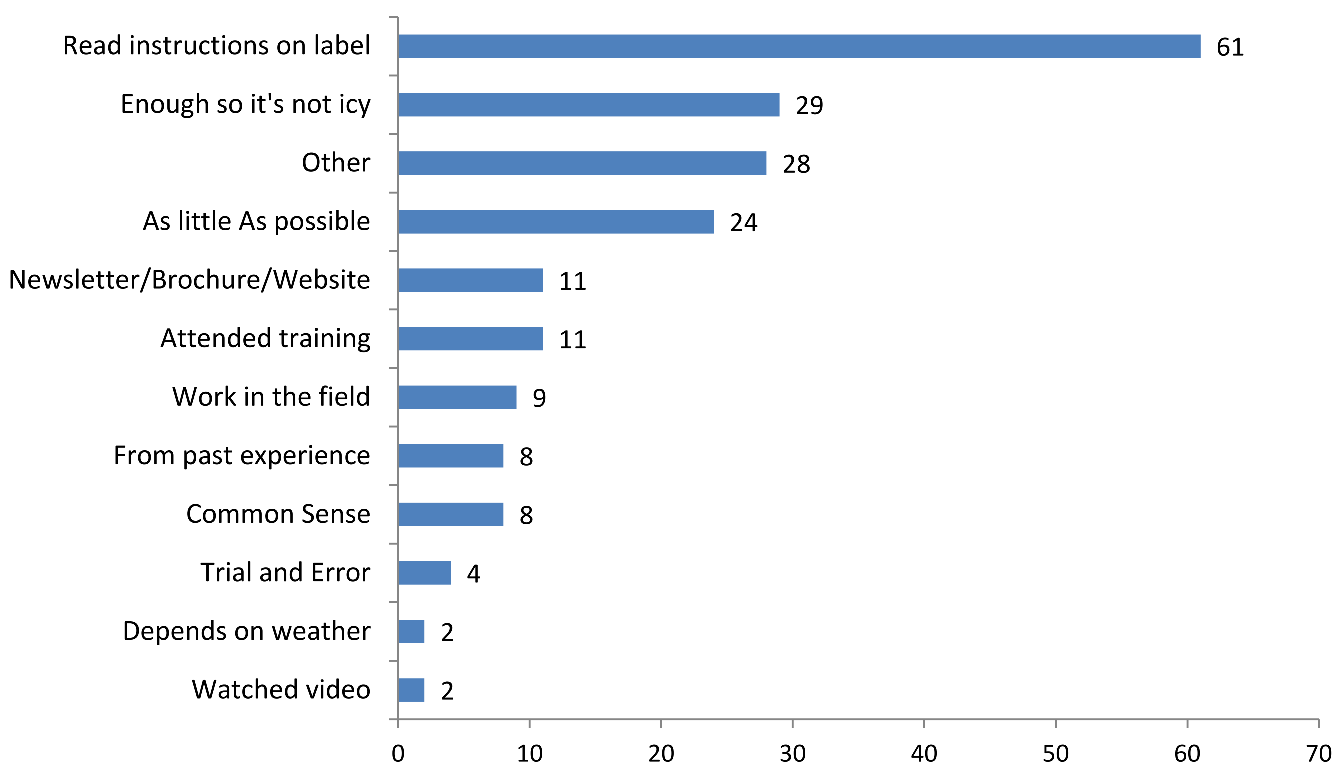
Question 4. How much sidewalk salt (lbs.) do you use in an average winter?



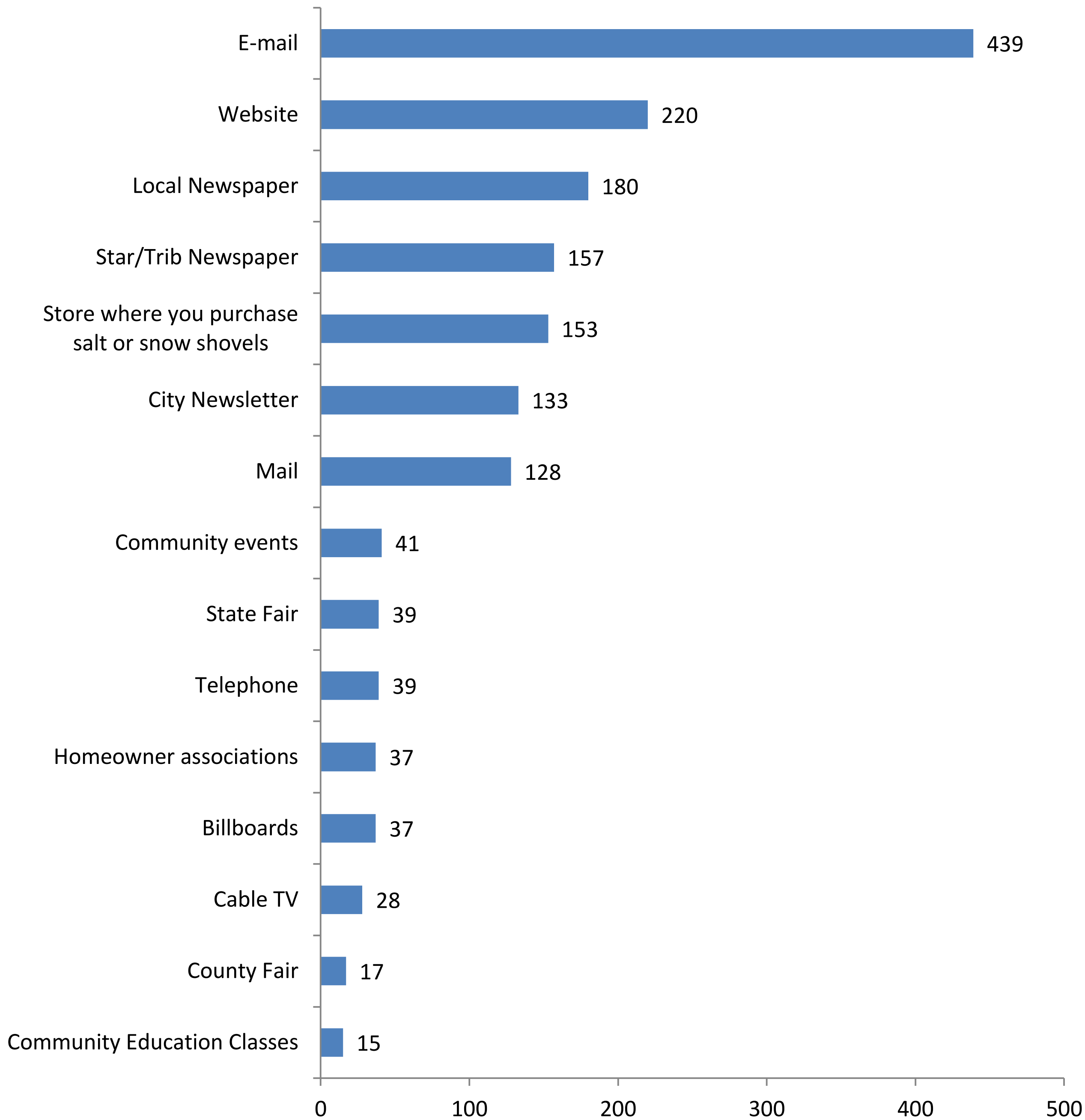
Question 5. Do you know how much sidewalk salt you should apply? (n = 754)



If yes, how do you know? (n=197)



Question 6. What are the best ways to get information to you?



Appendix D – Educational Resources

Table 1. Resources for Cities, Townships, Counties, and WMOs/WDs

Type of Resource	Title	Subject	Source
Brochure	Finding a balance: winter operations program	Winter performance goals, responsibilities, chemical information	MnDOT
Brochure	Snow happens	Snow ordinance operations and instructions for residents	City of Ankeny, IA www.ankenyiowa.gov
Brochure	The good, the bad, and the ugly	Advises public on proper winter and yard maintenance	MnDOT
Brochure	Don't pass the salt brochure	Includes information on salt in wastewater, and tips for homeowners	City of Farmington, MN fmtn.org/DocumentCenter/View/1190
Event	Freshwater Society's Annual Road Salt Symposium	Discussion on environmental impacts of road salt and innovations in transportation to reduce impacts	Freshwater Society freshwater.org/annual-road-salt-symposium-fights-chloride-pollution
Fact Sheet	Salt Affects our Water	How to prevent storm water pollution - for the public	City of Minneapolis www.minneapolismn.gov/publicworks/stormwater/
Fact Sheet	Chloride Usage Education and Reduction Program	Includes information on environmental concerns and alternatives to conventional road salting	Lower DuPage River Watershed Coalition www.dupagerivers.org/Chlorides.htm
Flier	More Salt: not always the cure for slippery roads	Includes information on temperatures where salt is most effective	Michigan DOT www.mi.gov/documents/mdot/MDOT_Salt_Cure_258508_7.pdf
Postcard	Get a Grip Postcard	Advises public to protect themselves from slips and falls	Smart About Salt www.smartaboutsalt.com/

Type of Resource	Title	Subject	Source
Postcard	Salt Pollutes Postcard	Includes winter maintenance tips for homeowners	MPCA www.pca.state.mn.us/programs/roadsalt.html
Resources: reports, manuals, videos	Various	Various	Local Road Research Board (LRRB) www.lrrb.org/
Resources: reports and technical summaries	Various	Various	MnDOT Research Services www.dot.state.mn.us/research/
Website	Reducing Road Salts Use	Comprehensive and integrated approach to road salt use	Riversides www.riversides.org/
Website	Road salt and water quality	Includes tips for homeowners, environmental concerns, educational resources, and training opportunities	MPCA www.pca.state.mn.us/r0pgb86
Website	Working to Advance Road Weather Information Systems Technology	Reports on winter maintenance projects	Aurora www.aurora-program.org/

Table 2. Resources for Winter Maintenance Professionals

Type of Resource	Title	Subject	Source
Clip Board Pages	Parking lot/sidewalk winter maintenance. Stickers for clipboards	Easy to reference highlights from Winter Maintenance for Parking Lots and Sidewalks training	MPCA www.pca.state.mn.us/programs/roadsalt.html
Event	Minnesota Fall Maintenance Expo	Exhibits, competitions, classes	Minnesota Fall Maintenance Expo mnfallexpo.com
Event	Minnesota Nursery and Landscape Association (MNLA) Snow Day	Tradeshow, seminars	MNLA www.mnla.biz
Event	Freshwater Society's Annual Road Salt Symposium	Discussion on environmental impacts of road salt and innovations in transportation to reduce impacts	Freshwater Society freshwater.org/annual-road-salt-symposium-fights-chloride-pollution
Event	Snow and Ice Symposium	Tradeshow, educational sessions on winter maintenance issues	Snow and Ice Management Association (SIMA) www.sima.org/show/schedule
Fact Sheet	Chloride Usage Education and Reduction Program	Includes information on environmental concerns and alternatives to conventional road salting	Lower DuPage River Watershed Coalition http://www.dupagerivers.org/Chlorides.htm
Handbook	Minnesota Snow and Ice Control Field Handbook for Snowplow Operators	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Information Tools	City of Eagan Snow and Ice Control Policy for City Streets	Example city snow and ice control policy	City of Eagan www.pca.state.mn.us/index.php/view-document.html?gid=5501
Information Tools	Calibrating Manual Sanders	Instructions for calibrating manual sanders	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5495
Information Tools	Control Point Calibration	Instructions for control point calibration	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5493

Type of Resource	Title	Subject	Source
Information Tools	Field Guide for Testing Deicing Chemicals	Instructions for testing deicing chemicals	MnDOT www.dot.state.mn.us/maintenance/pdf/research/field-testing-deicers.pdf
Information Tools	Goodhue County Snow Removal Policy	Example snow removal policy	Goodhue County www.pca.state.mn.us/index.php/view-document.html?gid=5498
Information Tools	MnDOT Snowplow Salt and Sander Controller Calibration guide	Instructions for controller calibration	MnDOT www.dot.state.mn.us/maintenance/pdf/research/SaltSanderCalibrationGuide.pdf
Information Tools	Olmsted County Snow and Ice Removal Policy	Example snow and ice control policy	Olmsted County www.pca.state.mn.us/index.php/view-document.html?gid=5499
Information Tools	Open Loop Calibration	Instructions for open loop calibration	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5494
Information Tools	Scott County Snow Plow Route Book	Example snow plow route book	Scott County www.pca.state.mn.us/index.php/view-document.html?gid=5497
Manual	MnDOT Anti-icing Guide	What is anti-icing, why anti-ice, when to anti-ice, where to anti-ice, how to anti-ice	MnDOT www.dot.state.mn.us/maintenance/pdf/research/AntiIcingGuide8Full.pdf
Manual	Winter Parking Lot and Sidewalk Manual - Reducing Environmental Impacts of Chlorides	Winter maintenance best practices for professionals	MN LTAP www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf
Newsletter	Clear Roads newsletter	Winter maintenance news	Clear Roads clearroads.org

Type of Resource	Title	Subject	Source
Report	Salt Brine Blending to Optimize Deicing and Anti-Icing Performance	Evaluation of ice melt capacity and performance factors of deicers	MnDOT www.dot.state.mn.us/research/documents/201220.pdf
Resources: reports, manuals, videos	Various	Various	Local Road Research Board (LRRB) http://www.lrrb.org/
Resources: reports and technical summaries	Various	Various	MnDOT Research Services www.dot.state.mn.us/research/
Tools	Calibration Data Record	Template for calibration records	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5496
Tools	Local Government Snowplow Salt and Sander Controller Calibration Guide	Easy-to-use steps for calibrating snowplow sander controls	LRRB http://www.lrrb.org/pdf/2009RIC08.pdf
Training	Minnesota Circuit Training and Assistance Program (CTAP)	Training on deicers and anti-icing, application rates, costs, and storage	MN LTAP www.mnltap.umn.edu/about/programs/ctap
Training	Salt Solutions Program Maintenance Training	Winter maintenance training	MNDOT http://www.dot.state.mn.us/maintenance/training.html
Training	Snow and Ice Control Application (CTAP)	Deicing material choices, application rates, effectiveness	MN LTAP www.mnltap.umn.edu/about/programs/ctap/

Type of Resource	Title	Subject	Source
Training	Snowplow Salt and Sander Controller Calibration Hands-on Workshop (CTAP)	In person calibration assistance	MN LTAP www.mnltap.umn.edu/about/programs/ctap/
Training	Winter Parking Lot and Sidewalk Maintenance	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Training	Winter Road Maintenance	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Video	Small Site Winter Maintenance	Winter maintenance best practices for areas that are too small for motorized equipment	MWMO and UMN www.pca.state.mn.us/programs/roadsalt.html
Website	Minnesota Local Technical Assistance Program (LTAP)	Programs, training events, publications, design tools, technical topics	MN LTAP http://www.mnltap.umn.edu/
Website	MPCA Road salt education program	Training schedule, training materials, manuals, technical information, list of those certified	MPCA www.pca.state.mn.us/programs/roadsalt.html
Website	Reducing Salt Use While Keeping Streets Safe	Describes the winter maintenance practices of the city of Minnetonka	City of Minnetonka www.eminnetonka.com/snowplowing
Website	Reducing Road Salts Use	Comprehensive and integrated approach to road salt use	RiverSides www.riversides.org
Website	Snow and Ice Management Association (SIMA)	Includes winter maintenance resource, educational resources, and events	SIMA sima.org

Table 3. Resources for Educators and Citizens

Type of Resource	Title	Subject	Source
Brochure	Residential Snow and Ice Care	Brochure about smart snow removal practices for homeowners	Nine Mile Creek www.ninemilecreek.org
Brochure	Don't pass the salt brochure	Includes information on salt in wastewater, and tips for homeowners	City of Farmington, NM http://fmtn.org/DocumentCenter/View/1190
Brochure	Winter Maintenance: Choosing a deicer	Brochure about choosing a deicer	Nine Mile Creek www.ninemilecreek.org
Brochure	Winter Maintenance: Hiring a Snow Removal Service	Brochure about hiring a certified snow removal contractor	Nine Mile Creek www.ninemilecreek.org
Fact Sheet	Salt Affects our Water	How to prevent storm water pollution - for the public	City of Minneapolis www.minneapolismn.gov
Fact sheet	Winter maintenance for homeowners	Tips for homeowners on winter maintenance	MWMO www.mwmo.org/wintertrainings.html
Fact Sheet	Chloride Usage Education and Reduction Program	Factsheets for different audiences: mayors/managers, public works staff, commercial operators, homeowners	Lower DuPage River Watershed Coalition www.dupagerivers.org/Chlorides.htm
Flier	More Salt: not always the cure for slippery roads	Includes information on temperatures where salt is most effective	Michigan DOT www.mi.gov/documents/mdot/MDOT_Salt_Cure_258508_7.pdf
Information-Hiring a Certified Contractor	List of Certified Contractors	Road Salt Applicators Training Certificate Holders	MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=5489
Video	Training video for residents	Winter maintenance best practices for residents	MWMO and UMN www.pca.state.mn.us/r0pgb86

Type of Resource	Title	Subject	Source
Website	Road Salt: Can we have safe roads and healthy streams?	Information on road salt, alternatives, and environmental concerns	Lake Superior Duluth Streams www.lakesuperiorstreams.org/understanding/impact_salt.html
Website	Reducing Salt Use While Keeping Streets Safe	Describes the winter maintenance practices of the city of Minnetonka	www.eminnetonka.com/snowplowing
Website	Road salt and water quality	Includes tips for homeowners, environmental concerns, educational resources, and training opportunities	MPCA www.pca.state.mn.us/r0pgb86
Website	Smart About Salt: Winter Salt Management Program	Winter maintenance tips and information for homeowners	www.smartaboutsalt.com

Prepared by:
Capitol Region Watershed District
and Emmons & Olivier Resources, Inc.

Como Lake TMDL

October 2010

water | ecology | community

wq-iw11-05e

Cover Image
Como Lake

Document Component Specs
T ®
Back Cover: Neenah Paper • Esse • T ®
Wire Binding: Manufactured using recycled high carbon steel

TMDL SUMMARY TABLE

<table>
<tr><th>EPA/MPCA Required Elements</th><th colspan="3">Summary</th><th>TMDL Page #</th></tr>
<tr><td>Location</td><td colspan="3">Capitol Region Watershed District (CRWD) in the Upper Mississippi Basin, Ramsey County, MN (HUC 7010206).</td><td>2</td></tr>
<tr><td>303(d) Listing Information</td><td colspan="3">Describe the water body as it is identified on the State/Tribe’s 303(d) list:
• Como Lake (62-0055-00)
• Impaired Beneficial Use(s) - Aquatic recreation
• Indicator: Nutrient/Eutrophication Biological Indicators
• Target start/completion date: 2010/2014
• Original listing year: 2002</td><td>2</td></tr>
<tr><td>Applicable Water Quality Standards/ Numeric Targets</td><td colspan="3">Class 2B waters, MN Eutrophication Standards for shallow lakes, MN Rule 7050.0222 Subp. 4
• TP < 60μg/L
• Chlorophyll-a < 20 μg/L
• Secchi depth > 1.0</td><td>15</td></tr>
<tr><td>Loading Capacity (expressed as daily load)</td><td colspan="3">Loading Capacity: 0.83 lbs TP/day
Critical condition: in summer when TP concentrations peak and clarity is typically at its worst</td><td>31</td></tr>
<tr><td rowspan="11">Wasteload Allocation</td><td colspan="3"></td><td></td></tr>
<tr><th>Source</th><th>Permit #</th><th>WLA</th><td rowspan="10">33</td></tr>
<tr><td>Permitted Stormwater (St. Paul MS4)</td><td>MS400054</td><td rowspan="7">0.68 lbs/day

(categorical)</td></tr>
<tr><td>Permitted Stormwater (Falcon Heights MS4)</td><td>MS400018</td></tr>
<tr><td>Permitted Stormwater (Roseville MS4)</td><td>MS400047</td></tr>
<tr><td>Permitted Stormwater (CRWD MS4)</td><td>MS400206</td></tr>
<tr><td>Permitted Stormwater (Ramsey County MS4)</td><td>MS400191</td></tr>
<tr><td>Permitted Stormwater (construction)</td><td>Various</td></tr>
<tr><td>Permitted Stormwater (industrial)</td><td>No current sources</td></tr>
<tr><td>Permitted Stormwater (Mn/DOT MS4)</td><td>MS400170</td><td>0.00022 lbs/day</td></tr>
<tr><td>Reserve Capacity (and related discussion in report)</td><td>NA</td><td></td></tr>
<tr><td rowspan="5">Load Allocation</td><td colspan="3"></td><td rowspan="4">36</td></tr>
<tr><th>Source</th><th colspan="2">LA (lbs/day)</th></tr>
<tr><td>Internal load</td><td colspan="2">0.10</td></tr>
<tr><td>Atmospheric deposition</td><td colspan="2">0.05</td></tr>
<tr><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Margin of Safety</td><td colspan="3">Implicit MOS: Conservative modeling assumptions</td><td>32</td></tr>
<tr><td>Seasonal Variation</td><td colspan="3">Seasonal variation: Critical conditions in these lakes occur in the summer, when TP concentrations peak and clarity is</td><td>37</td></tr>
</table>

	at its worst. The water quality standards are based on growing season averages. The load reductions are designed so that the lakes will meet the water quality standards over the course of the growing season (June through September).	
Reasonable Assurance	***Summarize Reasonable Assurance*** CRWD Rules CRWD Watershed Management Plan NPDES MS4 program Como Lake Strategic Management Plan	42
Monitoring	***Monitoring Plan included?*** Yes	38
Implementation	***1. Implementation Strategy included?*** Yes ***2. Cost estimate included?*** Yes	40
Public Participation	• Public Comment period (August 30, 2010 – September 29, 2010) • Comments received? Yes. • Summary of other key elements of public participation process	44

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ABBREVIATIONS

Atm	Atmospheric
BMP	Best management practice
CALM	Consolidation assessment and listing methodology
Chl	Chlorophyll-*a*
CLSMP	Como Lake Strategic Management Plan
CRWD	Capitol Region Watershed District
DNR	Minnesota Department of Natural Resources
EPA	United States Environmental Protection Agency
GSM	Growing season mean
LA	Load allocation
µg/L	Micrograms per liter
Mn/DOT	Minnesota Department of Transportation
MOS	Margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal separate storm sewer system
NCHF	North Central Hardwood Forest
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
SD	Secchi depth
SPRWS	St. Paul Regional Water Services
SWPPP	Stormwater pollution prevention program
TMDL	Total maximum daily load
TP	Total phosphorus
TSI	Trophic state index
WLA	Wasteload allocation

EXECUTIVE SUMMARY

Como Lake was listed as an impaired water by the Minnesota Pollution Control Agency (MPCA) in the 2002 303(d) list. The impaired use is aquatic recreation, with the stressor identified as "nutrient/ eutrophication biological indicators."

In 2002 the Capitol Region Watershed District developed a management plan for Como Lake. The Como Lake Strategic Management Plan (CLSMP) identified important management issues through input from key stakeholder groups, prioritized the issues and associated goals, and identified implementation activities. The CLSMP was used as the basis for this TMDL.

The Como Lake watershed is located in the north-central portion of the Capitol Region Watershed District (CRWD), which lies entirely within the North Central Hardwood Forest Ecoregion. Como Lake is located in the City of Saint Paul and the watershed is located within three municipalities in Ramsey County.

Phosphorus was identified as the main pollutant causing the impairment. The MN state eutrophication standards for shallow lakes were used to calculate the total maximum daily load (TMDL) for Como Lake.

Como Lake is a eutrophic lake, with relatively higher total phosphorus (TP) compared to chlorophyll-*a* concentrations and transparency. TP growing season means ranged from 100 to 400 µg/L. 2001 was the year with the poorest water quality. The same general pattern exists for chlorophyll-*a* and Secchi depth.

The sources of phosphorus loads to Como Lake are watershed runoff, internal loading, and atmospheric deposition. Phosphorus loads from each of these sources were estimated and used as input into the lake response model, which was used to estimate the assimilative capacity of the lake.

The watershed load to Como Lake represents approximately 34% of the total load to the lake, the internal load represents approximately 65% of the load to the lake, and atmospheric deposition represents the remaining 1% of the phosphorus load to the lake. A 60% reduction in watershed load and a 97% reduction in internal load is required in the TMDL. A categorical wasteload allocation is provided for all of the regulated sources, including communities regulated under a municipal separate storm sewer system (MS4) permit, construction stormwater, and industrial stormwater, with the exception of MNDOT, which has an individual allocation. The load reductions identified by the wasteload allocation will need to be met by this group as a whole. The load allocations for Como Lake consist of atmospheric deposition and internal loading.

A monitoring plan was outlined that lays out the different types of monitoring that will need to be completed in order to track the progress of implementation activities associated with Como Lake and of associated changes in water quality due to the management practices.

The implementation strategy lays out a subwatershed-based approach to reduce both the watershed load and the internal load in Como Lake.

1. BACKGROUND AND POLLUTANT SOURCES

1A. 303(d) Listings

Table 1. Impaired Waters Listing

Lake name:	Como Lake
DNR ID#:	62-0055-00
Hydrologic Unit Code:	7010206
Pollutant or stressor:	Nutrient/Eutrophication Biological Indicators
Impairment:	Aquatic recreation
Year first listed:	2002
Target start/completion (reflects the priority ranking):	2010/2014
CALM category[1]:	5B: Impaired by multiple pollutants and at least one TMDL study plans are approved by EPA*

*Como Lake has an aquatic consumption impairment due to mercury content in fish tissue. A statewide TMDL and implementation plan have been completed and approved.

1B. Background

Lake Management Plan

In 2002 the Capitol Region Watershed District (CRWD) developed a management plan for Como Lake. The Como Lake Strategic Management Plan (CLSMP) identified important management issues through input from key stakeholder groups, prioritized the issues and associated goals, and identified implementation activities. The CLSMP was used as the basis for this TMDL.

Watershed

The Como Lake watershed is located in the north-central portion of the CRWD and is within the Upper Mississippi Watershed. This area lies entirely within the North Central Hardwood Forest Ecoregion. Como Lake is located in the City of Saint Paul and the watershed is located within three municipalities (Table 2, Figure 1) in Ramsey County.

Como Lake has a 1783-acre watershed (not including the surface area of the lake) and is defined as a shallow lake according to the Minnesota Pollution Control Agency (MPCA). The majority of the watershed's water contribution to Como Lake is delivered through an extensive piped stormwater system consisting of twenty-two stormsewers discharging directly into the lake. A large portion of the northern runoff, including the golf course, runs through a series of two constructed wetland detention ponds. Gottfried's Pit collects the drainage from parts of Roseville, Falcon Heights, Ramsey County right-of-ways, and the City of Saint Paul. Gottfried's

[1] EPA's Consolidation Assessment and Listing Methodology [CALM] integrates the 305(b) Report with the 303(d) TMDL List. The primary purposes of the categorization are to determine the extent that all waters are attaining water quality standards, to identify waters that are impaired and need to be added to the 303(d) list, and to identify waters that can be removed from the list because they are attaining standards.

Pit is pumped to Como Lake. Como Lake discharges into the Trout Brook stormsewer and on to the Mississippi River.

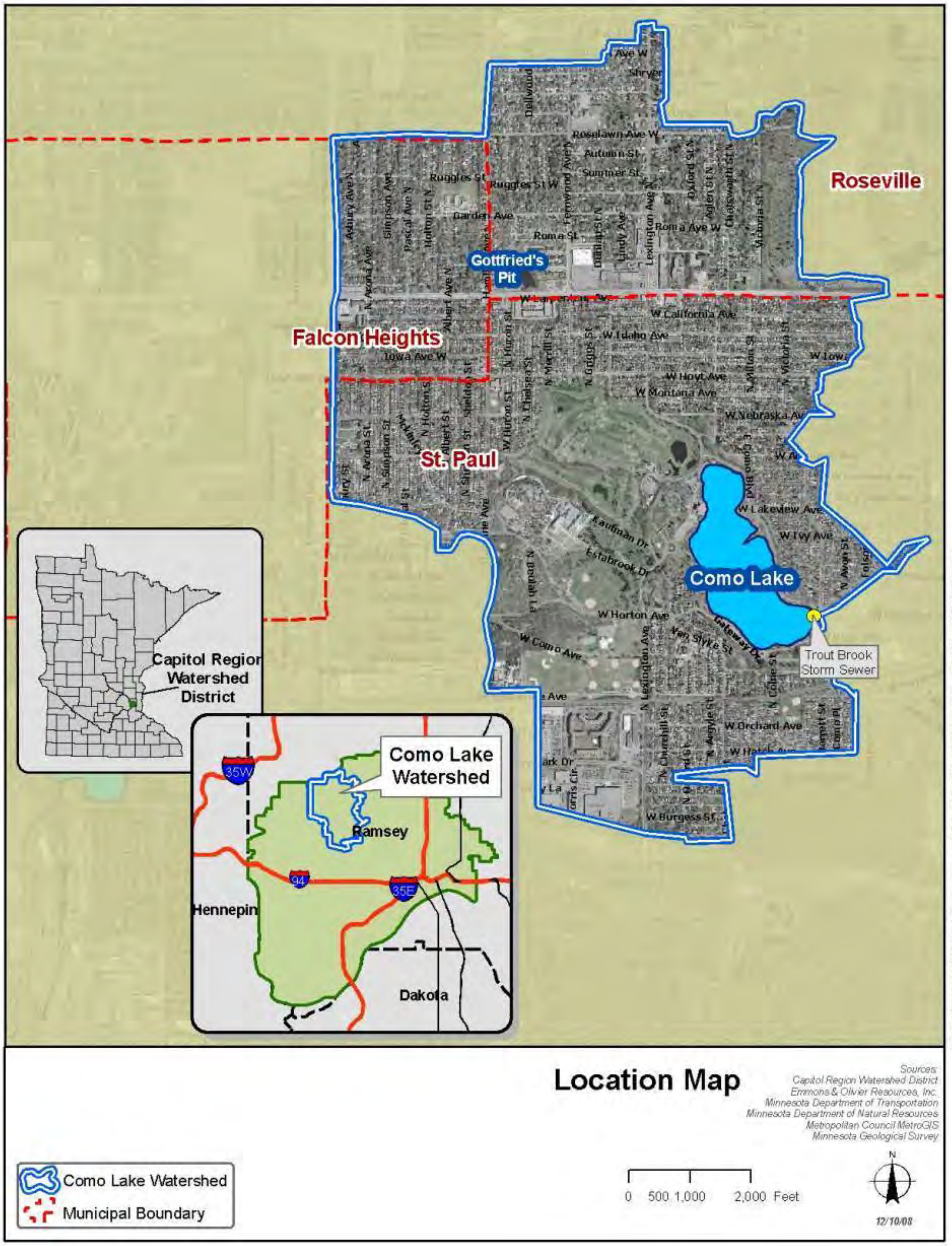

Figure 1. Como Lake Watershed Location

Table 2. Municipalities within Como Lake Watershed.

City	Area [acres]*
Saint Paul	1,205
Falcon Heights	230
Roseville	420
Total	**1,855**

*Areas include the watershed and the lake (72 ac.)

Land Use

The main land uses in the Como Lake watershed (Figure 2) are single family residential (54%), parks, recreation, and preserves (20.4%), institutional (7.5%), and commercial (6.7%). Open water makes up 4.3% of the total watershed.

Planned land use (Figure 3) shows increases in industrial, multi-family residential, and park, recreation, and preserves. Decreases are expected in railway, commercial, institutional, single family residential, and undeveloped lands (Table 3).

Table 3. Como Lake Watershed Land Use Summary.

Land Use Classification	2005 Area[1] [acres]	2020 Area[2] [acres]	% Change 2005-2020
Commercial[3]	112	104	-7%
Industrial	15	23	55%
Institutional	110	103	-7%
Mixed Use	-	6	-
Multi-Family Residential	63	96	53%[4]
Open Water	69	69	0%
Parks, Recreation, & Preserves	384	396	3%
Railway	19	20	4%
Single Family Residential	1070	1038	-3%
Undeveloped	13	-	-
Total	**1855**	**1855**	

[1]Data source: Generalized Land Use 2005 for the Twin Cities Metropolitan Area
[2]Data source: Regional Planned Land Use - Twin Cities Metropolitan Area
[3]Commercial includes 2020 land use classified as Limited Business
[4]The apparent conversion of single family residential to multi-family residential land use is due to a higher degree of resolution in the 2020 land use plans. The actual land use is not expected to change.

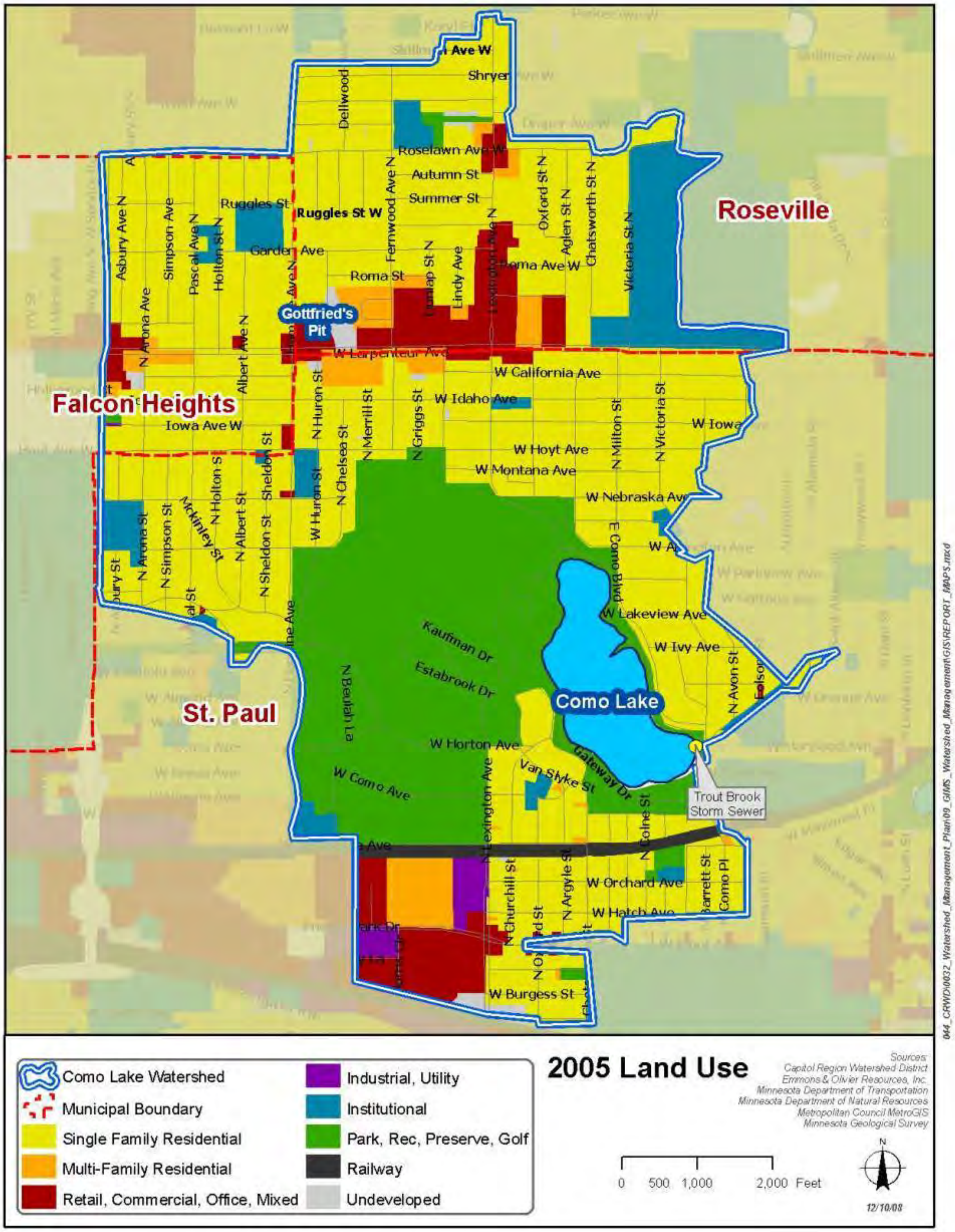

Figure 2. Land Use, 2005

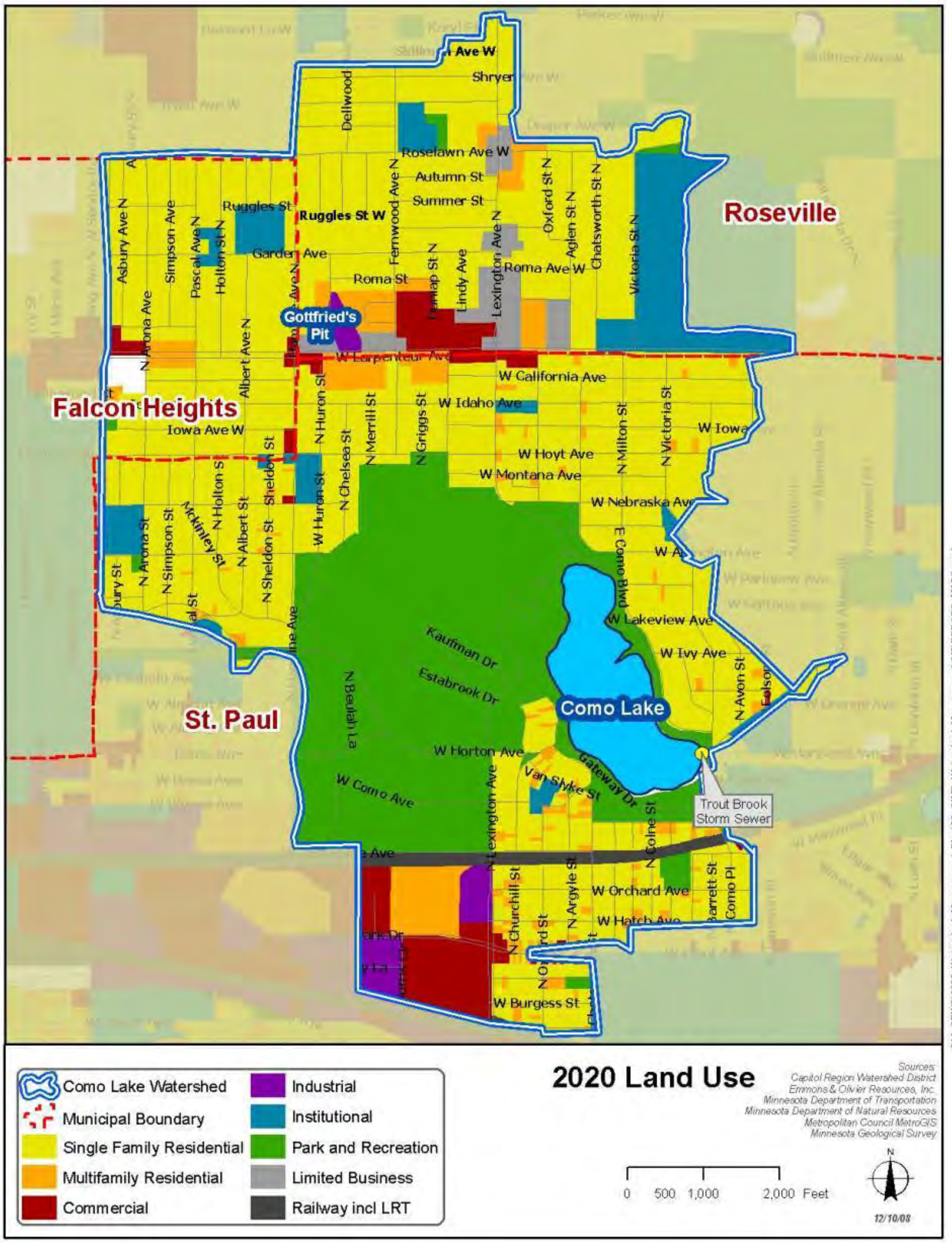

Figure 3. Planned Land Use, 2020

Population

Population is expected to increase in the cities that intersect the Como Lake watershed, with slightly greater percent increases projected to occur in St. Paul and Roseville (Table 4).

Table 4. Current population and population forecasts for cities within the Como Lake Watershed.

City	County	Population				% increase 2000-2030
		2000	2010	2020	2030	
Saint Paul	Ramsey	286,840	305,000	320,000	331,000	15.4 %
Falcon Heights	Ramsey	5,572	6,100	6,100	6,100	9.5 %
Roseville	Ramsey	33,690	36,000	37,000	38,300	13.7 %

Data from the Metropolitan Council's 2030 Regional Development Framework - Revised Forecasts, January 9, 2008.

Wildlife Resources

In 1995 the St. Paul Department of Parks and Recreation performed a Natural Resource Inventory for Como Park. The inventory cataloged the entire park. From the 1995 inventory and testimony from local residents cited in the Como Lake Strategic Management Plan, it is evident that the Como Lake watershed is home to many of the types of birds, amphibians, reptiles, and mammals typical of wetland and upland areas in this portion of the North Central Hardwood Forests Ecoregion. Como Park contains 90 acres of intermediate upland forest that includes various oak species, maple species, black cherry, basswood, elm, and aspen.

Lake Uses

Como Lake is an important recreational resource for the area and the centerpiece for Como Park, which is one of the most visited parks in the metropolitan area. Como Lake's use for recreation dates back to 1857. The lake is used recreationally for fishing, boating, and aesthetic viewing from the extensive trail surrounding the lake.

Soils

The soils information for the Como Lake watershed was gathered from the 2006 NRCS county soil survey data for Ramsey County. Soils within the Como Lake watershed are mapped as urban/unknown, with some areas of group B hydric soils also present (Figure 4).

Permitted Sources

Municipal Separate Storm Sewer Systems (MS4)

The stormwater program for municipal separate storm sewer systems (MS4s) is designed to reduce the amount of sediment and pollution that enters surface and ground water from storm sewer systems to the maximum extent practicable. These stormwater discharges are regulated through the US EPA National Pollutant Discharge Elimination System (NPDES) program, which has been delegated to the MPCA. Phase I of the NPDES Storm Water Program identified the City of St. Paul as a large MS4, and the city has an individual NPDES permit (on public notice as of June 2010). The MPCA has issued an MS4 general permit that regulates each Phase II MS4 and requires the owner or operator to develop a Stormwater Pollution Prevention Program (SWPPP) that incorporates best management practices applicable to their MS4. Roseville and Falcon Heights are covered under the Phase II MS4 general permit. In addition, Ramsey County and the Minnesota Department of Transportation (Mn/DOT) Metro District are regulated MS4s.

CRWD is also regulated by an MS4 permit, but does not currently have any regulated stormwater conveyances within the Como Lake watershed; it is included in this TMDL to cover the possibility that it could have regulated conveyances in the future. Table 5 includes each regulated MS4 and their NPDES permit number. There are no industrial stormwater permits issued within the Como Lake watershed; construction permits are not listed as they are very time-dependent and can change often.

Table 5. Permitted Point Sources.

MS4	NPDES Permit Number	Area in Como Lake Watershed (ac)	Percent Area in Watershed
Capitol Region WD	MS400206	0	0%
City of Saint Paul	MS400054	1178	64%
City of Falcon Heights	MS400018	226	12%
City of Roseville	MS400047	408	22%
Ramsey County	MS400191	42	2.3%
Mn/DOT Metro District	MS400170	0.6	0.032%

Construction and Industrial Stormwater

Construction sites can contribute substantial amounts of sediment to stormwater runoff. The NPDES Stormwater Program requires that all construction activity disturbing areas equal to or greater than one acre of land must obtain a permit and create a Stormwater Prevention Pollution Plan (SWPPP) that outlines how runoff from the construction site will be minimized during and after construction. Construction stormwater permits cover construction sites throughout the duration of the construction activities, and the level of on-going construction activity varies.

The Industrial Stormwater General Permit applies to facilities with Standard Industrial Classification Codes in ten categories of industrial activity with significant materials and activities exposed to stormwater. Significant materials include any material handled, used, processed, or generated that when exposed to stormwater may leak, leach, or decompose and be carried offsite. The NPDES Stormwater Program requires that the industrial facility obtain a permit and create a Stormwater Prevention Pollution Plan (SWPPP) for the site outlining the structural and/or non-structural best management practices used to manage stormwater and the site's Spill Prevention Control and Countermeasure Plan. An annual report is generated documenting the implementation of the SWPPP.

There are no facilities with industrial stormwater permits within the boundaries of this project.

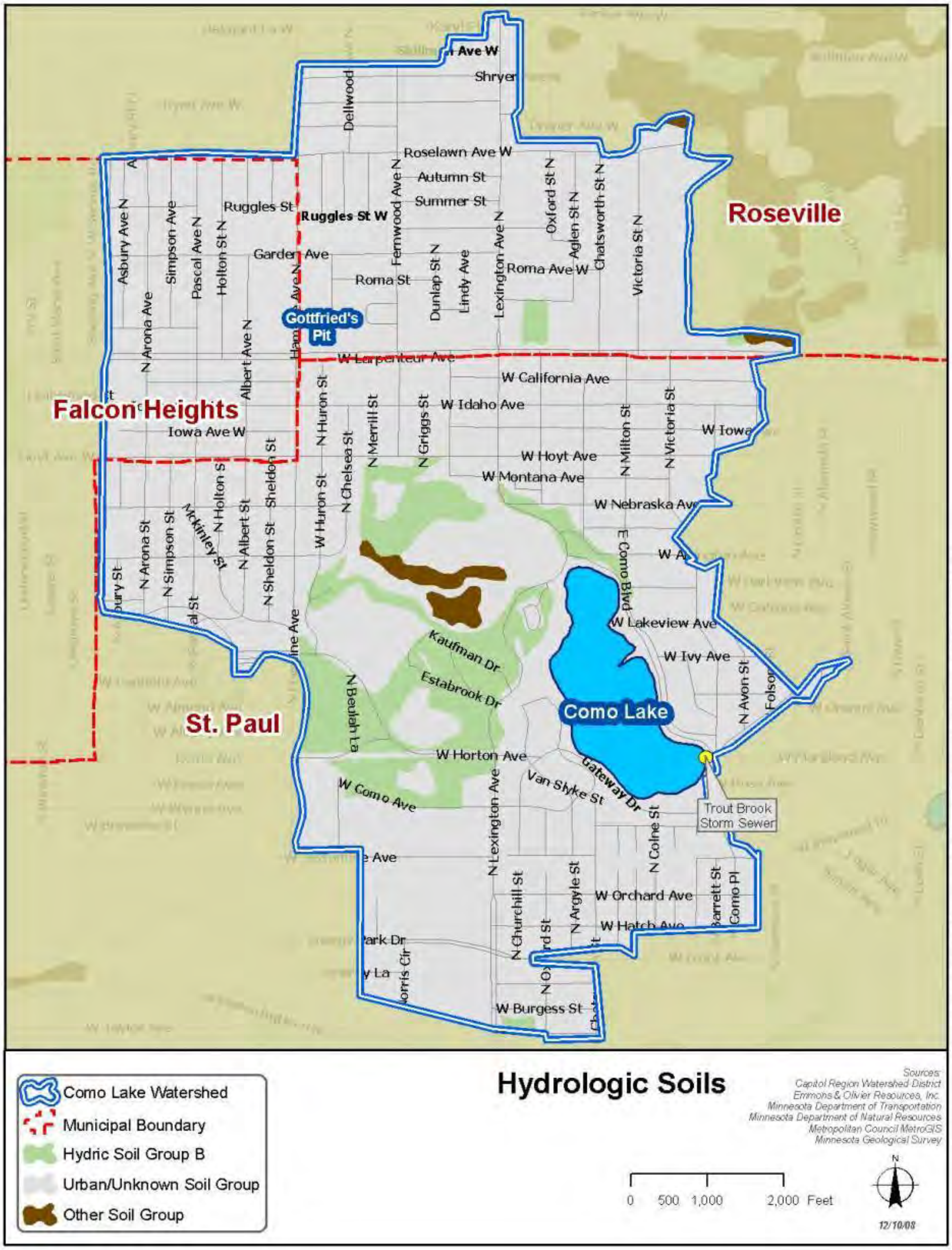

Figure 4. Soils

1C. Pollutant of Concern

Role of Phosphorus in Shallow Lakes

Como Lake is classified by the MPCA as a shallow lake. The MPCA defines a lake as shallow if its maximum depth is less than 15 ft, or if the littoral zone covers at least 80% of the lake's surface area.

Total phosphorus is often the limiting factor controlling primary production in freshwater lakes. It is the nutrient of focus for this TMDL, and is sometimes referred to as the causal factor. As phosphorus concentrations increase, primary production also increases, as measured by higher chlorophyll-*a* concentrations. Higher concentrations of chlorophyll lead to lower water transparency. Both chlorophyll-*a* and Secchi transparency are referred to as response factors, since they indicate the ecological response of a lake to excessive phosphorus input.

There is often a positive relationship between TP and chlorophyll-*a,* and a negative relationship between TP and Secchi depth, as is the case with Como Lake (Figure 5 and Figure 6). Similarly, a negative relationship is apparent between chlorophyll-*a* and Secchi depth (Figure 7).

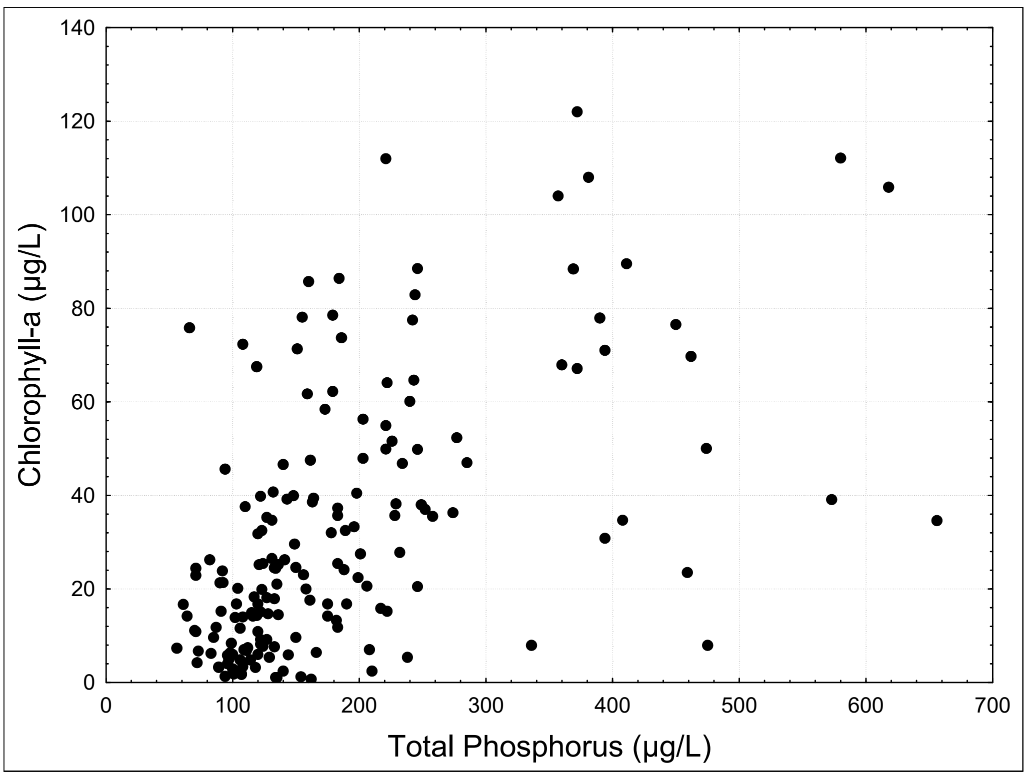

Figure 5. Relationship of Chlorophyll-*a* to TP in Como Lake, 1993-2007.

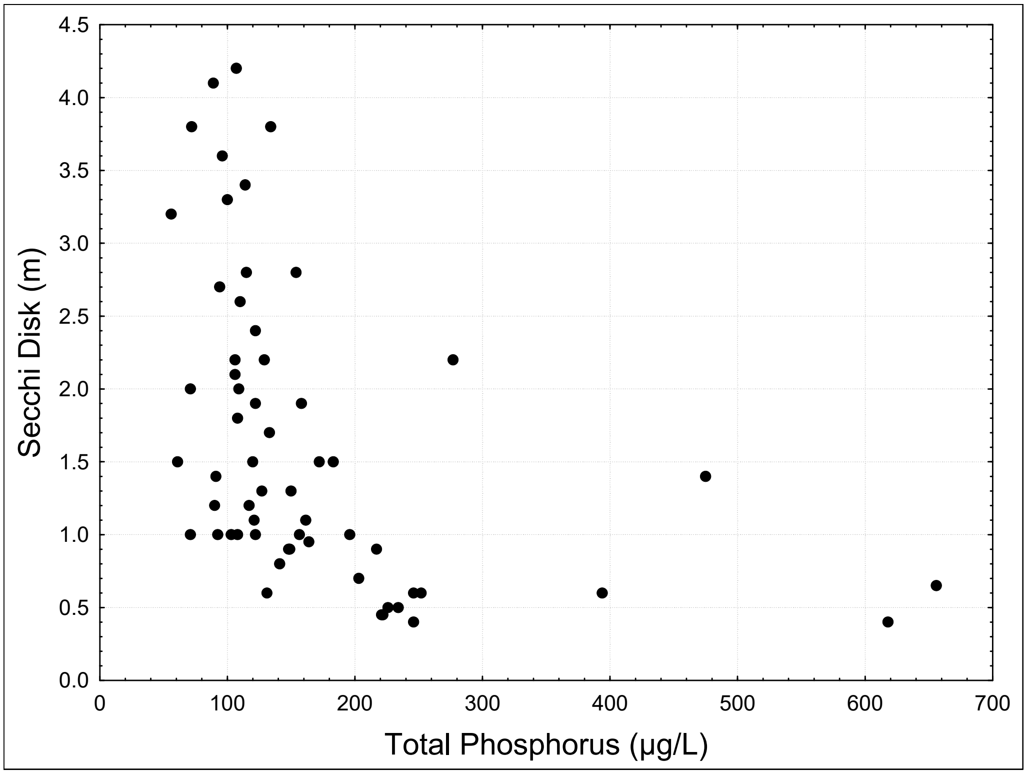

Figure 6. Relationship of Secchi Depth to TP in Como Lake, 1993-2007.

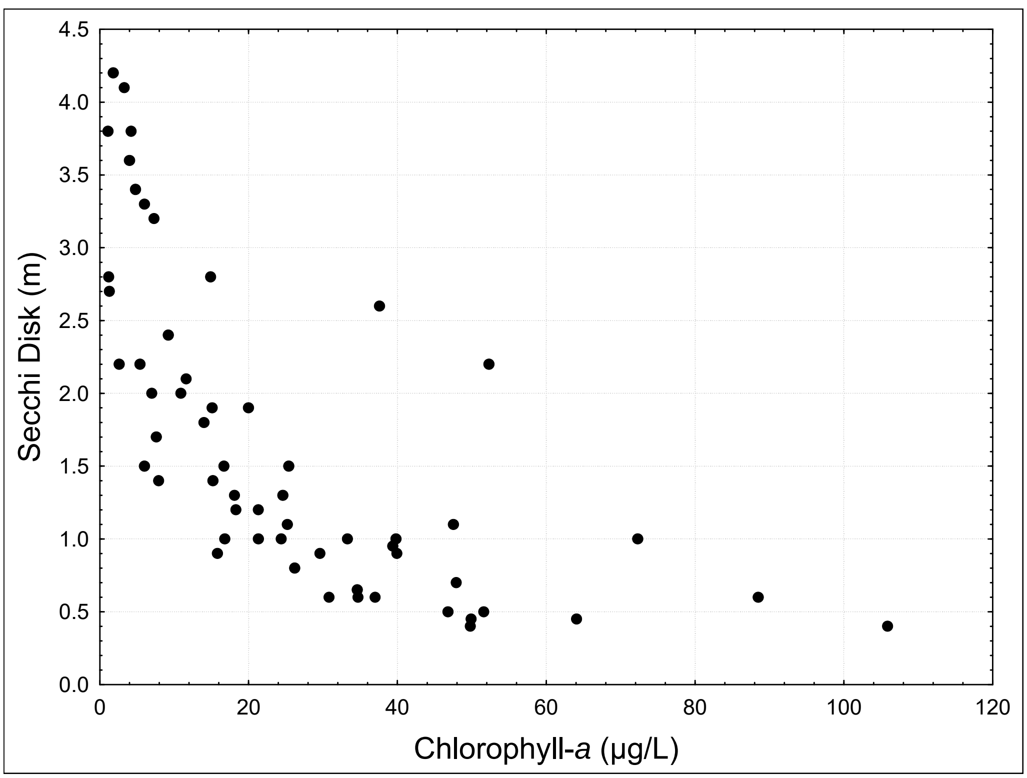

Figure 7. Relationship of Secchi Depth to Chlorophyll-a in Como Lake, 1993-2007.

The relationship between phosphorus concentration and the response factors (chlorophyll and transparency) is often different in shallow lakes as compared to deeper lakes. In deeper lakes, primary productivity is often controlled by physical and chemical factors such as light availability, temperature, and nutrient concentrations. The biological components of the lake (such as microbes, algae, macrophytes, zooplankton and other invertebrates, and fish) are distributed throughout the lake, along the shoreline, and on the bottom sediments. In shallow lakes, the biological components are more concentrated into less volume and exert a stronger influence on the ecological interactions within the lake. There is a more dense biological community at the bottom of shallow lakes than in deeper lakes because of the fact that oxygen is replenished in the bottom waters and light can often penetrate to the bottom. These biological components can control the relationship between phosphorus and the response factors.

The result of this impact of biological components on the ecological interactions is that shallow lakes normally exhibit one of two ecologically alternative stable states (Figure 8): the turbid, phytoplankton-dominated state, and the clear, macrophyte (plant)-dominated state. The clear state is the most preferred, since phytoplankton communities (composed mostly of algae) are held in check by diverse and healthy zooplankton and fish communities. Fewer nutrients are released from the sediments in this state. The roots of the macrophytes stabilize the sediments, lessening the amount of sediment stirred up by the wind.

Nutrient reduction in a shallow lake does not lead to a linear improvement in water quality (indicated by turbidity in Figure 8). As external nutrient loads are decreased in a lake in the turbid state, slight improvements in water quality may at first occur. At some point, a further decrease in nutrient loads will cause the lake to abruptly shift from the turbid state to the clear state. The general pattern in Figure 8 is often referred to as "hysteresis," meaning that when forces are applied to a system, it does not return completely to its original state nor does it follow the same trajectory on the way back.

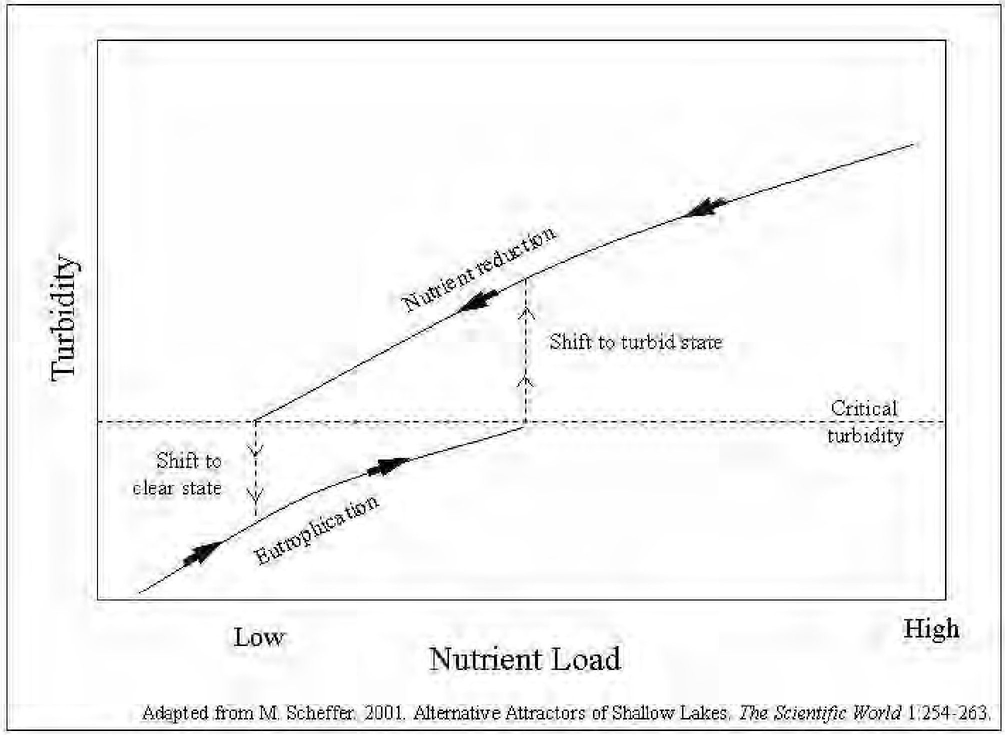

Figure 8. Alternative Stable States in Shallow Lakes.

The biological response of the lake to phosphorus inputs will depend on the state that the lake is in. For example, if the lake is in the clear state, the macrophytes may be able to assimilate the phosphorus instead of algae performing that role. However, if enough stressors are present in the lake, increased phosphorus inputs may lead to a shift to the turbid state with an increase in algal density and decreased transparency. The two main categories of stressors that can shift the lake to the turbid state are:

- Disturbance to the macrophyte community, for example from wind, benthivorous (bottom feeding) fish, boat motors, or light availability (influenced by algal density or water depth)
- A decrease in zooplankton grazer density, which allows unchecked growth of sestonic (suspended) algae. These changes in zooplankton density could be caused by an increase in predation, either directly by an increase in planktivorous fish that feed on zooplankton, or indirectly through a decrease in piscivorous fish that feed on the planktivorous fish.

This complexity in the relationships among the biological communities in shallow lakes leads to less certainty in predicting the in-lake water quality of a shallow lake based on the phosphorus load to the lake. The relationships between external phosphorus load and in-lake phosphorus concentration, chlorophyll concentration, and transparency are less predictable than in deeper lakes, and therefore lake response models are less accurate.

Another implication of the alternative stable states in shallow lakes is that different management approaches are used for shallow lake restoration than those used for restoration of deeper lakes. Shallow lake restoration often focuses on restoring the macrophyte, zooplankton, and fish communities to the lake.

2. APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGETS

2A. Designated Uses

Como Lake is classified as Class 2B, 3B, 4A, 4B, 5, and 6 waters. The most protective of these classes is Class 2 waters, which are protected for aquatic life and recreation. MN Rules Chapter 7050.0140 Water Use Classification for Waters of the State reads:

> Subp. 3. Class 2 waters, aquatic life and recreation. Aquatic life and recreation includes all waters of the state which do or may support fish, other aquatic life, bathing, boating, or other recreational purposes, and where quality control is or may be necessary to protect aquatic or terrestrial life or their habitats, or the public health, safety, or welfare.

2B. Water Quality Standards

Water quality standards are established to protect the designated uses of the state's waters. If a water body is meeting the applicable standards, then it is assumed that the designated uses of the water body are being attained. Amendments to Minnesota's Rule 7050, approved by the MPCA Board in December 2007 and approved by the EPA in May 2008, includes eutrophication standards for lakes (Table 6). Eutrophication standards were developed for lakes in general, and for shallow lakes in particular. Standards are less stringent for shallow lakes, due to higher rates of internal loading in shallow lakes and different ecological characteristics.

To be listed as impaired, the monitoring data must show that the standards for both TP (the causal factor) and either chlorophyll-*a* or Secchi depth (the response factors) were violated. If a lake is impaired with respect to only one of these criteria, it may be placed on a review list; a weight of evidence approach is then used to determine if these lakes will be listed as impaired. For more details regarding the listing process, see the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment* (MPCA 2007).

According to the MPCA definition of shallow lakes, a lake is considered shallow if its maximum depth is less than 15 ft, or if the littoral zone (area where depth is less than 15 ft) covers at least 80% of the lake's surface area. 97% of the surface area of Como Lake is littoral, and the lake is therefore considered shallow.

A lake is considered to be meeting water quality standards when it is meeting the TP standard in addition to either the chlorophyll-*a* or Secchi depth standard. Under the TMDL allocations presented in Section 6, it is expected that the lake will meet at least the TP and the Secchi depth standards.

Como Lake is a shallow lake that is in the turbid, phytoplankton-dominated state commonly seen in impaired shallow lakes. To improve water quality and meet the state eutrophication standards, the goal is to switch the lake to the clear, macrophyte (plant)-dominated state. If this were to occur, chlorophyll concentrations would decrease, water clarity would improve, and rooted macrophyte abundance would increase. While this clearwater phase improves water quality, it has the potential side effect of interfering with certain types of recreation.

Table 6. MN Eutrophication Standards, North Central Hardwood Forests Ecoregion.

Parameter	Eutrophication Standard, Shallow Lakes
TP (µg/l)	TP < 60
Chlorophyll-*a* (µg/l)	chl < 20
Secchi depth (m)	SD > 1.0

3. IMPAIRMENT ASSESSMENT

Como Lake is 72 acres in size, with a watershed area to lake area ratio of 25 (Table 7). It has a maximum depth of 16 feet and a mean depth of 7.3 feet (Figure 9). Approximately 93% of the surface area of the lake is littoral (less than 15 feet depth). The 36-inch submerged outlet flows into a manhole with an eight-foot weir and stoplogs, which control the normal water level. The outlet discharges only periodically, during wet weather flows. Recent peak flows are approximately 6.5 cfs (2007) and 2.2 cfs (2008).

Table 7. Como Lake Characteristics.

Lake total surface area (ac)	72
Total littoral area (ac)	67[1]
Percent lake littoral surface area	92
Lake volume (ac-ft)	526
Mean depth (ft)	7.3[1]
Maximum depth (ft)	16[2]
Drainage area (acres)	1767[3]
Watershed area : lake area	25

[1]2006 DNR Fisheries report
[2]DNR LakeFinder
[3]Drainage area from CRWD P8 model; differs slightly from area calculated from updated watershed boundary file (1783 ac). This area (1767 ac) was used in the TMDL modeling, to be consistent with previous modeling efforts.

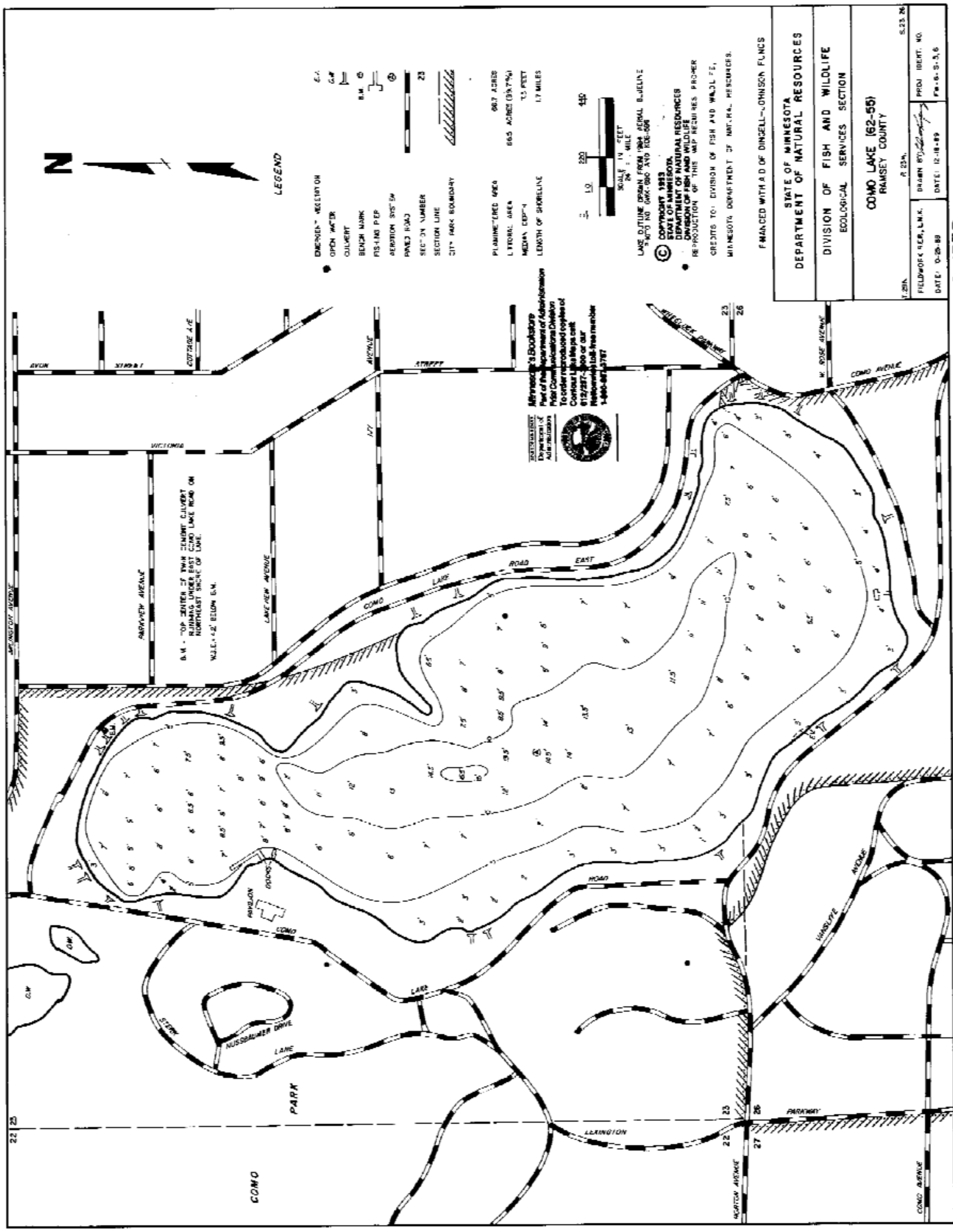

Figure 9. Como Lake Bathymetric Map

Monitoring data are available from as far back as 1946, although there were only one or two samples taken that year and conclusions should not be drawn from sampling at this low frequency. Sampling frequency increased in 1984 and has been conducted annually since then. The last ten years of data were used to calculate the water quality data means (Table 8). All in-lake data were collected by the Ramsey County Public Works Department.

Como Lake is a eutrophic lake, with TSI values for Secchi depths and chlorophyll-*a* in the eutrophic range and TP in the hypereutrophic range (Table 8). The high TP relative to the chlorophyll-*a* and the Secchi depths suggests that the lake has so much phosphorus in it that the algae are not limited by phosphorus, but by some other limiting factor. This does not mean that TP doesn't impact the water quality of the lake, but rather it means that phosphorus will have to be reduced by a substantial amount before improvements in the chlorophyll or Secchi depth are realized. While initial reductions in phosphorus loads to the lake may not translate into immediate improvements to water clarity, without these reductions the lake may never reach the point where algal concentrations will respond and lead to water clarity improvements.

The TP standard for shallow lakes in the North Central Hardwood Forest (NCHF) ecoregion is 60µg/L. TP concentration growing season means ranged from 100 to 400 µg/L in the years 1993 to 2007 (Figure 10), exceeding the ecoregion standard for shallow lakes each year. Chlorophyll-*a* concentration growing season means ranged from to 10 µg/L to 60 µg/L in 1993 to 2007 (Figure 11), only meeting the NCHF ecoregion shallow lakes standard of 20 µg/L in 1998, 1999, and 2004. The Secchi depth growing season means ranged from to 0.65 m to 3.5 m in 1993 to 2007 (Figure 12), meeting the NCHF ecoregion shallow lakes standard of 1.0 m in all years except 2005 and 2006. Water clarity measured by a Secchi disk can be relatively high even when chlorophyll concentrations are high; the relationship depends on the types of algae and their distribution. Without information on the types of algae in the lake, this relationship between chlorophyll concentrations and Secchi transparency can not be determined. One possible explanation is that, when there is a high concentration of blue-green algae, the Secchi disk can temporarily push aside the algae and lead to artificially high clarity measurements.

Water quality in Como Lake is generally poor throughout the growing season (Figure 13 through Figure 15).

Table 8. Surface Water Quality Means, 1998-2007.

	Growing Season Mean (June – September)	Trophic Status Index	Shallow Lakes Standard
TP	173 µg/L	78	< 60 µg/L
Chl-*a*	25 µg/L	62	< 20 µg/L
Secchi depth	1.6 m	53	> 1.0 m

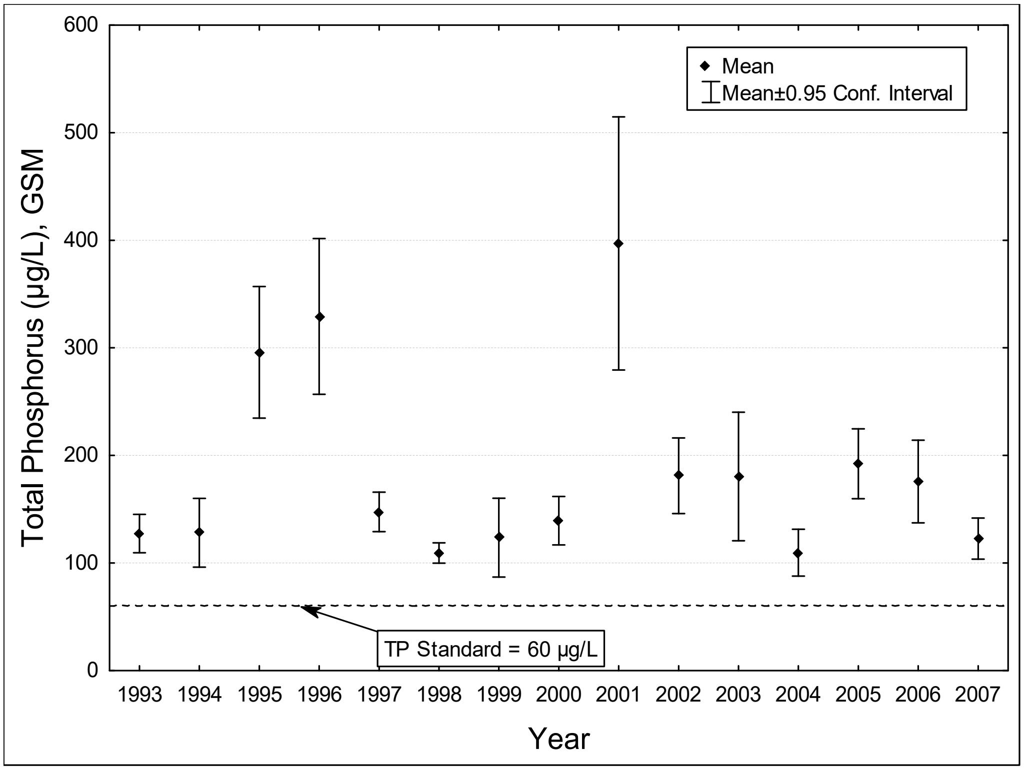

Figure 10. Total Phosphorus Monitoring Data, Como Lake, 1993-2007.

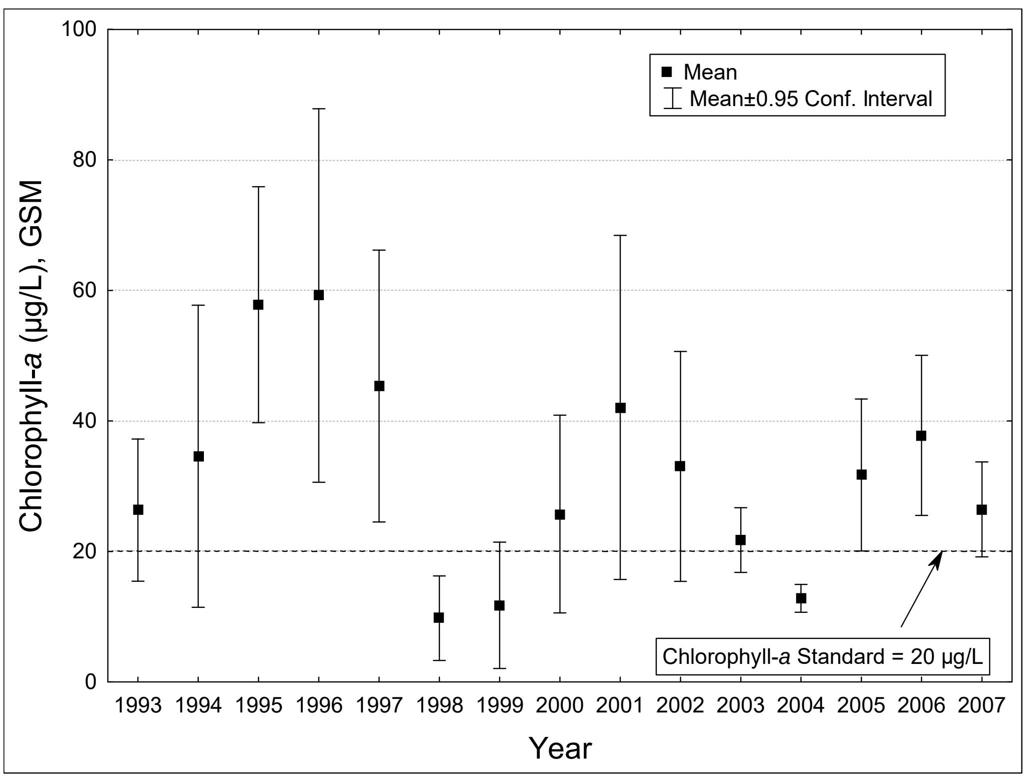

Figure 11. Chlorophyll-a Monitoring Data, Como Lake, 1993-2007.

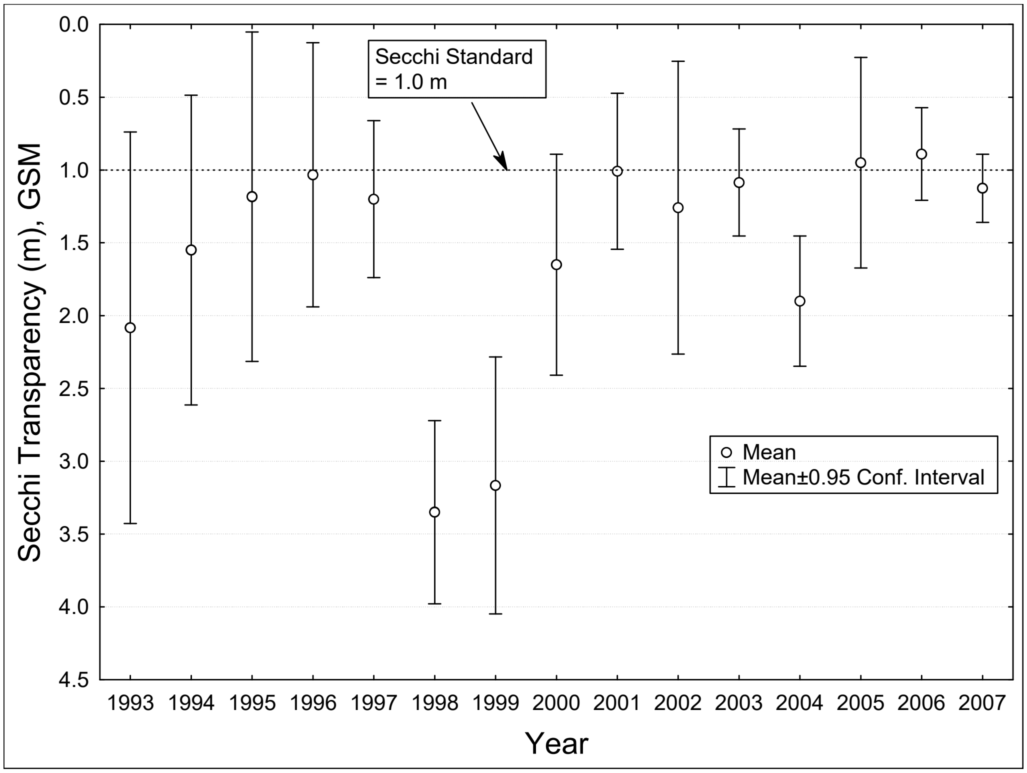

Figure 12. Secchi Depth Monitoring Data, Como Lake.

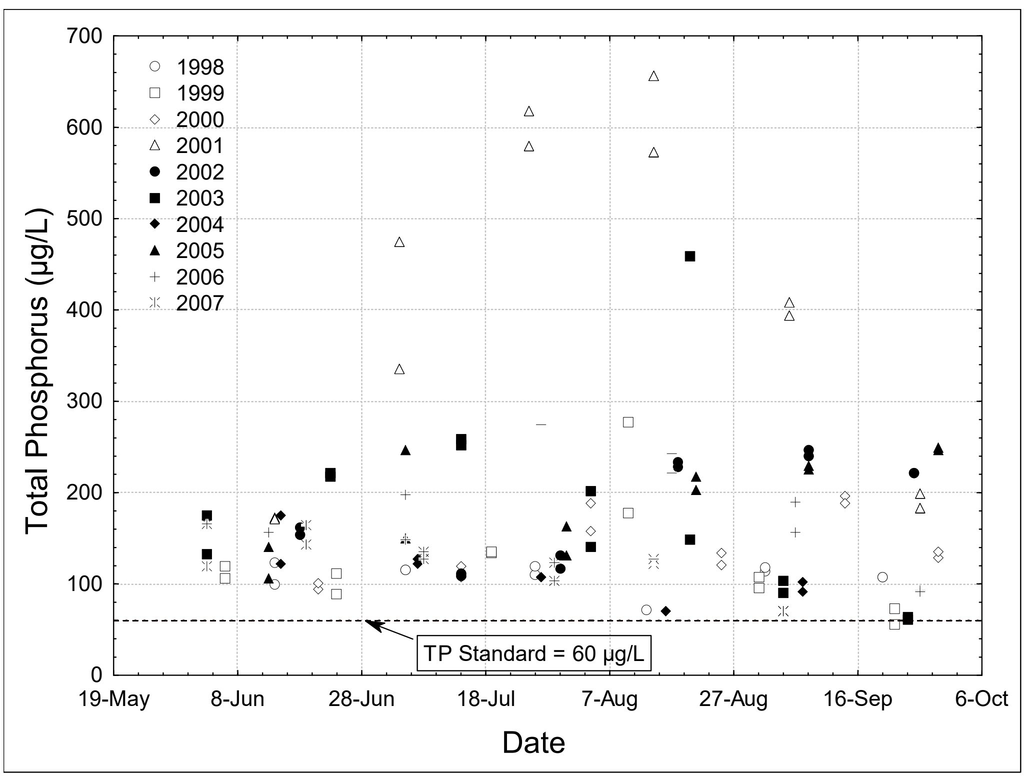

Figure 13. Como Lake Seasonal TP Patterns, 1998-2007.

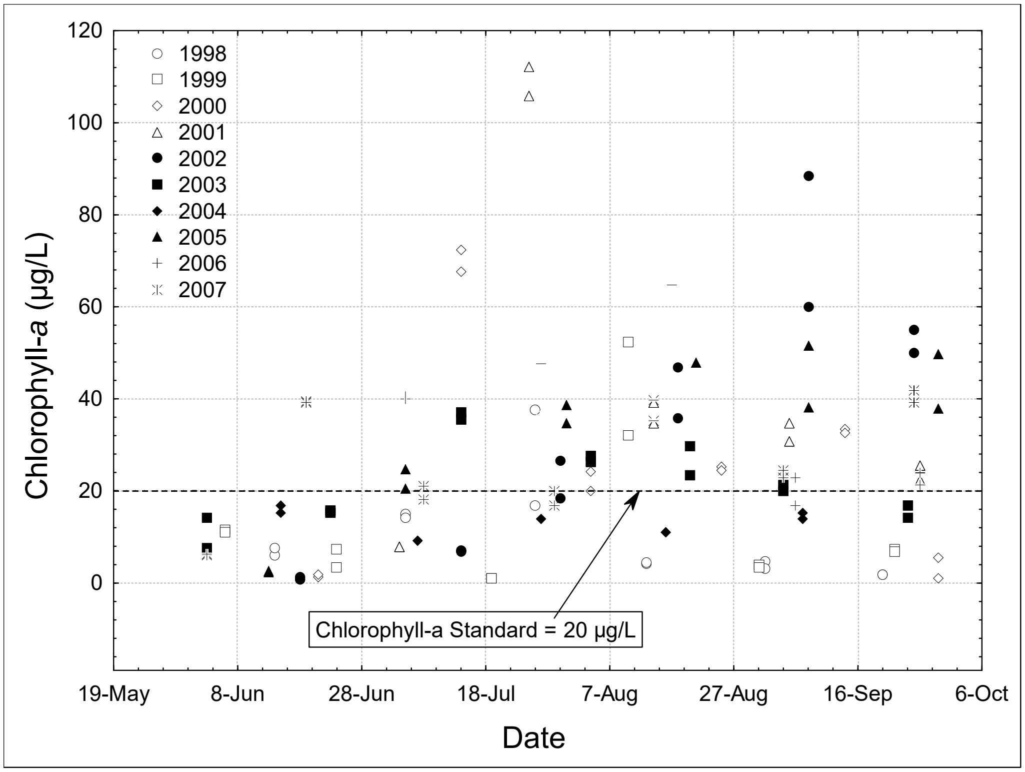

Figure 14. Como Lake Seasonal Chlorophyll-*a* Patterns, 1998-2007.

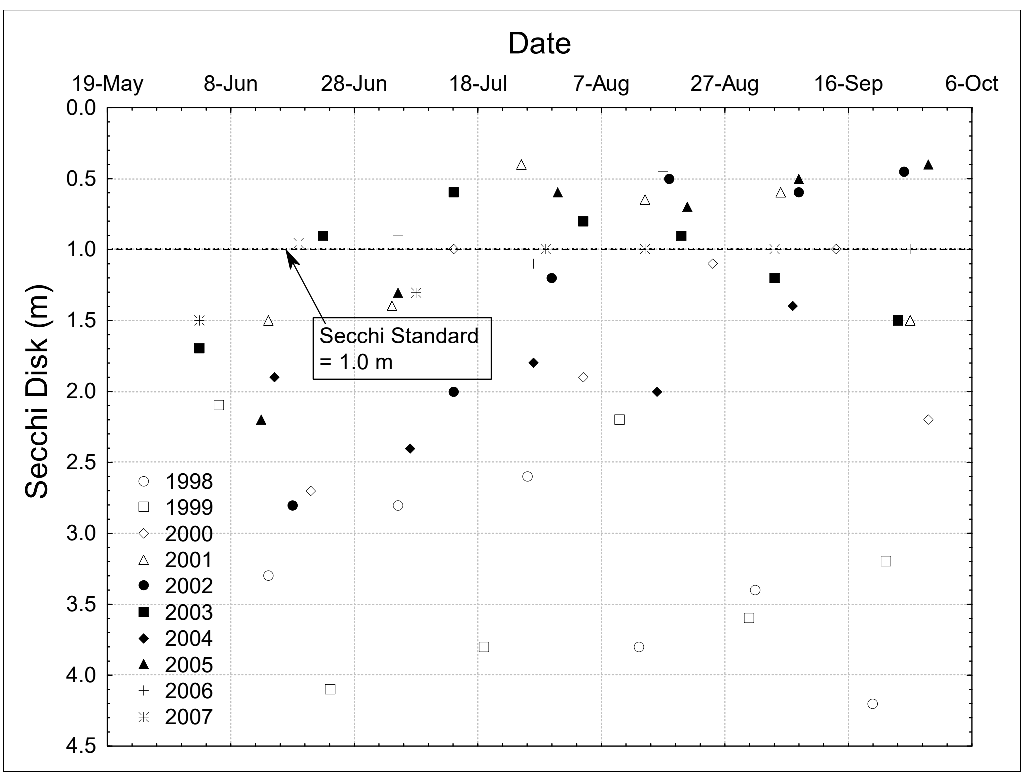

Figure 15. Como Lake Seasonal Transparency Patterns, 1998-2007

Como Lake's fishery is highly managed, and it is classified by the DNR as a bass panfish lake. Stocking took place as early as 1857. Winterkills have been frequent, and an aeration system was installed in 1985 to reduce the frequency of winterkills. The lake was treated in 1986 with rotenone. Following the rotenone treatment, the DNR began restocking fish with walleye, largemouth bass, and bluegill.

Based on a 2006 DNR fish survey, black bullhead, black crappie, bluegill, golden shiner, green sunfish, hybrid sunfish, northern pike, pumpkinseed sunfish, walleye, white sucker, yellow bullhead, and yellow perch were found in Como Lake. Black bullhead, bluegill, and northern pike were the most abundant species sampled within Como Lake. Channel catfish and largemouth bass were stocked in the lake in the 1990s but were not present in the 2006 sampling.

Bullhead abundance seems to be on the rise from low abundance in the 1990s. It is not certain if bullhead are considered a nuisance in Como Lake, but in general bullhead are benthivorous fish; they forage in the lake sediments, which physically disturbs the sediments and causes high rates of phosphorus release from the sediments to the water column. Bluegills are abundant with 20% of the fish sampled over 6 inches. The northern pike population has increased since the 1990s and are considered abundant. The walleye population seems to have increased since the 1996 sampling with moderate numbers present and large, 17 to 22-inch fish sampled in 2006.

The vegetative community in Como Lake lacks diversity (CLSMP, CRWD 2002). It is primarily made up of submergent vegetation, including elodea, coontail, and northern water milfoil. Curly leaf pondweed and elodea have been known to reach nuisance densities during the growing season. The emergent and floating leaf vegetation is diminished to two stands of narrow leaf cattail.

4. POLLUTANT SOURCES

The three categories of phosphorus loads to Como Lake are watershed runoff, internal loading, and atmospheric deposition. These sources of phosphorus loads were estimated and used as input into the lake response model (*Section 5: Loading Capacity*). This section describes the methods used to estimate the load from each phosphorus source category.

4A. Watershed Runoff

Methods

The Como Lake Watershed was modeled (Appendix A: CRWD Stormwater Modeling, CRWD 2000), along with the entire Capitol Region Watershed District, in the P8 (Program Predicting Polluting Particle Passage thru Pits, Puddles & Ponds) water quality model developed by William Walker, Jr. P8 is used to predict pollutants (TSS, TP, TKN, copper, lead, zinc, and hydrocarbons) generated from a watershed as well as the removal provided within treatment devices (e.g., ponds, swales, infiltration basins, pipes). The model accounts for routing of water from one watershed to another. The driving input parameters required in P8 are watershed (slope, curve number and percent impervious), devices (e.g. ponds and lakes), climatology (precipitation and temperature) and pollutant characteristics [based on the United States Environmental Protection Agency's Nationwide Urban Runoff Program studies and median sites (USEPA, 1986; Athayede et al., 1983)]. Simulations are driven by continuous hourly rainfall and daily air temperature time series data. The P8 model has implicit limitations. Although it is regularly used for watershed-wide applications and can be validated with monitoring data, the program was designed to simulate runoff from urban catchments into NURP treatment ponds. In addition, the model does not utilize sophisticated routing methods for flow and pollutants. Model strengths include continuous simulation and moderate adaptability to a selection of treatment BMPs. It is also a valuable tool because model set-up (including data input), calibration, and validation requirements are moderate.

This model was chosen for its ability to simulate flow conditions and pollutant transport in an urban environment. P8 was also chosen due to its ability to discretely model BMPs such as stormwater ponds, infiltration basins, and wetlands. The results of the P8 modeling work (calibrated to 1994 data) were used as input to the lake response model (WiLMS) described in Section 5.

Stormsewer maps from the cities were used to delineate subwatershed boundaries, which were then used to define inputs to the P8 model. Precipitation data were averaged across five nearby daily precipitation monitoring sites. Volume calibration consisted of computing runoff in the second antecedent moisture condition (AMC II) during the growing season and adjusting the impervious runoff coefficient and depressional storage parameters. The overall predicted volumes were within 10 perent of the observed volumes.

The P8 model was then calibrated to the average event flow-weighted TP concentraion. Calibration steps as described in *P8 Enhancements & Calibration to Wisconsin Sites* (Walker, 1997) were followed, with the following exceptions: 1) Monitored events greater than one inch of precipitation were not eliminated, and 2) Calibration of the dissolved fraction of water quality components differed. The NURP 50% particle file was used. For the median event, the predicted TP concentration was within seven percent of the observed concentration.

Results

The current (as of 1994) watershed phosphorus load to Como Lake is 625 lbs/yr, with an average loading rate of 0.35 lbs/ac-yr (Table 9). The subwatersheds to Como Lake are shown in Figure 16.

Table 9. Watershed Phosphorus Loads
Results from Como Lake P8 model, 2000 (CRWD)

Subwatershed	Area (ac)	TP Load (lbs/yr)	Average Surface Outflow (ac-ft/yr)	Runoff Depth (in/yr)	Areal Loading Rate (lbs/ac-yr)	Runoff TP Concentration (µg/l)
2	74	29	28	4.6	0.39	382
3	517	228	246	5.7	0.44	342
4	199	62	68	4.1	0.31	336
5	97	34	34	4.2	0.35	369
6	88	32	37	5.0	0.36	319
7	298	111	129	5.2	0.37	317
8	495	129	248	6.0	0.26	192
Total	***1767***	***625***	***790***	***5.36***	***0.35***	***292***

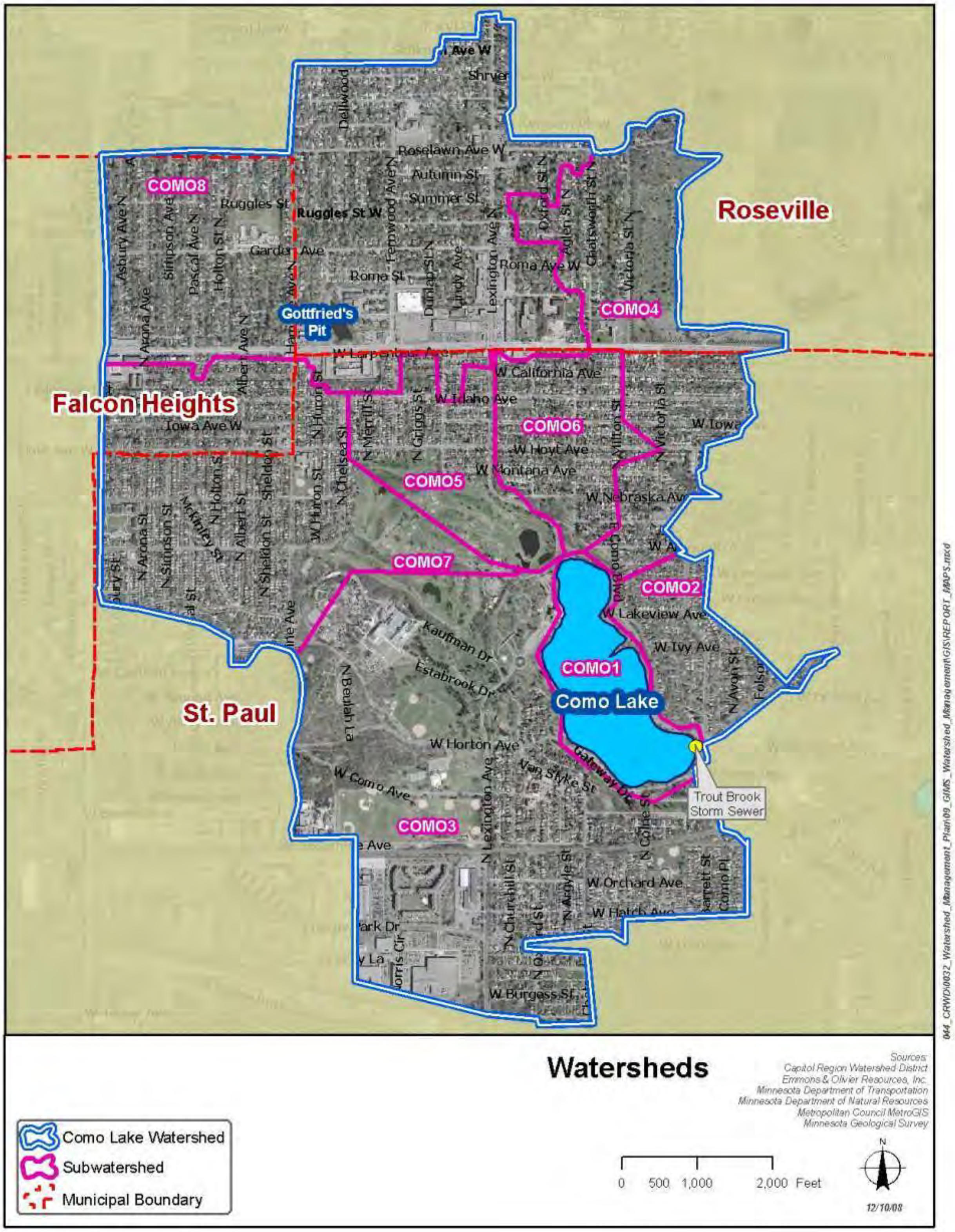

Figure 16. Como Lake Subwatersheds.

4B. Internal Loading

Internal loading in lakes refers to the phosphorus load that originates in the bottom sediments and is released back into the water column. The phosphorus in the sediments was originally deposited in the lake sediments through the settling of particulates (attached to sediment that entered the lake from watershed runoff, or as phosphorus incorporated into biomass) out of the water column. Internal loading can occur through various mechanisms:

- Anoxic (lack of oxygen) conditions in the overlying waters: Water at the sediment-water interface may remain anoxic for a portion of the growing season, and low oxygen concentrations result in phosphorus release from the sediments. If a lake's hypolimnion (bottom area) remains anoxic for a portion of the growing season, the phosphorus released due to anoxia will be mixed throughout the water column when the lake loses its stratification at the time of fall mixing. Alternatively, in shallow lakes, the periods of anoxia can last for short periods of time; wind mixing can then destabilize the temporary stratification, thus releasing the phosphorus into the water column.
- Physical disturbance by bottom-feeding fish such as carp and bullhead. This is exacerbated in shallow lakes since bottom-feeding fish inhabit a greater portion of the lake bottom than in deeper lakes.
- Physical disturbance due to wind mixing. This is more common in shallow lakes than in deeper lakes. In shallower depths, wind energy can vertically mix the lake at numerous instances throughout the growing season.
- Phosphorus release from decaying curly-leaf pondweed (*Potamogeton crispus*). This is more common in shallow lakes since shallow lakes are more likely to have nuisance levels of curly-leaf pondweed.

Water quality sampling and dissolved oxygen depth profiles were taken at the deep hole in Como Lake. The dissolved oxygen depth profile from 2007 indicates that the lake temporarily stratifies during the growing season with periods of mixing occurring during the growing season. The hypolimnion is intermittently anoxic during the growing season (Figure 17). Total phosphorus data from that site also show that the concentration in the hypolimnion is higher than the surface water samples taken at the same time when the lake is stratified (Figure 18). This suggests that internal loading is a source of phosphorus in Como Lake: the wind driven mixing causes phosphorus rich hypolimnetic water to be mixed with the surface waters and causes disturbance of the bottom sediments.

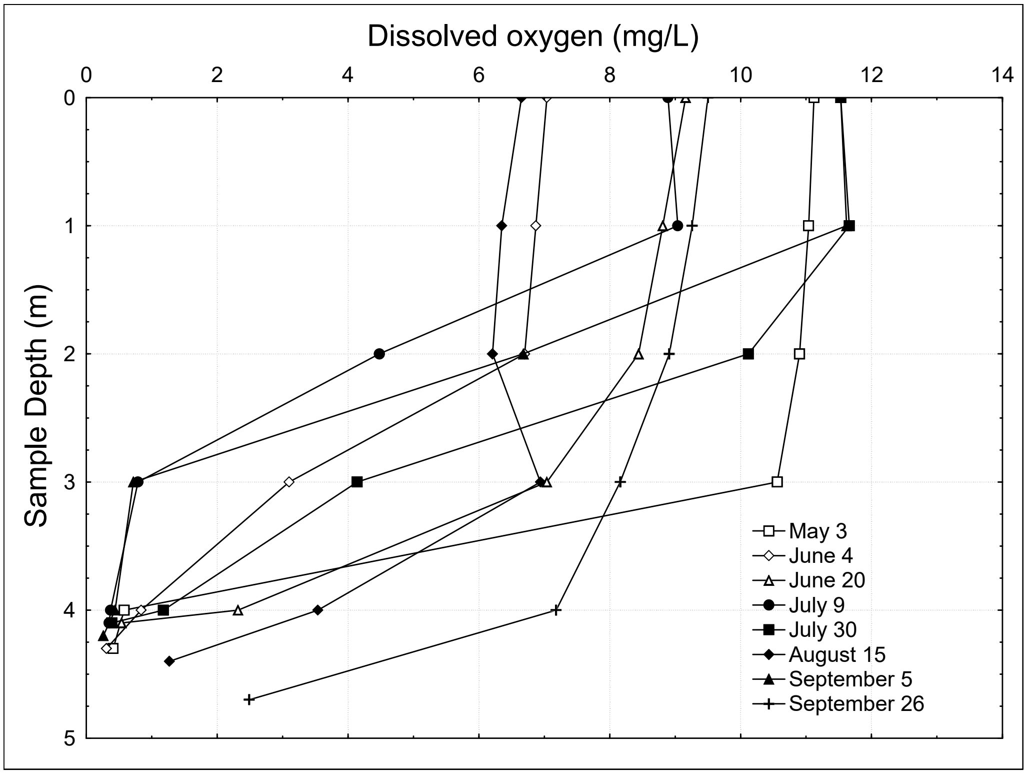

Figure 17. Como Lake Dissolved Oxygen Depth Profile, 2007

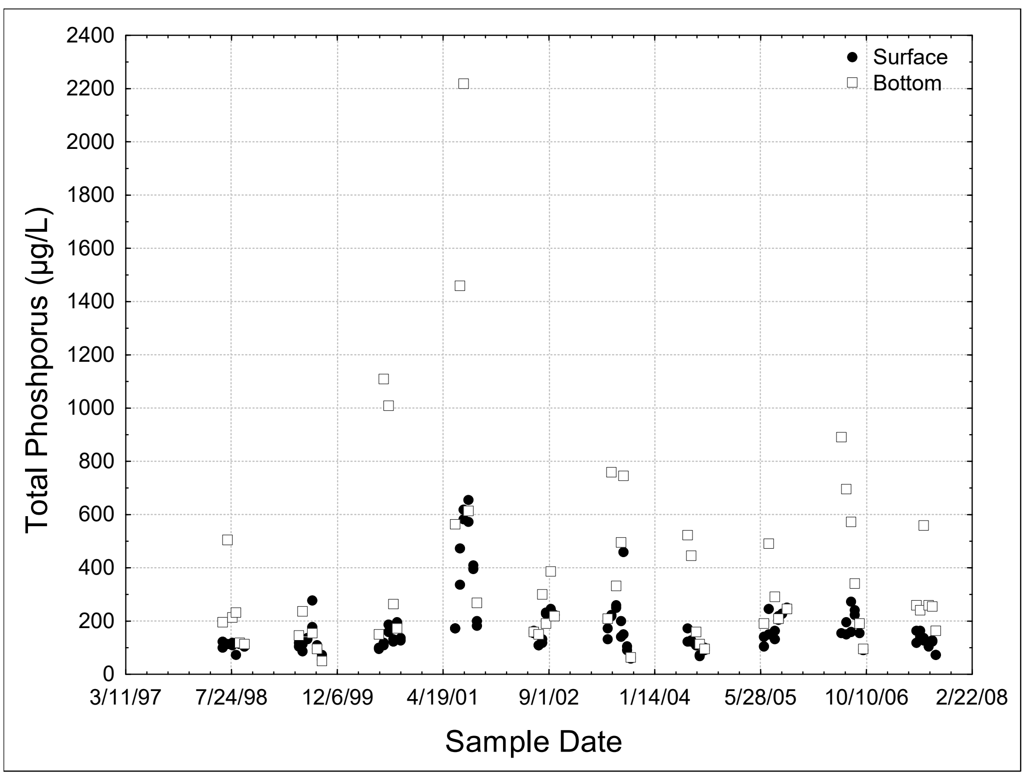

Figure 18. Como Lake Surface vs. Bottom Phosphorus Concentrations.

The internal load was calculated with the mass balance approach using the lake response model WiLMS (more details about WiLMS are included in Section 5: Loading Capacity). The watershed load was first input into the lake model. The additional load that was needed to calibrate the lake model to observed in-lake concentrations was assumed to be due to internal loading. This load was calculated to be 1,190 lbs/yr of TP (Table 11). If any unidentified watershed phosphorus sources exist, then the internal load estimated with the mass balance approach would be an overestimate.

4C. Atmospheric Deposition

Atmospheric deposition over the growing season was estimated to be 19 lbs/yr in Como Lake, calculated by using WiLMS default rate of 0.27 lbs/ac-yr. (See Section 5 for more information about WiLMS.) This rate falls within the range of rates reported by MPCA (2004), 0.09 to 0.5 lbs/ac-yr.

5. LOADING CAPACITY

This section describes the derivation of the TMDL for Como Lake. The year 2000 is the baseline year for the TMDL calculations.

5A. Methods

To estimate the assimilative capacity of the lake, an in-lake water quality model was developed using WiLMS (Wisconsin Lake Modeling Suite, Version 3.3.18), an empirical model of lake eutrophication developed by the Wisconsin Department of Natural Resources (Table 10). The model was selected based on its ability to predict how the in-lake total phosphorus concentration will respond to changes in phosphorus loading to the lake. An advantage of the model is its simplicity; model input parameters are miminal. WiLMS contains multiple phosphorus sedimentation models, but does not contain equations for modeling chlorophyll concentrations or transparency. The Walker 1987 Reservoir Model was used to model phosphorus sedimentation in Como Lake; this model was used to model in-lake TP concentrations in the development of the 2002 Como Lake Strategic Management Plan.

Input data consisted of the watershed load calculated by the P8 model (summarized in Section 4A), the internal load calculated using the mass balance approach (summarized in Section 4B), and the load from atmospheric deposition (summarized in Section 4C). Precipitation data are from the MN Climatology Working Group, and evaporation was estimated from rates published in the MN Hydrology Guide. No other inputs or changes to the model were made. The model was calibrated to the 1998 through 2007 average growing season mean (GSM, see Section 3: Impairment Assessment, and Table 8). In-lake TP concentrations had not changed substantially since the Como Lake Strategic Management Plan was finished (Figure 10); major BMPs implemented after the completion of the plan were completed in 2007. Practices implemented or initiated after 2000 can be used to achieve the load reduction requirements in Section 6 of this TMDL.

The mass balance approach in model calibration is a simple approach that assumes that the mass (load) of phosphorus that enters the lake is the same as the mass of phosphorus that leaves the lake. For the Como Lake model, the watershed load was input into the model and the predicted in-lake TP concentration was compared to the observed concentration. The observed concentration was substantially greater than the predicted concentration; it was assumed that the additional load to the lake needed to calibrate the predicted to the observed TP concentration is due to internal loading. This additonal load was then added to the model as internal loading.

Table 10. WiLMS Input Parameters

Lake Area (acres)	Volume (ac-ft)	Mean Depth (ft)	Drainage Area (ac)	Total Unit Runoff (inches)	Watershed TP Load to Lake (lbs/yr)	TP, GSM (µg/L)
72	525.6	7.3	1767	5.4	625	173

After the model was calibrated, the TP standard (60 µg/L) was used as the endpoint, and the TP loads to the lake were adjusted until the model predicted that the standard would be reached. This resultant load is the lake's assimilative capacity.

The TMDL was first determined in terms of annual loads. In-lake water quality models predict annual averages of water quality parameters based on annual loads. Symptoms of nutrient enrichment normally are the most severe during the summer months; the state eutrophication standards were established with this seasonal variability in mind. The annual loads were converted to daily loads by dividing the annual loads by 365.

5B. Results

Phosphorus Loads

The watershed load to Como Lake represents approximately 34% of the total load to the lake, the atmospheric load represents 1% of the total load to the lake, and internal load represents approximately 65% of the phosphorus load to the lake.

Table 11. Phosphorus Loads to Como Lake

Phosphorus Source	TP Load (lbs/yr)	% Total Load
Watershed	625	34%
Atmospheric	20	1%
Internal	1190	65%
Total	1835	

Assimilative Capacity

The TP assimilative capacity of Como Lake was calculated to be 306 lbs/yr (0.83 lbs/day), an overall reduction of 83% from the existing loading of 1835 lbs/yr. The assimilative capacity will be split up between the load allocation and the wasteload allocations in Section 6.

Critical Conditions

Critical conditions in Como Lake occur in the summer, often in July and August (see Figure 13, Figure 14, and Figure 15), when TP concentrations peak and clarity is at its worst. The water quality standards are based on growing season averages. The load reductions are designed so that the lakes will meet the water quality standards over the course of the growing season (June through September).

6. TMDL ALLOCATIONS

6A. Margin of Safety

The margin of safety (MOS) is included in the TMDL equation to account for both the inability to precisely describe current water quality conditions and the unknowns in the relationship between the load allocations and the in-lake water quality. A MOS may be either explicitly calculated or implicitly included in the modeling assumptions and approach to calculating the TMDL.

An implicit MOS was incorporated into this TMDL by using conservative assumptions. These were used to account for an inherently imperfect understanding of the lake system and to ultimately ensure that the nutrient reduction strategy is protective of the water quality standard.

Conservative modeling assumptions included applying sedimentation rates that likely under-predict the sedimentation rate for shallow lakes. Impaired lakes are often in the ecologically turbid phase, as opposed to the clear-water phase. In this case, the lake water quality models are calibrated to the turbid phase and estimate a loading capacity that reflects the lake meeting the phosphorus standard while still in the turbid phase. (While a lake with 60 µg/L TP is more likely to be in the clear-water phase than the turbid phase, it is possible for a lake to meet the standard and still exhibit characteristics of a lake in the turbid phase (Moss et al., 1996)). However, as the phosphorus loads to the lake decrease and the lake is restored, the goal is to switch the lake from the turbid phase to the clear-water phase; this switch can be reached before the lake achieves the phosphorus goal. In this clear-water phase, the zooplankton community is healthier and is able to better control algal densities. The loading capacity for this TMDL (based on the turbid phase) is an underestimate of the lake's loading capacity under the clear-water phase, since the lake should be able to assimilate more phosphorus while continuing to maintain the clear-water phase. This applies to shallow lake systems.

6B. TMDL Allocations

The final TMDL equation for Como Lake is as follows:

TMDL = Load Allocation + Wasteload Allocation

306 lbs/yr = 57 lbs/yr + 249 lbs/yr
0.83 lbs/day = 0.15 lbs/day + 0.68 lbs/day

The WLA represents the permitted phosphorus sources to Como Lake, which comprise the watershed load. During the development of the 2002 Como Lake Strategic Management Plan, the Data Collection and Management Work Group identified that a 60% reduction to the watershed TP load was the most aggressive achievable reduction possible. This 60% reduction in watershed load was used to calculate the total WLA to be 249 lbs/yr (Table 12).

After accounting for the 60% reduction in the watershed load, the remaining load reductions needed are required from the sources that constitute the LA: internal load and atmospheric deposition. An overall reduction of 95% is needed from these sources (Table 12). This high reduction needed is quite aggressive. However, smaller reductions in external and/or internal loads may shift the lake from the turbid phase to the clear-water phase, and the more aggressive load reductions may not be needed.

Table 12. Overall Load Reductions

Source	Existing Load (lbs/yr)	Allocated Load (lbs/yr)	% Reduction
Permitted sources (watershed runoff)	625	249	60%
Non-permitted sources (atmospheric deposition and internal load)	1210	57	95%
Total	*1835*	*306*	*83%*

6C. Wasteload Allocations

The wasteload allocation is that portion of the total TMDL that is allocated to permitted point sources. The permitted sources in the watershed were identified as regulated MS4 stormwater and construction stormwater (Section 1B). In the case of Como Lake, the entire watershed load is regulated under the NPDES program and is considered a point source (Figure 19). There are no other permitted point sources in the watershed; therefore the entire wasteload allocation will be shared by regulated entities under the NPDES program.

The majority of the stormwater sources (MS4, construction stormwater, and industrial stormwater) were given a categorical WLA for Como Lake. An individual WLA was given to Mn/DOT. Mn/DOT’s required load reductions have already been achieved through the implementation of BMPs since the TMDL baseline year of 1994 by other regulated MS4s. These BMPs will need to be documented in Mn/DOT’s SWPPP to show WLA achievement.

The load reductions identified by the categorical WLA will need to be met by the group as a whole. The regulated MS4 communities that are part of the categorical WLA will need to document progress towards meeting the WLA in their SWPPPs. Although there are no NPDES-regulated industrial stormwater sources, it is included in the categorical WLA to cover future industrial stormwater sources. Table 13 summarizes the wasteload allocations and includes each of the regulated MS4s within the Como Lake subwatershed.

Table 13. Wasteload Allocations

<table>
<tr><th>Permit Name</th><th>Permit Number</th><th>Existing (1994) TP Load (lbs/year)</th><th>WLA (lbs/year)</th><th>WLA (lbs/day)</th><th>Percent Reduction</th></tr>
<tr><td>City of Saint Paul</td><td>MS400054</td><td rowspan="7">624.80</td><td rowspan="7">248.92</td><td rowspan="7">0.68</td><td rowspan="7">60%</td></tr>
<tr><td>City of Falcon Heights</td><td>MS400018</td></tr>
<tr><td>City of Roseville</td><td>MS400047</td></tr>
<tr><td>Ramsey County</td><td>MS400191</td></tr>
<tr><td>Capitol Region Watershed District</td><td>MS400206</td></tr>
<tr><td>Construction stormwater</td><td>Various</td></tr>
<tr><td>Industrial stormwater</td><td>No current permitted sources</td></tr>
<tr><td>Mn/DOT</td><td>MS400170</td><td>0.20</td><td>0.08</td><td>0.00022</td><td>60%*</td></tr>
</table>

* Mn/DOT’s load reductions have already been achieved through the implementation of BMPs by other regulated MS4s

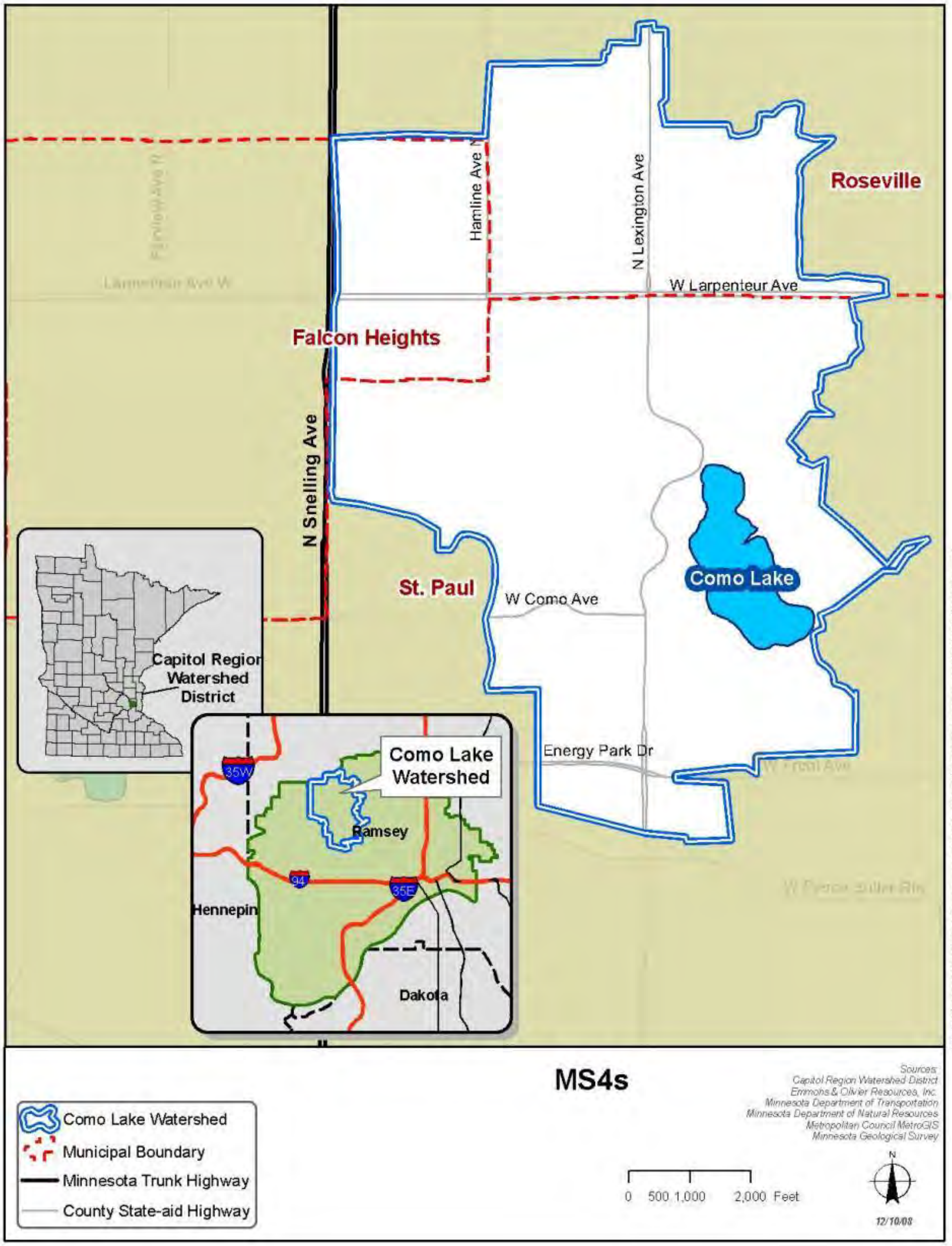

Figure 19. Regulated MS4s in the Como Lake Watershed

6D. Load Allocations

The atmospheric and internal sources of TP are considered under the load allocation. Since reductions in atmospheric loading are not expected, atmospheric deposition was held constant at 20 lbs/yr, and the internal load needs to be reduced by 97% to 37 lbs/yr (Table 14).

Table 14. Load Allocations, Annual and Daily

Source	Existing Load (lbs/yr)	Load Allocation (lbs/yr)	Required Load Reduction (lbs/yr)	Percent Reduction
Internal Load	1190	37	1153	97%
Atmospheric Load	20	20	0	0%
Total	1210	57	1153	95%

Source	Existing Load (lbs/day)	Load Allocation (lbs/day)	Required Load Reduction (lbs/day)	Percent Reduction
Internal Load	3.26	0.10	3.16	97%
Atmospheric Load	0.05	0.05	0	0%
Total	3.31	0.15	3.16	95%

6D. Reserve Capacity

Reserve capacity, an allocation for future growth, was not explicitly calculated for this TMDL, but rather was included as part of the WLAs and LAs. The watershed for Como Lake reached its development potential; therefore any further development that does take place will be redevelopment and is already included in the WLA.

6E. TMDL Allocation Summary

Table 15. TMDL Allocation Summary

Source		TMDL (lbs/yr)	TMDL (lbs/day)
Load Allocation		57	0.15
Wasteload Allocations			
MS4 or other source	NPDES Permit #		
City of Falcon Heights	*MS400018*	248.92	0.68
City of Saint Paul	*MS400054*		
City of Roseville	*MS400047*		
Ramsey County	*MS400191*		
Capitol Region Watershed District	*MS400206*		
Construction stormwater	*Various*		
Industrial site stormwater	*No current permitted sources*		
Minnesota Department of Transportation	*MS400170*	0.08	0.00022
Total TMDL		306	0.83

7. SEASONAL VARIATION AND CRITICAL CONDITIONS

In-lake water quality models predict growing season or annual averages of water quality parameters based on growing season or annual loads, and the nutrient standards are based on growing season averages. Symptoms of nutrient enrichment normally are the most severe during the summer months; the nutrient standards were set by the MPCA with this seasonal variability in mind.

This is the case for Como Lake; critical conditions occur during the summer (Figure 13), when TP concentrations peak.

8. MONITORING PLAN

The following monitoring plan lays out the different types of monitoring that will need to be completed in order to track the progress of implementation activities associated with Como Lake and of associated changes in water quality due to the management practices.

Monitoring should occur after implementation activities are initiated in order to evaluate the effectiveness of the BMPs, and should continue throughout the implementation period until water quality standards are attained. CRWD, in partnership with the regulated MS4s and Ramsey County Public Works, will ensure that the monitoring is completed.

The following parameters should be part of the in-lake monitoring plan:

- TP, soluble reactive phosphorus, nitrogen, chlorophyll-*a*, and transparency should be monitored biweekly during the growing season.
- At least one year of winter nitrate data should be obtained in Como Lake. Winter nitrate has been shown to be an indicator of plant species richness in shallow lakes and can provide information on nitrogen loading and the potential for aquatic macrophyte restoration (James et al. 2005). This information can help target future management practices aimed at reducing nitrogen loading to the lake.
- Depth profiles of temperature and dissolved oxygen should be taken biweekly during the growing season at the deepest portion of the lake.
- Zooplankton monitoring should be undertaken for a full season every five years. Monitoring should start in early spring (March or April), when large zooplankton peak; zooplankton community dynamics during this period influence the water quality during the remainder of the growing season.
- A fish survey should be completed once every five years to obtain data on fish population abundance, size distribution, and year class strength as well as to evaluate management activities. Surveys should be conducted following the *Manual for Instruction of Lake Survey*, Special Publication No. 147 from the Minnesota Department of Natural Resources (DNR).
- Spring and summer aquatic macrophyte surveys should be completed every five years, during the same years as the zooplankton and fish monitoring. The spring survey is important to monitor the abundance of curly-leaf pondweed and to understand its role in the overall lake phosphorus dynamics, and the summer survey tracks the presence and establishment of native macrophytes in the lake.

The following parameters should be part of the subwatershed monitoring plan:

- At the outlet of each subwatershed, TP, soluble reactive phosphorus, nitrogen, and TSS should be monitored during storm events causing discharge.
- At the outlet of each subwatershed, TP, soluble reactive phosphorus, nitrogen, TSS, and turbidity should be monitored biweekly during the growing season under baseflow conditions.

- At the outlet of each subwatershed, flows should be monitored to verify the modeled loadings.

9. IMPLEMENTATION STRATEGY

It is widely recognized that restoration of shallow lakes, particularly those in highly urbanized areas, can be a significant challenge. Lake restoration activities can be grouped into two main categories: those practices aimed at reducing external nutrient loads, and those practices aimed at reducing internal loads. The focus of restoration activities depends on the lake's nutrient balance and opportunities for restoration. This discussion separates the management strategies into practices addressing watershed load and internal load. In shallow lake restoration, the first step is to reduce the watershed load, after which management practices aimed at the internal load and in-lake ecological interactions should be addressed. If the watershed load is not brought under control first, there is a lower chance that the efforts aimed at the in-lake sources will be successful.

The initial five-year implementation program of priority activities for the restoration of Como Lake is anticipated to cost approximately $2.5 million. The implementation program and priority activities for restoration of Como Lake will be determined as part of development of the Como Lake TMDL Implementation Plan. The implementation plan will be developed through a process led by a stakeholder advisory group made up of all the MS4s. Projects that are not included in the implementation plan, yet achieve equivalent outcomes, can be implemented. The implementation plan will be built upon an adaptive management approach. Implementation activities will be continually monitored and evaluated to determine effectiveness in reaching the in-lake goals for Como Lake. The in-lake goal as well as the subwatershed TP reduction goals may need to be reevaluated at a future date as a result of the monitoring and evaluation.

CRWD will coordinate the implementation activities through a stakeholder process with all of the regulated MS4s within the Como Lake watershed, along with other stakeholders. The watershed district will annually report on progress made towards meeting the WLAs and LA, and, if necessary, will evaluate the goals set forth in this TMDL report.

9A. Watershed Load

Watershed load reduction planning will occur on a subwatershed basis (subwatersheds are indicated in Figure 16). Subwatershed evaluations were completed as part of the CLSMP, and potential projects were identified, including approximate costs. The implementation plan for the Como Lake TMDL will refine the projects identified and the estimated costs. The plan will contain a range of options for implementation; implementation partners can select from this range of options the practices that best suit local resources, needs, and constraints. Future evaluation, likely to be completed after development of the implementation plan, will include BMP siting and design.

The watershed load reduction activities will focus on programs (such as good housekeeping), regulatory controls, and projects. Due to the urban nature of the watershed, the majority of the projects will be retrofits and redevelopment projects. Opportunities within each subwatershed will be identified for retrofits including small and large scale water quality treatment practices. Opportunities for water quality treatment should be investigated on public and private property located in key areas.

Regulatory controls include construction and industrial stormwater permits. Construction stormwater activities are considered in compliance with provisions of the TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install, and maintain all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or meet local construction stormwater requirements if they are more restrictive than requirements of the State General Permit.

Industrial stormwater activities are also considered in compliance with provisions of the TMDL if they obtain an Industrial Stormwater General Permit or General Sand and Gravel general permit (MNG49) under the NPDES program and properly select, install, and maintain all BMPs required under the permit, or meet local industrial stormwater requirements if they are more restrictive than requirements of the State General Permit.

9B. Internal Load

The focus of internal load management will be to shift Como Lake from the current turbid, algal-dominated state to a clear state dominated by aquatic macrophytes (plants). This will be done through management activities designed to stabilize the lake-bottom sediments, improve aquatic macrophyte species composition and abundance, and increase the density of zooplankton. Strategies may include fisheries management to control populations of benthivorous fish and to prevent overgrazing on zooplankton through increasing the relative abundance of piscivorous fish (fish that eat other fish) relative to planktivorous fish (fish that eat organisms that float in the water). Other approaches will include shoreline management, waterfowl management, and investigation into operation of the current aerator.

10. REASONABLE ASSURANCES

There are federal, state, watershed, and local authorities in place to provide a reasonable assurance that the implementation efforts within this TMDL study will go forward. This TMDL report recommends that the CRWD work with the many stakeholders involved in lake management to implement a series of improvement measures for the lake. The District will serve as the 'aggregator' or TMDL coordinator to assist each of the MS4s, in coordination, in meeting their individual TMDL requirements. This role will include completing an annual inventory and accounting for reductions in the watershed, serving as a technical resource for the MS4s, providing monitoring to determine implementation effectiveness, and providing documentation to collectively meet the annual reporting requirements of the MS4 permits.

CRWD Rules

On March 5, 2008 the CRWD adopted revisions to the watershed rules adopted September 6, 2006. Under the CRWD rules the district reviews projects within the watershed. CRWD has successfully implemented these rules since adoption.

Specific rules expected to contribute to water quality improvement in Como Lake include stormwater management (Rule C), wetland management (Rule E), erosion and sediment control (Rule F), and illicit discharge and connection (Rule G).

CRWD Watershed Management Plan

The Como Lake TMDL, as well as other TMDLs within the watershed district, is referenced in CRWD's draft 2010 Watershed Management Plan. The plan describes the process by which the watershed district will coordinate the implementation of the TMDLs.

NPDES MS4 Program

The Como Lake watershed has MS4 permit programs in place for Capitol Region Watershed District, Mn/DOT, St. Paul, Falcon Heights, Roseville, and Ramsey County.

Under the MS4 program, each permitted community must develop a SWPPP that lays out the ways in which the community will actively and effectively manage its stormwater. SWPPPs are required to incorporate the results of any approved TMDLs within their area of jurisdiction, subject to review by the MPCA.

Given implementation of the various rules and programs noted above, reasonable assurance can be given that communities within the subject watershed will be properly managing their stormwater.

Como Lake Strategic Management Plan

The CLSMP was completed in 2002. The CLSMP was developed though a high level of public participation with strong technical guidance. This plan lays out the implementation strategy needed to accomplish the TMDL.

The framework in the CLSMP lays out a logical approach, under the leadership of the CRWD, for an existing group of district cooperators to accomplish the implementation of the management activities needed to meet to meet the TMDL. Members of this group include all of the regulatory and planning stakeholders committed to the success of the implementation plan. These entities will continue to work together to implement the program to accomplish it.

11. PUBLIC PARTICIPATION

Public participation for the Como Lake TMDL study was the public participation process for the Como Lake Strategic Management Plan.

The public participation process for the CLSMP was carefully designed to balance technical needs with those of the Como Lake watershed communities. It was determined that three work groups were needed: a technical committee to analyze the data and make recommendations, a public relations/communications committee that could provide the neighborhood perspective, and a steering committee that managed the entire process.

Three work groups were formed around the identified needs. These work groups were the Advisory Group, Data Collection and Management, and Public Outreach. Participants for each of the groups were recruited from government, organizations, businesses, and citizens active in the Como Lake watershed communities including St. Paul, Roseville, Falcon Heights, and Ramsey County. Some of the members were participating as staff members for their respective organizations and some of the members were volunteers. All three of the committees were designed to work independently but to continually feed information to each other so both their individual and project goals could be realized.

Sixteen meetings were held from July 2000 through June 2001. The general format for the meetings was to meet together at the beginning of the meetings and then to break out into the work groups afterwards.

Advisory Group

The Advisory Group was the steering committee of the entire strategic planning process. Members represented key governmental agencies, the Minnesota State Legislature, business, non-profit organizations, and citizen-based groups. The Advisory Group identified key objectives for each of the work groups, coordinated the development of a list of issues to be addressed, prioritized issues, analyzed and selected options for addressing those issues, and assisted in creating an implementation and monitoring process. It also reviewed the draft CLSMP and recommended changes based upon the committees' feedback and their own analysis.

Data Collection and Management Work Group

This committee reviewed and evaluated existing watershed and water quality information and provided educational presentations to the Advisory Group and the Public Outreach Work Group. It provided feedback to the Advisory Group regarding issues, management concerns, options and implementation scenarios. Members had a technical background and represented local and state government and non-profit organizations.

Public Outreach Work Group

This committee assisted the Advisory Group in the development and prioritization of issues, and developed a communications plan that identified short and long-term projects. The short-term projects were designed to build the public's awareness regarding the CLSMP, the state of Como Lake, and current and future water quality enhancement activities. The long-term projects were designed to create ongoing interest and commitment to improve the water quality of the lake through the media, stewardship activities, and outreach to schools and local governments.

Members represented community organizations and citizens. Generally, volunteers facilitated the meetings, determined the work plan, and used staff and consultants to assist and generate work products recommended at the meetings.

Attendee organizations of these meetings:

City of Falcon Heights
City of Roseville
City of Saint Paul
City of Saint Paul, Div. of Parks and Recreation
City of Saint Paul Public Works
CRWD Board of Managers
CRWD Citizens Advisory Committee
Community Council District 6
Community Council District 10
Como Northtown Credit Union
Como Shoreline Interests
Emmons & Olivier Resources
Lynch Associates
Neighborhood Energy Consortium
Metropolitan Council Environmental Services
Minnesota Department of Natural Resources
Minnesota Pollution Control Agency
Minnesota State Legislature
Ramsey County
Ramsey County Public Works
Ramsey Soil and Water Conservation District
University of Minnesota Water Resources Center

Stakeholder Meetings during TMDL Process

Regulated MS4s were provided the opportunity to review the draft TMDL report in early 2010. Individual meetings were held with the municipalities in February 2010 to discuss the TMDL and its derivation from the CLSMP. A meeting with all regulated MS4s was held on February 17, 2010 to further discuss the TMDL, the form of the WLA (categorical vs. individual), and the implementation strategies. Regulated MS4s were provided another opportunity to review and comment on the draft report before preliminary review by the MPCA and EPA and the public comment period.

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APPENDIX A. CRWD STORMWATER MODELING

Capitol Region Watershed District
Stormwater Modeling

May 16, 2000

BARR

Capitol Region Watershed District Stormwater Modeling

May 16, 2000

BARR

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Capitol Region Watershed District
Stormwater Modeling

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1.0 Background

Barr Engineering was asked by Capitol Region Watershed District (CRWD) to complete a stormwater modeling project for the entire District using the P8 Urban Catchment Model (IEP, Inc., 1990 and Walker, 1990). In this project, subwatersheds tributary to the Mississippi River, District Lakes, and public stormwater detention ponds were evaluated. Stormwater monitoring information for four minor subwatershed areas obtained by the City of St. Paul in 1994 (Montgomery Watson, 1994) was used to calibrate the P8 model. Calibrated P8 model parameters for the monitored subwatersheds were utilized to model the unmonitored portions of the District based on impervious area and land use information for the remaining District subwatersheds. Modeling simulations of the entire District were performed for recent (1999), wet, dry, and average climatic conditions.

1.1 Land Use Information

The land use information provided by the District contained the following eight categories: (1) Commercial, (2) Industrial, (3) Institutional, (4) Parks and Open Space, (5) Residential High Density, (6) Residential Low Density, (7) Water, and (8) Undeveloped. The land use shapefile provided was based on parcel data and therefore, was missing all of the roadways throughout the District. As a result the missing roadway data was filled in using ArcView to create a ninth land use type, "Roads".

1.2 Impervious Surface Information

Impervious surface information is considered to be a basic measurement unit of an urbanized watershed. As such, the CRWD completed a project to create an ArcView shapefile for the major impervious surfaces throughout the District, including roads, alleys, structures, tennis courts, and parking lots. The impervious surface GIS data layer from the District did not contain polygons for all the sidewalks and driveways within the District. To overcome the lack of information for sidewalks and driveways, Barr Engineering determined the areal extent of sidewalks and driveways for representative areas within each of the various land use categories. To accomplish this, the 1997 Metropolitan Council Aerial Photographs of the District were used to digitize the sidewalks and driveways at six different, but representative, locations throughout the District. Whenever possible the location was selected to correspond to the stormwater monitoring sites. This was done to aid in model calibration. Table 1 summarizes the results of the sidewalk and driveway areal extent analysis.

Table 1 Sidewalk and Driveway Areal Extents

Land Use Category	Sidewalk Extent (%)	Driveway Extent (%)
Commercial	4.67	1.83
Industrial *	0.00	21.32
Institutional	5.78	7.18
Parks and Open Space	1.21	0.21
Residential High Density	6.74	1.70
Residential Low Density	3.62	2.81
Roads	6.61	2.14
Undeveloped	11.07	9.83
Water	N/A	N/A

* The extent of sidewalk for industrial land use was estimated to be 0% because sidewalk could not be differentiated from driveways, parking lots, or other impervious surfaces on the 1997 Metropolitan Council Aerial Photos.

Connectivity estimation of the various impervious surface types was accomplished by associating each surface type with a land use category. Using the 1997 aerial photos, the connectivity percentages of representative impervious surfaces were visually estimated. A minimum of four locations of various land use types were observed, including the monitoring sites and downtown areas. It was discovered that the Downtown and Urban subwatershed had higher connected impervious percentages, as indicated in Table 2. Table 2 provides the connected percent impervious for the various surface and land use types. Roads, alleys, parking lots, and driveways were assumed to be 100 percent connected to the storm sewer network. The connectivity of structures was estimated based on the number of sides of the structure that were in close proximity or adjacent to a connect impervious surface (i.e., if the structure was surrounded by a parking lot, the structure was assumed to be 100 percent connected, while if a structure had roads or alleys adjacent to two sides, the structure was assumed to be 50 percent connected). One exception to this methodology was structures in low density residential areas. The impervious areas of these structures were assumed to not be directly connected to the storm sewers. The assumption is based on the fact the runoff from these impervious surfaces typically must flow through pervious areas, such as lawns, prior to reaching the storm sewers.

Table 2. Connected Percent for Various Impervious Surface and Land Use Types

Impervious Surface Type	Apply to Watersheds	Land Use Type								
		Commercial	Industrial	Institutional	Low Density Residential	High Density Residential	Parks & Open Space	Undeveloped	Water	Road
Alley	All	100	100	100	100	100	100	100	N/A	100
Parking Lot	All	100	100	100	100	100	100	100	N/A	100
Structure	Downtown & Urban	100	100	100	0	100	50	100	N/A	100
	Others	80	100	50	0	50	50	75	N/A	100
Tennis Court	All	0	0	0	0	0	0	0	N/A	0
Road	All	100	100	100	100	100	100	100	N/A	100
Driveway	All	100	100	100	100	100	100	100	N/A	100
Sidewalk	Downtown & Urban	100	100	100	0	100	25	0	N/A	100
	Others	75	100	50	0	50	25	0	N/A	100

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1.3 Monitoring Site Watershed Data

The land use types, impervious surface areas, and soils data were determined for each monitoring site. Based on the various land uses in each monitored watershed, the areal extent of sidewalks and driveways were determined. Using the impervious surface data and the respective connectivity percentages of each land use type, the connected impervious fraction was determined. Based on consultation with the SCS National Engineering Handbook (SCS, 1964), the pervious curve number was selected for each site based upon soil types, land use, and hydrologic conditions (i.e., if watershed soils are type B and pervious areas are comprised of grassed areas with 50% to 75% cover, then a Curve Number of 69 would be selected). A composite pervious curve number was estimated for each site based on the area and hydrologic soil group (HSG) of each soil type within the site subwatersheds. This pervious curve number was then weighted with indirect (i.e., unconnected) impervious areas in each subwatershed. Table 3 lists the various watershed characteristics for each site.

Table 3. Monitoring Site Subwatershed Characteristics

Watershed Characteristic	Monitoring Site			
	Lawson	**Vandalia**	**Charles**	**Hartford**
Major Land Use Type	Low Density Residential	Industrial	Mixed	Low Density Residential
Subwatershed Area (acres)	53.8	82.0	61.6	72.5
Pervious Curve Number	78	81	75	77
Connected Impervious Fraction	0.400	0.882	0.444	0.355

2.0 Water Volume Calibration

After compiling volunteer, University of Minnesota, St. Paul Campus, (UofM), and Minneapolis-St. Paul International Airport rainfall data and looking at the various monitoring site locations in relation to the precipitation sites, it was decided to average the daily total precipitation amounts from the UofM and the four volunteer sites. This averaging was done because the precipitation-monitoring site bordered the stormwater monitoring locations. This enabled one precipitation file to be developed for calibration. At this point it is important to mention that if the flow volumes predicted by P8 were dramatically different from observed, one possible explanation is that the precipitation file does not represent site specific rainfall events. The rainfall hyetographs were developed for each event based on either the UofM or Airport hourly precipitation observations. The average event precipitation totals were compared to the event totals recorded at the UofM and the Airport. The hyetograph from which ever of the two sites provided the closest event precipitation total to the average of the four volunteer and UofM sites was used to develop a PCP file for P8. The selected hyetograph was adjusted to reflect the average precipitation totals.

Based on the observed monitoring event periods and the overlap of some events for one site and not for the others, as well as the large difference between observed and predicted flow volumes, independent precipitation files had to be developed for each site. The monitoring site locations are shown in Figure 1.

- **Vandalia** – The UofM rain gage is located in relatively close proximity to this site. Therefore, the precipitation charts from the UofM rain gage, as supplied as part of the City of St. Paul 1994 Stormwater Monitoring Report, were used to develop the PCP file for the Vandalia monitoring site. For other unmonitored events, the Airport rainfall data were used. (Vandcal.pcp)

- **Hartford** – The volunteer rainfall monitoring site 28-23-9 is located in relatively close proximity to this site. Therefore, the event precipitation total observed by this volunteer were used in conjunction with the hyetographs for the same events from the Airport. (Hartcal.pcp)

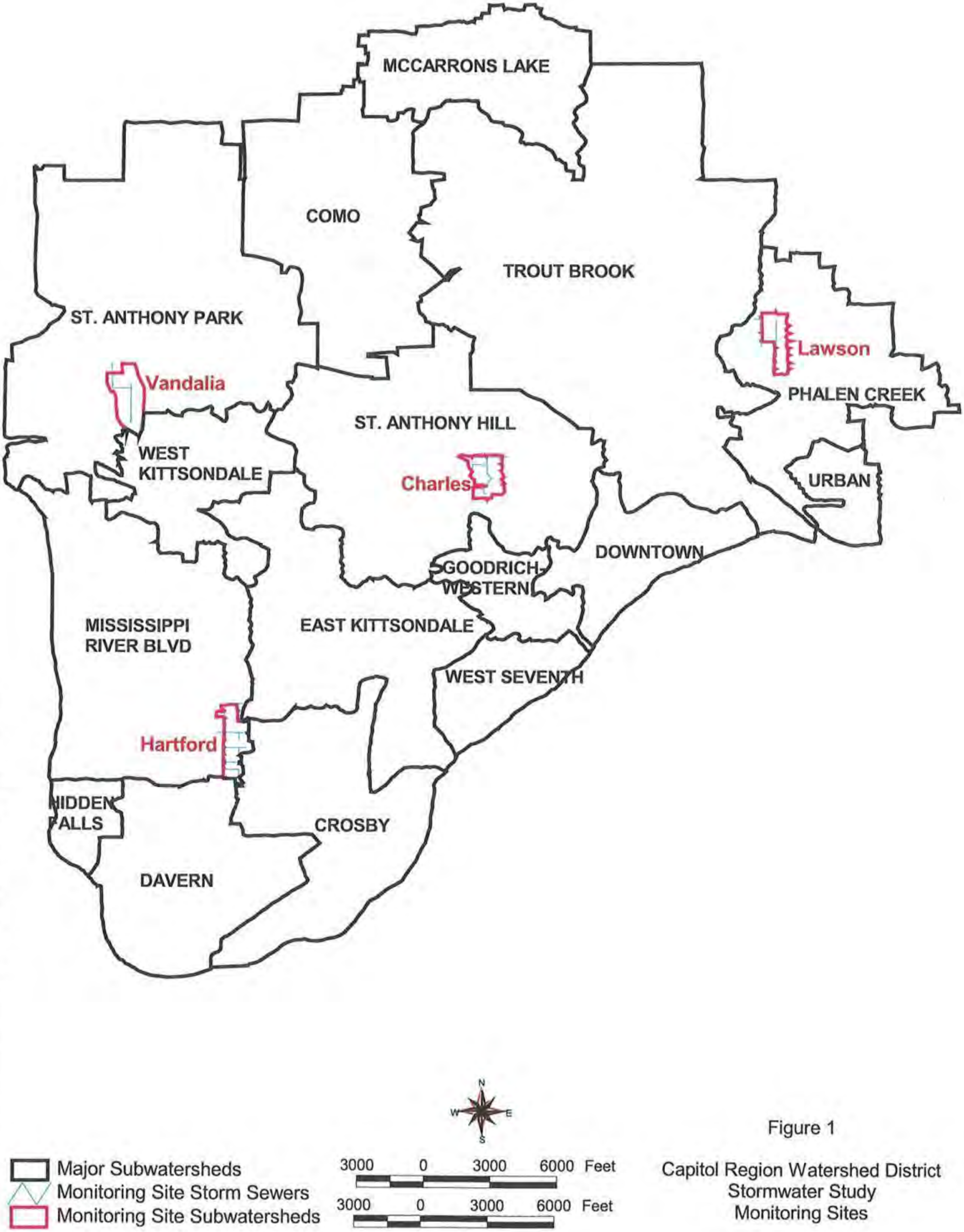

Figure 1

Capitol Region Watershed District
Stormwater Study
Monitoring Sites

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- **Lawson** – This stormwater monitoring site is closest to volunteer sites 29-22-23 and 29-22-26. Therefore, the average observed event precipitation total from these sites was used with either the UofM or Airport hyetographs. The appropriate hyetograph was selected based on which location provided the closest match to the average volunteer site rainfall total for the respective event. (Lawscal.pcp)

- **Charles** – This site is centrally located within the area of the precipitation monitoring sites listed in the 1994 Stormwater Report. Therefore the average precipitation amount, from the four volunteers and the UofM sites, was used with either the UofM or Airport hyetograph to develop the precipitation file for this site. The appropriate hyetograph was selected based on which location provided the closest match to the overall average rainfall total for the respective event. (Charcal.pcp)

Model calibration was based on observed runoff totals for the monitoring events at a given site, as reported in the 1994 Stormwater Monitoring Report. Model calibration was based on the overall arithmetic mean of the individual site total estimated runoff volume divided by the observed runoff volume for all of the representative events at all of the monitoring sites. The models were considered calibrated when the average of the individual site ratios was 100 percent, meaning the models were predicting 100 percent of the observed runoff volume for the analyzed events. Early on in the calibration process it became evident that observed runoff volumes for all of the events at Hartford, the first event at Charles, and the second event at the Lawson monitoring sites were unrealistic, given the watershed characteristics and the best estimate of rainfall volumes. The difference between observed and predicted runoff volumes could be caused by several factors, including inaccurate precipitation data, flow monitoring data, impervious surface data, storm sewer data, or any combination of this type of information. The Hartford site was closely examined using aerial photos, storm sewer maps, and topographic information to try and explain the large difference between observed and predicted runoff volumes. Because no physical explanation could be found, the monitored flow rates were placed in doubt for the above mentioned sites and events. To facilitate model calibration, those events in question (Event 2 at Lawson, Event 1 at Charles, and Events 1, 2, and 3 at Hartford) were eliminated from the calibration procedure.

The initial model run for each site was conducted using the models default watershed parameters. Model runs with the default watershed parameters resulted in an over prediction of runoff volumes for the majority of the observed events. The initial model runs also revealed the majority of the runoff was from the impervious surfaces only. This is unrealistic for the larger observed events (precipitation > 1-inch). Examination of the events file revealed that the models were generally computing pervious runoff using antecedent moisture condition (AMC) I. The default P8 model parameters used to determine pervious runoff are set such that the model will utilize curve numbers from one of three different antecedent moisture conditions based on the 5-day antecedent precipitation total. An examination of the observed runoff volumes versus the total 5-day antecedent precipitation amounts showed that a significant relationship did not exist between these variables. As a result, the model was forced to compute runoff in the second antecedent moisture condition (AMC II). This was accomplished by setting the cut off between AMC I and AMC II equal to 0 while the division between AMC II and AMC III was set equal to 100. This forced the model to compute runoff in the second AMC as long as the pervious 5-day rainfall plus snowmelt was between 0 and 100-inches. Because the monitoring data were only collected during the growing season (May through September), the model was only forced to run in the AMC II during that period. Based on the aerial photos of the monitoring it was assumed the grassed areas were in fair condition. Because of soil compaction due to urbanization it was assumed that soil group A would produce runoff volumes similar to group B. This was also done to produce pervious runoff to aid in the calibration process. The following pervious CN's were selected for the various HSG's:

Table 4. Modeled CN's for Various HSG's

HSG	CN
A	69
B	69
C	79
D	84

In addition to forcing the model to compute runoff in AMC II, the impervious runoff coefficient and depression storage parameters were adjusted to aid in model calibration of runoff from the impervious surfaces. Initial model runs indicated that the models were over predicting the runoff volumes for small events (precipitation total <0.5-inches). Based on this, the depression storage was increased from the default value of 0.02-inches to 0.1-inch. Even after the above adjustments, the models were over-predicting the runoff volumes. Therefore, the impervious runoff coefficient was reduced until the overall runoff observed and predicted runoff volumes were equal (This is essentially Step 13 of Walker's report, *P8 Enhancements & Calibration to Wisconsin Sites*). The resulting impervious runoff coefficient, 0.9, produced an overall predicted to observed ratio of 100 percent. In addition, the individual sites had ratios ranging between 93 and 110 percent. The best fit was at Vandalia where the overall average ratio was 100 percent for the three monitoring events. The remaining variation in individual events is likely due to inaccurate site specific rainfall data. Table 5 shows the difference between the model runs with the default parameters and the calibrated model. It also lists the calibration parameters.

An impervious area watershed runoff coefficient equal to 0.9, a depression storage amount of 0.1 inches, running the model in the second AMC during the growing season, and using pervious CN's for grassed areas with fair cover conditions produced the best calibration with respect to water volumes. This is supported by the fact that the overall predicted volumes for each site were all within 10 percent of the observed volumes.

Table 5. Water Volume Calibration Results

	Charles	Lawson	Hartford	Vandalia
Initial Results				
Impervious Runoff Coefficient	1	1	1	1
Depression Storage (inches)	0.02	0.02	0.02	0.02
Weighted Pervious CN (Good Condition)	58	73	71	76
Growing Season AMC I – AMC II Divide	1.4	1.4	1.4	1.4
Growing Season AMC I – AMC II Divide	2.1	2.1	2.1	2.1
Individual Site Predicted/Observed Volume Ratios*	76%	122%	449%	118%
Overall Arithmetic Mean Predicted/Observed Volume Ratios	191%			
Calibrated Results				
Impervious Runoff Coefficient	0.9	0.9	0.9	0.9
Depression Storage (inches)	0.1	0.1	0.1	0.1
Weighted Pervious CN (Fair Condition)	75	78	77	81
Growing Season AMC I – AMC II Divide	0	0	0	0
Growing Season AMC I – AMC II Divide	100	100	100	100
Individual Site Predicted/Observed Volume Ratios*	110%	93%	N/A	97%
Overall Arithmetic Mean Predicted/Observed Volume Ratios	100%			

* For representative storm events considered for this analysis.

3.0 Pollutant Calibration

The P8 model was calibrated to the average event flow-weighted concentration for total suspended solids (TSS), total phosphorus (TP), total copper, and total zinc. With two exceptions, Barr Engineering's calibration steps followed those discussed in the report "P8 Enhancements & Calibration to Wisconsin Sites", Walker (1997). The first exception relates to identifying calibration events. Since many of the monitored events for the four subwatersheds occurred during rainfall events that received more than 1-inch of precipitation, those events were not eliminated as recommended by Step 12 of Walker's report. The second exception relates to calibrating the dissolved fraction of the remaining water quality components, as outlined in Step 15 of Walker's report.

Barr Engineering performed an extensive review of the monitored water quality data and its relationship to the loadings from the pervious and impervious areas of the various land use types. It was determined that significant differences do not exist between the major land use types and therefore the calibration parameters can be optimized such that one particle file with one set of scale factors can be used for all subwatersheds.

Review of observed water quality data revealed that several of the events were not sampled over the entire storm event. Therefore, the concentrations listed in the 1994 Stormwater Monitoring Report do not represent the event flow weighted mean concentrations. As a result, modeling output was identified over the water quality sampling period (i.e., for Event 1 the sampling period was only the first 1.75 hours. Therefore, P8 model only the output data for just the first 1.75 hours of the event was compared to the observed data.). When possible, the flow volumes over the water quality sampling period were estimated from the flow data in the 1994 Stormwater Report. The flow volumes predicted by the calibrated P8 model for the Hartford site were used for pollutant calibration because the Hartford site's observed flow volumes were eliminated from the water volume calibration (See Section 2.0 Water Volume Calibration).

The pollutant calibration process started with the NURP50% particle file as developed by Walker for the median NURP monitoring site. The pollutant calibration process was conducted in a manner similar to the water volume calibration process (i.e., when the arithmetic mean of the individual site overall flow weighted mean predicted concentration to observed concentration ratio equaled 100 percent, the constituent was considered calibrated).

3.1 Total Suspended Solids Calibration

Following Walker's calibration steps, suspected monitored outliers were eliminated from the calibration process (Step 5). The 1994 Stormwater Report states "the Lawson watershed is fully developed with residential and older commercial areas and contains a number of gravel parking lots. It was also noted during the monitoring period that several inches of sediment generally accumulated in the manhole at the Lawson site." Because anomalous sedimentation was not observed at all of the sites, the Total Suspended Solids (TSS) concentrations at the Lawson site are likely not representative of the rest of the watersheds. As a result, the Lawson site was removed from the calibration process.

After completing the water volume calibration, Walker recommends calibrating the TSS (Step 14). Because all other pollutant concentrations are dependent on the amount of solids, TSS calibration is a critical step. The P8 model results using the NURP50% particle file indicated that P8 was over predicting TSS concentrations from impervious areas and under predicting concentrations from pervious areas, based on the relative magnitude of impervious and pervious area runoff volumes taken from the model calibrated for water volume.

To address the runoff TSS concentration from the pervious areas the pervious runoff concentration and the pervious runoff exponent were adjusted for the various particle classes. According to *P8 Urban Catchment Model Program Documentation, Version 1.1*, Walker 1990, based on typical sediment rating curves the pervious runoff exponent ranges between 0.1 and 1.6 for rivers. Other particle files supplied with the P8 model (NURP90.par, Monroe.par, and Lincoln.par) were reviewed to determine a range for the pervious runoff concentration since no pervious area monitoring data were available. Based on this review the P10% to P50% concentrations were found to range between 100 and 400 mg/L while the P80% concentration ranged between 200 and 800 mg/L. Numerous combinations of the pervious runoff concentration and exponent were examined. A pervious runoff concentration for the P10%-P50% of 100 mg/L and 200 mg/L for the P80% with a runoff exponent of 0.1 produced the best results for pervious runoff concentrations.

According to *P8 Urban Catchment Model Program Documentation, Version 1.1*, Walker 1990, any of the buildup/washoff parameters can be adjusted for calibration. Rescaling the impervious area particle loading for the different particle classes (P10% - P80%) as recommended in Step 14 of Walker's report was done to reduce the impervious runoff concentration. The NURP50% accumulation rates (1.75 and 3.5 lb/ac/day for P10%-P50% and P80% respectively) were reduced to 1 lb/ac/day for the P10%-P50% particle classes and 2 lb/ac/day for the P80% particle class. These adjustments alone did not sufficiently reduce the impervious runoff concentration. The P8 documentation states that the exponential washoff relationship used by the model is similar to that employed by the EPA's Stormwater Management Model (SWMM). Therefore, documentation for SWMM (Huber et al., 1987) was reviewed to determine acceptable values for the washoff parameters. The documentation revealed that the impervious washoff coefficient could range between 1 and 10. It also mentions that this coefficient can vary by almost five orders of magnitude. The SWMM documentation also indicates that the impervious washoff exponent typically ranges between 1.1 and 2.6, with most values near 2.0. The SWMM documentation states that both of the parameters can be varied to calibrate the model to observed data. In addition to the ranges supplied by the SWMM documentation, the other particle files supplied with P8 were reviewed for typical ranges in the buildup/washoff parameters. Again various combinations for the buildup/washoff parameters were simulated with the best results produced from the following parameters:

- Accumulation rates : 1 lb/ac/day (P10%-P50%) and 2 lb/ac/day (P80%)
- Accumulation Decay Rate : 0.3 day^{-1}
- Impervious Washoff Coefficient : 10.5
- Impervious Washoff Exponent : 2.1

Using the buildup/washoff and pervious runoff parameters listed above resulted in the overall arithmetic mean predicted to observed ratio of the flow weighted mean TSS concentration to equal 100 percent based on the representative monitoring site data. Table 6 summarizes the results of the TSS calibration procedure.

Table 6. TSS Calibration Results

	Charles	Lawson	Hartford	Vandalia
Initial Results (using NURP50.par)				
Accumulation Rate (lb/ac/day) (P10%-P50%/P80%)	1.75/3	1.75/3	1.75/3	1.75/3
Accumulation Decay Rate (1/day)	0.25	0.25	0.25	0.25
Impervious Runoff Coefficient	20	20	20	20
Impervious Runoff Exponent	2	2	2	2
Pervious Runoff Concentration (mg/L) (P10%-P50%/P80%)	100/200	100/200	100/200	100/200
Pervious Runoff Exponent	1	1	1	1
Individual Site Predicted/Observed Volume Ratios	449%	N/A	118%	286%
Overall Arithmetic Mean Predicted/Observed Volume Ratios	284%			
Calibrated Results (CRWDPart.par)				
Accumulation Rate (lb/ac/day) (P10%-P50%/P80%)	1/2	1/2	1/2	1/2
Accumulation Decay Rate (1/day)	0.3	0.3	0.3	0.3

	Charles	Lawson	Hartford	Vandalia
Impervious Runoff Coefficient	10.5	10.5	10.5	10.5
Impervious Runoff Exponent	2.1	2.1	2.1	2.1
Pervious Runoff Concentration (mg/L) (P10%-P50%/P80%)	100/200	100/200	100/200	100/200
Pervious Runoff Exponent	0.1	0.1	0.1	0.1
Individual Site Predicted/Observed Volume Ratios	144%	N/A	82%	74%
Overall Arithmetic Mean Predicted/Observed Volume Ratios	100%			

3.2 Total Phosphorus Calibration

The total dissolved fractions for many of the monitored water quality components are not known, so for phosphorus, we set the "Particle Content" for the dissolved fraction (P0%) such that the concentration was not less than the observed flow-weighted mean dissolved reactive phosphorus concentration for any of the monitoring sites. This is consistent with Step 15 of Walker's 1997 report. The total phosphorus (TP) particle composition for the P0% particle fraction was set equal to the largest observed dissolved reactive phosphorus concentration of any of the sites (0.16 mg/L) times 10^6, or 160000mg TP/kg TSS. The remaining TP particle compositions for the other particle fractions (P10%-P80%) were then reduced until the overall arithmetic mean predicted to observed ratio was 100 percent. The results of the TP calibration procedure are listed in Table 6. While the overall ratio was 100 percent, the median ratio of the individual events was 93 percent indicating that for the median event the predicted TP is within 7 percent of the observed.

Table 7. TP Calibration Results

	Charles	Lawson	Hartford	Vandalia
Calibrated Results (CRWDPart.par)				
TP P0% Particle Composition (mg TP/kg TSS)	160000	160000	160000	160000
TP P10%-P80% Particle Composition (mg TP/kg TSS)	2625	2625	2625	2625
TP Scale Factor	1	1	1	1
Individual Site Predicted/Observed Volume Ratios	119%	N/A	73%	107%
Overall Arithmetic Mean Predicted/Observed Volume Ratios	100%			

3.3 Trace Metal Calibration

Since no total dissolved fractions for the monitored trace metal water quality components were determined, the NURP50% speciation was retained during the calibration process. Based on the data presented in the 1994 Stormwater Monitoring Report, only copper (Cu) and zinc (Zn) had sufficient data for calibration. Only the sample data that were above the detection limits were used for calibration. The calibration of these parameters was accomplished by adjusting the respective scale factor in the "Components" screen of P8.

The default Cu scale factor caused the P8 model to under-predict the Cu concentrations. Therefore, the Cu scale factor was increased until the overall arithmetic mean predicted to observed Cu concentration ratio was 100 percent. A Cu scale factor of 1.37 produced the best calibration.

The default Zn scale factor caused the P8 model to over-predict the Zn concentrations. Therefore, the Zn scale factor was decreased until the overall arithmetic mean predicted to observed Zn concentration ratio was 100 percent. A Zn scale factor of 0.67 produced the best calibration.

3.4 Pollutant Calibration Summary

Because no significant differences in the pervious and impervious loadings exists between the major land use types, a single particle file (CRWDPart.par) was developed. Table 8 summarizes the resulting parameters in the "CRWDPart.par" file that were adjusted to calibrate the various P8 models to representative observed data. The resultant particle file was considered to be applicable to the entire Capitol Region Watershed District.

Table 8. Pollutant Calibration Results

Parameter Adjusted	Calibrated Value
Accumulation Rate (lb/ac/day) (P10%-P50%/P80%)	1 / 2
Accumulation Decay Rate (1/day)	0.3
Impervious Runoff Coefficient	10.5
Impervious Runoff Exponent	2.1
Pervious Runoff Concentration (mg/L) (P10%-P50%/P80%)	100/200
Pervious Runoff Exponent	0.1
TP P0% Particle Composition (mg TP/kg TSS)	16000
TP P10%-P80% Particle Composition (mg TP/kg TSS)	2625
TSS Scale Factor	1
TP Scale Factor	1
Cu Scale Factor	1.37
Zn Scale Factor	0.67

4.0 P8 Modeling of Entire CRWD

With the calibration process described in Sections 2.0 and 3.0 completed, the unmonitored areas of the District could now be modeled. Due to the large extent of the District, six individual P8 models were created. The models were developed in order to keep the number of devices at or below the maximum allowable of 48. Figure 2 illustrates the areas combined for a given model. Figure 3 illustrated the various subwatersheds and their flow direction modeled for this study. Table 9 lists the various major subwatersheds that were combined into one P8 model, explains any connections between models, and describes any unique modeling techniques.

Table 9. CRWD P8 Models

P8 Model Identifier	Major Subwatersheds Containing in Model	Comment
CRWD1	Lake Como and McCarrons Lake	Como and McCarrons Lakes were modeled as pipes so the total water and pollutant loads into the lakes could be easily determined. Devices 4, 5, 6, and 7 were setup as general devices with no particle removal to simulate diversion structures in the existing storm sewer system.
CRWD2	Trout Brook	Como and McCarrons Lakes discharge into Trout Brook. The generalized representation of these lakes and their tributary area were entered into this model (See Section 4.2 for further description). Due to the limited number of devices allowed in P8, runoff from subwatersheds TRT18, TRT19, TRT20, & TRT22 was combined and routed to device TRT20. Similar routing was done for subwatersheds TRT 14 & TRT16. Devices 18 and 19 were setup as general devices with no particle removal to simulate diversion structures in the existing storm sewer system.
CRWD3	Phalen Creek and Urban	
CRWD4	Downtown, St. Anthony Hill, Goodrich-Western, West Seventh, East Kittsondale, Croby, Davern, and Hidden Falls	A generalized representation of the Crosby Lake and its tributary area were entered into this model (See Section 4.2 for further description). To determine the loadings into Crosby Lake a separate watershed and device were entered into the model ("CrosbyLK")
CRWD5	Mississippi River Boulevard and West Kittsondale	
CRWD6	St. Anthony Park	

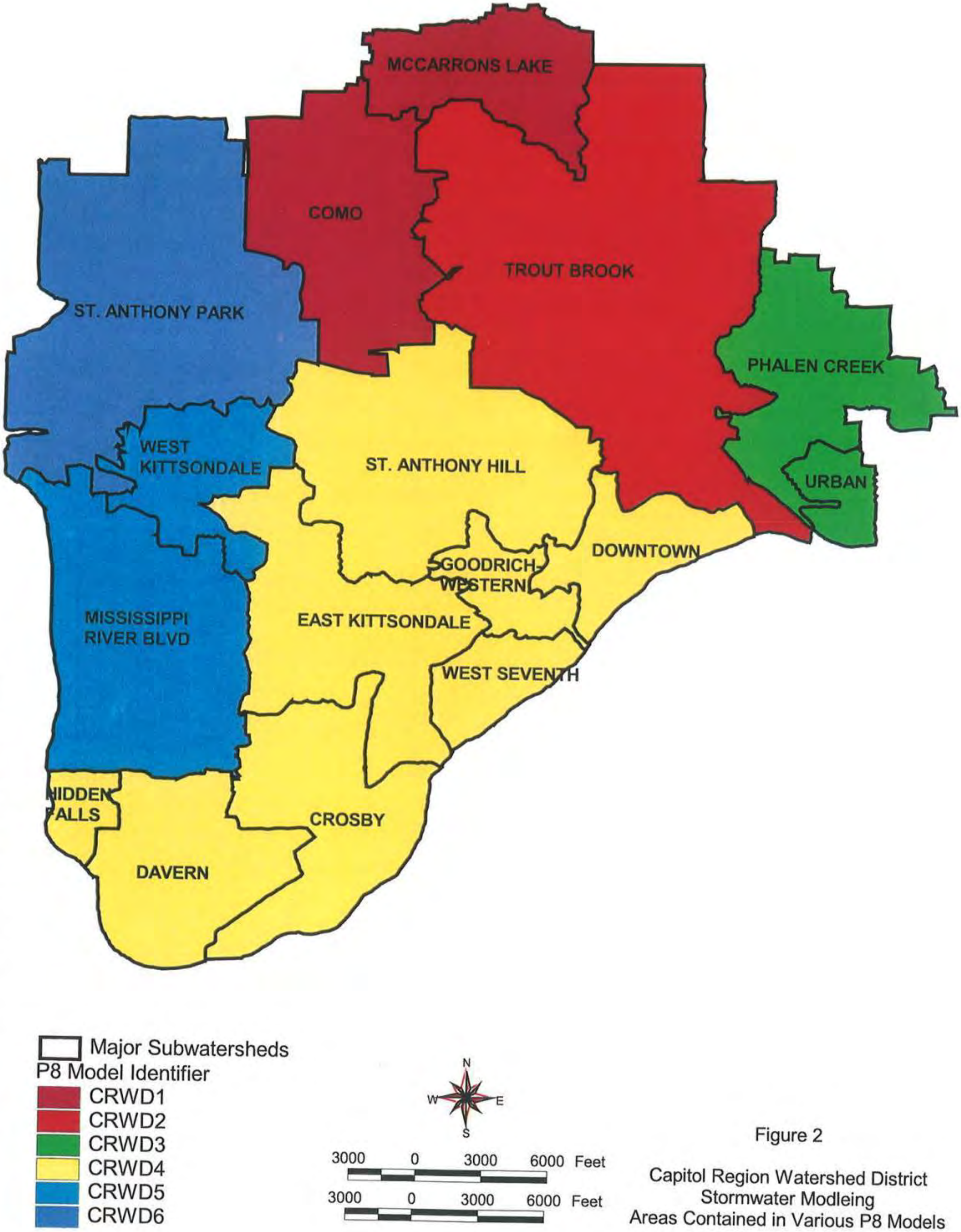

Figure 2

Capitol Region Watershed District
Stormwater Modleing
Areas Contained in Various P8 Models

Barr: Arcview 3.1,PIIDE, i:\projects\23\62\695\gis\project\capitol_deliver.apr, Layout: Layout1:Figure2, SAS, Thu May 18 17:54:48 2000

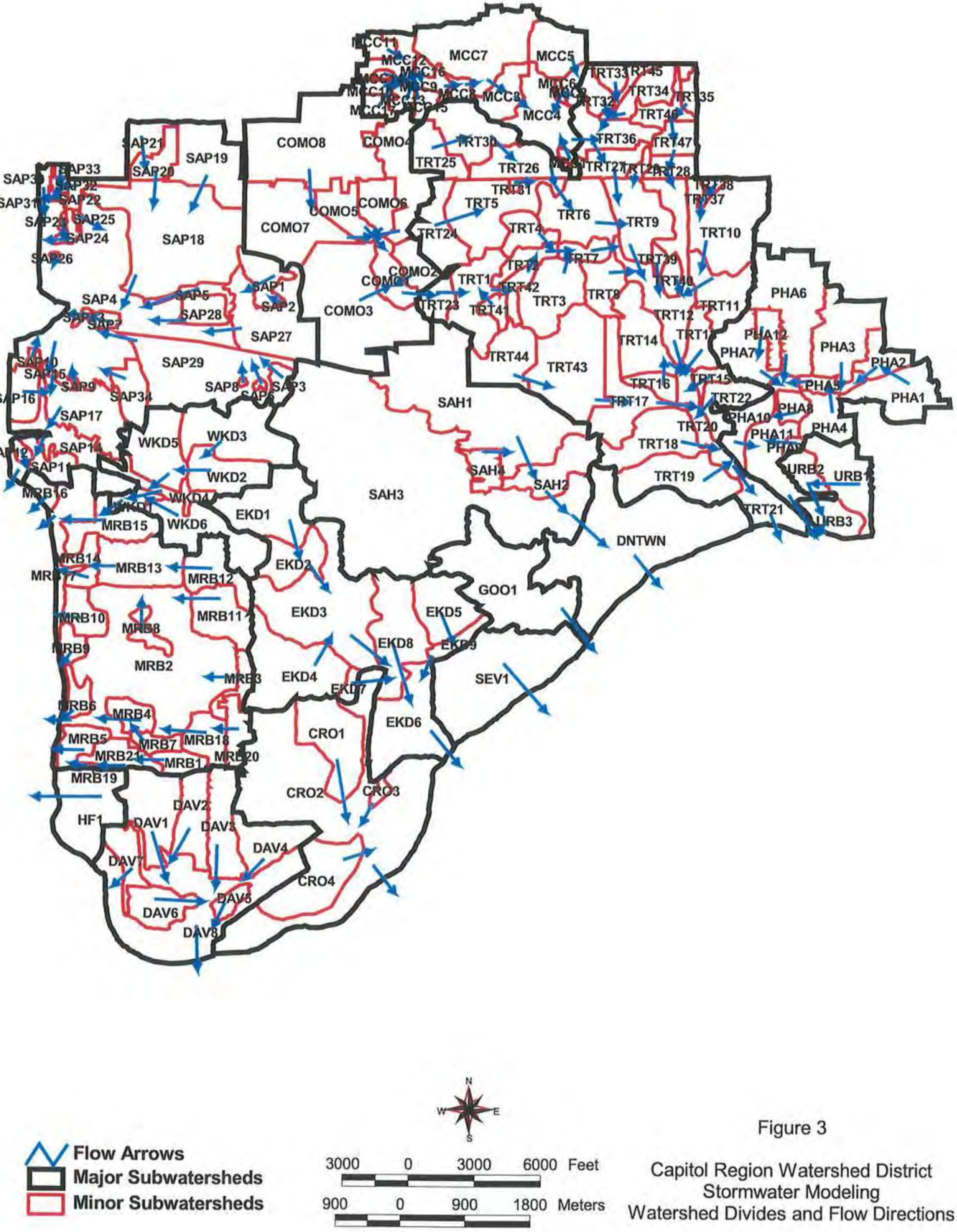

Figure 3

Capitol Region Watershed District
Stormwater Modeling
Watershed Divides and Flow Directions

Barr: Arcview 3.1, PIIDE, I:\projects\23\62\695\gis\project\capitol_deliver.apr, Layout: Layout:Figure3, SAS, Thu May 18 17:54:13 2000

4.1 P8 Model Parameter Selection

From the data that were collected for the 1994 Stormwater Monitoring Report, model calibration afforded the opportunity to select P8 parameters that resulted in a good fit between modeled and observed data. The parameters selected for the CRWD P8 models are discussed in the following paragraphs. P8 parameters not discussed in the following paragraphs were left at the default setting. P8 version 2.3 was used for the modeling.

4.1.1 Time Step, Snowmelt, & Runoff Parameters (Case-Edit-Other)

- Time Steps Per Hour (Integer)— 10. Selection was based upon the number of time steps required to eliminate continuity errors greater than two percent.

- Growing Season AMC—II = 0 and AMC—III = 100. Selection of this factor was based upon the observation that the model accurately predicted runoff water volumes from monitored watersheds when the Antecedent Moisture Condition II was selected (i.e., curve numbers selected by the model are based upon antecedent moisture conditions). Modeled water volumes from pervious areas were less than observed volumes when Antecedent Moisture Condition I was selected, and modeled water volumes exceeded observed volumes when Antecedent Moisture Condition III was selected. The selected parameters tell the model to only use Antecedent Moisture Condition I when less than 0 inches of rainfall occur during the five days prior to a rainfall event and to only use Antecedent Moisture Condition III if more than 100 inches of rainfall occur within five days prior to a rainfall event. (See Section 2.0 Water Volume Calibration for further discussion)

4.1.2 Particle Scale Factor (Case-Edit-Components)

- Scale Fac.—Cu—1.37. The particle scale factor determines the copper load generated by the particles predicted by the model in watershed runoff. The factor for copper was selected as 1.37 . (See Section 3.3 Trace Metal Calibration for more discussion on the selection of trace metal scale factors)

- Scale Fac.—Zn—0.67. The particle scale factor determines the zinc load generated by the particles predicted by the model in watershed runoff. The factor for zinc was selected as

0.67. (See Section 3.3 Trace Metal Calibration for more discussion on the selection of trace metal scale factors)

4.1.3 Particle File Selection (Case—Read—Particles)

- CRWDPart.PAR. The particle file developed during the calibration process was applied to the entire CRWD. (See Section 3.0 for discussion on how this particle file was developed)

4.1.4 Precipitation File Selection (Case—Edit—First—Prec. Data File)

- MSP4999.PCP. The precipitation file MSP4999.PCP is comprised of hourly precipitation measured at the Minneapolis–St. Paul International Airport were used for the period between 1949 and the end of September 1999.

4.1.5 Air Temperature File Selection (Case—Edit—First—Air Temp. File)

- MSP4999.tmp. The temperature file was comprised of temperature data from the Minneapolis–St. Paul International Airport during the period from 1949 through 1999.

4.1.6 Devices Parameter Selection (Case—Edit—Devices—Data—Select Device)

- Detention Pond— Permanent Pool— Area and Volume— The surface area and dead storage volume of each detention pond was determined and entered here. Where available, Barr used outlet stage-discharge relationships or other rating information and pond volume information supplied by the District. If limited information was supplied, Barr assumed an average depth of 4-feet and estimated the surface area information (based on USGS quad maps or aerial photos) to determine the pond permanent pool volume.

- Detention Pond— Flood Pool— Area and Volume— The surface area and storage volume under flood conditions (i.e., the storage volume between the normal level and flood elevation) was determined and entered here. The areas and volumes were estimated based on information provided by the District.

- Detention Pond— Infiltration Rate (in/hr)— Infiltration rates were only entered for landlocked basins. This was done to simulate no surface outflow from those areas. It was assumed that the soils under the basin would act similar to SCS group D soils. Therefore, an infiltration rate between 0 and 0.05 in/hr (recommended range for group D soils in P8) was selected.

- Detention Pond— Orifice Diameter and Weir Length— The orifice diameter or weir length was determined from field surveys or development plans of the area for each detention pond and entered here.

- Detention Pond or Generalized Device— Particle Removal Scale Factor— Particle Removal Scale Factor— 0.3 for ponds less than two feet deep (including dry ponds) and 1.0 for all ponds three feet deep or greater.

- Detention Pond or Generalized Device— Outflow Device Nos.— The number of the downstream device receiving water from the detention pond outflow was entered.

- Pipe/Manhole— Time of Concentration— Because detailed topographic information was not available for the entire District the time of concentration for each pipe/manhole device was entered as 0 hrs. A pipe device was entered for most watersheds in the District unless (1) there were more than 48 watersheds or (2) a given watershed contained a detention pond. A "dummy" pipe/manhole was installed in the network to represent District Lakes. This forced the model to total all loads (i.e., water, nutrients, etc.) entering the lake. Failure to enter the "dummy" pipe requires the modeler to manually tabulate the loads entering the lake.

4.1.7 Watersheds Parameter Selection (Case—Edit—Watersheds—Data—Select Watershed)

- Outflow Device Number— The Device Number of the device receiving runoff from the watersheds was selected to match the watershed number. For example, subwatershed COMO3 (watershed No. 3) flows into device 3 (labeled COMO3).

- Pervious Curve Number— A weighted SCS Curve number was used, as outlined in the following procedure. The Ramsey County soil information was provided by the District. It was discovered that this coverage was missing the hydrologic soil group (HSG) classifications for several soil types. To fill in the missing data the individual soil descriptions for each soil type was consulted from the *1980 Soil Survey of Washington and*

Ramsey Counties, Minnesota, SCS. Several of the soil types that were missing the HSG had a HSG listed in the soil survey. In this case the information from the soil survey was added to the soils layer coverage. For areas where the unknown HSG was consistently surrounded by a uniform soil type or HSG, the missing HSG was assumed to be the same as the adjacent soil. Soils in the downtown area of St. Paul were assumed to behave similar to D type soils due to their non-native and compacted nature. For udorthents, undorthents (wet subsratum), pits (gravel), udifluvents, and aquolls and histosols (pond) the soil drainage description given in the text of the soil survey was used to estimate a HSG. Table 10 lists the HSG's assumed for this study.

Table 10. Modeled Hydrologic Soil Group

Soil Type	Description	Modeled HSG
Udorthents	Moderately to Mostly Well Drained	C
Undorthents (wet subsratum)	Very Poorly to Poorly Drained	D
Pits (gravel)*	Variable	A or B
Udifluvents	Somewhat Poorly Drained	D
Aquolls and histosols	Very Poorly Drained	D
B/D	HSG Drained/Undrained	D
C/D	HSG Drained/Undrained	D
A/D	HSG Drained/Undrained	D

* Dependent on surrounding soil types

Based on consultation with the SCS National Engineering Handbook (SCS, 1964), a pervious curve number was selected for each subwatershed based upon soil types, land use, and hydrologic conditions (e.g., if watershed soils are type B and pervious areas are comprised of grassed areas with 50% to 75% cover, then a Curve Number of 69 would be selected). An overall composite pervious curve number was determined by weighting the areas for the given soil groups within the subwatershed. This composite pervious curve number was then weighted with indirect (i.e., unconnected) impervious areas in each subwatershed as follows:

$$WCN = \frac{[(Indirect\ Impervious\ Area] * (98)] + [(Pervious\ Area) * (Pervious\ Curve\ Number)]}{Total\ Area}$$

The direct, indirect, and total impervious areas were based upon measurements from the CRWD impervious shapefile.

- Swept/Not Swept—An "Unswept" assumption was made for the entire impervious watershed area. A Sweeping Frequency of 0 was selected. Selected parameters were placed in the "Unswept" column since a sweeping frequency of 0 was selected.

- Impervious Fraction—The direct or connected impervious fraction for each subwatershed was determined and entered here. The direct or connected impervious fraction includes driveways and parking areas that are directly connected to the storm sewer system. CRWD completed a project to create an ArcView shapefile for the major impervious surfaces throughout the District, including roads, alleys, structures, tennis courts, and parking lots. The impervious surface GIS data layer from the District did not contain polygons for all the sidewalks and driveways within the District. To overcome the lack of information for sidewalks and driveways, Barr Engineering determined the areal extent of sidewalks and driveways for representative areas within each of the various land use categories. Connectivity estimation of the various impervious surface types was accomplished by associating each surface type with a land use category. (See Section 1.2 Impervious Surface Information for additional information)

- Depression Storage— 0.1 (See Section 2.0 Water Volume Calibration for further discussion)

- Impervious Runoff Coefficient— 0.9 (See Section 2.0 Water Volume Calibration for further discussion)

4.1.8 Passes Through the Storm File (Case—Edit—First—Passes Through Storm File)

- Passes Through Storm File— The number of passes through the storm file was determined after the model had been set up and a preliminary run completed. The selection of the number of passes through the storm file was based upon the number required to achieve model stability. Multiple passes through the storm file were required because the model assumes that dead storage waters contain no pollutants. Consequently, the first pass through the storm file results in lower pollutant loading than occurs with subsequent passes. Stability occurs when subsequent passes do not result in a change in pollutant concentration in the pond waters. To determine the number of passes to select, the model was run with three passes, five passes, and ten passes. A comparison of pollutant predictions for all devices was evaluated to determine whether changes occurred between the three scenarios. If there is no difference between three and five passes, three passes are sufficient to achieve model stability. If differences are noted between three and five passes and no differences are noted between five and ten passes, then five passes are sufficient to achieve model stability and so on. This parameter was determined for all six of the CRWD P8 model areas. No differences were noted between five and ten passes for CRWD1, CRWD3, CRWD4, CRWD5, and CRWD6. Therefore, it was determined that five (5) passes through the storm file resulted in model stability for the those models. Therefore, all the models associated with CRWD1, CRWD3, CRWD4, CRWD5, and CRWD6 are setup with 5 passes through the storm file. It was determined that model stability for CRWD2 (the Trout Brook major subwatershed) required twenty (20) passes through the storm file. Therefore, all the models associated with CRWD2 are setup with 20 passes through the storm file.

4.2 P8 Modeling of District Lakes

In the event that subwatershed areas possess a network of stormwater detention ponds downstream of lakes and other large water bodies, the following steps were taken to ensure that the downstream portions of the major subwatersheds were more accurately modeled:

- The lake and its tributary watershed were generalized and added to the P8 model for the overall watershed

- The generalized representation of the lake and its tributary watershed, in the P8 model, was setup (by adjusting scale factors) to match the average annual water and pollutant (TP) export concentration for the most recent year of record (1999).

These steps ensured an accurate representation of the flushing effect that takes place in stormwater detention ponds downstream of lakes. Because water quality data were only provided for Como Lake, McCarrons Lake, and Crosby Lake, they were the only lakes generalized in the P8 models. During the monitoring site calibration process the P0% particle fraction for TP was set so the minimum dissolved phosphorus concentration would be 160 μg/L. The lakes were entered into the P8 model as large detention basins. Adjustments to the "Particle Removal Scale Factor" had little impact on the outflow TP concentrations for the lakes, thus indicating that essentially all the phosphorus leaving the lakes is in the dissolved form with an annual flow weighted mean concentration of

160 μg/L. In some cases, this concentration is greater than 4 times the observed annual in-lake concentration. In order to reduce to TP concentration leaving the lakes the watershed "Scale Factor for Pervious Area Loads" and unswept "Scale Factor for Particle Loads" were reduced to a value less than 1. Table 11 summarizes the variables used to calibrate the generalized representation of the District Lakes.

Table 11. P8 Parameters for Generalized Lakes

Parameter	Como Lake	McCarrons Lake	Crosby Lake
P8 Model Containing the Generalized Lake Representation	CRWD2	CRWD2	CRWD4
P8 Watershed Number/Label	22 / COMOLK	16 / MCCARLK	15 / CRO4
Scale Factor for Pervious Area Loads	0.665	0.227	0.2
Unswept Scale Factor for Particle Loads	0.665	0.227	0.2
Observed 1999 Annual TP Concentration (μg/L)	112	37	32
Modeled Outflow 1999 Annual TP Concentration (μg/L)	112	37	32

4.3 P8 Modeling Summary

Modeling simulations of the entire District were performed for recent (1998-99 water year), wet (1982-83 water year), dry (1987-88 water year), and average (1994-95 water year) climatic conditions. The models developed for the various climatic conditions were named by the a combination of the P8 model identifier and the given water year (i.e., model simulation of average climatic conditions for the Trout Brook major subwatershed are contained in the "CRWD295.cas" P8 case file).

The annual and snowmelt inflow loadings and export for water, TSS, TP, Cu, and Zn are summarized in a database file ("All_crwd_models.dbf"). Also included in this database file are the subwatershed characteristics (subwatershed name, drainage area, impervious area, unconnected impervious area, pervious curve number, impervious fraction, relative area of major land use classes, and downstream subwatershed name) used in the various P8 models. All of this information has been entered into ArcView and is associated with the shapefile named "All_crwd_models.shp".

As previously mentioned, several subwatersheds had to be routed to a single device in the P8 model for Trout Brook. As a result, the individual watershed loadings were combined into a single watershed load. Runoff from subwatersheds TRT14 and TRT16 was combined and routed to device TRT14 in the P8 model. Therefore, the loadings associated with the runoff from subwatershed TRT16 were combined with those from TRT14 and listed in the database file for subwatershed TRT14. Similarly, TRT18, TRT19, TRT20, and TRT22 were routed to a single device (TRT20) in the P8 model. Therefore, the loadings listed for subwatershed TRT20 are a combination of the individual loadings from subwatersheds TRT18, TRT19, TRT20, and TRT22. Because runoff from several subwatersheds was routed to a single device, the individual loadings could not be determined. Therefore, the database files does not contain estimated loading results for subwatersheds TRT16, TRT18, TRT19, and TRT22 (i.e., the data field are blank for these subwatersheds).

5.0 Lake Modeling

The District provided summer average water quality data for Como Lake, McCarrons Lake, and Crosby Lake within the District. Water and pollutant export from District lakes, that could not be reliably modeled in P8, were estimated based on their annual modeled inflow loading and the predicted assimilation from a lake water quality mass balance model. The calibrated P8 computer model was used to estimate annual water and phosphorus inflow loadings to those lakes. Volumes and surface areas for the individual lakes were estimated based on the Minnesota Department of Natural Resources lake map for the respective lake.

5.1 In-Lake Modeling

The mass balance models for the above mentioned lakes were optimized to match, as closely as possible, the observed TP concentration data, based on the same climatic conditions. The Wisconsin DNR's WiLMS 3.0 (the Wisconsin Lake Modeling Suite is a screening level land use management/lake water quality evaluation tool) lake modeling tool was utilized for in-lake water quality calibration. This model can evaluate numerous mass balance models simultaneously, allowing the selection of the model with the closest fit to observed data. A copy of WiLMS 3.0 is provided on the enclosed CD. In addition, the lake water quality data files developed as part of this study are also included on the CD.

5.1.1 Como Lake

The District provided data for numerous years for Como Lake. Table 12 lists the lake and watershed input data as well as the predicted in-lake TP concentration for the various climatic conditions analyzed for this study. The in-lake mass balance model was calibrated to 1999 data. Based on the WiLMS modeling, the Vollenweider 1982 OECD model fit the data within 3 percent. Another model within this suite, Walker 1987 Reservoir, fit the observed data within 8 percent. Because several models could be selected based on 1999 conditions, the in-lake modeling result were verified using 1998 data and climatic conditions. Based on the 1998 WiLMS modeling results the Walker 1987 Reservoir model produced the closest fit. This model predicted the average summer TP concentration (107 μg/L) within 3 percent of the observed (104 μg/L). Since the Walker 1987 Reservoir model consistently produced results within 10 percent of the observed TP concentrations, it provides the best fit based on 1998 and 1999 climatic conditions. Therefore, this model was used to assess in-lake TP concentrations for other conditions.

Table 12. Como Lake Modeling Results

	Climatic Condition				
Parameter	**1998**	**1999**	**Wet**	**Dry**	**Average**
Tributary Area (ac)	1783.2	1783.2	1783.2	1783.2	1783.2
Lake Surface Area (ac)	66.7	66.7	66.7	66.7	66.7
Lake Volume (ac-ft)	477.6	477.6	477.6	477.6	477.6
Total Unit Runoff (in)	6.52	5.8	10.69	4.22	5.36
Precipitation – Evaporation (in)	2.0	-0.8	5.9	-24.9	-4.8
Watershed TP Yield (kg/ha/yr)	0.561	0.47	0.91	0.341	0.398
Atmospheric Deposition (kg/ha/yr)	0.56	0.56	0.56	0.56	0.56
Observed In-Lake TP (□g/L)	104	112	N/A	N/A	N/A
Predicted In-Lake TP (□g/L)	107	103	112	115	100

Since individual sampling event TP data were not provided, estimates and impacts due to internal loadings (from anoxic sediment release, curlyleaf pondweed die-back, or other sources of TP) could not be determined or considered separately in the in-lake modeling for Como Lake.

5.1.2 McCarrons Lake

The District provided data for numerous years for McCarrons Lake. Table 13 lists the lake and watershed input data as well as the predicted in-lake TP concentration for the various climatic conditions analyzed for this study. The in-lake mass balance model was calibrated to 1999 data. Based on the WiLMS modeling, the Reckhow 1979 General model provides the best fit to observed data. This model predicted the average summer TP concentration (34 μg/L) within 8 percent of the observed (37 μg/L). The 1999 in-lake modeling results were verified using 1998 data and climatic conditions. Based on the 1998 WiLMS modeling results the Reckhow 1979 General model produced the closest fit (within 10 μg/L). Since the Reckhow 1979 General model consistently produced the best fit for TP concentrations for recent climatic conditions, this model was used to assess in-lake TP concentrations for other conditions. Similar to Como Lake, the impacts due to any internal TP loading could not be determined or considered separately in the in-lake modeling because individually sampled TP data were not supplied.

Table 13. McCarrons Lake Modeling Results

	Climatic Condition				
Parameter	**1998**	**1999**	**Wet**	**Dry**	**Average**
Tributary Area (ac)	1048.9	1048.9	1048.9	1048.9	1048.9
Lake Surface Area (ac)	75.7	75.7	75.7	75.7	75.7
Lake Volume (ac-ft)	1661.6	1661.6	1661.6	1661.6	1661.6

	Climatic Condition				
Parameter	1998	1999	Wet	Dry	Average
Total Unit Runoff (in)	4.89	4.28	8.21	3.19	3.94
Precipitation – Evaporation (in)	2.0	-0.8	5.9	-24.9	-4.8
Watershed TP Yield (kg/ha/yr)	0.35	0.29	0.57	0.21	0.25
Atmospheric Deposition (kg/ha/yr)	0.56	0.56	0.56	0.56	0.56
Observed In-Lake TP (□g/L)	29	37	N/A	N/A	N/A
Predicted In-Lake TP (□g/L)	39	34	55	28	30

5.1.3 Crosby Lake

The District only provided water quality data for 1999. Therefore, the in-lake mass balance model was calibrated to 1999 data and not verified based on water quality data from other growing seasons. Based on the WiLMS modeling, the Reckhow 1979 General model provides the best fit to observed data. This model predicted the 1999 average summer TP concentration (31 μg/L) within 3 percent or 1 μg/L of the observed (32 μg/L). Since only one year of water quality data were provided, this model was used to assess in-lake TP concentrations for other climatic conditions. Table 14 lists the lake and watershed input data as well as the predicted in-lake TP concentration for the various climatic conditions analyzed for this study.

Table 14. Crosby Lake Modeling Results

	Climatic Condition			
Parameter	1999	Wet	Dry	Average
Tributary Area (ac)	160.2	160.2	160.2	160.2
Lake Surface Area (ac)	46.5	46.5	46.5	46.5
Lake Volume (ac-ft)	111.2	111.2	111.2	111.2
Total Unit Runoff (in)	8.33	14.81	5.83	7.65
Precipitation – Evaporation (in)	-0.8	5.9	-24.9	-4.8
Watershed TP Yield (kg/ha/yr)	0.96	1.74	0.65	0.82
Atmospheric Deposition (kg/ha/yr)	0.56	0.56	0.56	0.56
Observed In-Lake TP (μg/L)	32	N/A	N/A	N/A
Predicted In-Lake TP (μg/L)	31	49	24	28

5.1.4 Loeb and Sandy Lakes

No water quality data were available for these lakes during this study. Therefore, no in-lake water quality model was developed for either Loeb Lake or Sandy Lake. Loeb Lake likely has minimal impact on downstream water bodies because it is landlocked, according to St. Paul storm sewer information.

6.0 References

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DRAFT Ramsey-Washington Metro Watershed District Total Maximum Daily Load (TMDL) Study

Quantification of the pollutant reductions necessary
to restore aquatic recreation in Bennett Lake, Wakefield Lake and Fish Creek;
and to restore aquatic life in Battle Creek

Minnesota Pollution Control Agency

April 2016

wq-iw8-54b

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Cover Photo of Bennett Lake Courtesy of Ramsey-Washington Metro Watershed District (Barr Engineering Co.)

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Acronyms

ac-ft	acre feet
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CADDIS	Casual Analysis/Diagnosis Decision Information System
cfu	colony-forming unit
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
E. coli	*Escherichia coli* bacteria
EPA	Environmental Protection Agency
GS	Growing season
GW	Groundwater
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
LA	Load Allocation
lb	pound
m	meter
MDA	Minnesota Department of Agriculture
mg/L	milligrams per liter
mL	milliliter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MSHA	MPCA Stream Habitat Assessment
NCHF	North Central Hardwood Forest Ecoregion
NLCD	National Land Use Dataset
NPDES	National Pollutant Discharge Elimination System
P8	Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds
RWMWD	Ramsey Washington Metro Watershed District
SID	Stressor Identification Report
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment System or Systems
SWPPP	Stormwater Pollution Prevention Plan
TCMA	Twin Cities Metropolitan Area
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total Suspended Solids
µg/L	microgram per liter
WLA	Wasteload Allocation
WMP	Watershed Management Plan
WOMP	Watershed Outlet Monitoring Program
WRAPS	Watershed Restoration and Protection Strategy

Executive Summary

This Total Maximum Daily Load (TMDL) study addresses aquatic life and aquatic recreation impairments in Battle Creek and Fish Creek, and nutrient impairments in Bennett Lake and Wakefield Lake. The goal of this TMDL report is to quantify the pollutant reductions needed to meet the Minnesota Pollution Control Agency's (MPCA's) water quality standards for all four RWMWD water bodies. This TMDL was established in accordance with Section 303(d) of the Clean Water Act and provides the wasteload allocations (WLAs) and load allocations (LAs) for the impaired water resources.

This report outlines the development of the TMDLs for Battle Creek, Bennett Lake, Fish Creek, and Wakefield Lake and describes best management practices (BMPs) that can be implemented to work towards achieving the required pollutant reductions to these resources.

A Biological Stressor Identification (SID) Report was completed in spring 2015 for Battle Creek using the United States Environmental Protection Agency's (EPA's) 2010 Casual Analysis/Diagnosis Decision Information System (CADDIS) (Barr 2015). The SID report found that chloride and total suspended solids (TSS) are the primary stressors to the fish and macroinvertebrate assemblages within Battle Creek. To evaluate sources of TSS to Battle Creek, sediment transport modeling was compared to annual TSS loading predicted from observed water quality data. This analysis indicates that elevated TSS concentrations in Battle Creek are caused by high sediment loading mobilized by watershed runoff and erosion within the immediate stream channel and stream corridor.

The TSS load reductions of 66% to 91% are required to meet water quality standards, depending on the flow conditions. Primary implementation strategies include increasing flow detention and treatment within the watershed and restoration of sections of the stream corridor.

Fish Creek was placed on the 303(d) list for *E. coli* impairment in 2014. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a human health risk. A population source inventory and assumed bacteria availability was used to estimate the sources of bacteria loading to Fish Creek. The analysis indicated that runoff from urban areas mobilizing bacteria from improperly managed pet waste is the main source of *E. coli* loading during wet-weather conditions, and failing subsurface septic treatment systems (SSTSs) and sanitary sewer exfiltration are the main sources of loading during dry-weather conditions.

Overall *E. coli* load reductions between 0% and 62% are required in order to meet water quality standards, depending on the flow conditions. The primary implementation strategies include education and outreach related to pet waste management, and an inventory of and improvements to non-compliant SSTSs and sanitary sewer infrastructure within the watershed.

Bennett and Wakefield Lakes are impaired for aquatic recreation due to excess nutrients. The major source of phosphorus loading to Wakefield Lake is phosphorus mobilized by watershed runoff. Secondary sources of phosphorus loading include release from lake sediment, release from die back of aquatic plants, and direct atmospheric deposition.

To achieve the TMDL and state water quality standards, a 71% reduction of the growing season phosphorus load is required for Bennett Lake and a 46% for Wakefield Lake. The primary implementation strategies to address internal load for Bennet Lake include carp and Curlyleaf pondweed management to reduce internal phosphorus loading. Whole-lake alum treatment and herbicide treatment to control Curlyleaf pondweed are the primary recommendations to reduce internal phosphorus loading in Wakefield Lake. A variety of water quality BMPs can be implemented to achieve the required watershed runoff phosphorus loading reduction in both watersheds.

1. Project Overview

1.1 Purpose

Section 303(d) of the Clean Water Act requires that every two years all states publish a list of streams and lakes that do not meet water quality standards. Waters placed on the list are considered impaired. States are required to set TMDLs for impaired waters in order to define the maximum amount of pollutant a waterbody can receive while maintaining water quality standards and to determine the load reductions necessary to achieve water quality standards. A TMDL is divided into a WLA for point sources (permitted sources), a LA for nonpoint sources (non-permitted sources) and natural background, a reserve capacity for future loadings (if necessary) and a margin of safety (MOS).

The Ramsey-Washington Metro Watershed District (RWMWD) is located in eastern Ramsey County and western Washington County in the state of Minnesota. The RWMWD historically covered an area of about 56.5 square miles. However in 2012, the RWMWD boundary expanded with the acquisition of the area formerly encompassed by the Grass Lake Watershed Management Organization, an additional nine square miles. The RWMWD encompasses portions of a number of communities including White Bear Lake, Vadnais Heights, Gem Lake, Little Canada, Maplewood, Landfall, North St. Paul, St. Paul, Oakdale, Woodbury, Roseville, and Shoreview.

One of the primary goals of the Ramsey-Washington Metro Watershed District is to maintain or improve the quality of surface waters to meet or exceed the water quality necessary to support the District's designated beneficial uses. The District has established beneficial use categories based on desired recreational activities for a waterbody in the Ramsey-Washington Metro Watershed Management Plan (WMP) (Barr 2007).

1.2 Identification of Waterbodies

Table 1-1 summarizes the year the water resource was listed as impaired, the targeted start date, and the completion dates for the TMDLs.

Battle Creek was listed on the 303(d) list for chloride impairment and biological impairment in 2008 and 2014, respectively. Impairment of aquatic life has been identified due to elevated chloride loading and poor fish and macroinvertebrate assemblages. The chloride impairment in Battle Creek has been addressed in the Twin Cities Metropolitan Area (TCMA) Chloride TMDL developed by the Minnesota Pollution Control Agency (MPCA), and will not be addressed in this TMDL study. A Biological Stressor Identification (SID) Report was completed in spring 2015 to identify primary sources of stress to fish and macroinvertebrate within Battle Creek (Barr 2015). The report found that chloride and TSS are the primary stressors to the fish and macroinvertebrate assemblages within Battle Creek, therefor requiring TMDLs to address the biological impairments. Additionally, analysis of water quality data conducted for the report found that the stream is impaired for TSS, based on the Class 2B stream standard for the Central River Nutrient Region (Section 2.2). Chloride impairment will not be included in this TMDL study, as a chloride TMDL for Battle Creek has been developed as part of the TCMA Chloride TMDL (MPCA 2016).

Fish Creek was placed on the MPCA's 303(d) list of impaired waters in 2014. The affected designated use was identified as aquatic recreation due to bacteria (*E. coli)*. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a health risk to humans.

Bennett Lake and Wakefield Lake were listed on the MPCA 303(d) list of impaired waters in 2006 and 2002, respectively for not meeting the MPCA's shallow lake eutrophication standards for the North Central Hardwood Forests (NCHF) ecoregion. The affected designated use for both lakes was identified as aquatic recreation due to excess nutrients. In freshwater lakes, phosphorus is often the limiting nutrient and there is typically a direct relationship between the amount of phosphorus and the amount of algae in the lake. Excess phosphorus in lakes can result in nuisance algal blooms that impact water clarity, recreational uses of the lake, and overall aesthetics. In addition to excess nutrients, Bennett Lake was listed for mercury impairment in 2012. Bennett Lake is included in the approved MPCA Statewide Mercury TMDL (EPA ID# 52290) and, for this reason; mercury impairment will not be addressed in this TMDL study.

Table 1-1 Impairments addressed in the TMDL Report

Water Body	Pollutant or Stressor	Impaired Use	Year Listed as Impaired	Target Start Date	Target Completion Date
Battle Creek (07010206-592)	Chloride	Aquatic Life	2008	2009	2015
	Fishes Bioassessments	Aquatic Life	2014	2011	2015
	Aquatic Macroinvertebrate Bioassessments	Aquatic Life	2014	2011	2015
Fish Creek (07010206-606)	*E. coli*	Aquatic Recreation	2014	2011	2015
Bennett Lake (62-0048-00)	Nutrient/Eutrophication Biological Indicators	Aquatic Recreation	2006	2012	2015
	Mercury in fish tissue	Aquatic Consumption	2012	N/A[1]	N/A[1]
Wakefield Lake (62-0011-00)	Nutrient/Eutrophication Biological Indicators	Aquatic Recreation	2002	2011	2015

[1] Mercury impairment in Bennett Lake addressed in approved MPCA Statewide Mercury TMDL.

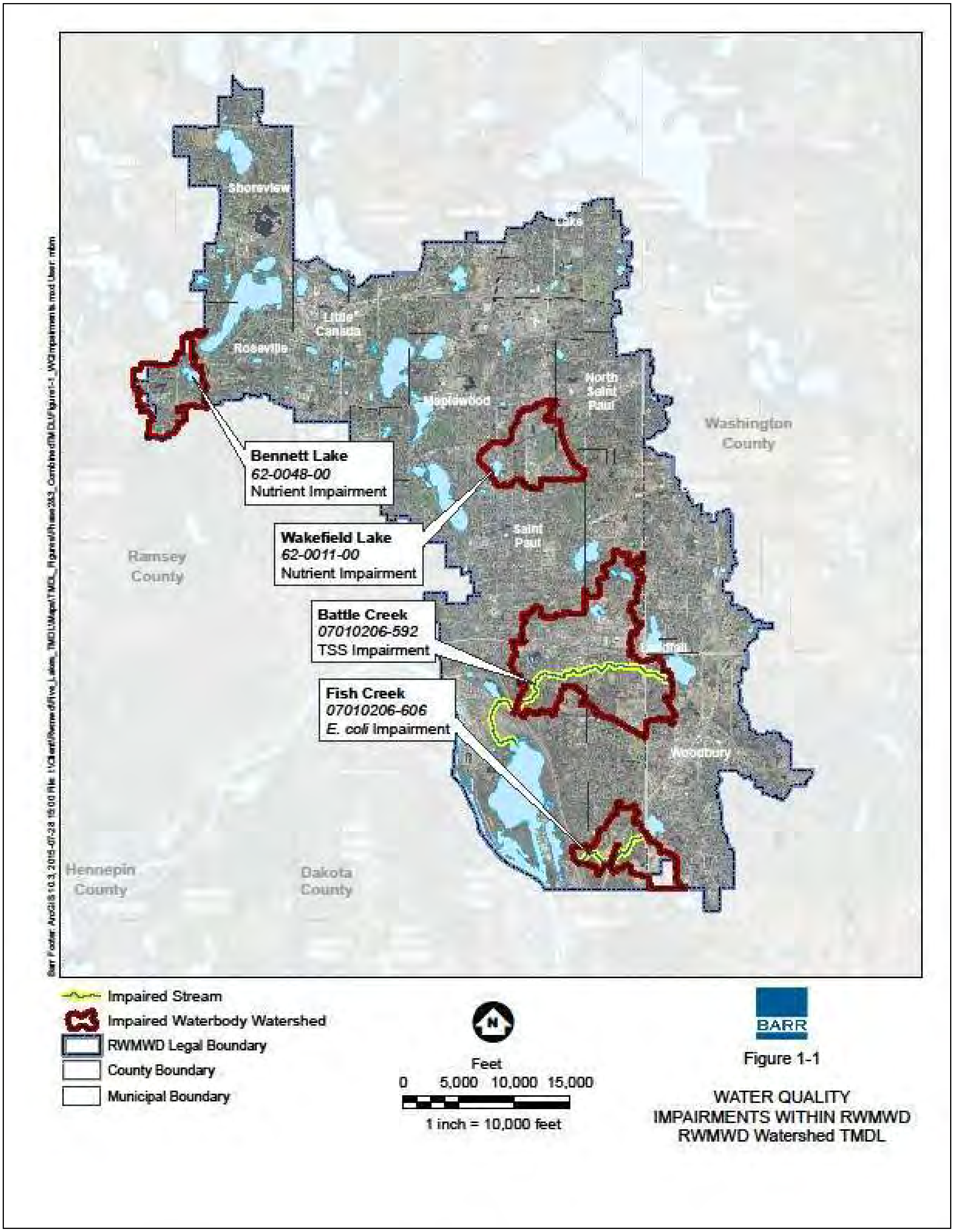

Figure 1-1 Water Quality Impairments within RWMWD

2. Applicable Water Quality Standards and Numeric Water Quality Targets

The following sections discuss the applicable water quality standards that apply to the TMDLs being completed as part of this study.

2.1 Biological Impairment

The narrative standard for biological impairment in Class 2 waters (aquatic life and recreation) is defined in Minn. R. 7050.0150:

> *For all Class 2 waters, the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters.*

Biological impairment is evaluated using an Index of Biological Integrity (IBI), which aggregates and scores diversity and abundance within an aquatic population based on grouped attributes of the community, often referred to as biological metrics. These biological metrics are groupings of similar species, based on structural (e.g., species composition) or functional (e.g., feeding habits) characteristics which respond to human disturbance in predictable ways. Fish and macroinvertebrate scores vary from 0-100, with 100 representing the highest quality of species abundance and diversity.

The MPCA has evaluated aquatic populations at minimally-impacted references sites across the state and has developed impairment thresholds for various stream classifications. Stream classifications are defined by stream drainage area, morphology, ecoregion, and major basin. A stream within a given classification is considered impaired if its fish and/or macroinvertebrate IBI score falls below the established threshold IBI value. The IBI threshold values and stream classifications applicable to Battle Creek are shown in Table 2-1.

Table 2-1 IBI threshold values applicable to Battle Creek

Community	Class	Classification	Threshold IBI Value
Fish	2	Southern Headwaters	54
Fish	3	Southern Streams	58
Macroinvertebrate	5	Southern Streams (Riffle/Run)	36
Macroinvertebrate	6	Southern Streams (Glide/Pool)	47

2.2 Total Suspended Solids (TSS)

The total suspended solid (TSS) standards for rivers and streams were adopted at a June 24, 2014, MPCA Citizen Board meeting. Adopted TSS standards supersede and replace all standards related to turbidity (i.e., the measure of the cloudiness or haziness of water caused by suspended and dissolved substances in the water column) formerly listed in Minn. R. 7050.0222.

Battle Creek is classified as Class 2B water (cool/warm water) and is located in the Central River Nutrient Region. The TSS standard applicable to Battle Creek as defined by Minn. R. 7050.0222 is outlined below:

- TSS Standard (Class 2B, Central River Nutrient Region) = 30 mg/L
- TSS standards for the Class 2B North, Central, and South River Nutrient Regions and the Red River mainstem may be exceeded for no more than 10% of the time. This standard applies April 1 through September 30.

2.3 Bacteria (*E. coli*)

Fish Creek is classified as Class 2C water (indigenous fish and associated aquatic life and habitat). Narrative and numeric standards for *E. coli* applicable to Class 2C streams are outlined below.

The narrative standard for Class 2B waters (also applicable to Class 2C waters) is defined in Minn. R. 7050.0222:

> *The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life, and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.*

The numeric standard for Class 2C waters is in terms of *E. coli*:

> *Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.*

2.4 Excess Nutrients

According to Minn. R. ch. 7050.0150 and Minn. R. ch. 7050.0222, subp. 4, Bennett Lake and Wakefield Lake are located in the NCHF ecoregion and both are considered shallow lakes.

The MPCA's shallow lake eutrophication standards for the NCHF ecoregion are shown in Table 2-2. To be listed as impaired by the MPCA, the monitoring data must show that the standards for both total phosphorus (TP) (the causal factor) and either Chlorophyll *a* (Chl-*a*) or Secchi disc transparency depth (the response factors) are not met (MPCA 2014a).

To demonstrate compliance with the MPCA lake eutrophication standards, in addition to meeting phosphorus limits, Chl-*a* and Secchi disc transparency standards must also be met. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor TP and the response variables Chl-*a* and Secchi disc transparency. Based on these relationships it is expected that by meeting the phosphorus target in each lake, the Chl-*a* and Secchi disc transparency standards will likewise be met.

Table 2-2 Numeric water quality standards for shallow lakes in the North Central Hardwood Forest Ecoregion

Parameters	Shallow[1] Lake Standard
Total Phosphorus µg/L	≤ 60
Chlorophyll *a* (µg/L)	≤ 14
Secchi Disc (meters)	≥ 1.0

[1] Shallow lakes are defined as lakes with a maximum depth of 15 feet or less, or with 80% or more of the lake being classified as littoral (shallow enough to support emergent and submerged aquatic plants).

2.4.1 Analysis of Impairment

The criteria used for determining impairments are outlined in the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List (MPCA 2014a).

3. Watershed and Waterbody Characterization

The RWMWD is a special purpose unit of local government that manages water resources on a watershed basis. Watershed district boundaries generally follow natural watershed divides, rather than political boundaries. The general purposes of a watershed district are to conserve natural resources through land use planning, flood control, and other conservation projects to protect the public health and welfare and for the wise use of the natural resources. The boundaries of the RWMWD are shown on Figure 1-1.

The communities that lie or partially lie within the RWMWD include the city of Gem Lake, city of Landfall, city of Little Canada, city of Maplewood, city of North St. Paul, city of Oakdale, city of Roseville, city of Shoreview, city of St. Paul, city of Vadnais Heights, city of White Bear Lake and the city of Woodbury. The RWMWD lies within the Upper Mississippi River Basin and all eventually drains to the Mississippi River.

The mission statement, as outlined on the RWMWD website (www.rwmwd.org), is as follows:

> *The mission of the RWMWD is to protect and improve the water resource and water related environment in the District. The RWMWD seeks to accomplish its mission through analysis of the causes of harmful impacts on the water resources, public information and education, regulation of land and water resource disturbing activities, and capital improvement projects.*

3.1 Streams

Battle Creek and Fish Creek (Figure 1-1, Figure 3-1 and Figure 3-2) are perennial streams located in the southern-portion of the RWMWD. Battle Creek drains from Battle Creek Lake 5.2 miles through the cities of Woodbury, Maplewood, and St. Paul before discharging the Pigs Eye Lake and ultimately the Mississippi River. The direct drainage area to Battle Creek is about 4.5 square miles, and land use within the watershed is primarily low-density residential and developed parkland. Fish Creek is a 1.8 mile reach, draining from Carver Lake through the same three municipalities listed above before discharging to Eagle Lake and ultimately the Mississippi River. The direct drainage area to Fish Creek is 783 acres. Land use within the watershed includes park and open space owned by Ramsey County or the city of Maplewood as well as single-family residential land use, some highway, and commercial areas.

The RWMWD has completed large restoration projects on both streams. In response to urbanization, both stream reaches were becoming highly incised and unstable. The Battle Creek Restoration Project was completed from 1981-1982 and involved the installation of many gradient control structures (step weirs, sheet pile check dams, etc.) as well as a high-flow diversion system. A similar project was completed on Fish Creek in 1988-1989, also involving installation of gradient control structures and a high-flow diversion system. The restoration projects significantly reduced degradation of both stream channels.

3.2 Lakes

Bennett Lake is a shallow lake located in the city of Roseville's Central Park, roughly 0.4 miles southwest of Lake Owasso. Circled by softball fields, picnic areas, and an adjacent lakeshore pavilion, Bennett Lake is an important recreational and aesthetic amenity the city of Roseville's park system. The drainage area to the shallow lake is over 750 acres and is considered fully developed and is completely contained with this municipal boundary of the city of Roseville. The dominant land use within the watershed is low-density residential, followed by institutional and developed parkland. The lake has an open surface area of 28 acres and a maximum depth of 9 feet. Wakefield Lake is a shallow lake located in the city of Maplewood within the greater Lake Phalen drainage area. The Lake is surrounded by city of Maplewood developed parkland, and is used primarily for shoreline and pier fishing, picnicking, wildlife habitat, and aesthetic viewing. The majority of the 945-acre drainage area to Wakefield Lake is contained within the city of Maplewood, with small portions of the watershed crossing the municipal boundaries of the cities of North St. Paul and St. Paul. The dominant land use in the watershed is low-density residential, followed by developed parkland, institutional, and commercial. Lake morphometry of Bennett Lake and Wakefield Lake is described in Table 3-1.

Table 3-1 Lake morphometry of Bennett Lake and Wakefield Lake

Parameter	Bennett Lake	Wakefield Lake
Surface Area (acres)	28	22
Drainage Area (acres)	772	945
Average Depth (ft)	5.6	4.6
Maximum Depth (ft)	9	9
Lake Volume (acre-ft)	158	101
Littoral Area (%)	100	100
Depth Class	Shallow	Shallow

3.3 Subwatersheds

Drainage areas to the four waterbodies included in this TMDL study span 8.4-square miles (5400 acres) across the RWMWD, covering nearly 13% of the total area within the legal boundary of the RWMWD. Figures depicting subwatershed divides generated for impaired waterbodies included in this TMDL study are shown in Figure 3-1 through Figure 3-4, below.

3.4 Land Use

Land use throughout the TMDL study areas was analyzed using Metropolitan Council 2010 land use classifications (Metropolitan Council 2011). Typical land use varies widely across the four study areas. The Bennett Lake and Wakefield Lake drainage area are nearly fully developed, whereas the Battle Creek and Fish Creek drainage areas, located in the less-developed southern portion of the District, contain significant portions of agricultural and undeveloped land area. The single-family detached classification is the dominant land use type across all four study areas, composing 35% in Battle Creek, 24% in Fish Creek, 50% in Bennett Lake and 44% in Wakefield Lake, of the drainage areas. Metropolitan Council Land use classifications area summarized for each study area below in Table 3-2.

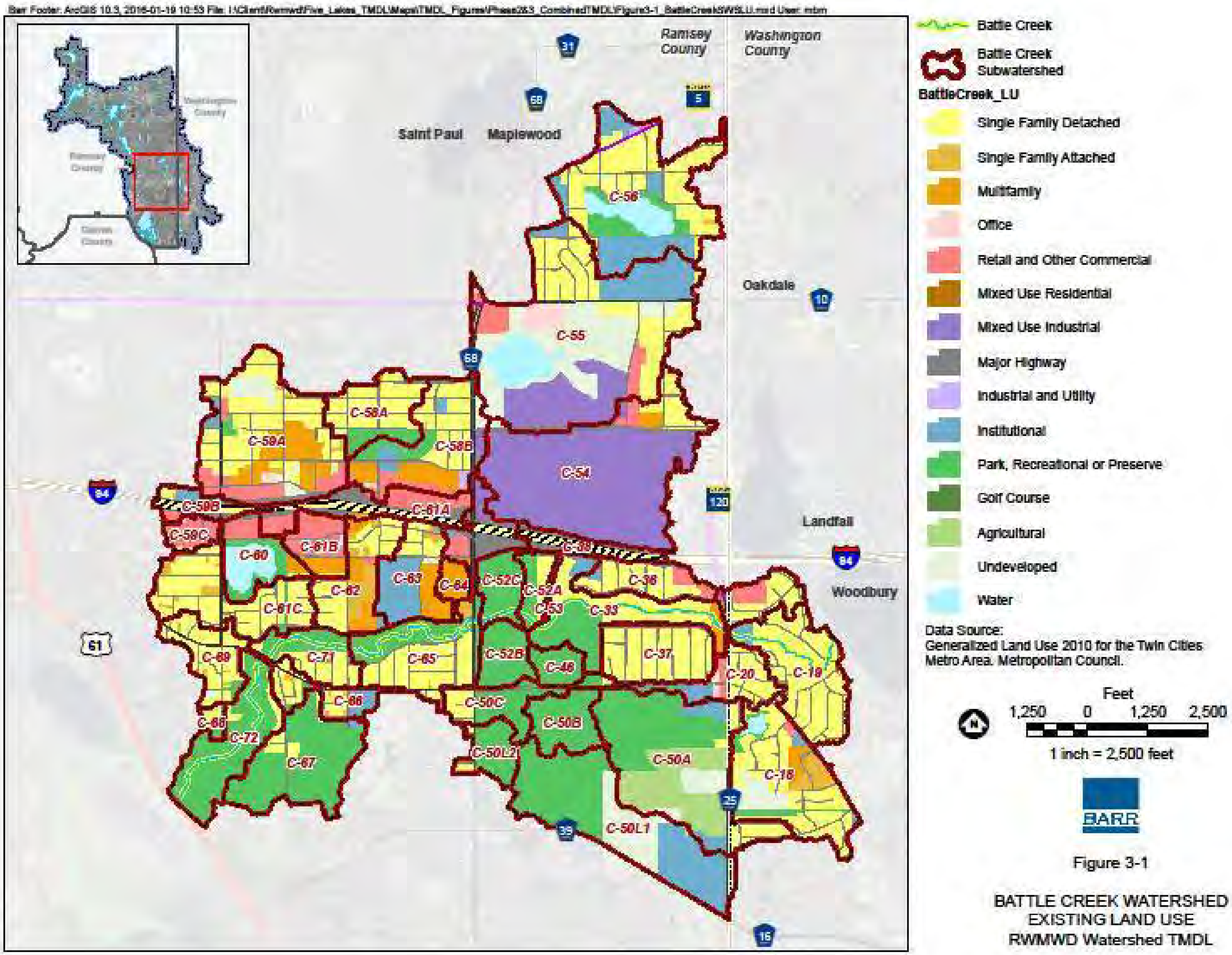

Figure 3-1 Battle Creek Watershed existing land use

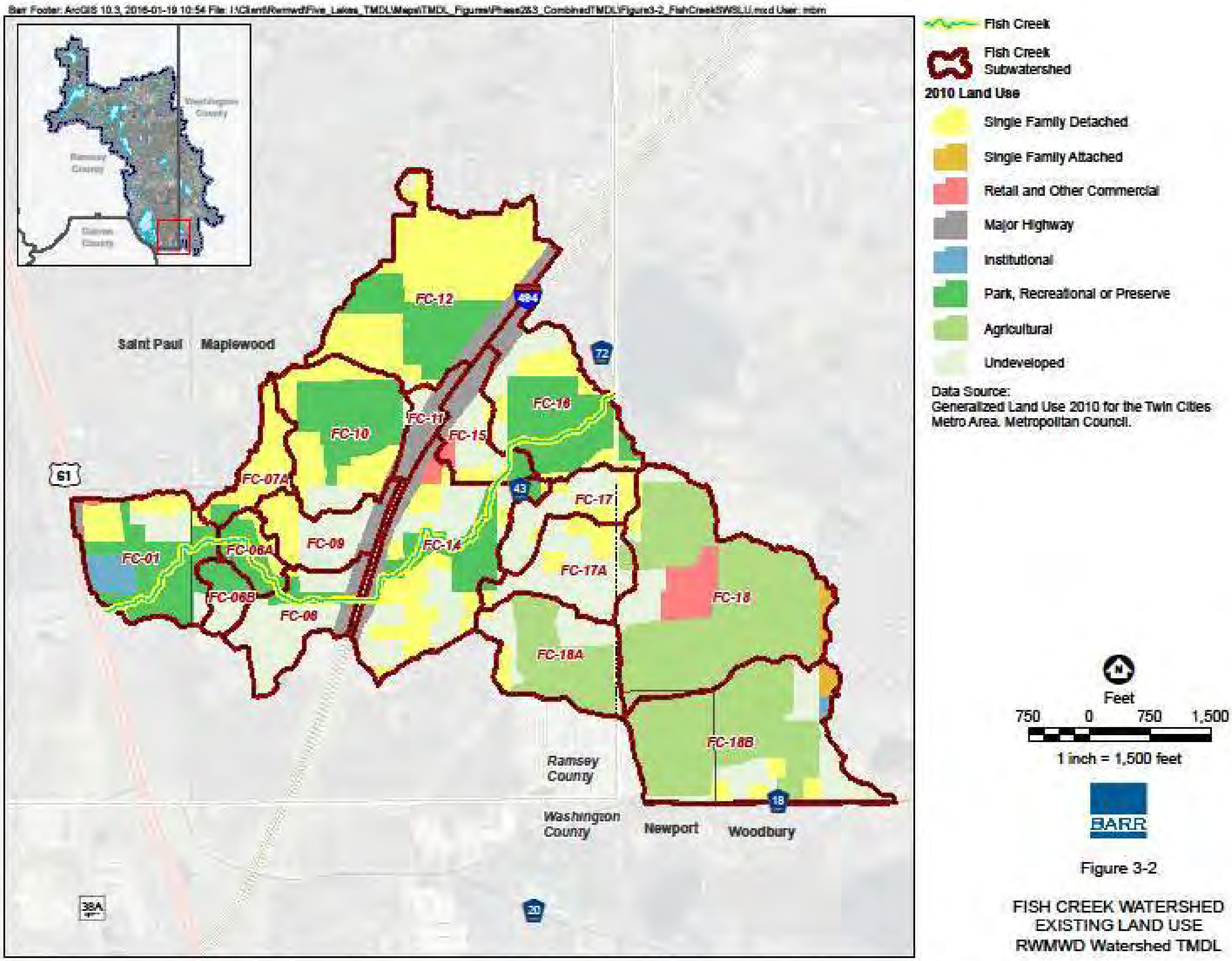

Figure 3-2 Fish Creek Watershed existing land use

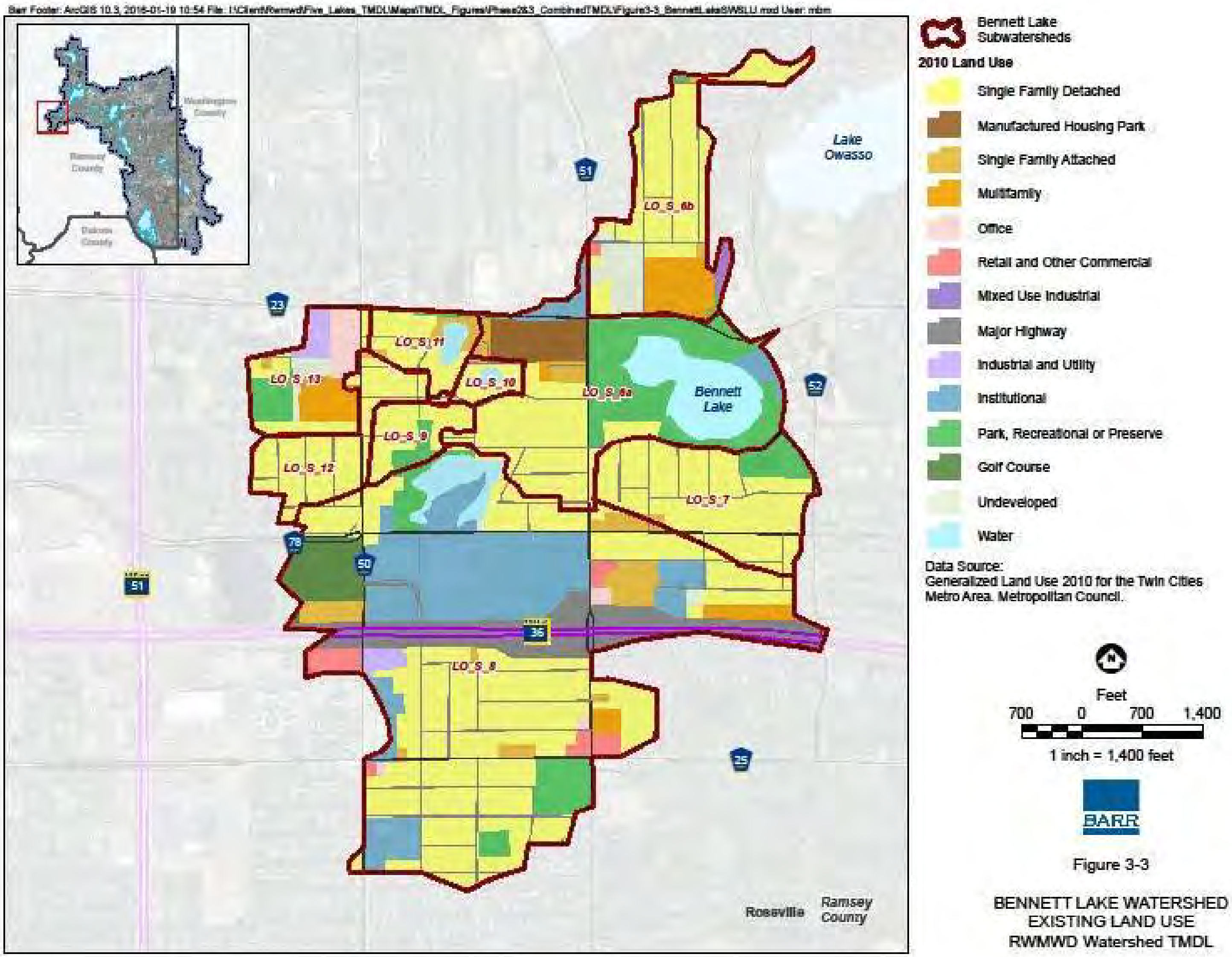

Figure 3-3 Bennett Lake Watershed existing land use

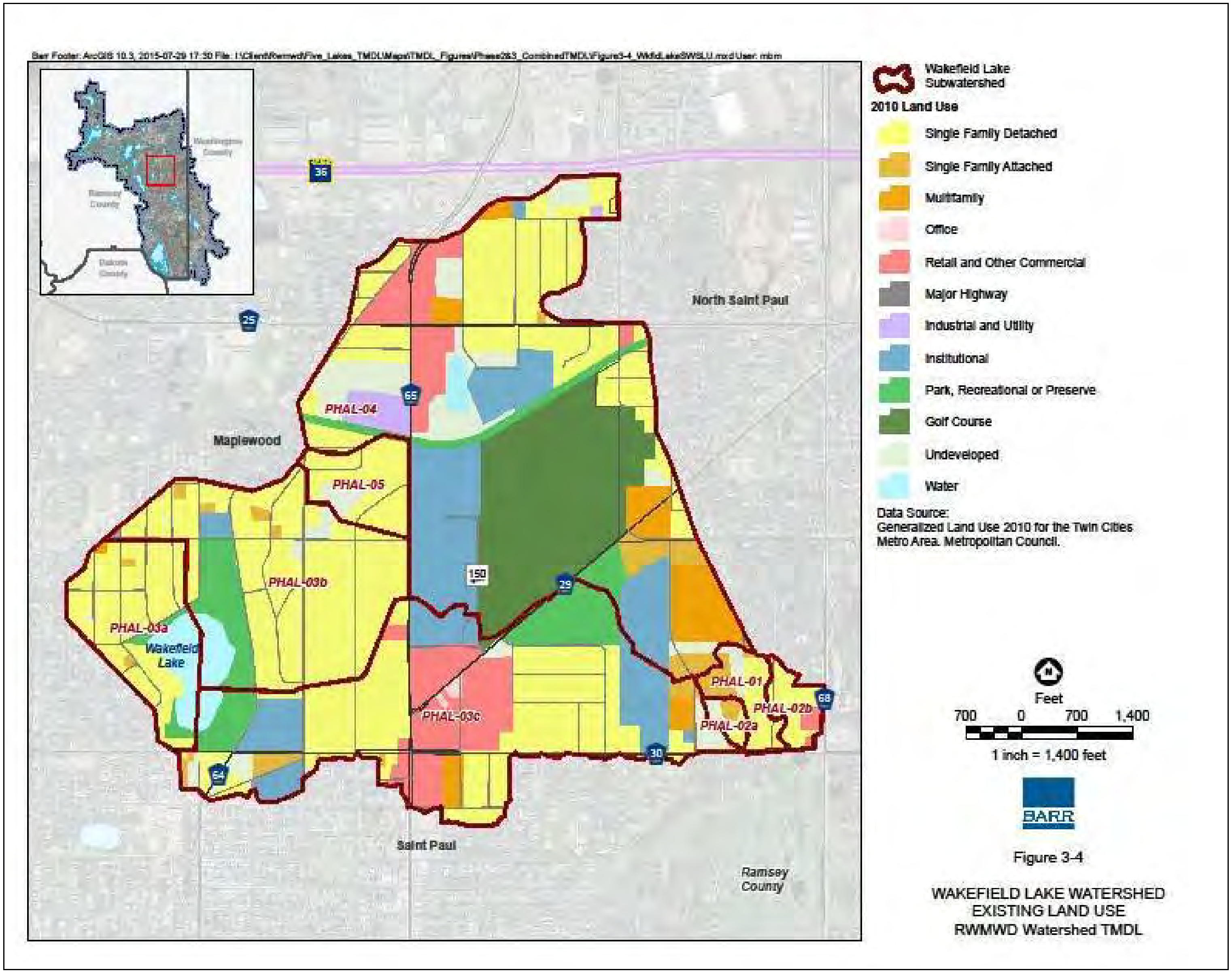

Figure 3-4 Wakefield Lake Watershed existing land use

Table 3-2 Met Council 2010 Land Use Classification of the RWMWD TMDL study areas

2010 Generalized Land Use	Land Use Area (acres) Battle Creek	Fish Creek	Bennett Lake	Wakefield Lake	Total (ac)	Percent of Study Area (%)
Agricultural	62.5	183.4	--	--	245.8	5%
Golf Course	0.2	--	15.1	105.5	120.7	2%
Institutional	208.5	7.2	93.7	114.2	423.6	8%
Major Highway	112.1	46.5	47.3	0.6	206.5	4%
Manufactured Housing Parks	--	--	12.6	--	12.6	0%
Park, Recreational, or Preserve	661.2	153.7	76.5	65.5	956.8	18%
Retail and Other Commercial	168.0	15.2	20.2	80.2	283.6	5%
Mixed Use Industrial and Utility	277.7	--	9.3	9.1		
Mixed Use Residential and Multifam	122.4	--	28.0	37.3		
Single Family	1053.2	191.0	414.5	447.7	2106.3	39%
Undeveloped	170.6	186.3	15.4	58.8	431.1	8%
Water	66.8	--	39.6	25.7	132.2	2%
Total (ac)	2903	783	772	945	5403	100%

[1] Green bars indicate the relative percent of total land area within each generalized land use group.

3.5 Water Quality

3.5.1 Biological Integrity

Assessment of the aquatic community was done through the use of an IBI. An IBI integrates multiples features of the aquatic community to evaluate the overall health of the biological community. This approach functions on the theory that biological assemblages are a direct reflection of pollutants, habitat alteration, and hydrologic modification over time. For further information regarding the development of stream IBIs, refer to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List (MPCA 2014a).

Fish and macroinvertebrate IBI scores developed from all biological surveys performed on Battle Creek are summarized in Table 3-3. As can be seen, every observed IBI score falls below the defined threshold IBI scores, indicating that the fish and macroinvertebrate assemblages within Battle Creek are impaired. Analysis shows no longitudinal or temporal trends in observed IBI scores. Biological monitoring stations are shown in Figure 3-5.

Table 3-3 Battle Creek IBI scores by biological survey station

Fish IBI summary				Macroinvertebrate IBI summary			
Date	**Station ID**	**Threshold IBI[1]**	**Observed IBI**	**Date**	**Station ID**	**Threshold IBI[1]**	**Observed IBI**
8/18/1998	97UM008	51	16	97UM008	8/23/2010	36	28
9/23/1997	97UM008	51	21	04UM011	9/2/2004	47	9
6/17/2010	97UM008	51	33	99UM075	8/13/2012	36	25
7/13/2010	97UM008	51	28	00UM071	9/11/2000	47	34
7/23/2012	97UM008	51	6				
6/14/1999	99UM076	51	42				
6/14/1999	99UM075	51	23				
7/31/2012	99UM075	51	39				
8/21/2000	00UM071	45	30				

[1] Threshold IBI scores correspond to stream classification at each station.

The Battle Creek Stressor Identification Report (Barr 2015) was completed in in the spring of 2015 to identify the primary cause(s) of biological impairments to the fish and macroinvertebrate populations in Battle Creek. The SID process is a critical part of TMDL development as it identifies factors, which are primarily responsible for the biological impairment observed within the stream. The SID report prepared as part of this TMDL study was completed using the EPA's Causal Analysis/ Diagnoses Decision Information System (CADDIS) (EPA 2010a). CADDIS, a methodology for conducting a stepwise analysis of candidate causes of impairment, characterizes the potential relationships between candidate causes and stressors, and identifies the probable stressors based on the strength of evidence from available data.

Potential candidate causes of the biological impairments that were either ruled out or inconclusive based on review of available data include: temperature, nickel, chromium, nitrate, pH, and altered hydrology. Potential candidate causes were eliminated when water quality was found to be within Minnesota water quality standards or there was found to be a lack of biological response. Candidate causes were deemed inconclusive when water quality data or collected biological monitoring data was insufficient to relate the candidate cause to biological impairment.

Excess sediment (TSS), chloride, low dissolved oxygen (DO), TP, altered habitat, habitat fragmentation, and four heavy metal (Zinc, Cadmium, Copper, and lead) were all found to impact stream biology to varying extents, and were therefore identified as candidate causes of biological stress. A summary of evidence for each of the identified candidate causes is provided in the following subsections. As a result of the SID process, TSS and chloride were found to be the primary stressors to the fish and macroinvertebrate communities. A summary for each candidate stressor is provided below; more detailed information can be found in the Battle Creek Stressor Identification Report.

3.5.1.1 Excess Sediment (TSS)

Excess TSS was identified as a primary stressor to both the fish and macroinvertebrate assemblages in Battle Creek. Water quality measurements indicate that TSS and turbidity routinely exceed the MPCA standards (see Section 4.1.2). Excess TSS loading can adversely affect biota by four main pathways: (1) impairment of filter feeding, by filter clogging or reduction of food quality; (2) reduction of light penetration and visibility in the stream, which may alter interactions between visually-cued predators and prey, as well as reduce photosynthesis and growth by submerged aquatic plants, phytoplankton, and periphyton; (3) physical abrasion by sediments, which may scour food sources (e.g., algae) or directly abrade exposed surfaces (e.g., gills) of fishes and invertebrates; and (4) increased heat absorption, leading to increased water temperatures (Cormier 2007).

Biological metric and Tolerance Indicator Value analysis both shows a clear response to TSS stress, with both fish and macroinvertebrate communities being dominated by species and taxa highly tolerant to stress related to suspended sediment.

3.5.1.2 Chloride

Chloride was identified as a primary stressor to the macroinvertebrate community in Battle Creek. Battle Creek was listed on the 303(d) list for chloride impairment in 2008. Review of collected chloride data shows that exceedance of the MPCA standard (230 mg/L) are common. Additionally, review of historic water quality monitoring of Battle Creek (1977 through 2013) shows a significant increase in average growing season concentrations of chloride. The increase in baseline concentration of chloride over the historic dataset is likely driven by anthropogenic sources, including the application of chloride-containing deicers on paved surfaces. Because chloride is a conservative pollutant, anthropogenic application of chloride has elevated chloride concentrations in water bodies throughout the TCMA. To address this issue, the MPCA has developed a Chloride TMDL and Management Plan for the entire TCMA. Battle Creek is included in the TCMA Chloride TMDL .

Ephemeroptera (mayflies) have been shown to be particularly sensitive to chloride (MPCA 2010; MPCA 2014b; Piscart et al. 2005; Echols et al. 2009). Although the exact mechanism by which elevated chloride concentrations affect stream biota is not well understood, but it is likely related to osmotic and ionic regulation. An analysis of the ephemeroptera population in Battle Creek over a 40 year period showed that total ephemeroptera counts and relative ephemeroptera abundance decline s as average annual chloride concentration in the stream increases. The impact of chloride on fish was also evaluated, but it was found that chloride is likely not a primary driver of stress to the fish assemblage in Battle Creek.

3.5.1.3 Low Dissolved Oxygen

Low DO was determined to be a secondary stressor to the fish assemblage, and an inconclusive stressor to macroinvertebrates in Battle Creek. The DO concentrations in Battle Creek have not been extensively monitored. The modern (post-2000) DO data set consists of two synoptic surveys, one performed in 2012 and one performed in 2013, and 12 days of continuous DO monitoring completed by the MPCA in the late summer of 2012. The synoptic survey and continuous DO monitoring data suggest that DO concentrations are at their lowest and possible below the MPCA standard at monitoring stations immediately downstream of Battle Creek Lake and McKnight basin, although the small dataset is insufficient to make a determination of impairment. Low DO immediately downstream of detention areas may be attributed to (a) low dissolved-oxygen content in outflows from upstream waterbodies caused by eutrophication, or (b) attenuation in stream flow caused by upstream waterbodies.

3.5.1.4 Excess Total Phosphorus (TP)

Excess TP loading was determined to be a secondary stressor to fish and an inconclusive stressor to macroinvertebrates in Battle Creek. The TP measured in Battle Creek has routinely exceeded the eutrophication criteria concentration for streams in the Central River Nutrient Region (0.10 mg TP/L; MPCA 2013) over the period of record (1977 through 2013). Analysis of the water quality dataset shows that TP concentrations in the stream are highly positively correlated to TSS concentrations, suggesting TP concentrations are driven by phosphorus associated with sediment delivery. This finding also suggests that steps taking to reduce sediment loading will also reduce TP concentrations in the stream.

Although TP is not a proximate stressor, excessive phosphorus loading to a waterbody can lead to accelerated primary production (a process known as eutrophication), which can effect stream ecology by (a) altering food resources; (b) altering habitat structures; and (c) allowing for growth of toxic algae and bacteria (EPA 2010a).

3.5.1.5 Altered Habitat

Altered habitat was determined to be a secondary stressor to macroinvertebrates and an inconclusive stressor to fish in Battle Creek. Watershed urbanization has had significant impacts on the geomorphology of Battle Creek. To resolve routine flooding issues and address major erosion issues within the channel, a large restoration project was completed on Battle Creek in 1982. The project included the installation of several sheet pile drop structures and step weir structures, a major flood detention basin (McKnight Basin), and a flood-flow diversion structure which routes high flows into an underground pipe. Since completion of the project, bank erosion and channelization have been significantly reduced. In-stream habitat in Battle Creek has been monitored using the MPCA Stream Habitat Assessment (MSHA) methodology. The MSHA scoring at stations along Battle Creek generally found in stream habitat to by “fair” or “good”. There are few clear trends in the dataset, with the exception that scoring of substrate and the overall MSHA score tends to decrease from upstream to downstream.

3.5.1.6 Habitat Fragmentation

Habitat fragmentation was determined to be a secondary stressor to fish and an inconclusive stressor to macroinvertebrates in Battle Creek. As discussed in Section 3.5.1.5, many gradient control structures were installed along the length of Battle Creek during the 1981 through 1982 Battle Creek restoration project. Beginning at Century Avenue North (just east of station 12UM148) a total of 23 drop structures and 6 step-weir structures were installed. The height of gradient control structures along Battle Creek eliminates the potential for upstream movement of fish and most macroinvertebrate species between many biological survey stations. Instream structures can limit or reduce upstream migration, which can lead to changes in community structure (Brooker 1981 as cited by MPCA 2014d). These structures can also impact the physiochemical properties of the stream by altering water temperature, sediment transport and stream flow, and can affect upstream primary production and nutrient cycling (Cumming 2004).

Longitudinal analysis of fish and macroinvertebrate IBI scores shows no trend in scores from upstream to downstream, suggesting that limited upstream migration is not impacting the quality of biological communities. However, it may be the case that the biological condition of Battle Creek has been sufficiently degraded by other stressors that potential negative impacts of habitat fragmentation are overwhelmed or not currently assessable.

3.5.1.7 Heavy Metals (Cadmium, Copper, Lead, and Zinc)

Metal toxicity was found to be an inconclusive stressor to both the fish and macroinvertebrate populations within Battle Creek. Beginning in 2000, concentrations of six heavy metal species has been tracked within Battle Creek: Pb, Cu, Cr, Cd, Ni, and Zn. Of the metals analyzed, Cd, Cu, Pb and Zn have failed to meet chronic standards), maximum standards , or final acute values for Class 2B streams, pursuant to Minn. R. 7050.0222, subp. 4. In addition to exceeding the MPCA standards, water quality analysis showed that all four heavy metals are highly correlated to TSS concentration, suggesting that heavy metal delivery via sediment loading is the primary cause of elevated metal concentration within Battle Creek.

To determine if elevated metal concentrations are impacting aquatic communities, biological metrics sensitive to metal toxicity were evaluated. Fish species typically identified as being tolerant or sensitive to metal toxicity have not been identified in large numbers in Battle Creek, and for this reason impairment of the fish community could not be related to metal toxicity. All biological metrics were compared to monthly metal standard exceedances and average monthly metal concentrations, but no relationship could be identified. Based on the results of this analysis, a clear impact of metal toxicity on the fish and macroinvertebrate communities in Battle Creek could not be identified, and metal toxicity is therefore considered an inconclusive stressor to both communities.

3.5.1.8 Candidate Cause Summary

A summary of the probable primary, secondary, and inconclusive stressors to aquatic communities in Battle Creek is presented in Table 3-4. Identification of probable stressors was based on strength of evidence scoring as outlined in the EPA's CADDIS methodology (EPA 2010). Many of the candidate causes analyzed are interrelated, meaning that addressing one may indirectly impact another (e.g., reducing watershed sediment loading may reduce phosphorus and metal loading associated with sediment). For this reason, it is recommended that candidate causes identified as probable primary stressors be addressed with precedence over secondary and inconclusive stressors. Specific recommendations to resolve biological impairment developed in the Battle Creek SID Report are outlined in Table 3-5.

Table 3-4 Summary of probable stressors in the Battle Creek Watershed

Stream Name	AUID	Biological Impairment	Candidate Causes: Excess Sediment	Specific Conductance and Chlorides	Dissolved Oxygen and BOD	Excess Total Phosphorus	Altered Habitat	Habitat Fragmentation	Metal Toxicity
Battle Creek	07010206-592	Fish	●	○	●*	◐	○	◐	○
		Macroinvertebrates	●	●	○	○	◐	○	○

● = probable primary stressor; ◐ = probable secondary stressor; ○ = inconclusive stressor

●* = probable station-specific primary stressor (e.g., DO impairment immediately downstream of detention areas)

Table 3-5 Recommendations to address biological impairment developed in the Battle Creek SID

Stressor	Priority	Recommendations
Candidate Causes		
Excess Sediment	High	· Create and implement TMDL for sediment loading (TSS loading). · TMDL should focus on watershed sediment loading, as well as sediment loading from the immediate stream channel.
Specific Conductance and Chloride	High	· Implementation of recommendations from Twin Cities Metropolitan Area Chloride TMDL and Management Plan.
Dissolved Oxygen and Biological Oxygen Demand (BOD)	Medium-High	· Increase longitudinal DO and BOD monitoring efforts along Battle Creek. · Efforts should focus on determining (a) whether or not DO impairment is limited to stations immediately downstream of detention areas and (b) the source of DO impairment (BOD? TP? Temperature? In-stream detention? Low Flow? Chl-a? Etc.). · Consider (a) longitudinal deployment of continuous dissolved oxygen monitoring sensors and (b) additional pre-9 AM synoptic surveying efforts during the growing season. Simultaneous measurements of DO, BOD, TP, temperature, and flow will help determine potential sources of DO impairment.
Excess Total Phosphorus	Medium	· Continue longitudinal monitoring of TP concentrations. · TP monitoring should be conducted during TSS monitoring associated with sediment loading TMDL (to determine if reduced TSS loading also reduces TP loading).
Altered Habitat	Medium	· Continue MSHA surveying and request quantitative substrate measurements be taken during each survey. · Monitor survey results throughout sediment loading TMDL.
Habitat Fragmentation	Low	· Reassess biological metric impacts after other primary and secondary stressors addressed.
Metal Toxicity	Low	· Monitor concentrations of Cd, Cu, Pb, and Zn throughout sediment loading TMDL (to determine if reduced sediment loading reduces metal toxicity). · Reassess biological metric impacts after other primary and secondary stressors addressed.

Stressor	Priority	Recommendations
Inconclusive Causes		
pH	Unknown	· Expand pH monitoring efforts along Battle Creek. · Include pH in event based sampling at station 99UM075 (WOMP station). · Include pH in future synoptic surveys (include pH flux monitoring).
Altered Hydrology	Unknown	· Continue flow monitoring at station 99UM075, and consider installing flow monitoring stations further upstream (potentially upstream and downstream of McKnight Basin). · Continue vegetation clearing and sediment removal maintenance efforts.

3.5.2 Total Suspended Solids (TSS)

The TSS concentrations in Battle Creek were monitored from 2000 to 2013 at a Metropolitan Council WOMP Station, located roughly 1,500-feet downstream of the Highway 61 crossing (Figure 3-5). Observed TSS concentrations are compared to the TSS standard for Class 2B waters located in the Central River Nutrient Region, defined by Minn. R. 7050.0222 (see Section 2.2), in Table 3-6. As can be seen, Battle Creek exceeds the Class 2B TSS standard every year from 2000 through 2013. In the entire period of record, 53% of samples collected between April 1 and September 30 of each year (174 or 329 samples) exceed the standard of 30 mg TSS/L. Based on available data, it appears Battle Creek is impaired for TSS. For this reason, it is anticipated that when the Battle Creek TSS data are assessed it will be included in the MPCA's 303(d) impaired waters list.

To analyze the relationship between sediment loading and flow rate at the Battle Creek WOMP Station, TSS concentrations are compared to the flow duration curve developed for Battle Creek (discussed in Section 4.1.1) in Figure 3-6 and Table 3-7. As shown in Figure 3-6, TSS concentrations are strongly correlated with stream flow, with high flows generating higher TSS concentrations on average, and lower flows producing lower TSS concentrations. Table 3-7 shows that a majority of samples taken at high flow and moist conditions exceeded the MPCA standard for TSS, while only 15% of samples taken at the low flow condition, exceeded the standard. Only during low flow conditions does the average TSS concentration in the stream drop below the MPCA standard.

Longitudinal surveys conducted during 2012 and 2013 (Table 3-8) found relatively low levels of TSS. Only 3 of 52 total samples exceeded the MPCA TSS standard. The greatest exceedance recorded at the outlet of Battle Creek Lake (140 mg/L) occurred during a low flow condition at the WOMP station. For this reason, it is likely that there was low outflow from Battle Creek Lake on this sampling date, and that the elevated TSS observed was caused by algae suspended in the outflow from Battle Creek Lake. From the 13 samples collected at 4 different sites over a 2-year period, it is difficult to identify any longitudinal trends in TSS concentration. From the more robust dataset collected at the WOMP station, it is clear that TSS concentrations exceeding the MPCA standard are common at downstream portions of the stream. More data will need to be collected to determine the extent to which this degraded condition propagates upstream.

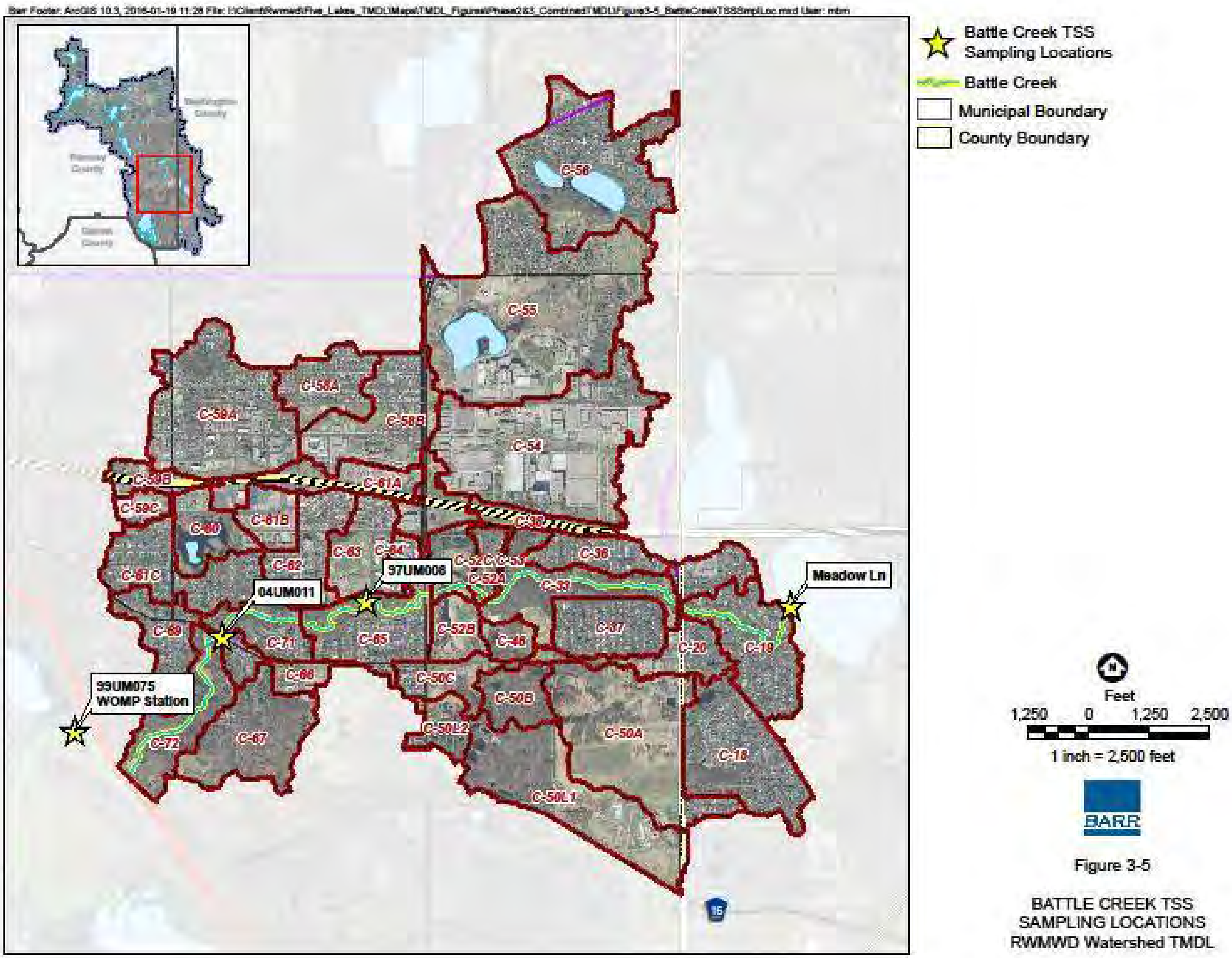

Figure 3-5 Battle Creek sampling locations

Table 3-6 Battle Creek TSS summary at WOMP station (99UM075), April 1 through September 30

	Battle Creek TSS Summary (April 1 through Sept 30 samples only)														
Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Entire Dataset**
Number of Samples	13	17	20	12	32	29	25	32	26	20	35	20	26	22	329
Average TSS Concentration (mg/L)	60.5	36.4	78.6	93.1	64.9	125.9	73.6	76.3	91.8	108.7	64.5	46.1	31.6	20.4	70.2
Percentage of Samples exceeding Standard (30 mg/L)	54%	35%	70%	50%	56%	79%	44%	56%	58%	60%	60%	35%	42%	23%	53%

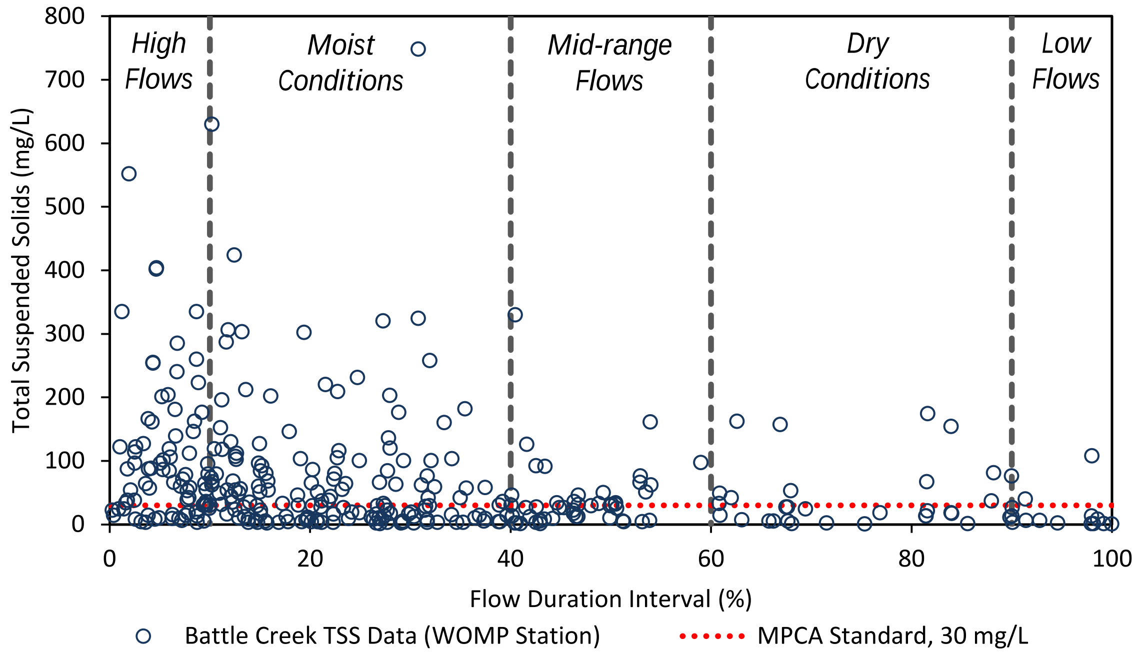

Figure 3-6 TSS water quality duration curve at WOMP station (99UM075)

Table 3-7 TSS and flow duration interval summary at WOMP station (99UM075)

Flow condition	High Flows	Moist Conditions	Mid-range Flows	Dry Conditions	Low Flows
Flow duration interval	**0-10%**	**10-40%**	**40-60%**	**60-90%**	**90-100%**
Average TSS concentration (mg/L)	103	74	40	41	17
Percentage of samples exceeding MPCA TSS standard (30 mg TSS/L)	71%	54%	42%	38%	15%

Table 3-8 Summary of TSS measurement from 2012 and 2013 longitudinal surveys

Upstream → *Downstream*

		TSS (mg/L) samples, 2012-2013 longitudinal survey			
Date	**Flow Condition at WOMP Station**	**Meadow Lane (at the outlet from Battle Creek Lake)**	**97UM008**	**04UM011**	**99UM075 WOMP Station**
9/20/2012	Mid-Range Flows	ND[1]	ND	ND	ND
9/26/2012	Mid-Range Flows	6.1	10.5	ND	ND
10/10/2012	Moist Conditions	6.8	9.4	11.4	ND
3/23/2013	Dry Conditions	7.5	12	7.5	7
3/28/2013	Mid-Range Flows	48[2]	15	12	9
4/25/2013	High Flows	ND	5.5	14	12
5/29/2013	High Flows	1.5	4.5	5	4.5
6/27/2013	High Flows	2	3.5	14	14
7/25/2013	Dry Conditions	4	3.5	2	ND
8/15/2013	Dry Conditions	13	16	5	3.5
8/29/2013	Moist Conditions	26	36	9.5	8
9/24/2013	Low Flows	140	6	1.5	ND
10/22/2013	Mid-Range Flows	2.5	6.5	3	4.5

[1] ND = not detectable (below laboratory detection limits).
[2] Cells highlighted in red exceed the MPCA TSS standard (30 mg/L).

3.5.3 Bacteria (*E. coli*)

The Metropolitan Council operates a Watershed Outlet Monitoring Program (WOMP) station located on Fish Creek near U.S. Highway 61 (Figure 3-7). *E. coli* data collected at the WOMP station from 2008-2013 were evaluated and compared to numeric *E. coli* standards for Class 2C waters defined in Minn. R. 7050.0222 (Section 2.3). In addition to the WOMP station, *E. coli* was also collected in 2012 and 2013 at the three sampling locations along Fish Creek shown in Figure 3-7. Data were collected at sites along the length of Fish Creek so that changes in *E. coli* concentrations from upstream to downstream could be tracked and analyzed. Understanding spatial differences in *E. coli* concentrations can help to identify or rule-out potential sources of bacteria.

As discussed in Section 2.3, a stream is considered impaired for bacteria if the monthly geometric mean value of one or more months (from April through October) exceeds 126 organisms per 100 mL (the MPCA chronic standard), based on a minimum of five aggregated samples and/or if 10% of the individual samples exceed 1260 organisms per 100 mL (the MPCA acute standard). Table 3-9 summarizes monthly sample counts and the monthly geometric mean *E. coli* concentrations at each of the four sample sites along Fish Creek. Also included in the table is the summary of the available bacteria data collected in Carver Lake. The results in Table 3-9 are also shown graphically in Figure 3-8. As can be seen, *E. coli* concentration at the Fish Creek WOMP station exceeds the monthly geometric mean impairment condition for the months of June through October, meaning that the reach is impaired for bacteria. Although the other sampling sites did not contain the requisite number of monthly samples, the data indicate that *E. coli* concentrations are highest at the Fish Creek WOMP station and at the location upstream of the I-494 crossing. In general, *E. coli* levels are lower at the upstream monitoring locations and typically these locations meet the chronic monthly standard.

In addition exceeding the chronic standard *E. coli* standard, there were regular exceedances of the acute standard of 1,260 organisms per 100 mL in Fish Creek during the monitoring period. The acute *E. coli* standard and a summary of each of the monitoring location are summarized in Table 3-10. As can be seen, the WOMP station exceeded the acute *E. coli* standard in 11% of samples. No exceedances of the acute standard occurred at stations upstream of the I-494 station, again suggesting that *E. coli* concentration increase from upstream to downstream.

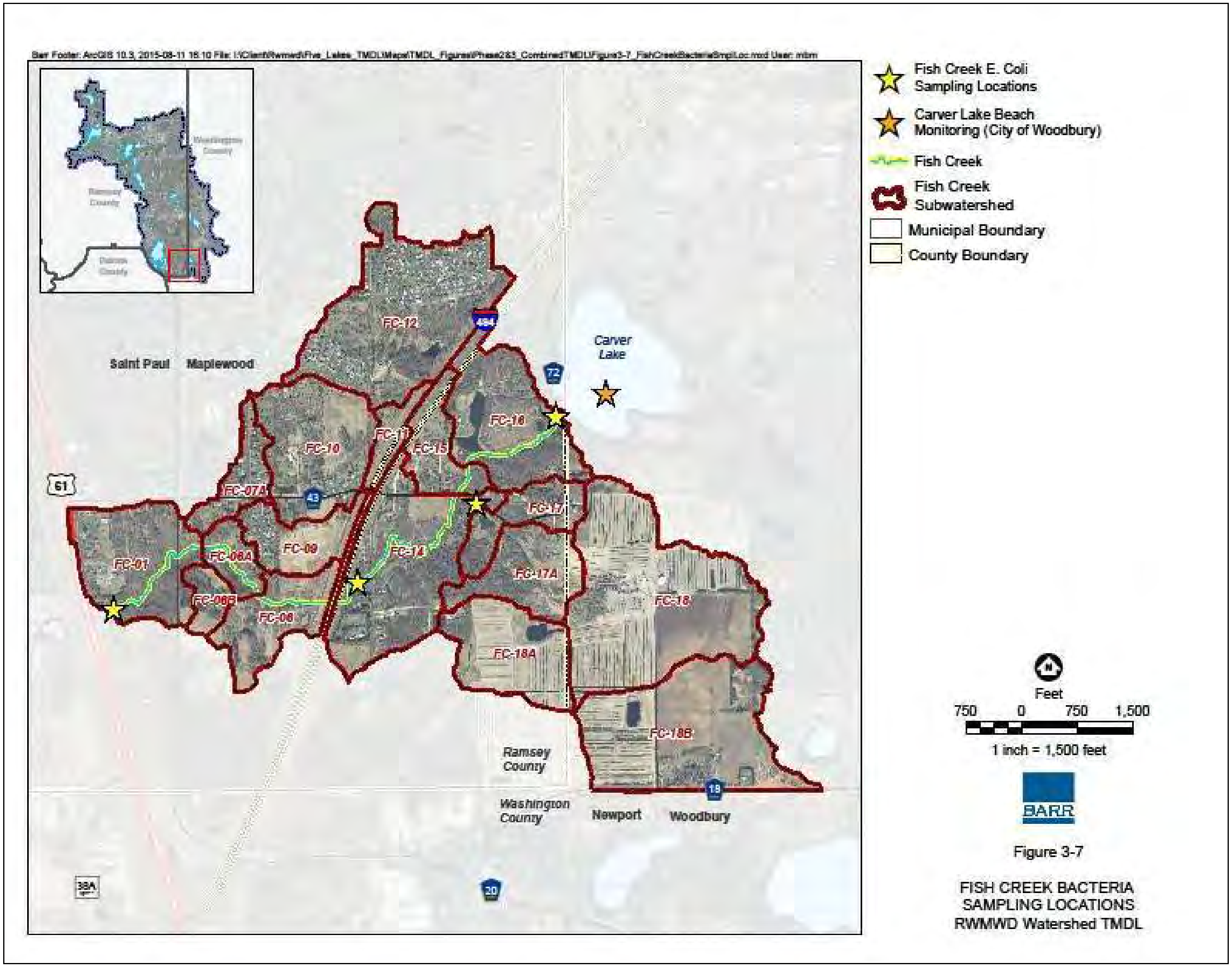

Figure 3-7 Fish Creek sampling locations

Table 3-9 Exceedances of chronic *E. coli* standard and sampling location along Fish Creek

Chronic *E. coli* standard summary	
Minimum Samples Per Month (#)	5
Monthly Geometric Mean Criterion (org/100 mL)	126

		Month						
Sampling Site		**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**
Fish Creek WOMP Station	Samples Per Month (#)	5	5	5	5	6	6	6
	E. coli Geometric Mean (org/100 mL)	36	74	223[1]	330	466	450	164
I-494 upstream of Highway Crossing	Samples Per Month (#)	1	1	1	1	1	3	2
	E. coli Geometric Mean (org/100 mL)	7	30	47	248	1553	150	73
Downstream of Double Driveway Pond	Samples Per Month (#)	1	1	1	1	1	1	1
	E. coli Geometric Mean (org/100 mL)	135	10	308	2	2	32	86
Century Ave at the outlet of Carver Lake	Samples Per Month (#)	0	0	0	0	0	2	1
	E. coli Geometric Mean (org/100 mL)	N/A	N/A	N/A	N/A	N/A	81	68
Carver Lake - Main	Samples Per Month (#)	0	8	12	11	6	0	0
	E. coli Geometric Mean (org/100 mL)	N/A	6	9	3	3	N/A	N/A
Carver Lake - North	Samples Per Month (#)	0	9	16	9	3	0	0
	E. coli Geometric Mean (org/100 mL)	N/A	6	6	5	4	N/A	N/A

[1] Values highlighted in red indicate the geometric mean of samples collected exceeded the monthly geometric mean criterion (126 org/100 mL).

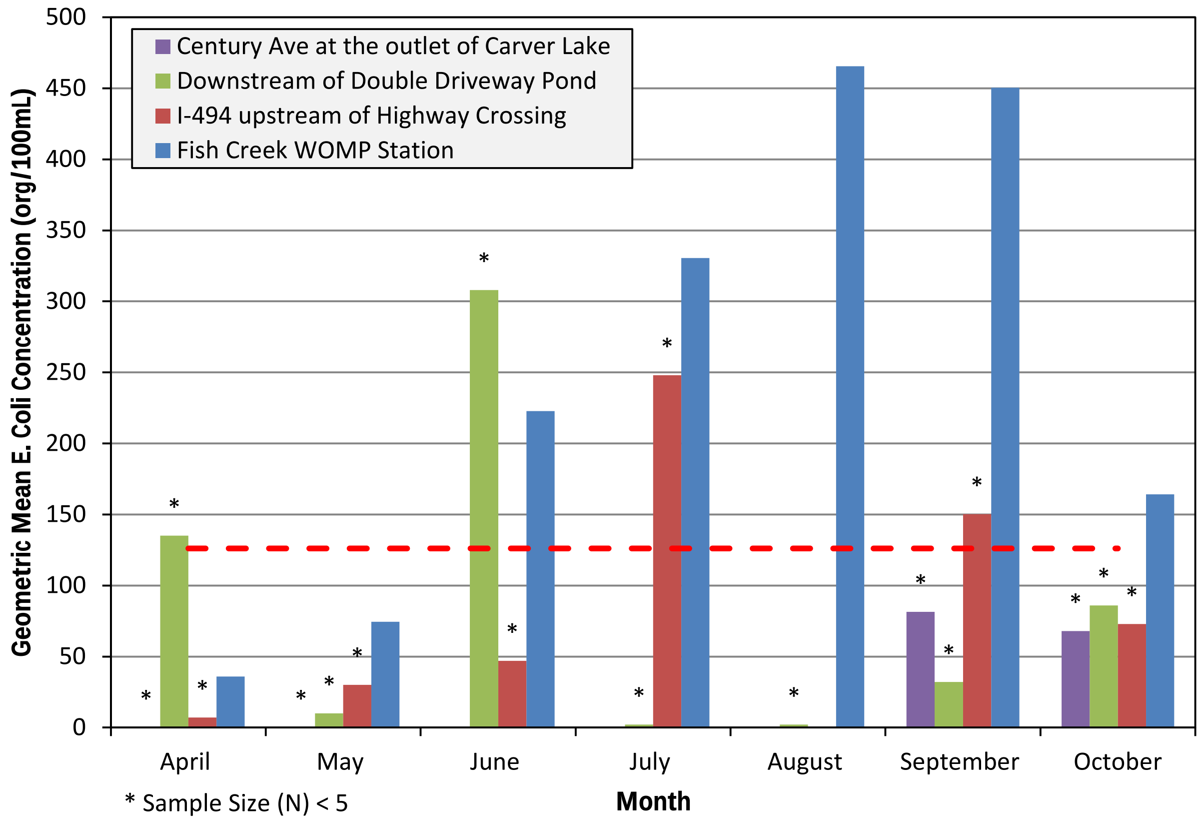

Figure 3-8 Fish Creek bacteria monthly geometric mean by monitoring station

Table 3-10 Exceedances of acute *E. coli* standard and sampling location along Fish Creek

Acute *E. coli* standard summary	
Minimum Number of Samples	**15**
Standard Exceedance Threshold (Exceeds 1,260 orgs/100 mL)	**> 10%**

Sampling Site	Years Sampled	Total Number of Samples	Percent > 1,260 org/100 mL
Fish Creek WOMP Station	2008-2013	38	11%[1]
I-494 upstream of Highway Crossing	2012-2013	10	10%
Downstream of Double Driveway Pond	2013	7	0%
Century Ave at the outlet of Carver Lake	2012	3	0%
Carver Lake - Main	2005-2008	37	0%
Carver Lake - North	2005-2008	37	0%

[1] Value(s) highlighted in red exceed the MPCA standard for maximum proportion of standard exceedances.

3.5.4 Excess Nutrients

Water quality trends in Bennett Lake and Wakefield Lake were evaluated by analyzing 10 years of water quality data from each lake (based on the start of the TMDL evaluation). For the purposes of this TMDL report, growing season (June 1 through September 30) mean concentrations of TP, Chl-*a*, and Secchi disc transparency were used to evaluate the water quality of Bennett and Wakefield Lake. Additionally, the summarized data reflects the surface samples (samples collected from 0-2 meters in depth). The growing season (GS) is often used to evaluate lake water quality, as it is the time period encompassing the months during which the water quality is most likely to suffer due to algal growth.

Table 3-11 summarizes the historical water quality information compared to the MPCA shallow lake eutrophication criteria. Historic growing season means of TP, Chl-*a*, and Secchi disc transparency for Bennett and Wakefield Lake are shown in Figure 3-9 and Figure 3-10, respectively.

Table 3-11 Bennett Lake and Wakefield Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Bennett Lake (2003-2012) GS Average	Wakefield Lake (2002-2011) GS Average
Total Phosphorus (µg/L)	≤ 60	138.4	106.1
Chlorophyll-*a* (µg/L)	≤ 20	37.5	29.4
Secchi disc transparency (m)	≥ 1.0	0.9	1.5

The EPA requires that during the TMDL development, the maximum allowable pollutant load or loads needed to meet water quality standards for a given water body are defined for "critical conditions". Critical conditions are represented by the combination of loading, waterbody conditions, and other environmental conditions that result in impairment and violation of water quality standards. For the purposes of this TMDL, the critical condition was determined to be equal to the year which produced the highest growing season average TP concentration during the most recent decade of analysis (2003-2012 for Bennett Lake, 2002-2011 for Wakefield Lake), as phosphorus is the causal factor for the nutrient impairment in both lakes. Growing season average water quality for the critical year of Bennett Lake (2005) and Wakefield Lake (2004) are summarized below in Table 3-12. The critical years for the waterbodies are also highlighted in Figure 3-9 and Figure 3-10.

Table 3-12 Growing season average water quality for critical year

		Critical Year Growing Season Average		
Waterbody	**Critical Year**	**Total Phosphorus (µg/L)**	**Chlorophyll-a (µg/L)**	**Secchi disc transparency (m)**
Bennett Lake	2005	210	56.8	0.7
Wakefield Lake	2004	154	58.1	0.6

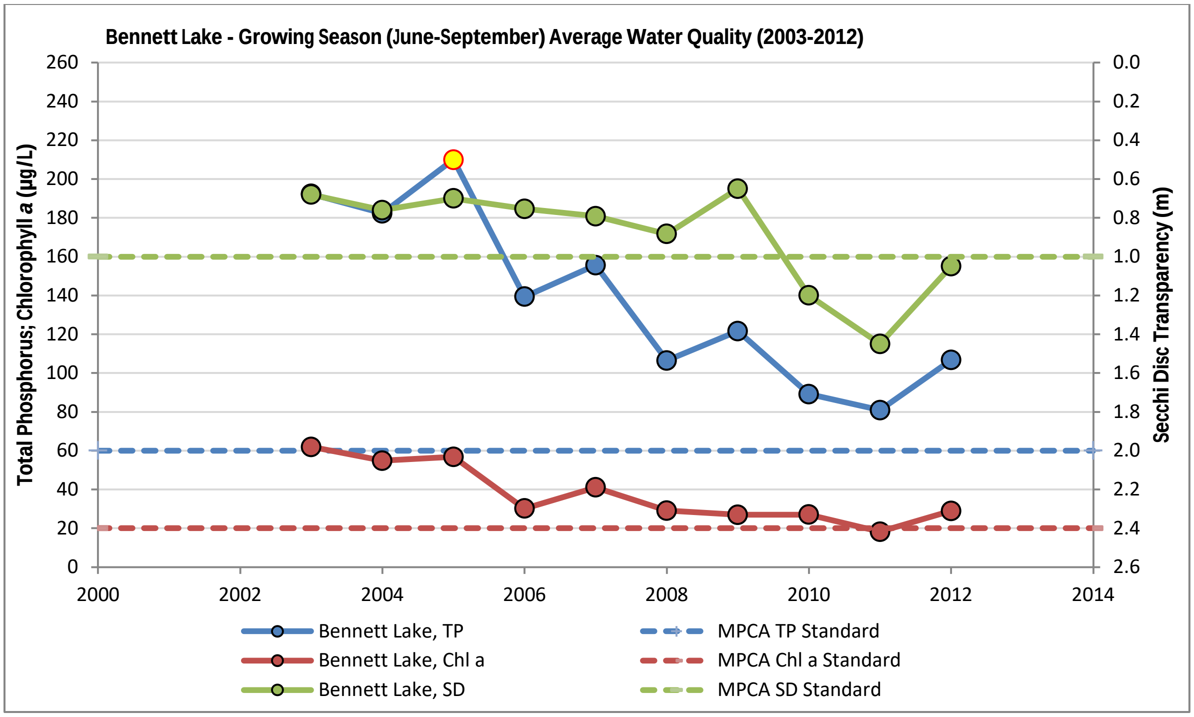

Figure 3-9 Bennett Lake Growing Season (June-September) Average Water Quality, 2003-2012

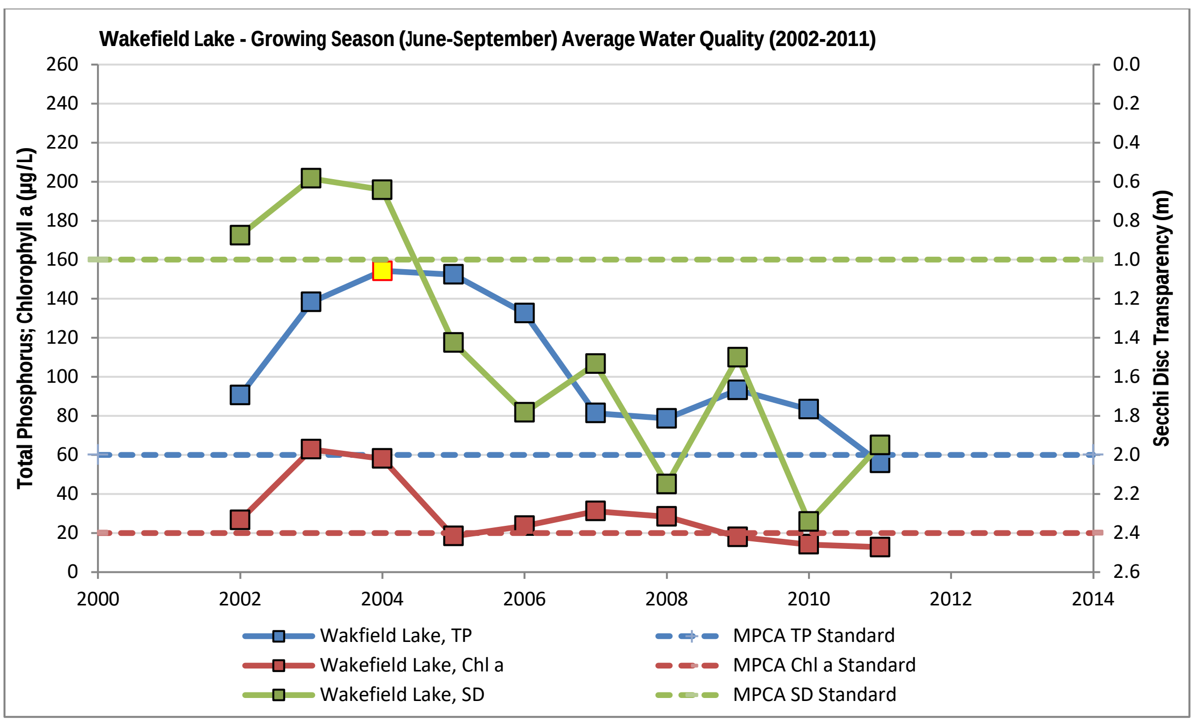

Figure 3-10 Wakefield Lake Growing Season (June-September) Average Water Quality, 2002-2011

3.6 Pollutant Source Summary

3.6.1 Total Suspended Solids (TSS)

These sections provide a brief discussion of the potential sources of sediment to Battle Creek, although the actual quantification of these sources will be further discussed in Section 4.1 of this TMDL report. The sources of sediment can be classified into permitted or non-permitted sources, which will be defined and discussed in the following sections.

3.6.1.1 Permitted Sources

Permitted sources of phosphorus are those that require a National Pollution Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit. Examples of typical permitted sources of phosphorus include the following:

- Municipal Separate Storm Sewer System (MS4) Permit (Permit) - Includes coverage of MS4s operators, which are operators of infrastructure that is used solely for stormwater and often include cities, townships, and public institutions. The goal of the MS4 General Permit is to improve the water quality of urban stormwater runoff and reduce pollutants in stormwater discharges.
- Construction Stormwater NPDES/SDS General Permit – Includes coverage of any construction activities disturbing one acre or more of soil, less than one acre of soil when part of a larger development that is more than one acre, or less than one acre when the MPCA determines the activity to pose a risk to water resources. The goal of the construction stormwater permit is to control erosion and reduce the amount of sediments and other pollutants being transported by runoff from construction sites.
- Multi-Sector Industrial Stormwater NPDES/SDS General Permit – Includes coverage of stormwater discharges associated with a variety of industrial activities. The goal is to reduce the amount of pollution that enters surface and ground water from industrial facilities in the form of stormwater runoff.
- NPDES/SDS Permit – Includes coverage of facilities that discharge treated wastewater to surface or ground water of the state. The goal of the permit is to establish minimum effluent limits for a variety of constituents that protect the water quality and designated uses of waters of the state.

3.6.1.2 Non-Permitted Sources

Non-permitted sources of phosphorus are those that are not regulated by the NPDES/SDS program. For many streams, these sources can be significant portion of the sediment load to the stream and can be a major contributor to impairment. The following are examples of the typical non-permitted sources of sediment:

- **Internal Sources** – Includes sediment resuspension within the stream channel, erosion and bank failure within the stream corridor, and in-channel algal production can all contribute to TSS loading.

- **Loading from upstream waterbodies** – Headwater ponds and other waterbodies that discharge flow into the stream corridor can be significant sources of sediment loading.

3.6.2 Bacteria (*E. coli*)

In order to develop the linkage between watershed sources of bacteria and water quality targets, this study followed an approach that was initially developed for the Regional Total Maximum Daily Load Evaluation of Fecal Coliform Bacteria Impairments in the Lower Mississippi River Basin in Southeast Minnesota (MPCA 2002) and utilized the bacteria production estimates from the Upper Mississippi River Bacteria TMDL (EOR 2014). The bacteria production estimates used in the Upper Mississippi River Bacteria TMDL were originally modified from daily fecal coliform production rates by animal type from Metcalf and Eddy (2003).

This section provides an inventory of the sources of bacteria within the Fish Creek Watershed. The sources of bacteria in the watershed include:

- Septic systems and human waste (Section 3.6.2.1)
- Stormwater runoff and pets (Section 3.6.2.2)
- Sanitary sewer exfiltration (Section 3.6.2.3)
- Fecal matter from wildlife (Section 3.6.2.4)

Figure 3-11 shows the available source information in the Fish Creek Watershed.

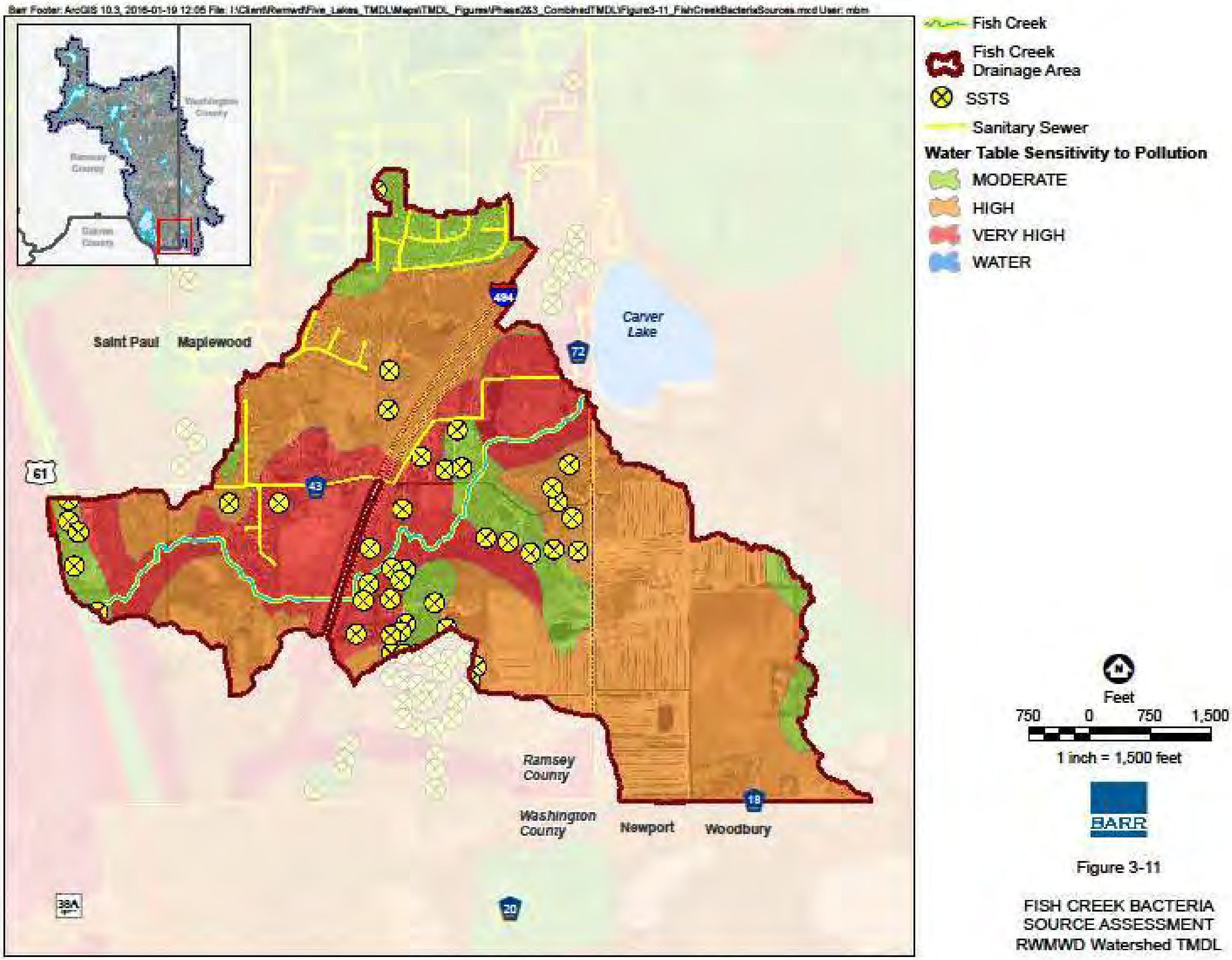

Figure 3-11 Fish Creek bacteria source assessment

3.6.2.1 Septic System and Human Waste

Human waste can be a significant source of bacteria loading to surface waters, especially during dry and low flow periods when human waste sources continue and there is little runoff to convey other sources to surface water bodies. Septic systems (SSTS) that are not properly designed or maintained can allow untreated or partially treated sewage to flow into surface waters. Minn. R. 7080.1500 establishes compliance criteria for individual subsurface sewage treatment systems, including the following:

- Minn. R. 7080.1500, subp. 4(A), states the SSTS "must be protective of human health and safety. A system that is not protective is considered an imminent threat to public health or safety. At a minimum, a system that is an imminent threat to public health or safety is a system with a discharge of sewage or sewage effluent to the ground surface, drainage systems, ditches, or storm water drains or directly to surface water…"
- Minn. R. 7080.1500, subpart 4(B), states the SSTS "must be protective of groundwater. At a minimum, a system that is failing to protect groundwater is a system that is a seepage pit, cesspool, drywell, leaching pit, or other pit; a system with less than the required vertical separation distance…, and a system not abandoned in accordance with part 7080.2500."
- Minn. R. 7080.1500, subpart 4(B), states the SSTS "must be operated, meet performance standards, and be managed according to its operating permit."

SSTS that do not meet these compliance criteria are considered non-compliant.

There are no permitted surface water discharges from municipal or industrial wastewater treatment facilities (WWTF) in the Fish Creek Watershed. Although portions of the Fish Creek Watershed are served by sanitary sewer, there are still many SSTS in the watershed. Based on SSTS data provided by the cities of Maplewood and St. Paul, there are 40 SSTSs within Fish Creek direct drainage boundary, which ultimately drains to the Fish Creek WOMP monitoring station as well as several SSTS located just outside the watershed boundary.

Of the 40 total SSTSs within the Fish Creek Watershed, 36 are located within the city of Maplewood. Pursuant to the SSTS ordinance adopted by the city of Maplewood in 2013, residents are required to have their SSTSs inspected and submit a MPCA Septic Tank Maintenance Reporting Form every three years. Prior to the 2013 ordinance, SSTS inspection reports were processed by the City only when maintenance requests were made by homeowners. The City, on average, receives a one to two maintenance requests per year, indicating an annual failure rate of about 1% of systems (Personal Communications 2014). However, information compiled for the MPCA's Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr 2004a) suggests a 25% failure rate for SSTS in the Upper Mississippi River Basin.

The four SSTSs not within the city of Maplewood are located within the city of St. Paul. According to Chapter 50 of the city of St. Paul's legislative code, St. Paul SSTSs are regulated by Minn. R. 7080 (Minn. R. 7082, 2014). Residents are required to maintain their SSTSs no less frequently than once every two years. Additionally, a permit is required for any installation, alteration, or repair of an SSTS, confirming that all sizing, location, and material requirements have been met.

The 40 SSTS systems within the Fish Creek Watershed are serving an estimated population of 102 people. Assuming a 25% non-compliant/failing rate based on the information above, the number of people associated with the estimated failing SSTS system is 26 people.

Additionally, information from the Minnesota Geological Survey also indicates that the water table susceptibility to pollution ranges from moderate to very high (See Figure 3-11).

3.6.2.2 Stormwater Runoff and Pets

Untreated urban stormwater can have bacteria concentrations as high as or higher than runoff from pastures and cropland (EPA 2001), primarily sourced from pet waste.

Approximately one-third of the direct drainage area to Fish Creek is considered urban, with the primary land use in the watershed being low-density residential housing. The northern portion of the watershed is the most densely populated, while the southern and eastern portions of the watershed are predominantly commercial nursery.

The total number of pets in the contributing watershed of Fish Creek is estimated from the American Veterinary Medical Association values of 0.66 cats and 0.58 dogs per household. Based on 2009 parcel data from Ramsey and Washington counties, there are 325 residences within the direct drainage area to Fish Creek. Based on this number of households, it is estimated that there are 189 dogs and 215 cats in the Fish Creek Watershed. Waste from these animals is conservatively assumed to be conveyed to surface waters with equal likelihood, regardless of the location of the household within the watershed.

3.6.2.3 Sanitary Sewer Exfiltration

According to the MPCA's 2014 Upper Mississippi River Bacteria TMDL Study and Protection Plan (EOR 2014), 37% of the sanitary sewer infrastructure in the Fish Creek Watershed is over 50-years old. Due to changes in material and construction standards, as well as deteriorating associated with aging (corrosion and cracking), sanitary sewer over 50-years old is typically well beyond its useful life, and can pose a risk to human health. Exfiltration from aging sanitary sewer infrastructure can cause raw, untreated sewage to enter nearby stormsewers. These phenomena can lead to chronic contamination of stormsewer systems and receiving water bodies.

Based on the study linking exfiltration from the sanitary sewer to the storm sewer, exfiltration rates from sanitary sewer can range from 0.01- 2 L/second per kilometer and at the sites evaluated; sewage comprised 0.0 to 20% of the baseflow in the storm sewer systems during dry conditions (Sercu, et. al. 2011). We have estimated that 122 people are served by the sanitary sewer systems in the Fish Creek Watershed with an average wastewater flowrate of 288 liters per person per day (Metcalf and Eddy 2003). Assuming that 37% of the sanitary sewer in the Fish Creek Watershed is older than 50 years and can exfiltrate at a rate of 0.1 L/s per kilometer, the estimated sewage exfiltration volume is 3% of the total wastewater load to the sanitary sewer.

3.6.2.4 Wildlife

The Minnesota Department of Natural Resources (DNR) compiles population estimates for various native wildlife species at locations throughout Minnesota. The 2013 Farmland Wildlife Populations estimate (DNR 2013) indicated that average deer populations in the management units surrounding the Fish Creek Watershed to the north and south (as density numbers were not available for the Twin Cities

Metro Area in this study) were approximately 12 deer per square mile. Based on the area of the Fish Creek Watershed contributing to the downstream monitoring station, there are approximately 13 deer within the watershed.

Based on 2000 wild turkey density estimates from the National Wild Turkey Federation, the density of wild turkeys in the Fish Creek Watershed is approximately 6-15 wild turkeys per square mile (NWTF 2000). At this density, there are approximately 11 wild turkeys in the Fish Creek Watershed. The total number of equivalent animal population based on this estimate is 0.2 turkeys (Minnesota Department of Agriculture (MDA) website 2014).

The DNR estimates there were 550,000 breeding ducks in Minnesota annually from 2005 to 2009 (DNR Roundtable 2010) during the common seven-month residence period (April through October). Following the procedure outlined in the MPCA's 2014 Upper Mississippi River Bacteria TMDL Study and Protection Plan (EOR 2014), it was assumed that the annual duck population was distributed evenly throughout 2006 National Land Cover Database (NLCD) Open Water and wetland land use types. Based on this distribution, it is estimated that there are 0.24 ducks residing in the direct drainage area to Fish Creek.

Based on methodology outlined in the MPCA's 2014 Upper Mississippi River Bacteria TMDL Study and Protection Plan (EOR 2014), it was assumed that there were 0.20 geese per acre of 2006 NLCD open water and wetland land use types. Based on this assumed density, it is estimated that there are 1.2 geese in the 6.0 acres of open water and wetland area within the direct drainage area to Fish Creek.

To account for all other wildlife in the Fish Creek Watershed, the total *E. coli* loads estimated for the quantified wildlife populations were doubled.

The riparian area of Fish Creek is mainly classified as forested wetlands. Additionally, the majority of forested, wetland, and open natural area in the Fish Creek Watershed is along or near the steam corridor. For this reason, it is expected that wildlife in the watershed would be most densely concentrated in the areas closest to Fish Creek, and waste from wildlife would be transported relatively quickly into the surface water.

3.6.2.5 Bacteria Available for Runoff

In the TMDL source assessment, it is not only necessary to estimate the total bacteria production by source, but it is also necessary to: (1) estimate the amount of bacteria potentially available for runoff from each source; and (2) assess the potential for the bacteria to reach surface waters under wet and dry conditions. This analysis results in the partitioning of the stream load by source, based on the total load estimated to reach surface waters under the given conditions.

The data and assumptions discussed in the previous sections result in total populations corresponding to potential sources and estimates of total bacteria production. The total source population inventory for the contributing watershed is shown in Table 3-13, along with the estimated quantity of *E. coli* bacteria produced monthly. The *E. coli* bacteria production rates were based on animal type.

Table 3-13 Estimated population and monthly *E. coli* production by source

Category	Source	Animal Population	*E. coli* Organisms per Unit per Month (10^9 organisms)*	Total *E. coli* Organisms Available per Month (10^9 organisms)	% of Total *E. coli* Organisms Available per Month
Human	Pop. using SSTSs	102	30	3066	8%
	Pop. using sanitary sewer	123	30	3679	10%
Urban Runoff	Cats	215	75	16088	43%
	Dogs	189	75	14138	38%
Wildlife	Deer	13	5.4	69	0.2%
	Wild Turkey	0.2	3.9	1	0%
	Geese	0.02	0.3	0	0%
	Ducks	0.002	165	0	0%
	Other Wildlife	--	--	141	0.4%

* From the Upper Mississippi River Bacteria TMDL (2014), modified from daily fecal coliform loading rates from MetCalf and Eddy (1991) and EPA (2001).

Once produced, *E. coli* bacteria is made available or applied on the land surface by several different methods. Table 3-14 shows the fraction of bacteria generated by different sources and application types that are available to runoff into Fish Creek. The methodology used here was originally applied in the Southeast Minnesota Regional Fecal Coliform TMDL (MPCA 2002), and assumes that the delivery of *E. coli* would be the same as for fecal coliform. The assumed availability and distribution between various application methods represent the characteristics of the Fish Creek Watershed.

Note that this analysis makes the simplifying assumption that all bacteria produced in the watershed remains in the watershed. For some sources (e.g., wildlife) all bacteria produced is assumed to be available for runoff. For other sources (e.g., humans), a portion of the bacteria produced is assumed to not be available for runoff under any circumstances, such as in adequately treated rural wastewater.

Table 3-14 Assumed *E. coli* availability by application method

Category	Application Method	Assumed Availability	Notes
Human	Adequately treated SSTS	75% of humans	Not available
	Inadequately treated SSTS	25% of humans	Available
	Exfiltration from Sanitary Sewer	3% of humans	Available
	Treated Sanitary Sewer	97% of humans	Not available
Urban Runoff	Properly managed pet waste	90% of pets	Not available for runoff
	Improperly managed pet waste	10% of pets	Available for runoff
Urban Wildlife Runoff	Wildlife Waste	100% of deer, wild turkey, geese, and ducks	Available for runoff

Once the estimated total bacteria produced in the contributing portion of the Fish Creek Watershed is calculated and assigned to various application methods, final assumptions must be made on the potential for each application method to deliver bacteria to surface waters. This analysis is adapted from that used in the TMDL for the Lower Mississippi River Basin in Minnesota (MPCA 2002). The TMDL analyses ranked each application method according to its risk of bacteria delivery and assigned a corresponding delivery percentage (see Table 3-15). This risk of delivery to the water resource was translated into delivery percentages. A very low potential delivers one percent, low potential is two percent, moderate is 4%, high is 6%, and very high is 8%. The delivery percentage represents the fraction of the total available bacteria that is assumed to be transported to Fish Creek for a given condition (wet or dry).

This analysis procedure reflects the conditions in the Fish Creek Watershed. The assumed dry weather application methods are inadequately treated wastewater (SSTS), exfiltration from the sanitary sewer system, and wildlife. All application methods are assumed to contribute bacteria to the stream in wet weather.

Table 3-15 Assumed *E. coli* delivery potential by application method

Application Method	Assumed Delivery Potential*	
	Wet Conditions	Dry Conditions
Inadequately treated wastewater (SSTS)	Very High (8%)	Very High (8%)
Exfiltration from the Sanitary Sewer	Very High (8%)	Very High (8%)
Improperly managed pet waste	Moderate (4%)	None
Wildlife	Very low (1%) for all other	Very low (1%) for all other

* Adapted from values used in MPCA (2002).

3.6.2.6 Estimated Source Load Proportions

The *E. coli* loading in the contributing Fish Creek Watershed was estimated by multiplying the total number of *E. coli* organisms available per month for each source by its corresponding availability and delivery potential. A comparison of sources contributing to wet weather and dry weather loading is shown in Figure 3-12 and Figure 3-13, respectively.

Bacteria loading to Fish Creek is dominated by loading from humans, primarily from inadequately treated wastewater SSTS, and improperly managed pet waste in both wet and dry weather conditions

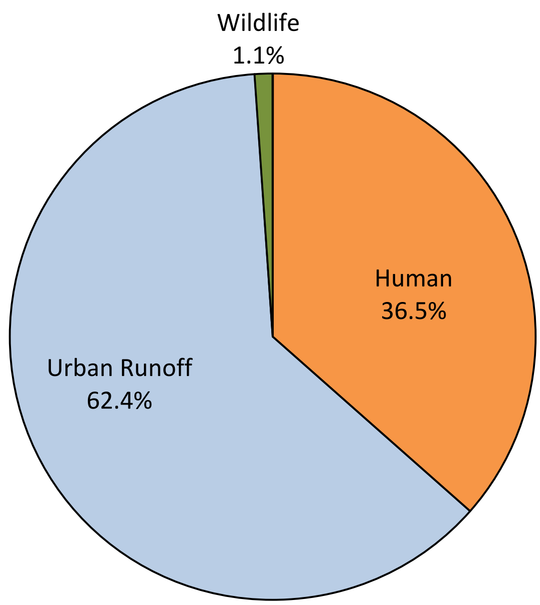

Figure 3-12 Estimated Bacteria Loading by Source for Wet Weather Conditions

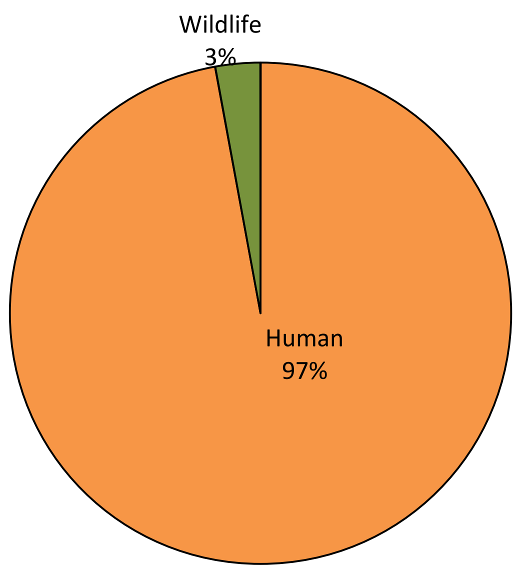

Figure 3-13 Estimated Bacteria Loading by Source for Dry Weather Conditions

3.6.3 Nutrients

These sections provide a brief discussion of the potential sources of phosphorus to Bennett Lake and Wakefield Lake, although the actual quantification of these sources will be further discussed in Section 4.3 of this TMDL report. The sources of phosphorus can be classified into permitted or non-permitted sources, which will be defined and discussed in the following sections.

3.6.3.1 Permitted Sources

Permitted sources of TSS are the same as described in Section 3.6.1.1.

3.6.3.2 Non-Permitted Sources

Non-permitted sources of phosphorus are those that are not regulated by the NPDES/SDS program. For many lakes, especially shallow lakes, these sources can be a significant portion of the TP load to the lake and can be a major contributor to impairment. The following are examples of the typical non-permitted sources of phosphorus:

- **Atmospheric Deposition** – Phosphorus can be deposited directly on the surface of the lake during precipitation events and as dry deposition of particles in between events (e.g., particles suspended by wind that settles out).

- **Watershed Loading** – Phosphorus loads from runoff from rural and/or urban portions of a watershed that are not regulated by an NPDES/SDS MS4 Permit and may also include discharges from upstream lakes (that may or may not be impaired/have an approved TMDL).

- **Internal Sources** – There are a variety of potential sources of phosphorus that can come from within the lake. Examples include release of phosphorus bound to lake bottom sediments during anoxic conditions, the senescence of certain aquatic vegetation (e.g., Curlyleaf pondweed) during the GS, the activity of benthivorous fish such as carp, suspension of bottom sediments due to wind and/or boat traffic, and GW interaction.

- **Non-compliant SSTS** – In rural areas not served by sanitary sewer systems, non-compliant SSTS on lakeshore properties and in other locations in the watershed can contribute to nutrient impairments.

4. TMDL Development

The TMDL is defined by the loading capacity for a given pollutant which is distributed among its components as follows:

TMDL = WLA + LA + MOS + Reserve Capacity

Where:

WLA	=	Wasteload Allocation to Point (Permitted) Sources
LA	=	Load Allocation to Nonpoint (Non-Permitted) Sources
MOS	=	Margin of Safety
Reserve Capacity	=	Load set aside for future allocations from growth or changes

A list of MS4 permittees within each impaired watershed area is included in Appendix E.

4.1 Total Suspended Sediment (TSS)

TSS was determined to be the primary stressor to aquatic life in the Battle Creek Stressor Identification Report. For this reason, a TSS TMDL for Battle Creek was developed using the load duration approach, as described in the following sections.

4.1.1 Flow Duration Curve

The applicable water quality standard for TSS applies to the months of April through September. Therefore, a flow duration curve was developed by calculating the average daily flow in Battle Creek for the months of April through September and ranking the resulting values from highest to lowest. Flow measurements were collected at the Battle Creek WOMP station (Figure 3-5) from 1996 through 2013. The flow-duration curve for Battle Creek shown in Figure 4-1 depicts the percentage of time that the average daily flow in any given month between April and October exceeds a particular flow rate value.

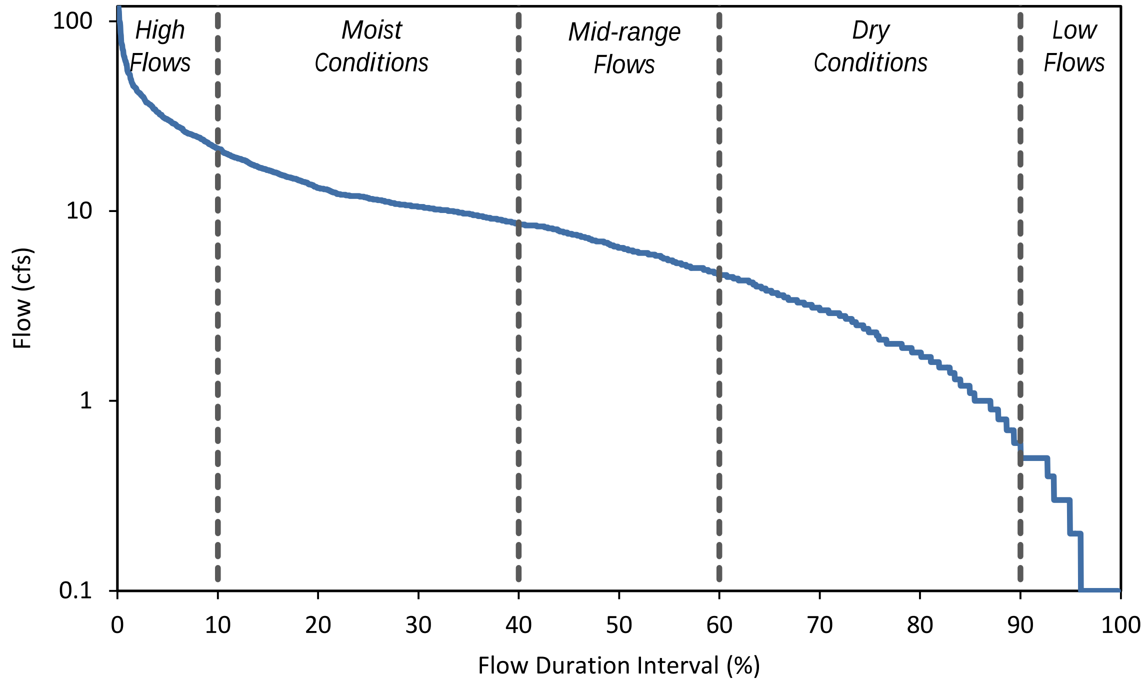

Figure 4-1 April through September Flow Duration Curve for Battle Creek

4.1.2 Load Duration Curve

Similar to the flow duration curve, the load duration curve relates TSS loading at a given flow to how often that flow value is exceeded in the stream. The load duration curve is calculated by multiplying the flow duration curve (Figure 4-1) by the MPCA TSS water quality standard for Class 2B streams (30 mg / 100 mL; see Section 2.2) and converting to a daily loading in terms of pounds of TSS per day. The resulting TSS load is then plotted relative flow duration interval. The final TSS load duration curve (Figure 4-2) represents the TMDL for Battle Creek for any given flow rate observed in the available data set.

Figure 4-2 shows the TSS load duration curve as well as observations of TSS loading (expressed in terms of pounds of TSS per day) collected at the Battle Creek WOMP station. Because it would be impractical to develop a TMDL for all potential flow rates in Battle Creek, the load duration curve is instead broken into the five flow conditions shown in Figure 4-2 (high flow, moist conditions, mid-range flows, dry conditions, and low flows). The median value (or midpoint) of the load duration curve within each flow condition defines the TMDL for each flow condition. Because the MPCA TSS standard states that the standard concentration (30 mg TSS / 100 mL) may be exceeded in no more than 10% of the time, the 90th percentile of observed TSS loading within each flow condition defines the existing load for each flow condition.

Figure 4-2 demonstrates that exceedances of the TSS standard in Battle Creek are common, particularly during high flows, moist conditions, and mid-range flows.

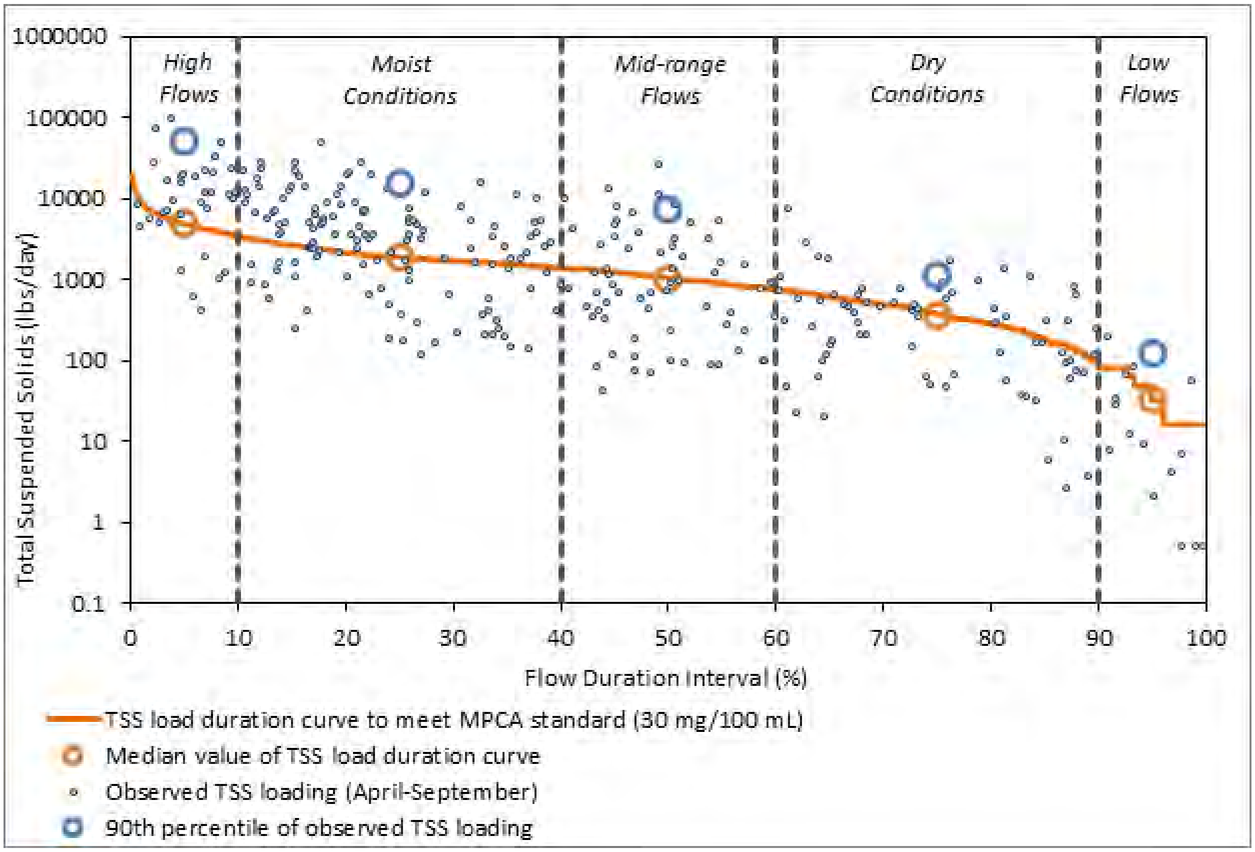

Figure 4-2 Battle Creek TSS load duration curve

4.1.3 Loading Capacity

As outlined in the TSS source assessment (Section 3.6.1), TSS loading to Battle Creek comes from a variety of sources, including point (permitted) and non-point (non-permitted) sources. The allowable TSS load is dependent upon flow conditions, and therefore is dynamic. The TMDL is expressed in terms of the total daily loading capacity for the various flow regimes. Because the TSS water quality standard states that the TSS water quality concentration of 30 mg/L may be exceeded no more than 10% of the time, the total daily loading capacity is compared to the 90th percentile value of existing loading within each flow regime to determine required loading reductions.

Table 4-2 shows the TMDL in terms of the total load capacity for the TSS water quality standard. The load duration curve was developed by multiplying the flow-duration curve (Figure 4-1) by the TSS water quality standard (30 mg/L). The TMDL for Battle Creek is defined by the midpoint daily total loading capacity for each of the five flow intervals. Existing loading is defined by the 90th percentile value of observed TSS loading within each flow interval.

4.1.4 Wasteload Allocation Methodology

The WLAs for TMDLs are typically divided into three categories: permitted MS4s, permitted point source dischargers, and construction and industrial storm water. The following sections describe how each of these allocations was estimated.

4.1.4.1 Construction and Industrial Stormwater Permits

The WLAs for the construction and industrial stormwater permits are based on estimates of the average annual percentage of the county area under an MPCA Construction Stormwater Permit, using the MPCA Construction Stormwater Permit data provided from 2007-2013 for Ramsey County and Washington County. From 2007-2013, the estimated average annual area under the MPCA Construction Stormwater Permit was 0.35% of the combined area of Ramsey and Washington County. We assumed that the same percentage for construction stormwater would apply for the MPCA Industrial Stormwater Permits, so the total percentage of the Battle Creek Watershed was assumed to be under MPCA Construction or Industrial Stormwater Permits was 0.7%. The WLA assigned to construction and Industrial Stormwater Permits was calculated by applying percent watershed area assumed to be under construction or industrial stormwater permit (0.7%) to the estimated loading capacity estimated for external watershed sources. The 3M Corporate Headquarters campus is an industrial stormwater permit holder within the Battle Creek Watershed. The 3M campus is entirely contained within the city of Maplewood, and comprises a significant portion of the total Maplewood drainage area within the Battle Creek Watershed. Therefor an individual WLA for 3M was not calculated separately, and was instead included within the total WLA assigned to all permitted sources.

Load reductions for construction stormwater activities are not specifically targeted in this TMDL. It should be noted that construction stormwater activities are considered in compliance with provisions of this TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install, and maintain all stormwater BMPs required under the permit, including any applicable additional BMPs required in the Construction General Permit for discharges to impaired waters; or meet local construction stormwater requirements if they are more restrictive than requirements of the Construction General Permit. Industrial stormwater activities are considered in compliance with provisions of the TMDL if they obtain an Industrial Stormwater General Permit or General Sand and Gravel General Permit (MNG49) under the NPDES program and properly select, install, and maintain all BMPs required under the permit.

4.1.4.2 Permitted MS4s

There are portions of six MS4s within the Battle Creek Watershed (Figure 4-3). Table 4-1 summarizes the total area of each MS4 within the Battle Creek Watershed. The MS4 WLAs were calculated by multiplying the municipalities' percent watershed coverage by the total watershed loading capacity after the MOS and permitted source discharge allocations were subtracted. Permitted sources of TSS include all TSS mobilized by watershed runoff and discharged into the stream through MS4 stormsewer infrastructure.

Table 4-1 MS4 summary for Battle Creek

MS4 Name	MS4 ID Number	MS4 Area within the Contributing Watershed (acres)[1]
Maplewood	MS400032	921
MnDOT Metro District	MS400170	118
Ramsey County	MS400191	552
St. Paul	MN0061263	790
Washington County	MS400160	6
Woodbury	MS400128	268

[1] Open water area removed from total MS4 contributing watershed area (open water summary in Table 3-2).

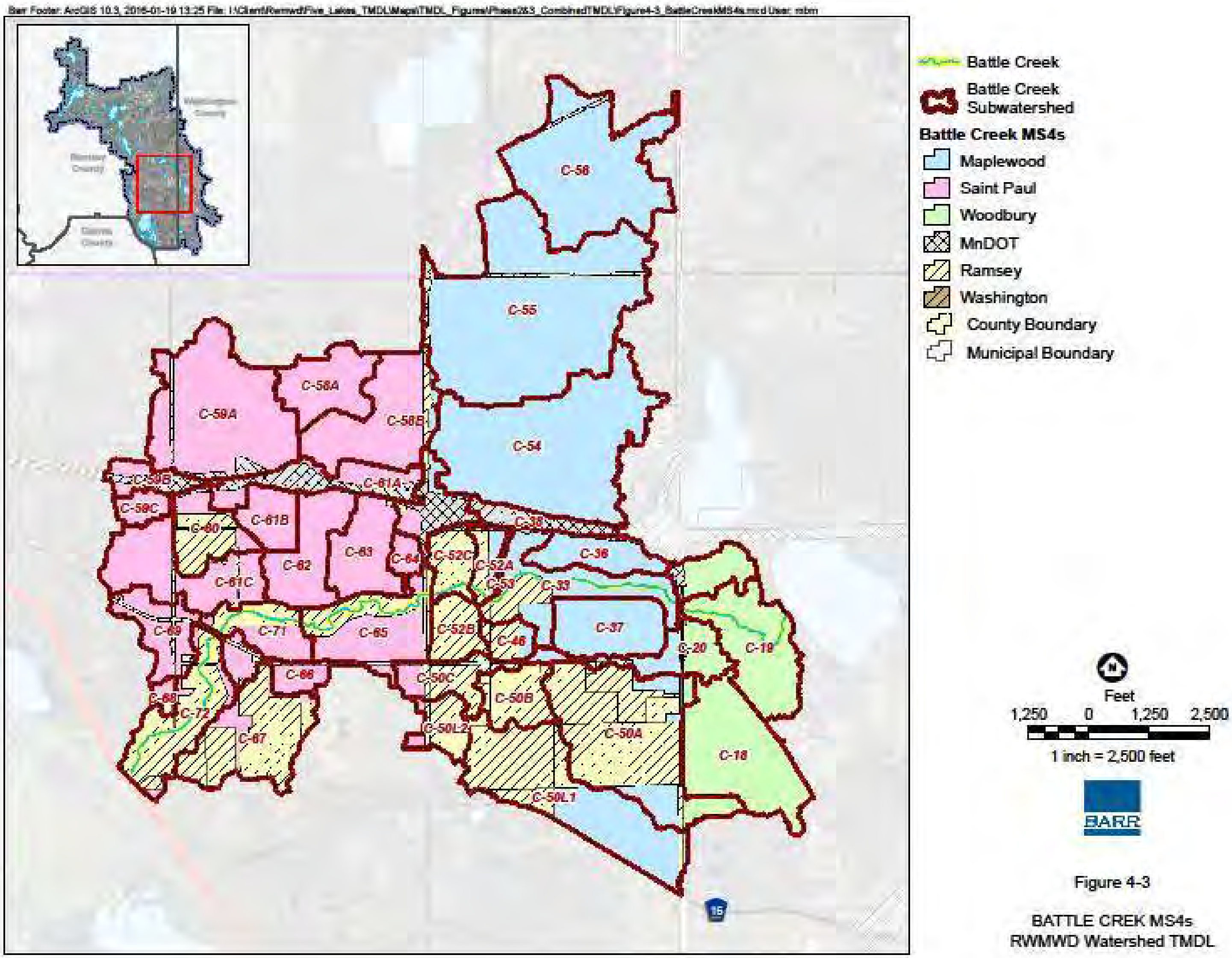

Figure 4-3 MS4s in Battle Creek Watershed

4.1.4.3 NPDES Point Source Dischargers

There are no non-stormwater NPDES permitted point source surface dischargers identified within the Battle Creek Watershed.

4.1.5 Load Allocation Methodology

The LA is the remaining load after the MOS and WLA are subtracted from the total load capacity of each flow zone. For this TMDL, the LA includes loading from upstream waterbodies (i.e., Battle Creek Lake), and loading from sources within the stream and stream corridor (e.g., sediment resuspension within the stream channel, erosion and bank failure within the stream corridor, in-channel algal production, etc.).

4.1.6 Margin of Safety

A reasonable MOS is necessary in order to account for natural variability and uncertainty in the effect that the calculated LAs will have on observed water quality. The MOS can be defined either explicitly, or implicitly, through the use of conservative assumptions. In this TSS TMDL study, an explicit 10% MOS was applied, whereby 10% of the loading capacity for each flow regime was subtracted before WLAs and LAs were calculated. A 10% MOS was considered to be appropriate because the load duration curve minimizes uncertainties that can arise through other approaches. Load duration curves are simply a function of average daily flow multiplied by numerical water quality standards.

4.1.7 Seasonal Variation

Seasonal variation is accounted for by the use of a load duration curve to set TMDLs over seasonal flow regimes. The in-stream data used for the source assessment and the calculation of required load reductions represents observations across the range of seasonal and annual flow variation and loading conditions. Because the TSS water quality standard only applies from April 1 through September 30, flow and loading data for the winter months were excluded from this analysis. Because several years of flow and TSS monitoring data were collected and utilized in this analysis, the TMDL accounts for both seasonal and annual variations.

4.1.8 TMDL Summary

Table 4-2 presents the TMDL for Battle Creek, expressed as pounds of loading per day, along with the WLA and LA for the creek. Also summarized in this table are the required TSS reductions, which were determined by comparing measured TSS loading data to the total daily load capacity within each flow zone. The WLAs presented in Table 4-2 is categorical, meaning that the total LAs to several permitted sources are grouped into a single WLA, with the exception of the MnDOT Metro District. The categorical WLA approach is being taken as the RWMWD is initially taking the lead role in implementing projects to achieve the WLA defined in the Battle Creek TSS TMDL.

Table 4-2 Battle Creek TMDL summary

	Flow Zone				
	Very High	High	Mid	Low	Very Low
	TSS Loading (lbs/day)				
Wasteload Allocation	**1,876**	**722**	**395**	**142**	**12**
Maplewood Ramsey County St. Paul Washington County Woodbury	1,763	679	371	133	12
Construction / Industrial	31	12	7	2	0
MnDOT Metro District	82	32	17	6	1
Load Allocation	2,551	982	537	193	17
Margin of Safety (10%)	492	189	104	37	3
Total Load Capacity (TMDL)	4,919	1,893	1,036	372	32
Existing Load, Permitted[1]	22,059	6,555	3,173	470	52
Existing Load, Non-Permitted[1]	29,992	8,912	4,314	639	70
Total Existing Load[1]	52,051	15,466	7,487	1,109	122
Required Load Reduction	47,132	13,573	6,451	737	90
Required Load Reduction (%)	91%	88%	86%	66%	73%

[1] Loading reported for all existing condition sources represents the 90th percentile of observed loading.

4.2 Bacteria (*E. coli*)

The TMDL for Fish Creek was developed using the load duration approach (MPCA 2009), as described in the following sections.

4.2.1 Flow Duration Curve

The applicable water quality standard for bacteria applies to the months of April through October. Therefore, a flow duration curve was developed by calculating the average daily flow in Fish Creek for the months of April through October and ranking the resulting values from highest to lowest. Flow measurements were collected at the Fish Creek WOMP station (Figure 3-7) from 1996 through 2013. The flow-duration curve for Fish Creek shown in Figure 4-4 depicts the percentage of time that the average daily flow in any given month between April and October exceeds a particular flow rate value.

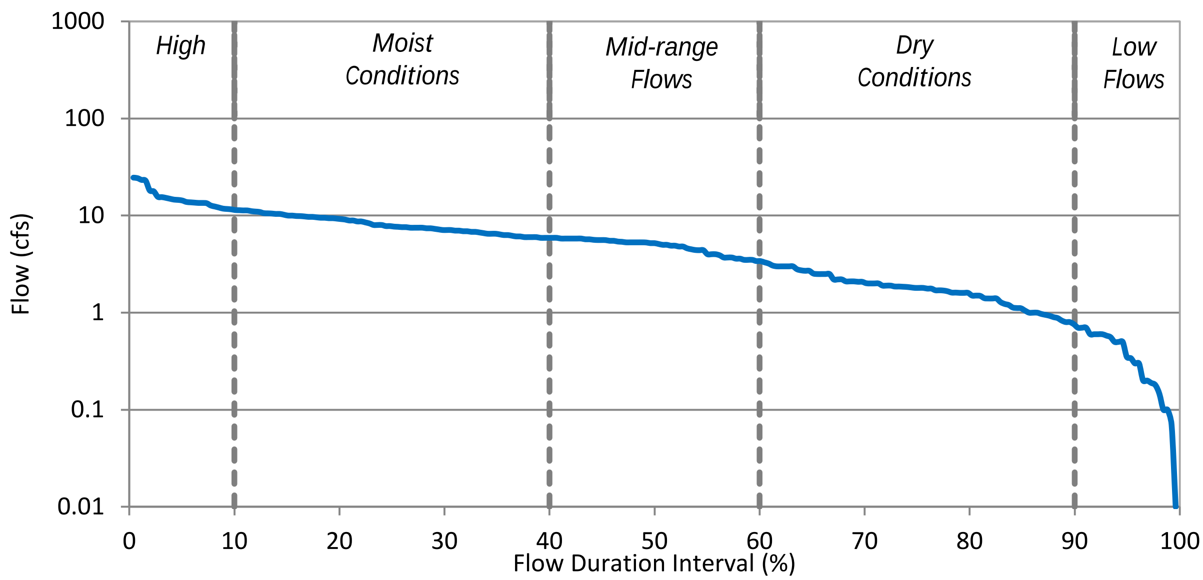

Figure 4-4 April through October Flow Duration Curve for Fish Creek

4.2.2 Load Duration Curve

Similar to the flow duration curve, the load duration curve relates bacteria loading at a given flow to how often that flow value is exceeded in the stream. The load duration curve is calculated by multiplying the flow duration curve (Figure 4-4) by the chronic *E. coli* standard for Class 2C streams (126 cfu / 100 mL) and converting to a daily loading in terms of billions of organisms per day. The resulting bacteria load is then plotted relative flow duration interval. The final chronic load duration curve (Figure 4-5) represents the TMDL for Fish Creek for any given flow rate observed in the available data set.

Figure 4-5 shows the chronic load duration curve as well as observations of bacteria abundance (expressed in terms of *E. coli*) collected at the Fish Creek WOMP station (station ID 99UM075). Because it would be impractical to develop a TMDL for all potential flow rates in Fish Creek, the load duration curve is instead broken into the five flow conditions shown in Figure 4-5 (high flow, moist conditions, mid-range flows, dry conditions, and low flows). The median value (or midpoint) of the chronic load duration curve within each flow condition defines the TMDL for each flow condition. Because the MPCA chronic bacteria standard is developed based on the geometric mean of observed *E. coli* concentrations, the geometric mean of observed data within each flow condition defines the existing load for each flow condition.

Figure 4-5 demonstrates that *E. coli* loading in Fish Creek is typically above the loading permitted by the chronic water quality standard of 126 organisms per 100 mL, particularly during moist conditions, dry conditions, and low flows.

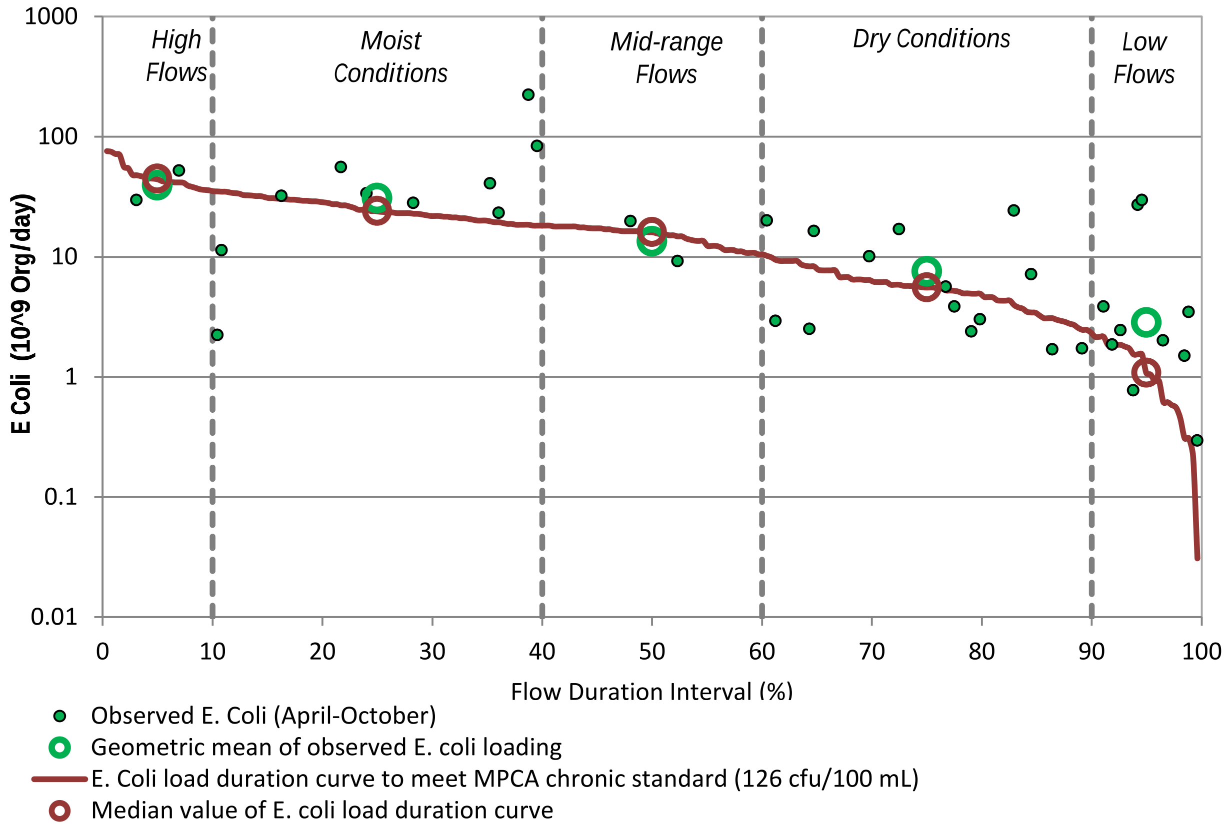

Figure 4-5 Fish Creek *E. coli* load duration data

4.2.3 Loading Capacity

As outlined in the bacteria source assessment (Section 3.6.2), bacterial loading to Fish Creek comes from a variety of sources, including point (permitted) and non-point (non-permitted) sources. The allowable bacteria load is dependent upon flow conditions, and therefore is dynamic. The TMDL is expressed in terms of the total daily loading capacity for the various flow regimes. The focus of this analysis is on the chronic *E. coli* standard of 126 organisms per 100 mL (applied to the monthly geometric mean) rather than the acute standard of 1,260 organisms per 100 mL. It is assumed that achieving the necessary reductions to meet the chronic standard will also reduce exceedances of the acute standard to within acceptable limits.

Table 4-4 shows the TMDL in terms of the total load capacity for the chronic water quality standard. As described in Section 4.2.2, the load duration curve was developed by multiplying the flow-duration curve (Figure 4-4) by the *E. coli* chronic water quality standard (126 organisms per 100 mL). The TMDL for Fish Creek is defined by the midpoint daily total loading capacity for each of the five flow intervals. Existing loading is defined by the geometric mean of observed *E. coli* loading within each flow interval.

4.2.4 Wasteload Allocation Methodology

The WLAs for TMDLs are typically divided into three categories: permitted MS4s, permitted point source dischargers, and construction and industrial storm water. The following sections describe how each of these LAs was estimated. The WLAs for regulated construction stormwater (permit #MNR100001) were not developed, since *E. coli* is not a typical pollutant from construction sites. The WLAs for regulated industrial stormwater were also not developed. Industrial stormwater must receive a WLA only if the pollutant is part of benchmark monitoring for an industrial site in the watershed of an impaired water body. There are no bacteria or *E. coli* benchmarks associated with any of the Industrial Stormwater Permit (permit #MNR050000).

4.2.4.1 Permitted MS4s

There are portions of seven MS4s within the Fish Creek Watershed (Figure 4-6). Table 4-3 summarizes the total area of each MS4 within the Fish Creek Watershed. The MS4 WLAs were calculated by multiplying the municipalities' percent watershed coverage by the total watershed loading capacity after the MOS and permitted point source discharge allocations were subtracted. *E. coli* from improperly managed pet waste mobilized by stormwater runoff was the only point source of *E. coli* identified in the Fish Creek Watershed.

Table 4-3 MS4 summary for Fish Creek

MS4 Name	MS4 ID Number	MS4 Area within the Contributing Watershed (acres)[1]
Maplewood	MS400032	394
Newport	MS400040	32
MnDOT Metro District	MS400170	45
Ramsey County	MS400191	104
St. Paul	MN0061263	21
Washington County	MS400160	4
Woodbury	MS400128	182

[1] Open water area removed from total MS4 contributing watershed area (open water summary in Table 3-2).

4.2.4.2 NPDES Point Source Dischargers

There are no non-stormwater NPDES permitted point source surface dischargers identified within the Fish Creek Watershed.

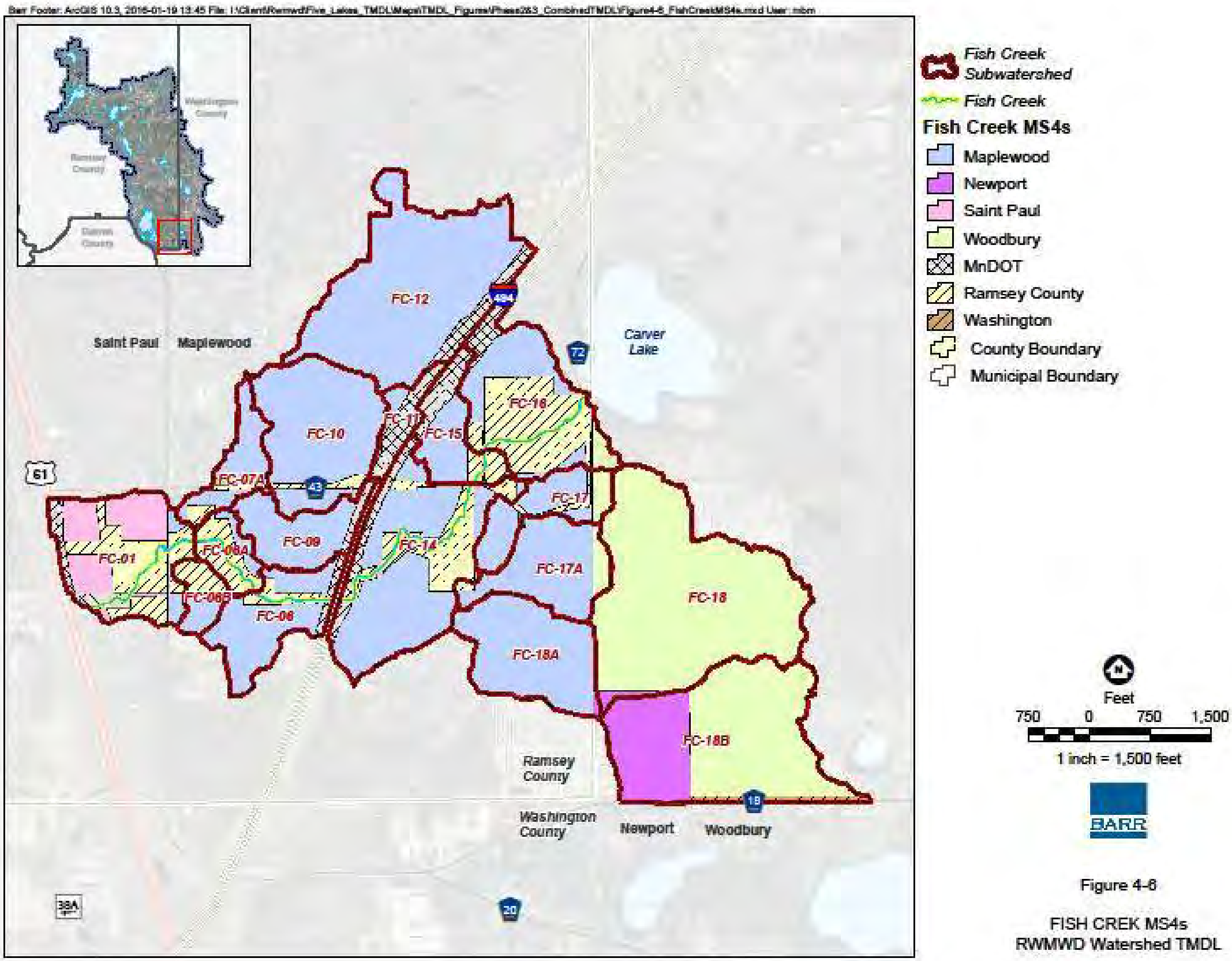

Figure 4-6 MS4s in Fish Creek Watershed

4.2.5 Load Allocation Methodology

The LA is the remaining load after the MOS and WLA are subtracted from the total load capacity of each flow zone. For this TMDL, the LA includes loads from non-compliant SSTS, sanitary sewer exfiltration, and bacteria loading from wildlife.

4.2.6 Margin of Safety

A reasonable MOS is necessary in order to account for natural variability and uncertainty in the effect that the calculated LAs will have on observed water quality. The MOS can be defined either explicitly, or implicitly, through the use of conservative assumptions. In this *E. coli* TMDL study, an explicit 10% MOS was applied, whereby 10% of the loading capacity for each flow regime was subtracted before WLAs and LAs were calculated. A 10% MOS was considered to be appropriate because the load duration curve minimizes uncertainties that can arise through other approaches. Load duration curves are simply a function of average daily flow multiplied by numerical water quality standards.

4.2.7 Seasonal Variation

Seasonal variation is accounted for by the use of a load duration curve to set TMDLs over seasonal flow regimes. The in-stream data used for the source assessment and the calculation of required load reductions represents observations across the range of seasonal and annual flow variation and loading conditions. Because the *E. coli* water quality standard only applies from April 1 through October 31, flow and loading data for the winter months were excluded from this analysis. Because several years of flow and bacteria monitoring data were collected and utilized in this analysis, the TMDL accounts for both seasonal and annual variations.

4.2.8 TMDL Summary

Table 4-4 presents the TMDL for Fish Creek, expressed as billion organisms per day of *E. coli*, along with the WLA and LA for the creek. Also summarized in this table are the required bacteria reductions which were determined by comparing measured *E. coli* data to the total daily load capacity within each flow zone. The WLAs presented in Table 4-4 is categorical, meaning that the total LAs to several permitted sources are grouped into a single WLA, with the exception of the MnDOT Metro District. The categorical WLA approach is being taken as the RWMWD is initially taking the lead role in implementing projects to achieve the WLA defined in the Fish Creek bacteria TMDL. Newport is not included in the MS4s implicated in the categorical WLA, as Newport is not currently within the legal limits of RWMWD. As such, RWMWD plans to help its official member cities achieve this WLA without the involvement of the city of Newport.

Table 4-4 Fish Creek TMDL Summary

	Flow Zone				
	Very High	High	Mid	Low	Very Low
	billion organisms per day (b-org/day)				
Wasteload Allocation	**18.2**	**9.8**	**6.5**	**2.3**	**0.4**
Maplewood	17.2	9.2	6.2	2.1	0.4
Ramsey County					
St. Paul					
Washington County					
Woodbury					
MnDOT Metro District	1.0	0.6	0.4	0.1	0.0
Load Allocation	22.0	11.8	7.9	2.7	0.5
Margin of Safety (10%)	4.5	2.4	1.6	0.6	0.1
Total Load Capacity (TMDL)	44.7	24.0	16.0	5.5	1.1
Existing Load, Permitted	17.8	13.9	6.1	3.4	1.3
Existing Load, Non-Permitted	21.5	16.8	7.3	4.1	1.5
Total Existing Load	39.3	30.7	13.4	7.5	2.8
Required Load Reduction	0	6.7	0	2.0	1.7
Required Load Reduction (%)	0%	22%	0%	26%	62%

4.3 Nutrients

The nutrient load capacity and TMDL established for Bennett Lake and Wakefield Lake are based on the 2005 and 2004 water quality conditions, respectively. The years analyzed produced the highest growing season concentrations of TP observed in each lake over the past decade of water quality data analyzed, and were chosen to reflect the critical condition of phosphorus loading to each water body.

4.3.1 Loading Capacity Methodology

The following section outlines the water quality modeling efforts performed as part of the establishment of the Bennett Lake and Wakefield Lake nutrient TMDLs. Table 4-5 summarizes precipitation and growing season average TP concentration during the critical year in Bennett and Wakefield Lake.

Table 4-5 Summary of precipitation and water quality during critical year in Bennett Lake and Wakefield Lake

Waterbody	Critical Year	Water Year Precipitation (inches)	Growing Season Precipitation (inches)	Growing Season Average TP (µg/L)
Bennett Lake	2005	29.8	18.4	210
Wakefield Lake	2004	28.6	13.1	154

Water quality modeling provided the means to estimate the TP sources to each lake and estimate the effects on lake water quality. Water quality modeling was a two-fold effort, involving:

- A stormwater runoff model (P8 Urban Catchment Model) that estimated the water and TP loads from the lake's tributary watershed; and

- An in-lake mass balance model that took the water and TP loads from the lake's external and internal sources, and generated the resultant lake TP concentration.

The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) Urban Catchment Model and the in-lake mass balance model are described in more detail below.

4.3.1.1 Watershed Loading (P8 Modeling)

The P8 Urban Catchment (computer) Model (Version 2.4) was used to estimate watershed runoff and TP loads from the Bennett and Wakefield Lake Watersheds. The model and its supporting information can be downloaded from the internet at http://wwwalker.net/p8/.

The P8 is a useful diagnostic tool for evaluating and designing watershed improvements and BMPs because it can estimate the treatment effect of several different kinds of potential BMPs. The P8 tracks stormwater runoff as it carries phosphorus across watersheds and incorporates the treatment effect of detention ponds, infiltration basins, flow splitters, etc. on the TP loads that ultimately reach downstream water bodies. P8 accounts for phosphorus attached to a range of particulate sizes, each with their own settling velocity, tracking their removal by treatment features accordingly.

The key inputs to the P8 model are based on the each subwatershed's total area, the fraction of each subwatershed that is directly-connected imperviousness and depression storage, as well as the composite pervious area curve number (representing both pervious and unconnected impervious areas). Directly-connected impervious areas create runoff that is hydraulically connected to the drainage systems, while runoff that drains from impervious surfaces to pervious surfaces is not considered directly-connected. The P8 model also requires climate data (hourly precipitation and daily average temperature), treatment device configurations information (outlets, storage volumes, seepage rates, etc.) and pollutant loading parameters to estimate pollutants in runoff and removal of those pollutants by various treatment devices.

The P8 models used in this TMDL were developed and updated for this study and reflect the natural wetlands and other stormwater management practices constructed throughout each watershed. The P8 was used to generate a range of water and phosphorus loadings from each lake's watershed during the critical water quality period. Table 4-6 summarizes the critical year water and phosphorus loads predicted using P8 for Bennett and Wakefield Lake.

Table 4-6 Summary of P8 modeled water and phosphorus loads

Waterbody	Critical Year	Water Year Water Load (ac-ft)	Growing Season Water Load (ac-ft)	Water Year TP Load (lbs)	Growing Season TP Load (lbs)
Bennett lake	2005	436	250	113.3	70.1
Wakefield Lake	2004	536	232	254.8	127.7

A detailed discussion about the P8 modeling used for this study along with the estimated P8 loadings to each lake for each precipitation event is located in Appendix A.

4.3.1.2 Atmospheric Deposition

Atmospheric deposition of phosphorus directly to the lake surface was quantified based on the estimated lake surface area throughout the year (determined by the water balance model) and a deposition rate of 0.2615 kg/ha/yr (0.000639 lb/ac/d), a rate established in the Detailed Assessment of Phosphorus Sources to Minnesota Watersheds (Barr 2005).

Table 4-7 Summary of estimated atmospheric deposition phosphorus load

		TP load from Atmospheric Deposition (lbs)	
Waterbody	**Critical Year**	**Water Year**	**Growing Season**
Bennett Lake	2005	7.0	2.3
Wakefield Lake	2004	4.8	1.4

4.3.1.3 Sediment Release

The net internal loading of phosphorus in Bennett and Wakefield Lake was calculated by deduction, using the difference between the predicted water quality using the in-lake mass balance model and the observed water quality data after all other phosphorus inputs to and losses from each lake were estimated (see Section 4.3.1.7 for additional details). To verify that the predicted internal load is reasonable, internal loading was checked against available sediment core data from Bennett and Wakefield Lake. Sediment phosphorus data are discussed below.

Four sediment cores were collected from Wakefield Lake in November 2006 and two sediment cores were collected from Bennett Lake in November of 2012. Sediment cores were analyzed for various phosphorus fractions, including mobile phosphorus and organic phosphorus fractions (Pilgrim et al. 2007). The mobile-phosphorus fraction includes loosely-sorbed phosphorus and iron-bound phosphorous, which are the portions of the sediment phosphorus pool that can most readily be released back into the water column as soluble phosphorus. The iron-phosphorus fraction is insoluble as long as the iron remains oxidized, but can become soluble again if the iron becomes reduced under anoxic conditions (i.e., absence of oxygen). The potential sediment phosphorus release rates were estimated by comparing concentrations of sediment phosphorus fractions to relationships developed by Pilgrim et al. (Pilgrim et al. 2007). The estimated mobile phosphorus release rate from the sediments ranged from 0.2 - 0.4 mg/m^2/day in Bennett Lake, and 2.4 - 3.0 mg/m^2/day in Wakefield Lake.

Lake sediments often become anoxic in summer months, and phosphorus that was previously bound to iron in the sediment becomes soluble and is released back into the water column. This newly released phosphorus is in the form of soluble reactive phosphorus, and is readily available for uptake and utilization by algae. Bennett Lake and Wakefield Lake are shallow, polymictic lakes, meaning the lakes do not experience strong thermal stratification and will mix multiple times during the growing season. However, review of DO levels collected along the profile of both lakes during various years suggests that the sediment-water interface may experience anoxic conditions intermittently. As such, enough phosphorus can be released from sediment to impact the relatively small volume of each shallow lake.

In addition to release of mobile phosphorus from sediment due to anoxic conditions, internal loading of phosphorus can also be increased by dieback and decomposition of aquatic macrophytes such as Curlyleaf pondweed, as well as resuspension of lake-bottom sediments caused by wind and the activity of benthivorous fish such as carp. Curlyleaf pondweed has been observed in Wakefield Lake, but not quantified in a macrophyte survey (surveys of the lake have historically taken place after die-back of Curlyleaf pondweed). A 2009 macrophyte survey found 63% coverage of Curlyleaf pondweed over the surface area of Bennett Lake. Carp have not been detected in Wakefield Lake, but have been observed in Bennett Lake as recently as 2012.

Table 4-8 summarizes the estimated phosphorus release rates over the average lake surface area during the GS from each in-lake mass balance model. As can be seen, the estimated magnitude of phosphorus load due to sediment release in Wakefield Lake aligns with the estimated anoxic phosphorus release rate based on collected sediment core data. The deduced internal loading rate for Bennett Lake is slightly greater than the release rate predicted by sediment core data with a 0.1% daily recycle rate assumed. This suggests that release from Curlyleaf pondweed and resuspension caused by carp activity contribute significantly to the total internal phosphorus loading within the Lake. Because the loading rate predicted by sediment core analysis reflects only anoxic release of phosphorus from lake-bottom sediments, it seems reasonable the internal loading rate predicted by the Bennett in-lake model is higher as the in-lake model predicts loading rate from all sources, including anoxic release, Curlyleaf pondweed dieback, and sediment resuspension caused by carp activity.

Table 4-8 Estimated growing season internal phosphorus release rate

Waterbody	Critical Year	Sediment Core TP Release Range ($mg/m^2/d$)	Sediment Core TP Release Range w/ 0.1% daily recycling rate ($mg/m^2/d$)	Estimated Growing Season Internal Loading Rate ($mg/m^2/d$)	Estimated Total Growing Season Phosphorus Load From Internal Sources (lbs)
Bennett Lake	2005	0.2 - 0.4	2.1 – 2.8	3.4	78.1
Wakefield Lake	2004	2.4 – 3.0	- -	3.0	60.4

4.3.1.4 Aquatic Vegetation

The RWMWD conducted qualitative macrophyte surveys on Bennett Lake in 2009 and on Wakefield Lake in 2008 and 2012. Curlyleaf pondweed (*Potamogeton crispus*), a non-native submerged aquatic macrophyte, was observed in Bennett Lake, but was not detected in Wakefield Lake (potentially due to the timing of the macrophyte survey, as anecdotal evidence indicates Curlyleaf pondweed has been seen in the Wakefield Lake). Because Curlyleaf pondweed dies back in the middle of summer, the invasive species can increase GS internal phosphorus loading in a lake as it senesces. Additionally, the decaying plant matter consumes oxygen, potentially exacerbating anoxic conditions at the sediment-water interface. Estimates of phosphorus loading due to the dieback of Curlyleaf pondweed were based on the coverage and density of Curlyleaf pondweed in Bennett Lake (as observed in the 2009 qualitative macrophyte survey) and information presented in a study completed on Half Moon Lake in Wisconsin (James et al. 2001).

Coontail (*Ceratophyllum demersum*) was observed in all three of the macrophyte surveys performed on Bennett and Wakefield Lake. Because this macrophyte grows suspended in the water column and does not root in the sediment, it directly uptakes phosphorus from the water column and can impact the observed phosphorus concentrations. Based on the estimated areal coverage and relative density estimates from the early and late summer surveys, the amount of TP uptake by Coontail was estimated based on the coverage and density from the qualitative macrophyte surveys. These densities were associated with an amount of biomass determined from data from multiple lakes in the Twin Cities (Newman 2004) and average daily phosphorus uptake information (Lombardo and Cooke 2003).

Table 4-9 summarizes the estimated phosphorus load due to the dieback of Curlyleaf pondweed and the estimated phosphorus uptake by Coontail.

Table 4-9 Estimate growing season Curlyleaf Pondweed TP loading and TP uptake by Coontail

Waterbody	Critical Year	Estimated Growing Season TP Load from Curlyleaf Pondweed (lbs)	Estimated Growing Season TP Uptake by Coontail (lbs)
Bennett Lake	2005	12.3	1.2
Wakefield Lake	2004	- -	16.9

4.3.1.5 AdH 2D Modeling in Wakefield Lake

There are three storm sewer inlets to Wakefield Lake, including discharges from the subwatersheds PHAL-03a (northwest inlet), PHAL-03b (northeast inlet), and PHAL-03c (southeast inlet, also known as the "Larpenteur Avenue storm sewer", see Figure 3-4). However, during the development of the Wakefield Lake Strategic Lake Management Plan (Barr 2008), it was suspected that much of the runoff coming from the area drained by the Larpenteur Avenue storm sewer (including subwatersheds PHAL 03c and upstream PHAL 01, PHAL 02a and PHAL 02b) may not significantly influence the observed water quality of Wakefield Lake. Because the flows from Larpenteur Avenue enter on the southeast end of the lake directly across from the lake's outlet on the southwest corner of the lake, it was suspected that flow may be effectively bypassing the lake (short-circuiting). Water quality in the southern part of the lake has not historically been monitored (historic monitoring location is in the center of the lake, see Appendix D), so the impact of PHAL-03c flows on Wakefield Lake's water quality in the southern end of the lake are unknown. However, if short-circuiting occurs, it must be accounted for as part of the in-lake modeling to appropriately quantify the watershed phosphorus loads to Wakefield Lake that influence the water quality (as observed) and to deduce the lake's internal phosphorus loads (see Section 4.3.1.7 for additional discussion of the in-lake mass balance modeling). In order to better understand the mixing dynamics of Wakefield Lake and to estimate the contribution of the runoff from the Larpenteur Avenue storm sewer to the observed water quality in the main body of the lake, a 2-dimensional (2D) hydraulic model of inflows and mixing patterns in Wakefield Lake was developed. For further details on 2D modeling of Wakefield Lake, refer to Appendix D.

As a result of this hydrodynamic analysis, it is likely that the watershed inflows to Wakefield Lake do not fully-mix within the lake and that the majority of the phosphorus load from the watershed along Larpenteur Avenue does not directly influence the observed water quality. Flows from the southeast portion of the watershed primarily influences the water quality in Wakefield Lake due to diffusion of the soluble fraction of phosphorus from the southern portion of the lake to the main basin of the lake (where the historic water quality data has been collected) during the storm event and after an event (for any runoff remaining in the lake). The degree of flow-induced mixing during any given runoff event will be variable; however the primary mechanism governing the influence of the Larpenteur Avenue storm sewer runoff on the observed lake water quality in Wakefield Lake is diffusion. Based on the scenarios run in AdH, the predicted P8 watershed phosphorus loads used in the in-lake mass balance modeling were reduced to reflect the "effective" watershed load from the Larpenteur Avenue storm sewer. We assumed that only 30% of the soluble phosphorus load from the runoff coming through the Larpenteur Avenue storm sewer (southeast inlet) to Wakefield Lake actually influences the observed water quality. Because the P8 model tracks the movement of five different particle sizes (with a certain amount phosphorus associated with each particle size fraction), we were able to estimate the amount of soluble phosphorus coming from the Larpenteur Avenue watershed and reduce the effect of the particulate loading from the Larpenteur Avenue storm sewer used in the in-lake mass balance model to represent the main body of Wakefield Lake.

4.3.1.6 In-Lake Mass Balance Model

In-lake modeling for Bennett and Wakefield Lake was accomplished through the creation of mass balance models that track flow of water and phosphorus through each lake for the critical water quality growing season as well as the previous year. The mass balance models, referred to throughout as in-lake models, consider influent water and phosphorus loads (as discussed in the sections above) for a 17-month period.

The estimated water and phosphorus loads of the year prior to the critical year (12 months from May through end of April of the following year) were used to establish the steady-state phosphorus concentration in each lake at the beginning of the water quality calibration period, using published empirical models which predict lake phosphorus concentrations. The influent water and phosphorus loads from the remaining five months were then used in the in-lake mass balance model to evaluate the period of May 1 through September 30 of the critical year. Modeling results from June 1 through September 30 of the critical year were used to estimate the GS average water and phosphorus loading.

The key input parameters for the in-lake mass balance model include direct precipitation data, evaporation data, runoff loads from the lake's watershed (as predicted by the P8 model), the lake storage and outlet rating curve, and in-lake water quality monitoring data. Additional data, including sediment core data and macrophyte survey information, were used to verify that model estimates of internal phosphorus loading were reasonable.

Prior to conducting the phosphorus mass balance modeling for each lake, a daily water balance model was calibrated to observed historical lake level data in Bennett and Wakefield Lake. The daily water balance model developed for each lake was used in conjunction with lake level data to calibrate P8-predicted watershed loading to provide the best fit between the predicted and observed water levels.

Once the water balance was calibrated, the phosphorus mass balance modeling was performed in two phases. The first step was to predict the steady-state phosphorus concentration in the lake at the beginning of the calibration period. As previously mentioned, the P8 model was used to not only estimate the watershed loads for the critical water quality year/calibration period (e.g., May 1 through September 30 of the critical year), but also for the year prior. These annual loads for the year prior to the calibration period were used to estimate the steady-state concentration at the beginning of the calibration period. Several published empirical models were evaluated for Bennett and Wakefield Lake, and the model that provided the best fit to the observed early season phosphorus data was selected. By selecting the empirical model that provides the best fit, the in-lake water quality model can be used to predict the impact of changes in water and phosphorus loads to the lake on the steady-state spring phosphorus concentrations in the lake and through the subsequent GS.

The following empirical relationships were used to estimate the steady state phosphorus concentration in Bennett Lake and Wakefield Lake. Note that different empirical relationships were used to define the phosphorus retention coefficient between Bennett and Wakefield Lake.

Empirical Model (Dillon and Rigler, 1974):

$P = L(1 - Rp)/(z * p)$

Where:

L = Areal loading rate (mg/m^2/yr)

z = Mean depth (m)

p = Flushing rate (1/yr)

Rp = Phosphorus Retention Coefficient

Bennett Retention Coefficient (Larsen and Mercier, 1976):

$Rp = 1/(1 + p^{\frac{1}{2}})$

Wakefield Retention Coefficient (Chapra, 1975):

$Rp = 16/(16 + q_s)$

Where:

q_s = Overflow Rate (m/yr)

The second step to the calibration of the phosphorus mass balance model was to predict the observed TP concentrations in each lake during the respective calibration periods (May through September) for the critical water quality conditions. Calibration was performed at intervals coinciding with the water quality monitoring dates for each lake. Calibrating to these intervals allows for internal loading to be evaluated at multiple points throughout the growing season.

Phosphorus loads from the watershed predicted in P8 were combined with estimated phosphorus loading from atmospheric deposition and Curlyleaf pond weed dieback and compared to estimated phosphorus losses due to flushing and uptake by Coontail. To calibrate the in-lake models, phosphorus loads and losses were compared to the observed in-lake water quality data on each water quality sampling date. The magnitude of the internal phosphorus load to each lake's surface water was deduced by comparing the observed water quality in each lake to the water quality predicted by the in-lake models using the following general mass-balance equation for each time step:

P Adjustment = Observed P + Settling P + Coontail Uptake P + Groundwater Loss P – Runoff P – Atmospheric P – Curlyleaf P –Groundwater Inflow P - P Initial

The key calibration parameter for both of the in-lake models was this estimation of the internal phosphorus loading rate. As previously discussed, this internal loading rate was verified against available sediment and macrophyte data. Table 4-10 summarizes the results of the in-lake water quality model calibration for Bennett Lake and Wakefield Lake during the spring steady state condition and during the GS.

Table 4-10 In-Lake Water Quality Model Calibration

Waterbody	Critical Year	Water Quality Monitoring Data		Calibration Conditions	
		Observed Spring TP (µg/L)	Observed Growing Season Average TP	Model-Predicted Spring TP	Model-Predicted Growing Season Average TP
Bennett Lake	2005	73[1]	210	71[3]	210
Wakefield Lake	2004	66[2]	154	67[4]	154

1 Observed spring steady-state phosphorus concentrations based on earliest sampling date collected from Bennett Lake in May of each respective year. Earliest observed concentrations were taken as the average TP concentration from 0 to 2 meters depth on 5/4/2005, 5/3/2006, and 5/6/2008, respectively.

2 Observed spring steady-state phosphorus concentrations based on earliest sampling date collected from Wakefield Lake in May of each respective year. Earliest observed concentrations were taken as the average TP concentration from 0 to 2 meters depth on 5/12/2004, 5/16/2006, and 5/21/2008, respectively.

3 Predicted spring steady-state phosphorus based on the empirical equation Dillon and Rigler (1974) with Larsen and Mercier (1976) phosphorus retention coefficient.

4 Predicted spring steady-state phosphorus based on the empirical equation Dillon and Rigler (1974) with Chapra (1975) phosphorus retention coefficient.

The growing season TP loads for the calibrated Bennett Lake and Wakefield Lake in-lake mass balance models are summarized in Figure 4-7 and Figure 4-8. Appendix A includes details of the in-lake mass balance model methodology and Appendix B and Appendix C include tables summarizing the mass balance for critical year modeling of Bennett and Wakefield Lake used to establish each lake's nutrient TMDL.

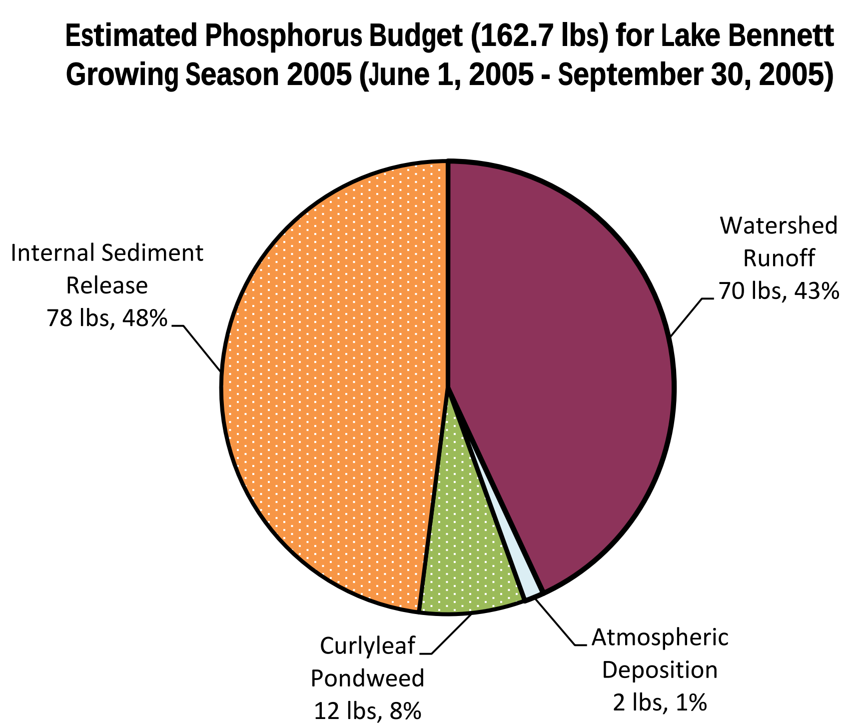

Figure 4-7 Bennett Lake 2005 growing season total phosphorus budget

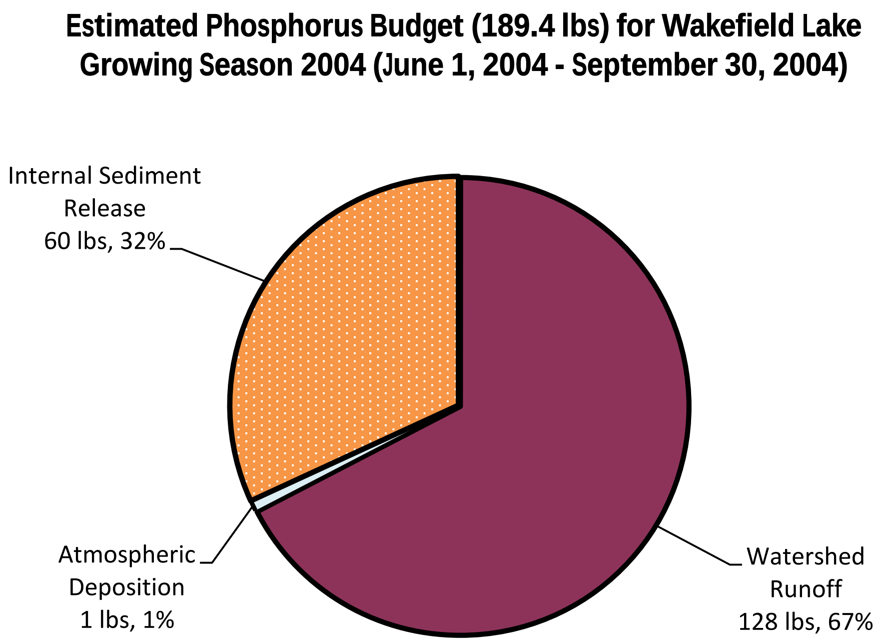

Figure 4-8 Wakefield Lake 2004 growing season total phosphorus budget

4.3.1.7 Load Capacity Summary

The existing conditions in-lake mass balance models were used to estimate the TP load to Bennett Lake and Wakefield Lake that would achieve the MPCA's shallow lake eutrophication TP standard (≤ 60 µg/L). The maximum allowable load is referred to as the lake's loading capacity. The estimated phosphorus load reduction (both internal and external) that would be required to achieve the MPCA shallow lake eutrophication TP standard for the critical year are defined for Bennett Lake and Wakefield Lake below in Table 4-11.

Table 4-11 Growing season load capacity for Bennett Lake and Wakefield Lake

Waterbody	Critical Year	Watershed Runoff	Atmospheric Deposition	Internal Loading[1]	Curlyleaf Pondweed	Total
Existing Conditions Total Phosphorus Load (lbs)						
Bennett Lake	2005	70.1	2.3	78.1	12.3	162.8
Wakefield Lake	2004	127.7	1.4	60.4	--	189.5
Estimated Load Capacity Total Phosphorus Load (lbs)						
Bennett Lake	2005	27.4	2.3	15.6	2.5	47.8
Wakefield Lake	2004	75.9	1.4	24.1	--	101.4

[1] Residual internal loading from all internal sources excluding P release from Curlyleaf Pondweed.

Estimated load capacity to Bennett and Wakefield Lake was determined reducing internal and external sources during critical year modeling to achieve the MPCA's shallow lake growing season eutrophication standard of 60 µg TP/L. The following assumptions were applied when evaluating phosphorus reductions to meet the MPCA water quality standards:

- The water loads and lake volumes would not change from existing conditions as a result of the phosphorus reductions.
- Atmospheric deposition was unchanged from existing conditions.
- Because the watersheds of both Bennett and Wakefield Lake are nearly fully-developed, our approach was to begin with internal sources of phosphorus (e.g., Curlyleaf pondweed and sediment release). A 60% reduction in internal load was targeted for Wakefield Lake, and an 80% reduction in internal load was targeted for Bennett Lake). After applying these internal load reductions, the required reduction of the external load from each lake's watershed was calculated based on the required total reduction to meet the MPCA's water quality standard.

4.3.2 Load Allocation Methodology

This section describes the methodology used to assign LAs to non-permitted phosphorus sources in the Bennett Lake and Wakefield Lake TMDLs. Existing phosphorus loads from non-permitted sources to Bennett and Wakefield Lake include direct atmospheric deposition to the lake surface and internal loading. The phosphorus LA for direct deposition to the lake surface and groundwater inflows is the same as existing conditions. Internal loading of phosphorus is a large proportion of TP load to both lakes. Based on identified implementation options, attainable percent reductions were applied to the internal load of Bennett Lake and Wakefield Lake. The resulting LAs for direct atmospheric deposition and internal loading for both waterbodies are discussed in greater detail in Section 4.3.1 .

4.3.3 Wasteload Allocation Methodology

4.3.3.1 Construction and Industrial Stormwater Permits

The WLAs for the construction and industrial stormwater permits are based on estimates of the average annual percentage of the county area under an MPCA Construction Stormwater Permit, using the MPCA Construction Stormwater Permit data provided from 2007-2013 for Ramsey County. From 2007-2013, the estimated average annual area under the MPCA Construction Stormwater Permit was 0.62% of Ramsey County. We assumed that the same percentage for construction stormwater would apply for the MPCA Industrial Stormwater Permits, so the total percentage of the Bennett and Wakefield Lake watersheds assumed to be under the MPCA Construction or Industrial Stormwater Permits was 1.24%. The WLA assigned to construction and industrial stormwater permits was calculated by applying percent watershed area assumed to be under construction or Industrial Stormwater Permit (1.24%) to the estimated loading capacity estimated for external watershed sources.

Load reductions for construction stormwater activities are not specifically targeted in this TMDL. It should be noted that construction stormwater activities are considered in compliance with provisions of this TMDL if they obtain a Construction General Permit under the NPDES program and properly select, install, and maintain all stormwater BMPs required under the permit, including any applicable additional BMPs required in the Construction General Permit for discharges to impaired waters; or meet local construction stormwater requirements if they are more restrictive than requirements of the Construction General Permit. Industrial stormwater activities are considered in compliance with provisions of the TMDL if they obtain an Industrial Stormwater General Permit or General Sand and Gravel General Permit (MNG49) under the NPDES program and properly select, install, and maintain all BMPs required under the permit.

4.3.3.2 Permitted MS4s

There are a total of three MS4s located within the Bennett Lake watershed, and four within the Wakefield Lake Watershed. Table 4-12 summarizes the total MS4 area within each watershed.

Table 4-12 MS4 summary for Bennett Lake and Wakefield Lake

Waterbody	MS4 Name	MS4 ID Number	MS4 Area within the Contributing Watershed (acres)[1]
Bennett Lake	City of Roseville	MS400047	632
	Ramsey County	MS400191	45
	MnDOT Metro District	MS400170	55
Wakefield Lake	City of Maplewood	MS400032	664
	Ramsey County	MS400191	181
	City of St. Paul	MN0061263	47
	City of North St. Paul	MS400041	27

[1] Open water area removed from total MS4 contributing watershed area (open water summary in Table 3-2).

Figure 4-9 and Figure 4-10 show the MS4s in the Bennett Lake and Wakefield Lake Watersheds, respectively. To determine the WLAs assigned to each individual MS4 in the Bennett Lake Subwatershed, the fraction of the watershed phosphorus wasteload for each MS4 was allocated proportional to the area of each MS4's contributing watershed. For example, the city of Roseville comprises 86% of the total land area in Bennett Lake, and receives 86% of the estimated load capacity for watershed sources of phosphorus.

The WLA calculation for MS4s in the Wakefield Lake watershed was based on a similar methodology, but accounts for the fact that 2D modeling in AdH (see Section 4.3.1.5) showed that subwatersheds PHAL-03a, PHAL-03b, and PHAL-03c located in the southern portion of the watershed short-circuit, and only 30% of the soluble phosphorus load from these subwatersheds contributes to water quality in Wakefield Lake. To account for short-circuiting, the portion of the WLA assigned to subwatersheds PHAL-03a, PHAL-03b, and PHAL-03c was adjusted based on the effective loading of 30% of the total soluble phosphorus loads from these areas. The WLA allocation for all other subwatersheds was based on the total contributing area of each MS4 within each subwatershed.

4.3.3.3 NPDES Point Source Dischargers

There are no non-stormwater NPDES permitted point source surface dischargers identified within the Bennett Lake or Wakefield Lake Watersheds.

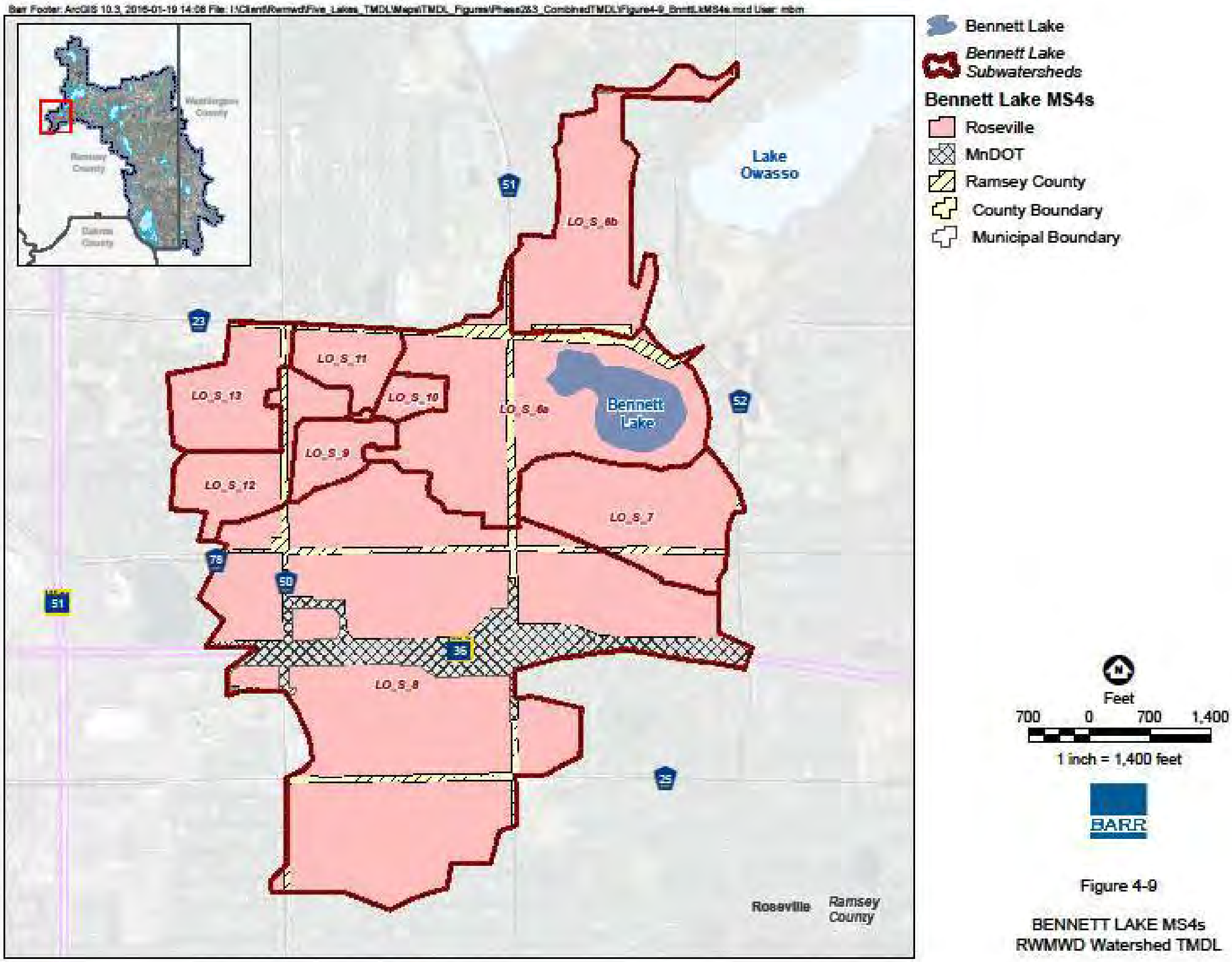

Figure 4-9 MS4s in Bennett Lake Watershed

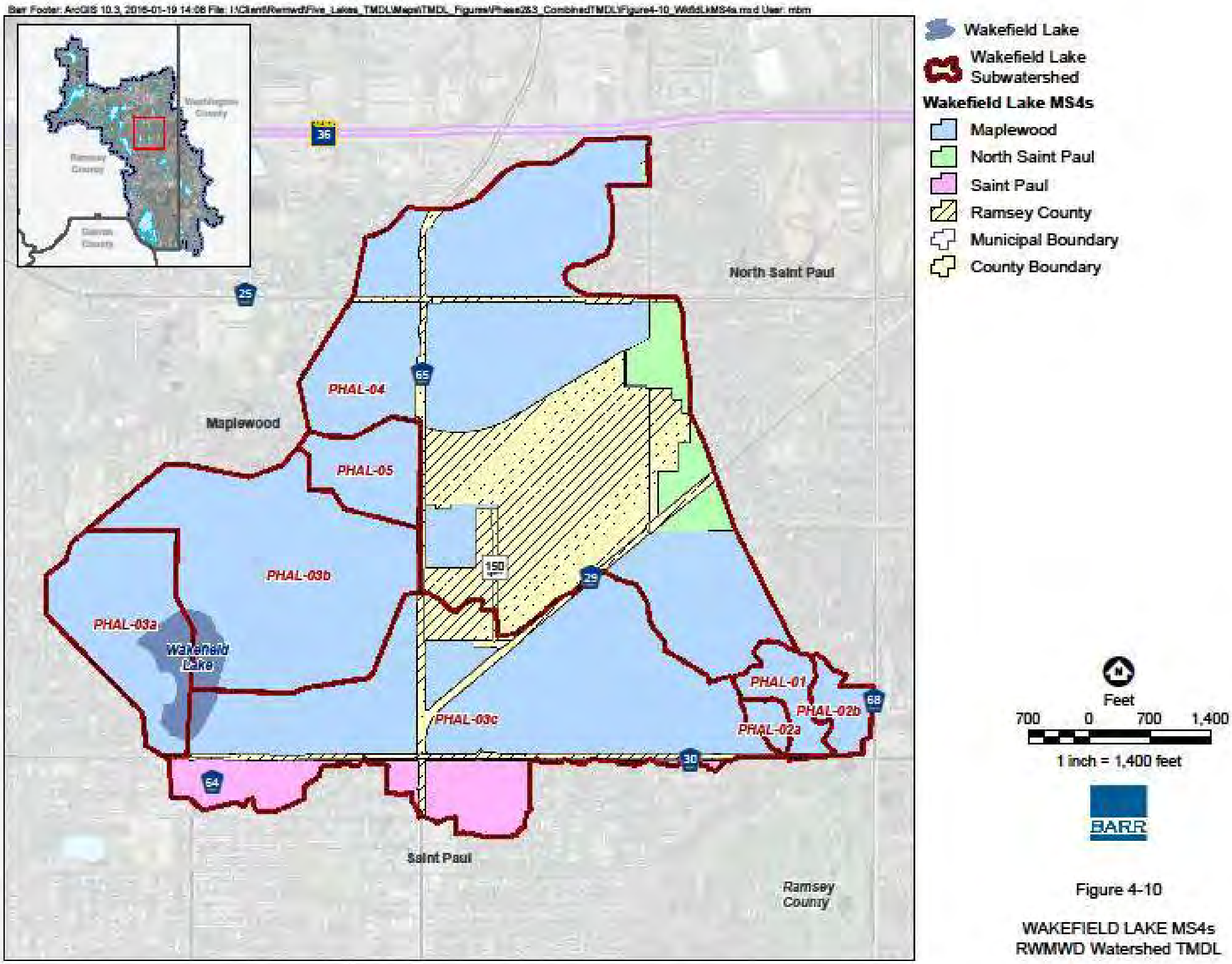

Figure 4-10 MS4s in Wakefield Lake Watershed

4.3.4 Margin of Safety

When modeling a natural system such as Bennett and Wakefield Lake, there can be some uncertainty associated with how the system will respond to changes in watershed loading. Therefore, a MOS is included to account for some of the unknowns associated with the behavior of the natural lake system.

An implicit MOS was incorporated into the Bennett Lake and Wakefield Lake TMDLs through application of conservative modeling assumptions. For example, when the load capacity was estimated for Wakefield Lake, it was assumed that the spring steady-state concentration in the lake after reductions to the phosphorus load was the same as for existing conditions. In reality, a reduction in the phosphorus load to Wakefield Lake will likely result in lower spring steady-state phosphorus concentrations when compared to existing conditions. Because the required percentage of external TP load reduction was significantly higher for Bennett Lake than for Wakefield Lake, the assumed spring steady-state concentration for Bennett Lake was reduced by assuming the required external TP load reduction applied to the watershed loading estimate used to calculate the spring steady-state concentration.

Additionally, the LAs for Bennett and Wakefield Lake were developed for the year that produced the worst water quality in each lake over the last 10 years of data analyzed (i.e., the critical year) rather than the average water quality condition over the last 10 years.

4.3.5 Seasonal Variation

The TP concentrations in Bennett Lake and Wakefield Lake vary during the GS, typically peaking in late summer. The TMDL guideline for TP is defined as the GS (June through September) mean concentration (MPCA 2014a). This critical period (GS) was used to estimate the required reduction of watershed and internal sources of phosphorus so that the predicted GS average would meet the MPCA lake standard (see additional discussion in Section 4.3.1.7) for the critical year.

4.3.6 TMDL Summary

The phosphorus load and WLAs for Bennett Lake and Wakefield Lake are described in Table 4-13 and Table 4-14, respectively. The load and WLAs are described in terms of the pounds of phosphorus per GS (lbs/GS), as well as pounds of phosphorus per day (lbs/day). Phosphorus loading under existing conditions during the GS of the critical year is outlined, as well as the phosphorus loading reduction required to achieve the MPCA lake eutrophication standard (TP < 60 µg/L). The WLAs presented in Table 4-13 and Table 4-14 are categorical, meaning that the total LA to several permitted sources are grouped into a single WLA, with the exception of the MnDOT Metro District. The categorical WLA approach is pursued for these TMDLs, as the RWMWD is initially taking the lead role in implementing projects to achieve the WLA defined in the Bennett Lake and Wakefield Lake nutrient TMDLs.

Table 4-13 Bennett Lake TMDL Summary

Total Phosphorus Source	Existing Conditions (lbs/GS[2])	Existing Conditions (lbs/day)	TMDL Allocation (lbs/GS[2])	TMDL Allocation (lbs/day)	Required Load Reduction (lbs/GS[2])	Percent Reduction (%)
Wasteload Allocation (Permitted Sources)						
City of Roseville *MS400047* Ramsey County *MS400191*	60.0	0.4915	24.6	0.2013	35.4	59%
NPDES-Permitted Construction and Industrial Stormwater	0.9	0.0071	0.9	0.0071	0	0%
MnDOT Metro District *MS400170*	9.2	0.0758	2.0	0.0163	7.3	79%
Total Wasteload Sources	70.1	0.5744	27.4	0.2247	42.7	61%
Load Allocations (Non-Permitted Sources)						
Atmospheric Deposition	2.3	0.0191	2.3	0.0191	0	0%
Internal Sources[3]	90.3	0.7405	18.1	0.1481	72.3	80%
Total Load Sources	92.7	0.7595	20.4	0.1672	72.3	78%
Margin of Safety[1]			N/A	N/A		
Total	162.7	1.3339	47.8	0.3919	114.9	71%

[1] Margin of safety implicitly included in modeling assumptions (see Section 4.3.4).

[2] GS = Growing Season of 2005 (June 1 through September 30).

[3] Reflects the sum of all internal sources of phosphorus (e.g., Curlyleaf Pondweed, sediment release, sediment resuspension due to wind and carp activity, etc.).

Table 4-14 Wakefield Lake TMDL Summary

Total Phosphorus Source	Existing Conditions (lbs/GS[2])	Existing Conditions (lbs/day)	TMDL Allocation (lbs/GS[2])	TMDL Allocation (lbs/day)	Required Load Reduction (lbs/GS[2])	Percent Reduction (%)
Wasteload Allocation (Permitted Sources)						
City of Maplewood *MS400047*	126.1	1.0335	74.3	0.6091	51.8	41%
City of St. Paul *MN0061263*						
City of North St. Paul *MS400041*						
Ramsey County *MS400191*						
NPDES-Permitted Construction and Industrial Stormwater	1.6	0.0130	1.6	0.0130	0.0	0%
Total Wasteload Sources	127.7	1.0465	75.9	0.6221	51.8	41%
Load Allocations (Non-Permitted Sources)						
Atmospheric Deposition	1.4	0.0115	1.4	0.0115	0	0%
Internal Sources[3]	60.4	0.4947	24.1	0.1979	36.2	60%
Total Load Sources	61.8	0.5063	25.6	0.2094	36.2	59%
Margin of Safety[1]			N/A	N/A		
Total	189.4	1.5527	101.4	0.8315	88.0	46%

[1] Margin of safety implicitly included in modeling assumptions (see Section 4.3.4).

[2] GS = Growing Season of 2004 (June 1 through September 30).

[3] Reflects the sum of all internal sources of phosphorus (e.g., Curlyleaf Pondweed, sediment release, sediment resuspension due to wind, etc.).

4.4 Future Growth Consideration / Reserve Capacity

For all TMDLs in the RWMWD, the following applies to determining the impact of future growth on allocations.

4.4.1 New or Expanding Permitted MS4 LA Transfer Process

Future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries:

1. New development occurs within a regulated MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. A new MS4 or other stormwater-related point source is identified and is covered under a NPDES Permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL**.** In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

4.4.2 New or Expanding Wastewater

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA-approved TMDL. This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with input and involvement by the EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

For more information on the overall process visit the MPCA's TMDL Policy and Guidance webpage.

5 Reasonable Assurances

Reasonable assurance activities are programs that are in place to assist in attaining the TMDL allocations and applicable water quality standards. The reasonable assurance evaluation provides documentation that the TMDL's WLAs and LAs are properly calibrated and the TMDL loads will ultimately meet the applicable water quality targets. Without such calibration, a TMDL's ability to serve as an effective guidepost of water quality improvement is significantly diminished. The development of reasonable assurance includes both state and local regulatory oversight, funding, implementation strategies, follow-up monitoring, progress tracking and adaptive management. (Note: Some of these elements are described in Sections 6 and 7). The following sections outline programs and policies that will provide reasonable insurance that TMDL objectives will be met.

5.1 Municipal Separate Storm Sewer System (MS4) Permits

The MPCA is responsible for applying federal and state regulations to protect and enhance water quality within the RWMWD. The MPCA oversees all regulated MS4 entities in stormwater management accounting activities. All regulated MS4s in the RWMWD fall under the Phase I or Phase II category. The MS4 NPDES/SDS Permits require regulated municipalities to implement BMPs to reduce pollutants in stormwater runoff to the Maximum Extent Practicable.

All owners or operators of regulated MS4s (also referred to as "permittees") are required to satisfy the requirements of the MS4 General Permit. The MS4 General Permit requires each permittee to develop a Stormwater Pollution Prevention Plan (SWPPP) that addresses all permit requirements, including the following six minimum control measures:

- Public education and outreach
- Public participation
- Illicit Discharge Detection and Elimination Program
- Construction-site runoff controls;
- Post-construction runoff controls; and
- Pollution prevention and municipal good housekeeping measures

A SWPPP is a management plan that describes the MS4 permittee's activities for managing stormwater within their jurisdiction or regulated area. In the event a TMDL study has been completed, approved by EPA prior to the effective date of the general permit, and assigns a WLA to an MS4 permittee, that permittee must document the WLA in their application and provide an outline of the BMPs to be implemented in the current permit term to address any needed reduction in loading from the MS4.

The MPCA requires applicants submit their application materials and SWPPP document to the MPCA for review. Prior to extension of coverage under the general permit, all application materials are placed on 30-day public notice by the MPCA, to ensure adequate opportunity for the public to comment on each permittee's stormwater management program. Upon extension of coverage by the MPCA, the permittees are to implement the activities described within their SWPPP, and submit annual reports to the MPCA by June 30 of each year. These reports document the implementation activities, which have been completed within the previous year, analyze implementation activities already installed, and outline any changes within the SWPPP from the previous year.

In the Wakefield Lake, Bennett Lake and Battle Creek Subwatersheds, the District will initially take the lead role in implementing projects to achieve the categorical WLA defined in this TMDL. However, cities and other MS4s in these watersheds are expected to fulfill their existing responsibilities in storm water management to help meet the goals of these TMDLs. Specifically, cities and other MS4s in the Wakefield Lake, Bennett Lake, and Battle Creek Subwatersheds will:

- Continue to implement volume reduction BMPs on all City projects to comply with District rules.
- Look for opportunities to implement voluntary projects to reduce runoff wherever possible, taking advantage of the District's cost-share program for water quality improvements.
- Continue to implement their SWPPPs and to improve their public works maintenance practices wherever possible. This work is facilitated through the District Public Works Forum and District sponsored and cosponsored training and education programs.

The District will keep record of District projects implemented in these subwatersheds and will assist the MS4s in their TMDL compliance reporting to the MPCA. After the first 10 years, an analysis of the program will be conducted to determine if the implemented projects are achieving the required reductions in phosphorus to Wakefield Lake and Bennett Lake, and in total suspended solids to Battle Creek. If the goals laid out in this report are not reached within the required time frame, the District will meet with city and county governmental units to determine future direction and if additional participation by these groups is needed.

In the Fish Creek Subwatershed, it is expected that the MS4s will take the lead role in implementing projects to achieve the categorical WLA defined in this TMDL. However, the District plans to assist in these activities by documenting progress toward reaching the *E. coli* WLA, and supporting the MS4s' efforts through educational assistance and creek monitoring, where needed.

This TMDL assigns TSS, TP, and *E. coli* WLAs to all regulated MS4s in the study and as previously discussed in Section 4. Regulated MS4s are required to develop compliance schedules for EPA approved TMDL WLAs not already being met at the time of permit application. A compliance schedule includes BMPs that will be implemented over the permit term, a timeline for their implementation, and a long term strategy for continuing progress towards assigned WLAs. For WLAs being met at the time of permit application, the same level of treatment must be maintained in the future. Regardless of WLA attainment, all permitted MS4s are still required to reduce pollutant loadings to the Maximum Extent Practicable.

The MPCA's stormwater program and its NPDES Permit program are regulatory activities providing reasonable assurance that implementation activities are initiated, maintained, and consistent with WLAs assigned in this study.

5.2 Regulated Construction Stormwater

Construction and industrial stormwater discharges in this TMDL study were included in the categorical WLAs for stormwater discharges. All construction activities disturbing one acre or more are required to obtain a Construction General Permit through the MPCA. Conditions in the Construction General Permit assure that stormwater discharged from the construction site will be in compliance with TMDL standards. It is assumed that construction sites will comply with conditions outlined in the State General Permit or with local construction stormwater requirements when those requirements are more restrictive.

5.3 Regulated Industrial Stormwater

As stated in Section 5.2, WLAs for industrial stormwater were included in the categorical WLA developed for each TMDL. All industrial stormwater dischargers are required to obtain permit coverage under the State's NPDES/SDS Industrial Stormwater Multi- Sector General Permit (MNR050000), or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). Compliance with permit standards assures that stormwater discharge will also be compliant with WLAs established in this study.

5.4 RWMWD Comprehensive Management Plan

The RWMWD was established in 1975 under the Minnesota Watershed District Act to effect the protection and provident use of the District’s water resources. The RWMWD adopted its first rules and regulations in 1976 and the first overall plan was adopted in 1977. Over the past 40 years, there have been several versions of the WMP. The most current version of the plan was adopted in 2007: RWMWD WMP (2006 through 2016) (Barr 2007).

The 2007 WMP outlines a partnership between the RWMWD and local government units (LGUs), which include all cities and townships, within the boundary of the District. The RWMWD’s main role in partnering with LGUs has been establishing a consistent regulatory framework throughout the RWMWD and through implementation efforts from the RWMWD’s WMP or local water resource management plans.

Prior to the development of this TMDL, the RWMWD has pursued water quality improvement projects within the TMDL study area boundaries. These efforts include various watershed studies, establishment of consistent and protective regulations, and targeted load reduction strategies. Additionally, in 2006 the District adopted volume reduction rules for all development and redevelopment within the watershed. The RWMWD plans to continue these types of efforts, and use this TMDL study to help strengthen targeted load reduction efforts throughout the RWMWD.

With the completion of the TMDLs, the RWMWD will serve to coordinate implementation efforts among LGUs and help ensure progress toward the TMDL targets. Adaptations will be made by the RWMWD and LGUs to ensure implementation efforts are having the desired effect on water resources. The RWMWD will take the lead role in tracking attainment of water quality standards will be a role primarily held by the RWMWD. Reductions for the non-regulated (LA) portions of the TMDLs will also be needed. These loads include non-MS4 runoff, which includes some agricultural land as well as shoreline and streambank erosion, and internal loading. The RWMWD, with assistance and cooperation from LGUs and other groups, will take the lead on efforts to reduce loading from these non-regulated sources.

5.5 Funding

Funding for water resource projects throughout the RWMWD generally comes from a combination of the following sources: general tax revenue (generated from a property tax levy), grant funds, and local cost-share funding. Historically, approximately 95% of the RWMWD's funds for implementing capital projects, programs, and other operations are raised through the property tax levy. The RWMWD utilizes this funding base to sponsor cost-share and grant programs to assist municipal partners with local water quality improvement projects.

There are other funding mechanisms that the RWMWD and LGUs may apply for in the state of Minnesota. Some of these sources include: grants under the Clean Water Legacy Act (CWLA) and funding through the Clean Water Partnership program. The RWMWD will also explore the funding mechanisms provided through the federal Section 319 grant program, which provides cost share dollars to implement voluntary activities in the watershed.

The CWLA amendment was passed by Minnesota voters in 2008 for the purposes of protecting, restoring, and preserving Minnesota water and providing significant funding to do so. The Act discusses how the MPCA and the involved public agencies and private entities will coordinate efforts regarding land use, land management, water management, etc. Cooperation is also expected between agencies and other entities regarding planning efforts, and various local authorities and responsibilities. This would also include informal and formal agreements to jointly use technical, educational, and financial resources.

The CWLA also provides details on the overall TMDL process and follow-up implementation strategy development, and how the funding will be used. The Minnesota Board of Soil and Water Resources administers the Clean Water Fund for restoration and protection grants, and has developed a detailed grants policy explaining what is required to be eligible to receive Clean Water Fund money (FY15 Clean Water Fund Competitive Grants Policy; Minnesota Board of Soil and Water Resources, 2014).

The Clean Water, Land, and Legacy Fund has several grant and loan programs that could be used for implementation of the BMPs, education and outreach, and WWTP modifications. The various programs and sponsoring agencies related to clean water funding and others are:

- Agriculture BMP Loan Program (Minnesota Department of Agriculture)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- TMDL Grant Program (Minnesota Public Facilities Authority)

- Wastewater and storm water financial assistance (MPCA)

5.6 Schedule and Tracking

After the approval of the TMDL by the EPA, the RWMWD will work with LGUs to develop a general timeline and strategy for implementation activities to be conducted within each permit cycle and/or plan cycle. It is likely that interim goals will be established within many LGUs, as immediate changes within the watershed to fully address any one or more impairment is unlikely. The RWMWD will adopt an updated Watershed Plan in 2017. Within the plan, the long-term goal of removal of waters from the impaired waters list may be projected out beyond the 10-year life of the plan. Five and 10-year goals will likely be established within the implementation plan as reasonable benchmarks to achieve towards water quality standard attainment. Progress toward the TMDL targets will be assessed as part of the implementation of the updated Watershed Plan. Future Watershed Plan revisions and updates will also look at establishing new targets to attain water quality standards, if they have not yet been met. Progress will also be assessed through the reporting requirements of the MPCA's stormwater program and NPDES Permit requirements.

6 Monitoring Plan

The RWMWD measures lake water quality, monitors biology (macrophytes, macroinvertebrates, and sometimes zooplankton and phytoplankton), lake levels, stream water quality, stream flow, and weather conditions at multiple locations throughout the entire RWMWD and has collected a large amount of water quality data over its history. In addition, other agencies have collected data for RWMWD waterbodies, including the MPCA, Metropolitan Council, and others. The amount of data currently available varies by waterbody.

Continued water quality data collection is necessary for the RWMWD to track water quality improvement or degradation, detect trends, and better understand water quality processes, and ultimately determine if there are water quality problems (e.g., impaired uses). This information is critical for RWMWD to identify and prioritize water quality improvement projects, and to determine appropriate methods for preventing water quality degradation. Detection of trends, specifically improvements, is critical to determining the effectiveness of actions implemented by the RWMWD.

The RWMWD will continue to monitor the Battle Creek, Fish Creek, and Bennett Lake and Wakefield Lake Watersheds. The following sections outline specific monitoring goals for each TMDL study area.

6.1 Battle Creek Monitoring Plan

The TSS data has historically been collected at the downstream WOMP station, owned and operated by the Metropolitan Council. To assess water quality trends as well as the impacts of implementation options identified in Section 7.3.1, it is important that continuous monitoring of water quality be maintained at the WOMP station. The RWMWD plans to continue to collet water chemistry and flow data from continuous monitoring at this station. Additionally, the RWMWD plans to perform a detailed sediment study to more accurately identify sources of sediment to the stream (Section 7.3.1).

Due to the biological impairment addressed in this study, continued monitoring of the fish and macroinvertebrate assemblage within Battle Creek will be required to track impairment as TMDLs and associated activities are implemented. Historically, fish and macroinvertebrate populations in Battle Creek have been assessed by several agencies, including the RWMWD, the United States Geological Survey (USGS), and DNR, and the MPCA. More recent surveys (2004, 2010, and 2012) were performed by the MPCA. The MPCA is required to asses 10% of waters in the state annually, resulting in 100% coverage over a 10-year period. For this reason, it is anticipated that biological monitoring of Battle Creek will be performed every 10 years.

6.2 Fish Creek Monitoring Plan

For the purposes of this TMDL, the most important data is that from the downstream monitoring station on Fish Creek (Figure 3-7). The RWMWD plans to continue to collect water chemistry and flow data through a continuous water monitoring station in cooperation with other entities and will report the results of its stream monitoring. The continued collection of flow and monthly *E. coli* data will be essential to track water quality trends, assess progress towards implementation goals, and make adaptive management decisions.

6.3 Bennett Lake and Wakefield Lake Monitoring Plan

The RWMWD plans to continue the regular collection of water quality and macrophyte data for Bennett Lake and Wakefield Lake. Water quality measurements include Secchi disc transparency depth, TP, chlorophyll-*a* (Chl-*a*), and other lake eutrophication parameters at the lake surface. Several measurements will likely be collected each year over the course of the GS, as well as in the spring. When degrading water quality trends are identified, the RWMWD may collect more detailed water quality data, including evaluation of phosphorus concentrations, DO, specific conductance, turbidity, and pH data at depth which can be used to help assess the problems.

According to the RWMWD WMP, the RWMWD water quality monitoring program tracks water quality and quantity in lakes within the watershed, including Wakefield Lake and Bennett Lake, on an annual basis. The annual monitoring program includes in-lake monitoring in collaboration with the Ramsey County Environmental Services Office. In this partnership, Ramsey County collects and RWMWD sends the samples to local laboratories for analysis and reports the results. The RWMWD plans to continue District-wide monitoring efforts into the future.

7 Implementation Strategy Summary

7.1 Implementation Framework

This section provides implementation strategies designed to help meet the required pollutant load reductions that are required as a result of this TMDL study. These strategies are potential actions that will help reduce nutrient, bacteria, and TSS loading in the RWMWD watershed and will be incorporated into the separate RWMWD Watershed Restoration and Protection Strategies (WRAPS) Report.

7.1.1 Adaptive Management

The proposed implementation strategies will typically follow the adaptive management approach (Figure 7-1). Proposed projects will be implemented in a phased manner, selecting specific projects for construction/implementation followed by a period of monitoring to evaluate the impact of the projects on the water quality of the impaired resources. Depending on the resulting water quality, additional projects may be evaluated and selected for implementation, or it may be determined that the water quality meets the MPCA standards and the management approach may change from improvement to anti-degradation/protection.

Figure 7-1 Adaptive Management

7.2 Permitted Sources

7.2.1 MS4s

The NPDES Permit requirements must be consistent with the assumptions and requirements of an approved TMDL and associated WLAs. For the purposes of this TMDL, the baseline year for implementation will be the critical year for the lake nutrient TMDLs and the mid-range year of the data years used for the development of the TSS and bacteria load duration curves (Table 7-1).

The rationale for establishing a baseline year is that projects undertaken recently may take a few years to influence water quality. Any point source load-reducing BMP implemented since the baseline year will be eligible to “count” toward an MS4’s load reductions. If a BMP was implemented during or just prior to the baseline year, the MPCA is open to presentation of evidence by the MS4 Permit holder to demonstrate that it should be considered as a credit.

Table 7-1 Implementation Baseline Years

Water body	ID	Baseline Year
Battle Creek	07010206-592	2007
Fish Creek	07010206-606	2011
Bennett Lake	62-0048-00	2005
Wakefield Lake	62-0011-00	2004

7.2.2 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the State's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local construction stormwater requirements must also be met.

7.2.3 Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES Industrial Stormwater Permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS General Permit for Construction Sand & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS Permit and properly selects, installs, and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local stormwater management requirements must also be met.

7.3 Strategies and Costs

7.3.1 Total Suspended Solids (TSS)

Potential BMPs and other implementation strategies developed to reduce TSS loading to Battle Creek are presented in Table 7-2. These potential BMPs will be explored more thoroughly in the WRAPS report, using results of the recommended sediment study to prioritize implementation strategies. Table 7-2 also shows typical cost ranges for each practice, and an estimated overall cost that will be refined in the WRAPS report. The RWMWD and the individual MS4s within each watershed have already undertaken projects similar to those outlined in Table 7-2 since the baseline year, and will continue to implement BMPs in order to attain water quality goals outlined in this TMDL.

Table 7-2 Potential TSS reduction strategies

Reduction Target	Potential BMP/Reduction Strategy	Total Estimated Associated Cost
N/A	**Sediment Study –** sediment chemical composition study and/or particle scale analysis to help identify sources of sediment to Battle Creek.	$30,000
Permitted	**Education Programs** – Provide educational and outreach opportunities about responsible land management practices and other BMPs to encourage good individual property management practices to reduce soil loss and upland erosion.	$2,000 - $10,000
	Retrofit BMPs – A variety of BMPs may be implemented throughout the watershed. New and improved technologies will be evaluated and implemented if determined to be practicable. Examples of retrofit BMPs considered include: - Incorporation on infiltration BMPs throughout watershed, including water quality projects which take advantage of RWMWD's cost-share program. - Retrofit commercial, school, and church properties with green infrastructure practices. - Partnering with Ramsey County Parks and Recreation to retrofit stormwater management features on park properties tributary to Battle Creek. Continue enforcement of the District's Permit Program (including the volume reduction rule) in redeveloping areas.	$3,000,000 - $8,000,000
Non-Permitted	**Streambank Stabilization** – Repair and stabilize actively eroding sections of bank along the stream channel. Extend stabilization practices through stream corridor when necessary.	$50,000 - $200,000
	Dredging – dredge accumulated sediment from McKnight basin as well as portions of the stream where sediment has accumulated.	$200,000 - $300,000

7.3.2 Bacteria (*E. coli)*

Table 7-3 lists BMPs and implementation strategies that may be successful in reducing bacteria loading to Fish Creek. Due to the nature of *E. coli* loading, there are few structural BMPs which can remove or treat bacteria within the watershed. For this reason, many of the BMPs listed in Table 7-3 are procedural. These potential BMPs will be explored more thoroughly, including targeting the most appropriate BMPs by location, in the accompanying WRAPS report.

Table 7-3 Potential bacteria reduction strategies

Reduction Target	Potential BMP/Reduction Strategy	Total Estimated Associated Cost
Permitted	**Education Programs** – Provide education and outreach on proper fertilizer use and proper pet waste management.	$2,000 - $10,000
	Pet Waste Management – Review member cities local ordinances and associated enforcement for residents who do not practice proper pet waste management.	$5,000 - $15,000
Non-Permitted	**Septic System Inspection Program Review –** review ordinances pertaining to inspection and maintenance of septic systems in the watershed. This could include a survey to homeowners inquiring about SSTS maintenance.	$25,000 - $30,000
	Streambank Buffer Enhancement – Stabilize native vegetation to filter runoff from land adjacent to the stream. A recommended goal is buffer enhancement on 25%-50% of each impaired reach. Enhancements should include at least 50 feet of buffer on both sides of the stream.	$300,000 - $1,500,000
	Sanitary Sewer Inspection – televise sanitary sewer within Fish Creek Subwatershed. Identify damaged sections where exfiltration is possible.	$40,000 – $80,000
	Sanitary Sewer Repair- repair damaged sections to prevent exfiltration.	$10,000 - $100,000

7.3.3 Nutrients

Table 7-4 lists BMPs that may be successful in reducing nutrient loads and managing lake water quality in Bennett Lake and Wakefield Lake. These potential BMPs will be explored more thoroughly, including targeting the most appropriate BMPs for each water body, in the accompanying WRAPS report. Table 7-4 also shows typical cost ranges for each practice that will be further refined in the WRAPS report as well as feasibility studies and design planning. The RWMWD and the individual MS4s within each watershed have already undertaken projects similar to those outlined in Table 7-4 since the baseline year, and will continue to implement BMPs in order to attain water quality goals outlined in this TMDL.

Table 7-4 Potential nutrient reduction strategies

Reduction Target	Potential BMP/Reduction Strategy	Total Estimated Associated Cost
Permitted	**Education Programs** – Provide education and outreach on proper fertilizer use, low-impact lawn care practices, installation of native shoreline buffers, etc.	$2,000 - $10,000/lake $4,000 - $20,000 total cost
	Street Sweeping Program Review/Implementation – Identify target areas for increased frequency of street sweeping and consider upgrades to traditional street sweeping equipment.	$100,000 - $200,000/lake $200,000 - $400,000 total cost
	Retrofit BMPs – A variety of BMPs may be implemented in either or both watersheds. New and improved technologies will be evaluated and implemented if determined to be practicable. Examples of retrofit BMPs considered include: - Outlet modification (e.g., Fe-enhanced sand or spent lime filtration, etc.). - Incorporation of infiltration BMPs throughout watershed, including water quality projects which take advantage of RWMWD's Cost-Share program. - Partnering with cities to retrofit stormwater management features on park properties tributary to lakes. - Retrofit commercial, school, and church properties with green infrastructure practices. - Continue enforcement of the District's Permit Program (including the volume reduction rule) in redeveloping areas.	$1,500,000 - $2,500,000/lake $3,000,000 - $5,000,000 total cost
Non-Permitted	**Drawdown to Consolidate Sediments –** draw water down in the winter to consolidate sediments, reduce regrowth of Curlyleaf pondweed and carp populations.	$10,000-$20,000
	Dredging – dredge accumulated sediment from pond, existing wetlands, and/or tributary grit chambers.	$1,000,000 - $2,500,000/lake $2,000,000 - $5,000,000 total cost
	Shoreline Restoration – Encourage property owners to restore their shoreline with native plants and install/enhance shoreline buffers.	$50,000 to $250,000/lake $120,000 - $350,000 total cost
	In-Lake Phosphorus Treatment – take measures to reduce internal cycling of phosphorus within the lake: - Alum treatment to bind and remove phosphorus from the water column. - Herbicide treatment to eliminate invasive Curlyleaf Pondweed from Bennett Lake. - Carp management (reduce sediment and phosphorus resuspension caused by activity of carp).	$250,000 - $1,500,000/lake $500,000 - $3,000,000 total cost

8 Public Participation

Several TMDL stakeholder meetings were held between representatives of the various stakeholders in the watershed, and other applicable local and state agencies. Public meetings were also held. The goal of this process was to discuss the development and conclusions of the TMDL study, obtain input from, review results with, and take comments from those interested and affected parties.

The official TMDL public comment period was held from XX, 2016 through XX, 2016. XX public comment letters were received.

8.1 “Community Conversations”, “Community Confluence” Event and TMDL Meetings

During the early months of development of the RWMWD WMP update, WRAPS report, and this TMDL, nearly 100 residents came together in a series of three Community Conversations within Ramsey-Washington Metro Watershed District between mid-September and early October 2013. The Community Conversations were held on the following dates:

- September 17, 2013, at Maplewood Community Center
- September 26, 2013, at Woodbury City Hall
- October 3, 2013, at Shoreview Community Center

The goal of these Community Conversations was two-fold. The first goal was to teach residents about the history of the District, how the budget is established, and the major District initiatives and recent accomplishments. The second goal of the Community Conversations was to solicit input from participants. These gatherings were designed to begin the public input process in updating the District’s WMP and to help brainstorm ideas for implementation to improve water quality, as well as to achieve other RWMWD goals.

At each Community Conversation, people reflected on how they value and interact with the District’s lakes, wetlands and creeks, identified many of their concerns, and offered potential solutions to the identified watershed issues through a “brain-sprinting” exercise. In the first round of the exercise, the participants generated an expanded list of issues/concerns in the watershed such as invasive species, animal habitats, stormwater and other pollutants, water quality, water levels, aquatic vegetation (macrophytes), increased development/impervious surfaces and the need for education and maintenance. A second round of small group interchanges in the exercise then precipitated insights and suggestions to address the problems and make improvements. Each night the discussions culminated in a large group sharing of what the participants valued in the watershed and a summary of the key issues and ideas for improvement.

The culmination of all of these community meetings was a “Community Confluence” event held on January 30, 2014. Members of the public, government agencies, city and county staff were invited to hear the results from the three community conversations meetings, and to review eight posters that represented a series of goal “themes” and ideas and/or issues that pertained to those themes. These themes were developed from the feedback received during the Community Conversations meetings. A ninth poster titled "What Did We Miss?" was included for citizens to write-in additional ideas and issues that they thought were not represented in the other eight posters.

The ideas pertaining to Battle Creek, Fish Creek, Wakefield Lake and Bennett Lake were revisited during the TMDL study, and informed the implementation strategies considered for each waterbody.

The TMDL technical stakeholder meetings were held on the following dates:

- June 23, 2015: Presentation of the source assessment and draft TMDL WLAs and LAs and discussion of implementation ideas
- XXXX, 2016: Presentation of the final Battle Creek TMDL and implementation strategies

As part of this TMDL study, the following public meeting(s) are scheduled:

- A public meeting is scheduled for XXXX, 2016.

The TMDL technical stakeholder meetings were held on the following dates:

- August 13, 2013: Kickoff meeting presenting the project and historic water quality of Fish Creek and Battle Creek
- June 23, 2015: Presentation of the source assessment and draft TMDL WLAs and LAs and discussion of implementation ideas
- XXXX, 2016: Presentation of the final Fish Creek TMDL and implementation strategies

The TMDL technical stakeholder meetings were held on the following dates:

- August 8, 2013: Kickoff meeting presenting the project and historic water quality of Bennett Lake
- August 12, 2015: Presentation of the source assessment and draft TMDL WLA and LA and discussion of implementation ideas
- XXXX, 2016: Presentation of the final Bennett Lake TMDL and implementation strategies

As part of this TMDL study, the following public meeting(s) are scheduled:

- A public meeting is scheduled for XXXX, 2016.

The TMDL technical stakeholder meetings were held on the following dates:

- December 12, 2011: Kickoff meeting presenting the project and historic water quality
- May 16, 2013: Presentation of the source assessment and draft TMDL WLAs and LAs and discussion of implementation ideas
- XXXX, 2016: Presentation of the final Wakefield Lake TMDL and implementation strategies

As part of this TMDL study, one public meeting was held to specifically discuss the Wakefield TMDL study:

- March 17, 2013: A public meeting was held to inform the general public about the findings of the Wakefield TMDL and to discuss the proposed implementation strategies.

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Appendices

Appendix A: Lake (Nutrient) TMDL Modeling

Nutrient TMDL Modeling

The lake water quality modeling performed for the *Ramsey Washington Metro Watershed District TMDL Study* (TMDL study) included three different models to estimate the TMDL phosphorus load capacity required to meet the MPCA water quality standards. The models in the P8 pollutant loading model, a daily water balance model, and a phosphorus mass balance model that included empirical steady-state phosphorus equations and GS phosphorus balance model. Figure A-1 shows a schematic of the TMDL modeling approach.

1.0 P8 Pollutant Loading Model

The P8 pollutant loading model was used to estimate the water and phosphorus loads to Bennett and Wakefield Lake. Runoff volumes predicted by the P8 model were verified using a water balance model and observed lake level data (see Water Balance Model discussion). The P8 event load file was used to extract the watershed runoff volume (acre-ft) and the predicted phosphorus associated with the different particle classes in P8 (i.e., TP loads in lbs) for each event that was modeled. Both the water and the TP loads were used in the steady state phosphorus model and the phosphorus mass balance model.

1.1 P8 Model Parameter Selection

The P8 models used to estimate the watershed loads to Bennett and Wakefield Lake were developed in P8 version 2.4 specifically for this TMDL study. The following section discusses the selected P8 model parameters used for the TMDL study. P8 parameters not discussed in the following paragraphs were left at the default setting.

1.1.2 Time Step, Snowmelt, & Runoff Parameters

Time Steps Per Hour (Integer) — 15 for Bennett Lake; 4 for Wakefield Lake. Selection was based upon the number of time steps required to minimize continuity errors.

Minimum Inter-Event Time (Hours)—10 for Bennett Lake; 6 for Wakefield Lake. The selection of this parameter was based upon an evaluation of storm hydrographs to determine which storms should be combined and which storms should be separated to accurately depict runoff from the lake's watershed. It should be noted that the average minimum inter-event time for the Minneapolis area is 6.

Passes through Storm File—5 for Bennett Lake; 10 for Wakefield Lake. The number of passes through the storm file was determined after the model had been set up and a preliminary run completed. The selection of the number of passes through the storm file was based upon the number required to achieve model stability. Multiple passes through the storm file were required because the model assumes that dead storage waters contain no phosphorus. Consequently, the first pass through the storm file results in lower phosphorus loading than occurs with subsequent passes. Stability occurs when subsequent passes do not result in a change in phosphorus concentration in the pond waters. To determine the number of passes to select, the model was run with three passes, five passes, and ten passes. A comparison of phosphorus predictions for all devices was evaluated to determine whether changes occurred between the three scenarios.

1.1.3 Particle Selection

Bennett Lake Particle File - NURP50.PAR: The particle file reflects the values typically associated with the NURP50 particle file. To estimate pollutant loading, P8 tracks the build-up, washoff, and settling of particles of varying size classes and settling velocities (5 sizes classes, with the smallest particle size class representing non-settling particles). A mass of pollutant (e.g. phosphorus) is associated with a given mass of the particle size classes. The model uses pollutant loading values consistent with the National Urban Runoff program (NURP50 particle file). Table A-1 summarizes the particle class settling velocities as well as the mass of phosphorus associated with a given mass of each particle class.

Table A-1 Bennett Lake P8 Particle Classes and Associated Phosphorus

P8 Particle Class	Description	Settling Velocity (ft/hr)	TP (mg TP/kg Particle)
P0%	Non-Settling / Dissolved	0	99,000
P10%	10^{th} Percentile	0.03	3,850
P30%	30^{th} Percentile	0.3	3,850
P50%	50^{th} Percentile	1.5	3,850
P80%	80^{th} Percentile	15	0

Wakefield Lake Particle File - PHALEN.PAR: because Wakefield Lake is within the Phalen Lake Watershed, a calibrated particle file developed for a P8 model of Phalen Lake was applied to the P8 model of Wakefield Lake. Table A-2 summarizes the particle class settling velocities as well as the mass of phosphorus associated with a given mass of each particle class in the calibrated Phalen Lake particle file.

Table A-2 Wakefield Lake P8 Particle Classes and Associated Phosphorus

P8 Particle Class	Description	Settling Velocity (ft/hr)	TP (mg TP/kg Particle)
P0%	Non-Settling / Dissolved	0	514,000
P10%	10^{th} Percentile	0.03	15,000
P30%	30^{th} Percentile	0.3	15,000
P50%	50^{th} Percentile	1.5	15,000
P80%	80^{th} Percentile	15	0

1.1.4 Climatic Data Selection

Precipitation File - FVLKPPT.pcp: The P8 model uses long-term climatic data so that watershed runoff and BMPs can be evaluated for varying hydrologic conditions. Most of the hourly precipitation obtained from the Minneapolis-St. Paul airport. The St. Paul airport hourly precipitation data was used to fill in gaps in the hourly data from the Minneapolis-St. Paul airport and was used for the period from May through September 2008. A monthly adjustment factor was applied to the hourly precipitation data to match the monthly totals from a daily precipitation gage that is part of the high density precipitation network through the Minnesota State Climatology Office.

Air Temperature File - Msp4908.tmp: Average daily temperature data was obtained from the Minneapolis-St. Paul airport for the period from 1949 through 2008.

1.1.5 Watersheds Parameter Selection

Watershed delineation and hydrologic parameters were originally developed for the Bennett Lake and Wakefield Lake in the Lake Owasso Use Attainability Analysis (Barr 2009) and Phalen Chain of Lakes Strategic Lake Management Plan (Barr 2004b), respectively. For further information pertaining to development of watersheds and watershed hydrologic parameters, refer to the documents cited above.

1.1.6 Device Parameter Selection

The P8 models for Bennett and Wakefield Lake include devices that represent existing wetlands and constructed watershed BMPs (devices). Information for the various BMPs includes the bathymetry of ponds and wetlands within the watersheds as well as information about the outlet structures.

Detention Pond— Permanent Pool— Area and Volume—The surface area and dead storage (water quality) volume of each detention pond was determined and entered here.

Detention Pond— Flood Pool— Area and Volume—The surface area and storage volume under flood conditions (i.e., the storage volume between the normal level and flood elevation) was determined and entered here.

Detention Pond— Infiltration Rate (in/hr) — Infiltration from ponded area can be set to allow for the pond volume to drop below the normal water level (control elevation), especially during periods of limited rainfall.

Detention Pond— Orifice Diameter and Weir Length— The orifice diameter or weir length was determined from field surveys, development plans, or storm sewer data provided by the city of Lake Elmo of the area for each detention pond and entered here.

Detention Pond or Generalized Device— Particle Removal Scale Factor— Particle Removal Scale Factor— 0.3 for ponds less than 2 feet deep and 1.0 for all ponds 3 feet deep or greater. For ponds with normal water depths between 2 and 3 feet, a particle removal factor of 0.6 was selected. The particle removal factor for watershed devised determines the particle removal by device.

1.2 P8 Model Results

Table A-3 and Table A-4 summarize the total event precipitation (based on the hourly precipitation and average daily temperature data, as processed by P8) for the Bennett Lake and Wakefield Lake Watersheds for the 17-month modeled period used to establish the TMDL for each lake. Also summarized in the tables are the P8 predicted event watershed runoff water load and phosphorus load to each lake, along with event TP concentrations.

Table A-3 P8 Event Water and Phosphorus Loads to Bennett Lake (5/1/2004-9/30/2005)

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (µg/L)
5/5/2004	0.07	0.1	0.0	100
5/9/2004	0.63	7.1	2.5	131
5/12/2004	0.16	1.3	0.4	105
5/13/2004	0.44	4.7	1.3	103
5/16/2004	0.79	9.1	3.4	136
5/19/2004	0.22	2.0	0.6	106
5/21/2004	0.06	0.0	0.0	100
5/21/2004	0.15	1.0	0.3	102
5/22/2004	0.02	0.0	0.0	101
5/23/2004	1.03	12.1	3.4	105
5/25/2004	0.01	0.0	0.0	99
5/26/2004	0.59	6.6	2.0	114
5/28/2004	0.74	8.4	2.6	114
5/30/2004	0.47	5.0	1.5	110
5/30/2004	0.26	2.6	0.7	105
5/31/2004	1.20	24.6	7.8	118
6/5/2004	0.14	1.0	0.3	103
6/5/2004	0.38	4.0	1.2	109
6/8/2004	1.68	20.1	6.2	114
6/10/2004	0.19	1.6	0.4	103
6/11/2004	0.33	3.3	1.0	113
6/11/2004	0.47	5.4	1.9	132
6/23/2004	0.34	3.5	1.2	125
6/27/2004	0.05	0.0	0.0	100
7/3/2004	0.55	6.1	1.7	101
7/5/2004	0.71	8.1	2.3	104
7/11/2004	1.29	15.3	5.6	134
7/21/2004	0.08	0.3	0.1	101
7/28/2004	0.11	0.6	0.2	102
7/30/2004	0.07	0.2	0.0	100
7/31/2004	0.16	1.3	0.3	101
8/1/2004	0.01	0.0	0.0	99
8/3/2004	0.06	0.0	0.0	99
8/7/2004	0.15	1.1	0.3	101
8/11/2004	0.01	0.0	0.0	99
8/15/2004	0.54	6.0	1.7	102
8/22/2004	0.16	1.2	0.4	104
8/23/2004	0.20	1.7	0.5	102
8/26/2004	0.12	0.7	0.2	100
8/29/2004	0.12	0.7	0.2	100
9/5/2004	0.75	8.2	3.8	168
9/5/2004	0.99	11.9	4.0	124

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (µg/L)
9/13/2004	0.12	0.8	0.2	100
9/14/2004	2.86	36.8	12.9	129
9/17/2004	0.16	1.3	0.4	106
9/21/2004	0.03	0.0	0.0	100
9/22/2004	0.03	0.0	0.0	102
9/23/2004	0.26	2.5	0.7	102
10/1/2004	0.38	4.0	1.1	104
10/7/2004	0.14	1.0	0.3	103
10/13/2004	0.06	0.0	0.0	99
10/15/2004	0.12	0.7	0.2	99
10/17/2004	0.09	0.4	0.1	101
10/22/2004	0.18	1.5	0.4	101
10/23/2004	0.04	0.1	0.0	99
10/28/2004	1.04	12.1	3.7	113
10/29/2004	0.13	0.9	0.2	102
10/30/2004	0.00	0.0	0.0	100
11/1/2004	0.09	0.4	0.1	100
11/19/2004	0.75	8.6	2.3	100
12/4/2004	0.07	0.2	0.1	99
12/7/2004	0.19	1.6	0.4	101
12/9/2004	0.18	1.6	0.4	100
12/15/2004	0.01	0.0	0.0	99
12/30/2004	0.34	3.4	0.9	99
1/25/2005	0.03	0.0	0.0	99
2/1/2005	1.08	21.5	5.8	99
2/11/2005	0.95	17.2	4.6	100
3/4/2005	0.46	5.1	1.4	99
3/10/2005	0.14	1.0	0.3	99
3/21/2005	0.53	6.3	1.7	99
3/30/2005	0.94	10.9	3.8	128
4/2/2005	0.02	0.0	0.0	100
4/11/2005	0.02	0.0	0.0	98
4/11/2005	0.32	3.3	0.9	100
4/15/2005	0.13	0.8	0.2	101
4/16/2005	0.94	11.0	3.4	115
4/19/2005	0.39	4.1	1.1	102
4/25/2005	0.06	0.1	0.0	100
4/25/2005	0.14	1.0	0.3	101
4/26/2005	0.06	0.1	0.0	99
5/2/2005	0.03	0.0	0.0	99
5/7/2005	0.00	0.0	0.0	100
5/8/2005	0.02	0.0	0.0	100
5/8/2005	0.07	0.2	0.0	100

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (μg/L)
5/9/2005	0.05	0.0	0.0	98
5/10/2005	0.17	1.4	0.4	105
5/12/2005	1.08	12.7	3.5	102
5/14/2005	0.12	0.8	0.2	100
5/16/2005	0.24	2.2	0.6	103
5/17/2005	0.14	1.1	0.3	103
5/18/2005	0.89	10.3	2.9	104
5/21/2005	0.05	0.0	0.0	99
5/25/2005	0.21	1.8	0.5	100
5/26/2005	0.05	0.0	0.0	99
5/27/2005	0.25	2.4	0.7	100
5/29/2005	0.13	0.8	0.2	100
6/4/2005	0.18	1.5	0.4	101
6/5/2005	0.17	1.4	0.4	105
6/7/2005	0.03	0.0	0.0	99
6/7/2005	0.64	7.3	2.4	123
6/10/2005	0.44	4.7	1.7	129
6/11/2005	0.05	0.0	0.0	103
6/11/2005	0.08	0.2	0.1	103
6/13/2005	0.52	5.7	1.9	122
6/14/2005	0.07	0.3	0.1	104
6/15/2005	0.09	0.43	0.12	102
6/20/2005	0.62	6.96	2.51	133
6/24/2005	0.01	0.00	0.00	101
6/27/2005	0.80	9.05	4.08	166
6/27/2005	1.17	13.94	4.69	124
6/29/2005	0.19	1.64	0.47	106
6/29/2005	0.62	8.11	3.05	139
7/3/2005	0.18	1.50	0.43	106
7/17/2005	0.12	0.75	0.21	102
7/20/2005	0.51	5.60	1.98	131
7/23/2005	0.93	10.82	4.18	142
7/25/2005	1.71	21.48	7.99	137
8/3/2005	0.25	2.36	0.72	113
8/8/2005	0.06	0.05	0.01	100
8/9/2005	0.47	5.05	2.00	146
8/11/2005	0.15	1.12	0.32	104
8/16/2005	0.28	2.73	0.87	117
8/18/2005	0.44	4.73	1.34	105
8/19/2005	0.03	0.02	0.00	99
8/26/2005	2.60	31.93	11.84	137
9/2/2005	0.30	2.95	0.83	104
9/3/2005	0.34	3.51	0.97	102

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (µg/L)
9/5/2005	0.01	0.00	0.00	100
9/6/2005	0.31	3.11	1.02	121
9/8/2005	0.19	1.61	0.47	108
9/9/2005	0.07	0.13	0.04	101
9/13/2005	0.83	9.58	3.58	138
9/17/2005	0.16	1.30	0.37	104
9/18/2005	0.04	0.00	0.00	100
9/21/2005	2.13	25.77	7.49	107
9/23/2005	0.13	0.89	0.25	101
9/26/2005	0.10	0.49	0.13	100
9/27/2005	0.06	0.01	0.00	100
9/29/2005	0.35	3.61	1.24	126
Steady State Year (May 1, 2004 – April 30, 2005)	30	347	108	115
Growing Season (June 1, 2005 – Sept 30, 2005)	18.4	202	70	128

Table A-3 P8 Event Water and Phosphorus Loads to Wakefield Lake (5/1/2003-9/30/2004)

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (µg/L)
5/4/2003	0.95	14.7	9.6	240
5/8/2003	1.28	32.1	23.1	265
5/10/2003	1.64	58.0	25.9	165
5/13/2003	0.52	8.6	5.2	223
5/19/2003	0.88	13.6	9.7	262
5/22/2003	0.33	4.8	2.0	156
5/28/2003	0.06	0.5	0.2	183
5/30/2003	0.23	3.2	2.5	292
6/4/2003	0.17	2.2	1.4	234
6/6/2003	0.93	14.4	11.2	287
6/9/2003	0.05	0.3	0.1	114
6/12/2003	0.04	0.2	0.1	125
6/18/2003	0.13	1.6	1.5	360
6/23/2003	0.09	0.9	0.4	150
6/24/2003	4.48	101.6	70.8	257
6/28/2003	0.33	4.8	3.2	247
7/3/2003	0.65	9.9	8.8	327
7/4/2003	0.12	1.4	0.6	158
7/8/2003	0.07	0.6	0.3	169
7/9/2003	0.10	1.1	0.3	111
7/11/2003	0.04	0.2	0.1	134
7/14/2003	0.78	12.0	10.5	323
7/20/2003	0.06	0.5	0.1	93
7/22/2003	0.06	0.5	0.2	184
7/30/2003	0.05	0.3	0.1	81
7/31/2003	0.13	1.6	0.7	173
8/6/2003	0.01	0.0	0.0	51
8/19/2003	0.80	12.2	12.6	378
9/11/2003	1.43	22.4	15.7	258
9/18/2003	0.50	7.5	7.8	385
9/21/2003	0.05	0.3	0.1	114
9/26/2003	0.09	0.9	0.3	126
9/29/2003	0.08	0.8	0.3	122
10/11/2003	0.53	7.9	9.0	415
10/25/2003	0.05	0.3	0.1	153
10/27/2003	0.07	0.6	0.2	109
10/28/2003	0.07	0.6	0.1	87
10/29/2003	0.08	0.8	0.3	149
10/30/2003	0.09	1.0	0.5	195
11/10/2003	0.28	4.0	0.5	48
11/12/2003	0.17	2.2	0.7	118
11/17/2003	0.03	0.0	0.0	51

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (µg/L)
11/30/2003	0.09	0.9	0.1	39
12/8/2003	0.12	1.4	0.1	38
12/26/2003	0.58	10.1	1.0	37
2/19/2004	0.41	6.0	0.6	37
2/27/2004	1.46	47.4	7.8	61
3/9/2004	0.48	7.6	0.9	42
3/13/2004	0.41	6.2	0.7	44
3/17/2004	0.43	6.6	0.7	37
3/19/2004	0.03	0.0	0.0	52
3/25/2004	0.24	3.3	2.4	269
3/27/2004	0.41	6.1	2.8	170
3/28/2004	0.02	0.0	0.0	57
4/18/2004	1.51	23.8	17.8	275
4/20/2004	0.57	9.9	3.2	118
4/24/2004	0.52	7.8	4.1	192
5/5/2004	0.07	0.6	0.2	129
5/9/2004	0.63	9.6	10.7	413
5/12/2004	0.16	2.1	1.3	234
5/13/2004	0.44	6.5	3.6	202
5/16/2004	0.79	12.2	9.6	289
5/19/2004	0.22	3.0	1.8	220
5/21/2004	0.06	0.4	0.1	70
5/21/2004	0.16	2.1	0.9	159
5/23/2004	1.03	16.1	9.3	213
5/25/2004	0.01	0.0	0.0	73
5/26/2004	0.59	10.5	7.4	262
5/28/2004	0.74	11.4	6.6	215
5/30/2004	0.73	14.9	6.0	148
5/31/2004	1.20	35.1	15.8	166
6/5/2004	0.14	1.8	0.9	194
6/5/2004	0.38	5.6	4.4	292
6/8/2004	1.68	26.8	13.7	188
6/10/2004	0.99	24.1	13.5	207
6/23/2004	0.34	4.9	7.1	534
6/27/2004	0.05	0.3	0.1	79
7/3/2004	0.55	8.3	5.6	249
7/5/2004	0.71	10.9	7.1	242
7/11/2004	1.29	20.2	13.3	242
7/21/2004	0.08	0.8	0.5	224
7/28/2004	0.11	1.2	1.1	325
7/30/2004	0.07	0.7	0.3	160
7/31/2004	0.18	2.3	1.5	243
8/3/2004	0.06	0.5	0.1	113

Event Date	Event Precipitation (in)	Total P8 Runoff Volume to Lake (acre-ft)	Total P8 TP Load to Lake (lbs)	P8 Event TP Conc. (μg/L)
8/7/2004	0.15	1.9	1.5	297
8/11/2004	0.01	0.0	0.0	52
8/15/2004	0.54	8.1	6.2	282
8/22/2004	0.16	2.1	1.9	348
8/23/2004	0.20	2.7	1.9	252
8/26/2004	0.12	1.4	0.7	186
8/29/2004	0.12	1.4	0.6	154
9/5/2004	1.74	27.6	18.2	243
9/13/2004	0.12	1.5	0.5	126
9/14/2004	2.86	50.5	23.6	172
9/17/2004	0.16	2.1	0.7	119
9/21/2004	0.03	0.0	0.0	52
9/22/2004	0.03	0.0	0.0	52
9/23/2004	0.26	3.7	2.5	250
Steady State Year (May 1, 2003 – April 30, 2004)	26	488	279	211
Growing Season (June 1, 2004 – Sept 30, 2004)	13	211	128	223

2.0 Water Balance Model

A daily water balance spreadsheet model was used to verify the runoff volumes predicted by P8 models as well as observed lake level data (when available) to estimate each lake's volume and discharge. Stage-area-storage-discharge curves were developed for each lake based on available bathymetry data as well as outlet geometry. Water balance was estimated using the following equation:

$$\Delta \text{ in Lake Storage} = WR + DP + US - EV - GW - D - OL$$

Where:

WR	=	Watershed Runoff
DP	=	Direct Precipitation on the surface area of the lake
US	=	Flows from Upstream Lakes/Sources (when applicable; based on water balance models and/or lake levels & rating curves for upstream lakes)
EV	=	Evaporation for lake surface based on adjusted pan evaporation data from the University of Minnesota St. Paul Campus Climatological Observatory
GW	=	Average groundwater exchange fit to lake level monitoring data
D	=	Estimated average daily discharge based on outlet geometry
OL	=	Other losses (when applicable)

The results of the water (and phosphorus) balance model for Bennett and Wakefield Lake are included in Appendix B and Appendix C.

3.0 Phosphorus Mass Balance Model

After the P8 and water balance models were developed and checked against observed water level data, phosphorus mass balance models were calibrated to observed water quality data using a differencing methodology. This differencing method allowed the models to be used to estimate phosphorus loading sources and losses not explicitly accounted for in the mass balance modeling during the Bennett Lake and Wakefield Lake growing seasons.

The phosphorus mass balance model evaluates a period of 17 months (beginning on May 1 of a given year through September 30 of the following year), and is comprised of two phases. The first phase uses water and phosphorus loads for the first 12 months of the period (May 1 through April 30 of the following year) are used as the inputs to the empirical steady-state phosphorus equation to predict the in-lake phosphorus concentration at the beginning of the calibration period. The steady-state equations used to establish the late-spring phosphorus concentration are discussed in more detail in the main body of the report and in Appendix B and Appendix C.

The second phase of the water quality modeling considers the five month period from May 1 through September 30, to calibrate the mass balance model to observed water quality data and estimate phosphorus sources and losses to the lakes required to match the water quality monitoring data. The phosphorus mass balance model time step is variable, based on the period of time between each of the water quality monitoring events.

The mass balance equation used to estimate the internal load and calibrate the model to observed water quality data for each time step is as follows (also discussed in the main body of the report):

P Adjusted = Observed P + Outflow P + Coontail Uptake P –
Runoff P – Upstream P - Atmospheric P – Curlyleaf Pondweed P – P Initial

The following discusses each of the components of the mass balance equation and where these numbers come from based on the data available for this study as well as the P8 and water balance modeling that was performed. Summaries of phosphorus balance modeling for Bennett Lake and Wakefield Lake are included in Appendix B and Appendix C, respectively.

Observed P

The water quality data collected for each water body was used for the calibration of the mass balance model (estimation of the internal loading/losses). Surface TP is the primary parameter used for calibration (sampled collected at a depth of 0-2 m). The observed P is the amount of phosphorus in the epilimnion based on the TP concentration and the estimated epilimnion volume (estimated in the daily water balance model) at the time of the monitoring event (the end of the current timestep).

Other water quality parameters typically used to verify the water quality model include TP measurements along the water column profile (if available), water temperature, and DO data. Some of the water quality sampling dates have monitoring data available along the depth profile of the lake. The temperature profiles help identify the depth to the thermocline and when used in conjunction with the water balance, can estimate the epilimnetic volume during each period. Additionally, the TP and DO profile data can help verify if there is internal loading from the sediments due to anoxia below the thermocline and along the bottom sediments. Some of the water quality sampling dates may have only included surface water quality measurements and therefore, parameters such as depth to the thermocline, was estimated based on interpolation between known data.

Outflow P

Outflow P typically includes losses of phosphorus through surface discharge as well as through losses to the GW. The volumes of discharge during each time step were based on the daily water balance model. The TP concentration of the discharge is assumed to be the observed surface TP data from the prior time step.

Coontail Uptake P

Qualitative macrophyte surveys were performed on Bennett Lake and Wakefield Lake. These surveys included areal coverage estimates as well as relative densities for a variety of macrophyte species including Coontail. Typically, surveys were also available in early and late summer, so changes in coverage and density could be estimated throughout the GS. The uptake of TP by Coontail was estimated based on average daily uptake rates presented by Lombardo and Cooke (2003) and the estimated density and coverage of the macrophyte.

Runoff P

The P8 model results were used to estimate the phosphorus associated with watershed runoff. To estimate pollutant loading, the P8 model tracks the build-up, wash-off, and settling of particles and a mass of phosphorus is associated with each particle size (see P8 discussion above). The phosphorus mass balance model tracks the various particle sizes estimated by the P8 model and assumes particles will settle out of the epilimnion based on their settling velocity (as used in P8). As a result, the SRO TP used by the mass balance model to predict the water quality in the lake is less than the TP load directly estimated by the P8 model due to particle settling.

Upstream P

The in-lake mass balance model accounts for loads from upstream lakes and water bodies. In the case of Bennett Lake and Wakefield Lake, there are no upstream waterbodies. However, if there were upstream waterbodies (not modeled in the P8 model), the mass balance model estimates volumes from upstream sources during each timestep were based on the daily water balance model. Typically, discharge estimates are based on lake level data and the discharge rating curves or water balance models for the upstream lakes (if available). The TP concentrations associated with upstream sources are typically based on water quality monitoring data or the phosphorus mass balance model (if available).

Atmospheric P

Atmospheric phosphorus was applied at a constant loading rate of 0.2615 kg/ha/yr (Barr 2005). This was applied to the estimated surface area of the lake at each time step.

Curlyleaf P

Qualitative macrophyte surveys were performed on Bennett Lake and Wakefield Lake. These surveys included areal coverage estimates as well as relative densities for a variety of macrophyte species including Curlyleaf pondweed. Using the late-spring or early-summer surveys, the coverage and density of the Curlyleaf pondweed could be estimated. The estimated biomass phosphorus content was based on data collected as part of a study of Big Lake in Wisconsin (Barr 2001) and compared to recent biomass measurements made for Medicine Lake (Vlach & Barten 2006). The phosphorus RR was based on the Half Moon Lake study (James et al. 2001).

P Initial

This parameter represents the amount of phosphorus that currently exists in the epilimnion at the start of the timestep. It is equivalent to the amount of phosphorus in the epilimnion at the end of the previous time step. At the beginning of the calibration period, the initial phosphorus concentration is based on the spring steady state phosphorus concentration estimated from the empirical relationship selected for Bennett Lake and Wakefield Lake. At the subsequent time steps in the model, the phosphorus concentrations are calibrated to the observed water quality in the lake throughout the GS.

P Adjusted

Once the known sources and losses of phosphorus were quantified, the required TP loading adjustment could be back calibrated so that the predicted phosphorus concentration in the epilimnion matches the observed TP data. The phosphorus adjustment can be either loading or losses of phosphorus. Losses of phosphorus are minimized through the calibration process and the estimated TP loading into the lake is verified against the results of the sediment core analysis.

Using the Calibrated Mass Balance Model

Once the in-lake mass balance model was calibrated for each lake, the models were used in a predictive manner to evaluate the impact of changes in water and phosphorus loading on the lake water quality. Additionally, the mass balance was used to estimate the TMDL load capacity and required phosphorus load reduction that would result in the expected in-lake water quality that would meet the MPCA water quality standards during the GS period.

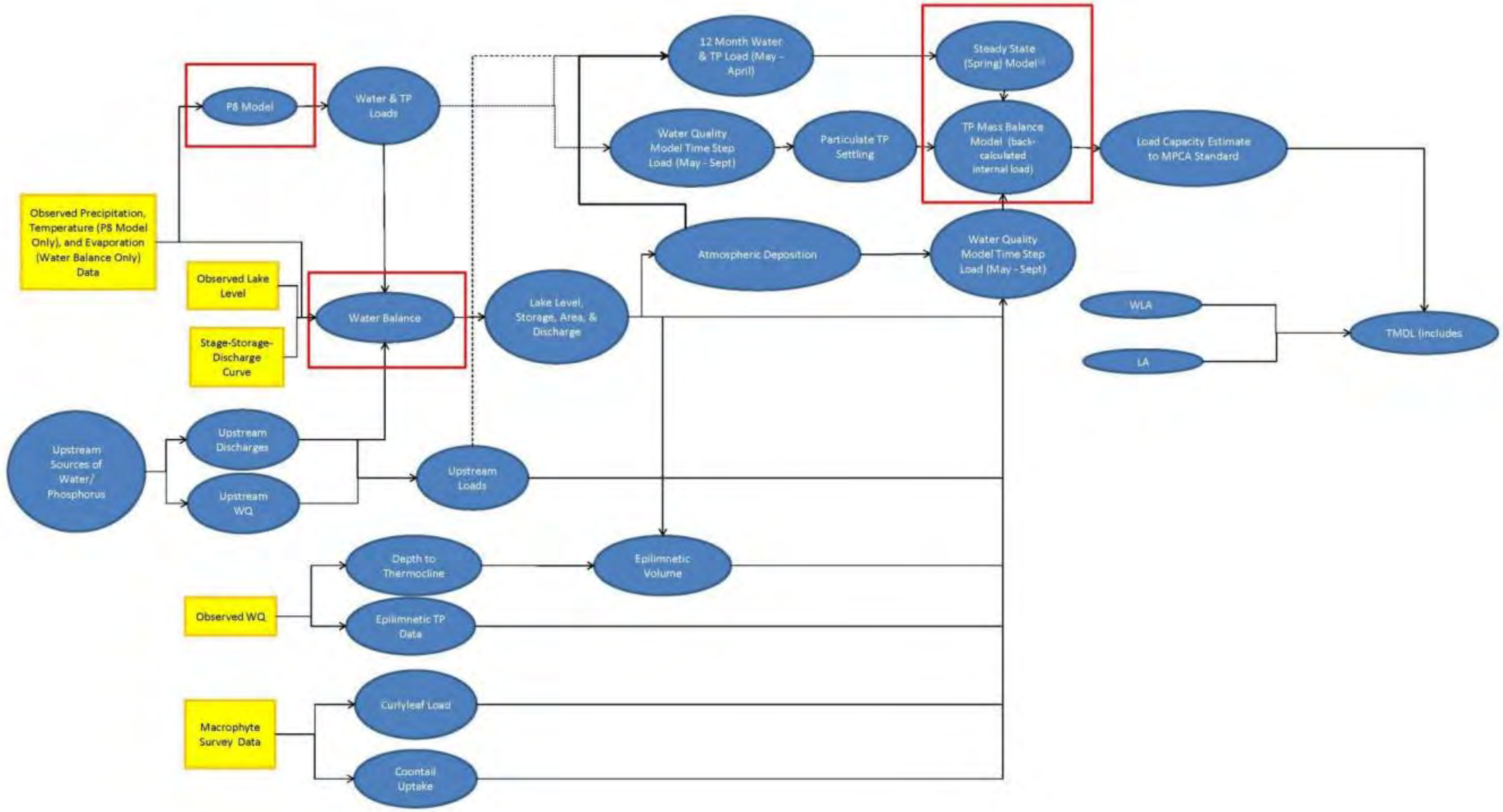

Figure A-1 TMDL modeling process flow chart

Appendix B:
Bennett Lake Water and Phosphorus Balance Model

B-1 Bennett Lake 2005 climatic conditions water balance summary

	Sample Period		A	B	C	D	E	F	G	H	I	J
			Total Lake Volume at the Start of the Period (acre-ft)	Direct Precipitation (acre-ft)	Evaporation (acre-ft)	Watershed Runoff (acre-ft)	Groundwater Inflow (acre-ft)	Surface Discharge (acre-ft)	Groundwater Outflow (acre-ft)	Change in Lake Volume (acre-ft)	Total Lake Volume at the End of the Period (acre-ft)	Lake Level at End of Period (ft MSL)
				+	-	+	+	-	-			
Steady State Year (May 1, 2004 - April 30, 2005)	5/1/2004	4/30/2005	180.4	76.9	64.7	347.1	0	372.4	0	-13.0	167.4	887.92
(Oct 1, 2004 - April 30, 2005)	10/1/2004	4/30/2005	167.1	25.5	13.5	118.7	0	130.5	0	0.3	167.4	887.92
In-Lake Water Quality Phosphorus Mass Balance Calibration Period (May 1, 2005 - Sept 30, 2005)	5/1/2005	5/4/2005	167.4	0.1	1.0	0.0	0	0.8	0	-1.7	165.7	887.87
	5/5/2005	5/26/2005	165.7	7.9	5.6	30.4	0	28.1	0	4.6	170.3	888.02
	5/27/2005	6/15/2005	170.3	6.8	7.5	24.7	0	21.4	0	2.6	172.9	888.10
	6/16/2005	7/6/2005	172.9	9.2	9.4	41.2	0	43.4	0	-2.4	170.6	888.02
	7/7/2005	7/28/2005	170.6	8.4	11.2	38.6	0	28.1	0	7.7	178.2	888.27
	7/29/2005	8/22/2005	178.2	4.3	9.8	16.1	0	20.0	0	-9.4	168.8	887.97
	8/23/2005	9/9/2005	168.8	9.8	6.0	43.2	0	44.1	0	2.9	171.7	888.06
	9/10/2005	9/30/2005	171.7	9.8	6.1	41.6	0	44.5	0	0.8	172.5	888.09
Total for Growing Season (June 1, 2005 - Sept 30, 2005)	6/1/2005	9/30/2005	169.2	47.3	48.8	202.2	0	197.4	0	3.3	172.5	888.09
Total for Water Year 2005 (Oct 1, 2004 - Sept 30, 2005)	10/1/2004	9/30/2005	167.1	81.8	70.2	354.6	0	360.8	0	5.4	172.5	888.09

Annual (2005 Water Year) Water Load to Bennett Lake (acre-ft)	10/1/2004	9/30/2005	436.4	Water Load = B + D + E

A - Based on the daily water balance model (calibrated to lake level data and using the lake stage-storage-discharge curve). See Tab "WaterBalance"
B - Based on precipitation data used for the P8 modeling and the daily water balance model (Direct Precip Volume = Depth of Precip * Lake Surface Area). See Tab "P8EventSummary".
C - Based on adjusted pan evaporation data from the University of Minnesota St. Paul Campus Climatological Observatory and the daily water balance model (Evap Volume = 0.7 * Depth of Evap * Lake Surface Area). See Tab "Evap"
D - Based on the water loads from the P8 model. See Tab "P8EventSummary"
E - Groundwater Inflow estimated in the daily water balance model.
F - Surface discharge from 24-hour average rating curve. See Tab "Lake Rating Curve"
G - Groundwater Discharge estimated in the daily water balance model.
H - Change in Lake Volume = B - C + D + E - F - G
I - Total Lake Volume @ End of Period = A + G
J - Estimated lake level based on the total lake volume and the stage-storage-discharge curve. See Tab "Lake Rating Curve"

B-2 **Bennett Lake 2005 climatic conditions in-lake growing season mass balance model summary[1]**

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Period Start		Epilimnion Volume	P In-Lake @ Start of Period	Total P Watershed Runoff	P Surface Runoff (after Particulate Settling)[5]	P From SSTS	P Atmospheric	P GW	P Release from Curlyleaf Pondweed[4]	P Uptake by Coontail[4]	P Loss due to Discharge	P Remaining in lake	In-Lake P before Adjustment	Observed In-Lake P	Residual Adjustment (Internal Loading / Losses)	Residual Adjustment (Internal Loading / Losses)[6]	P In-Lake @ End of Period	Predicted In-Lake P[2]
		acre-ft	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	µg/l	µg/L	µg/l	lbs	lbs	µg/L
Steady State Total (May 1, 2004 - April 30, 2005)[3,4,8]		159.5	N/A	108.1	92.5	0.0	7.0	0	N/A	N/A	71.8	N/A	N/A	N/A	N/A	N/A	N/A	70.9
(Oct 1, 2004 - April 30, 2005)[3,8]		159.5	N/A	33.9	29.0	0.0	4.1	0	0	0	25.2	N/A	N/A	N/A	N/A	N/A	N/A	70.9
5/1/05	5/4/05	159.8	30.8	0.0	0.0	0.0	0.1	0	0.0	0.0	0.1	30.6	70.5	77.8	7.2	3.1	33.8	78
5/5/05	5/26/05	164.1	33.8	8.5	8.2	0.0	0.4	0	0.0	0.1	5.9	36.4	81.5	128.0	46.5	20.7	57.1	128
5/27/05	6/15/05	186.5	57.1	7.9	7.1	0.0	0.4	0	0.0	0.1	7.4	57.1	112.5	173.5	61.0	30.9	88.0	174
6/16/05	7/6/05	172.2	88.0	15.2	12.7	0.0	0.4	0	6.1	0.2	20.5	86.5	184.7	190.5	5.8	2.7	89.2	191
7/7/05	7/28/05	174.4	89.2	14.4	12.1	0.0	0.4	0	5.5	0.2	14.6	92.5	194.9	279.0	84.1	39.9	132.4	279
7/29/05	8/22/05	167.5	132.4	5.3	4.4	0.0	0.5	0	0.6	0.3	15.1	122.5	269.0	239.5	-29.5	-13.4	109.1	240
8/23/05	9/9/05	167.8	109.1	15.2	11.8	0.0	0.3	0	0.0	0.2	28.7	92.3	202.4	167.5	-34.9	-15.9	76.4	168
9/10/05	9/30/05	176.0	76.5	13.0	11.7	0.0	0.4	0	0.0	0.3	20.3	68.0	142.0	167.5	25.5	12.2	80.2	168[7]
Growing Season Total (June 1, 2005 - Sept 30, 2005)[8]		N/A	N/A	70.1[9]	57.9[10]	0.0	2.3[10]	0	12.3[10]	1.2[10]	104.8[10]	N/A	N/A	N/A	N/A	78.1[11]	N/A	N/A
Total for Water Year 2005 (Oct 1, 2004 - Sept 30, 2005)[3,8]		N/A	N/A	113.3[9]	97	0.0	7.0	0	12.3	1.4	137.9	N/A	N/A	N/A	N/A	109.7[12]	N/A	N/A
Growing Season Average (6/1/2005 – 9/30/2005)[13]																		210

1 - Reflective of in-lake water quality model calibration conditions (2005 watershed conditions)

2 - Growing Season Average Reflects WQ data from June through September

3 - An empirical model (Dillon and Rigler (1974) with Larsen and Mercier (1976)) retention coefficient) was used to predict the steady state phosphorus concentration at the beginning of the phosphorus mass balance model developed for the period from May 1, 2004 - September 30, 2005.

4 - Phosphorus release from Curlyleaf pondweed and uptake by coontail was not estimated for the Steady State year because phosphorus mass balance modeling was not performed for the period from May 1, 2004 - April 30, 2005. Also, it was assumed that during the period from October 1 - April 30 the phosphorus loading due to Curlyleaf pondweed and uptake by coontail would be negligible due to the growth/die back cycles of these macrophytes during this season.

5 - The reported phosphorus load associated with surface runoff during the Steady State period, as well as the period from October 1, 2004 - April 30, 2005 reflects the total watershed runoff load multiplied by the ratio of watershed runoff P load after settling to the total watershed runoff P load.

6 - The individual total phosphorus adjustment values represent the net phosphorus load adjustment, including both phosphorus loads to the lake and losses such as sedimentation. Their algebraic sums year totals of these values will not match the growing season and water year totals below the data column nor the "internal loading from other sources" in Tab "PSourceSummary" which only summarizes the (positive) loads to the lake.

7 - Last P concentration observed (9/09/05) applied to the final growing season date (9/30/05) to establish a terminal boundary condition for growing season calculations.

8 - For Total Loads, total rounded to the nearest tenth of a pound for reporting purposes.

9 - Calculated from the P8 event loading for dates within the growing season (see Table A-3).

10 - Interpolated sum for the growing season (June 1, 2005 - Sept 30, 2005).

11 - Interpolated sum of positive loading values for the growing season (June 1, 2005 - Sept 30, 2005).

12 - Sum of positive loading values for the water year (Oct 1, 2004 – Sept 30, 2005).

13 - The growing season average total phosphorus concentration (µg/L) was calculated from values corresponding to observed growing season water quality concentrations in Bennett Lake (cells highlighted in blue).

A - See Tab "PhysicalParameters". The epilimnion volume represents the predicted epilimnion volume at the end of the time period.

B - Amount of phosphorus present in lake at the beginning of the timestep (based on spring steady state or observed TP concentration and epilimnetic volume from the previous timestep).

(Continued on following page)

(Table B-2: Continued from previous page)

C - Based on the Watershed TP Load before Particle Settling. See Tab "Particle Settling Summary"

D - Based on the Watershed TP Load after Particle Settling. See Tab "Particle Settling Summary"

E - Based on estimated load from failing SSTS in the direct watershed. See Tab "Upstream_DischargeSummary"

F - Atmospheric deposition applied at rate of 0.2915 kg/ha/yr (0.000639 lbs/ac/d) over the surface area of the lake

G - Load from Groundwater Inflow. See Tab "Upstream_DischargeSummary"

H - Based on a phosphorus release rate that is applied throughout the growing season according to estimated areal coverage and density from the available macrophyte survey information. See Tab "Curlyleaf Decay Summary"

I - Based on average daily uptake rate that is applied throughout the growing season according to estimated areal coverage and density from the available macrophyte survey information. See Tab "Coontail Uptake Summary"

J - Discharge from the lake includes surface discharge and losses to groundwater multiplied by the total phosphorus concentration from the previous time period. See Tab "Upstream_DischargeSummary"

K - P Remaining in Lake = B + D + E + F + G + H - I - J

L - In-Lake P before Adj = K / A / 0.00272

M - Water quality monitoring data. See Tab "WQ Data"

N - Residual Adjustment = M - L; The Residual Adjustment is the calibration parameter used to describe the internal phosphorus loads to the lake not explicitly estimated (e.g. release from bottom sediments, resuspension due to fish activity or wind, etc.), to estimate the uptake of phosphorus from the water column by algae growth, to estimate sedimentation of phosphorus from the water column, as well as to factor in possible error in the monitoring data.

O - Residual Adj Load = N*A * 0.00272. Positive values are treated as a phosphorus source to the lakes such as sediment release while negative values are handled as a sink, such as sedimentation.

P - P In-Lake at End of Period = K + O

Q - Predicted In-Lake P is a check against the Observed In-Lake P.

B-3 Bennett Lake 2005 climatic conditions in-lake growing season mass balance model allowable load estimate

Period Start		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		Epilimnion Volume	P In-Lake @ Start of Period	Total P Watershed Runoff	P Surface Runoff (after Particulate Settling)[4]	P From SSTS	P Atmospheric	P GW	P Release from Curlyleaf Pondweed	P Uptake by Coontail	P Loss due to Discharge	P Remaining in lake	In-Lake P before Adjustment	Observed In-Lake P	Residual Adjustment (Internal Loading / Losses)	Residual Adjustment (Internal Loading / Losses)	P In-Lake @ End of Period	Predicted In-Lake P
		acre-ft	lbs	lbs	Lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	µg/l	µg/L	µg/l	lbs	lbs	µg/L
5/1/05	5/4/05	160	13.2[1]	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	13.1				0.6	14	32
5/5/05	5/26/05	164	13.8	3.3	2.8	0.0	0.4	0.0	0.0	0.1	2.4	14.5				4.1	19	42
5/27/05	6/15/05	186	18.6	3.1	2.6	0.0	0.4	0.0	0.0	0.1	2.4	19.1				6.2	25	50
6/16/05	7/6/05	172	25.3	6.0	5.1	0.0	0.4	0.0	1.2	0.2	5.9	25.9				0.5	26	57
7/7/05	7/28/05	174	26.5	5.6	4.8	0.0	0.4	0.0	1.1	0.2	4.3	28.3				8.0	36	76
7/29/05	8/22/05	167	36.3	2.1	1.8	0.0	0.5	0.0	0.1	0.3	4.1	34.2				-3.7	30	67
8/23/05	9/9/05	168	30.5	5.9	5.1	0.0	0.3	0.0	0.0	0.2	8.0	27.7				-4.8	23	50
9/10/05	9/30/05	176	22.9	5.1	4.4	0.0	0.4	0.0	0.0	0.3	6.1	21.3				2.4	24	50
Growing Season Total (June 1, 2005 - Sept 30, 2005)		N/A	N/A	27.4	23.4	0.0	2.3	0.0	2.5	1.2	30.3	N/A				15.6	N/A	N/A
Growing Season Average (6/1/2005 - 9/30/2005)[5]																		60

Required load reduction (lbs / growing season) to meet MPCA standard for Bennett Lake

P Loading Source	Existing Conditions (2005)	TMDL Condition	Loading Reduction	Loading Reduction
	lbs	lbs	lbs	%
Watershed Runoff	70.1	27.4	42.7	61%[3]
Atmospheric	2.3	2.3	0	0%
Curlyleaf pondweed	12.3	2.5	9.8	80%[2]
Internal Loading	78.1	15.6	62.5	80%[2]
Total	**162.8**	**47.8**	**115**	**71%**

1 – Based on assumed initial in lake P concentration of 30 µg/L (see Table B-9).

2 – Internal load reduction (80%) applied to internal loading sources. Cells highlighted in yellow are the result of the noted percent reduction applied to the existing loading value. The reduction applied (80%) was chosen to represent the percent reduction achievable through methods of internal phosphorus removal and control (alum and herbicide treatment).

3 – The external (watershed) load reduction applied is the reduction value required to achieve the MPCA growing season total phosphorus water quality standard (60 µg/L). The reduction value (60.9%) applied to cells highlighted in orange was calculated by solving for the external load reduction required to meet the MPCA growing season total phosphorus water quality standard after applying of the internal load reduction (see item #1).

4 – The reported phosphorus load associated with surface runoff during the steady state period reflects the total watershed runoff load multiplied by the ratio of watershed runoff P load after settling to the total watershed runoff P load.

5 – The growing season average total phosphorus concentration (µg/L) was calculated from values corresponding to observed growing season water quality concentrations in Bennett Lake (cells highlighted in blue).

B-4 Bennett Lake 2005 water quality

Date	Water Surface Elevation (ft msl)	Secchi Disc Depth (m)	Depth to Thermocline (m)	Sample Depth (m)	Chl-a (mg/l)	D.O. (mg/l)	Temp. (°C)	Total P (mg/L)
5/4/05	888.00	2.9	2.4	0-2				0.08
5/4/05	888.00			0	6.4	11.2	10.8	0.06
5/4/05	888.00			0.999		10.4	10.2	
5/4/05	888.00			1.6	11.4			0.09
5/4/05	888.00			1.999		10.7	9.5	
5/4/05	888.00			2.2		1.6	9.3	
5/4/05	888.00			2.4		0.8	9.3	
5/26/05	888.19	1	2.4	0-2				0.13
5/26/05	888.19			0	21.10	9.0	18.5	0.10
5/26/05	888.19			1.002		8.5	18.2	
5/26/05	888.19			1.8	4.80			0.16
5/26/05	888.19			2.005		7.0	17.0	
5/26/05	888.19			2.41		0.2	16.0	
5/26/05	888.19			2.5		0.2	16.1	
6/15/05	888.53	1	2.9	0-2				0.17
6/15/05	888.53			0	13.50	5.5	22.9	0.18
6/15/05	888.53			0.999		5.6	22.9	
6/15/05	888.53			2.004		5.6	22.8	
6/15/05	888.53			2.1	12.00			0.17
6/15/05	888.53			2.525		3.9	22.8	
6/15/05	888.53			2.9		2.6	22.7	
7/6/05	888.07	0.9	2.8	0-2				0.19
7/6/05	888.07			0	87.60	12.9	24.3	0.20
7/6/05	888.07			1.003		12.6	23.5	
7/6/05	888.07			1.9	52.60			0.19
7/6/05	888.07			2.003		10.3	23.1	
7/6/05	888.07			2.592		0.3	23.0	
7/6/05	888.07			2.8		0.1	23.0	
7/28/05	888.15	0.6	2.8	0-2				0.28
7/28/05	888.15			0	95.00	7.8	24.5	0.24
7/28/05	888.15			1.013		7.8	24.4	
7/28/05	888.15			2.009	103.00	7.6	24.3	0.32
7/28/05	888.15			2.408		0.3	24.1	
7/28/05	888.15			2.831		0.4	24.2	
8/22/05	888.21	0.4	2.5	0-2				0.24
8/22/05	888.21			0	57.70	7.9	22.5	0.24
8/22/05	888.21			1.007		7.8	22.5	
8/22/05	888.21			1.8	62.10			0.24
8/22/05	888.21			2.005		7.2	22.2	
8/22/05	888.21			2.308		3.9	22.2	
8/22/05	888.21			2.5		2.2	22.2	
9/9/05	888.35	0.6	2.4	0-2				0.17
9/9/05	888.35			0	44.50	7.8	21.9	0.17
9/9/05	888.35			1.004		6.5	21.9	

Date	Water Surface Elevation (ft msl)	Secchi Disc Depth (m)	Depth to Thermocline (m)	Sample Depth (m)	Chl-a (mg/l)	D.O. (mg/l)	Temp. (^oC)	Total P (mg/L)
9/9/05	888.35			1.8	40.00			0.17
9/9/05	888.35			2.045		4.1	21.6	
9/9/05	888.35			2.306		1.4	21.5	
9/9/05	888.35			2.4		0.4	21.3	
9/30/05	888.71	0.6	2.4	0-2				0.17

B-5 Bennett Lake stage storage discharge rating curve

Elevation	Area	Cumulative Storage	Discharge[1]
(ft MSL)	(ac)	(ac-ft)	(cfs)
879.0	0.0	0.0	0.000
882.0	17.7	26.6	0.000
887.6	29.8	157.7	0.000
887.7	30.1	160.7	0.003
887.8	30.3	163.7	0.030
887.9	30.6	166.8	0.100
888.0	30.8	169.8	0.239
888.5	31.6	185.6	1.998
889.0	32.5	201.4	4.051
889.5	33.9	218.4	6.591
890.0	35.3	235.3	8.3
890.5	37.3	255.0	9.7
891.0	39.4	274.7	10.9
891.5	41.4	294.4	12.0
892.0	43.4	314.0	13.0
892.5	45.4	337.8	13.9
893.0	47.4	361.5	14.8
893.5	49.4	385.2	15.6
894.0	51.5	408.9	16.0

[1] 24-hour average discharge.

B-6 Bennett Lake historic lake level data (2004-2005)

Date	Elevation (NAVD88, feet)
1/2/2004	886.753
2/3/2004	886.643
2/26/2004	886.583
3/18/2004	887.763
4/15/2004	887.803
4/22/2004	888.433
5/11/2004	888.203
5/18/2004	888.643
5/25/2004	888.963
6/14/2004	888.383
6/22/2004	887.953
7/8/2004	888.633
7/29/2004	888.003
8/10/2004	887.843
8/24/2004	887.693
9/10/2004	887.753
9/27/2004	887.973
9/28/2004	887.973
10/5/2004	889.213
10/15/2004	886.963
11/5/2004	888.483
11/29/2004	888.323
1/11/2005	888.293
2/17/2005	888.133
3/15/2005	887.983
4/20/2005	887.893
5/24/2005	888.153
6/15/2005	888.533
7/18/2005	887.813
8/2/2005	888.313
8/17/2005	888.073
8/31/2005	888.453
9/14/2005	888.293
9/30/2005	888.713
10/17/2005	889.333
11/7/2005	888.563
11/21/2005	888.433

B-7 St. Paul Campus Monthly Pan Evaporation Data

ST. PAUL CAMPUS CLIMATOLOGICAL OBSERVATORY 21-8450-6								
Source	http://climate.umn.edu/img/wxsta/pan-evaporation.htm							
	MONTHLY PAN EVAPORATION, INCHES							
Year	**APRIL**	**MAY**	**JUNE**	**JULY**	**AUG.**	**SEPT.**	**OCT.**	**TOTAL**
2004	1.91	5.41	6.3	6.63	5.14	4.91	1.27	31.57
2005	1.2	4.35	6.96	8.82	6.49	4.81	1.2	33.83
Pan Coefficient	0.7							

B-8 Bennett Lake 2005 in-lake steady state summary

Parameter	Value[1]	Comments
L=Areal Load ($mg/m^2/yr$) From May to May	431.0	(Watershed Load + Atmospheric Load) / Surface Area
Watershed Load (mg/yr)	49,156,847	P8 Watershed Load[2] + Upstream Source Loads[3]
Atmospheric Load (mg/yr)	3,174,787	Atmospheric Deposition Rate * Surface Area = 0.2915 kg/ha/yr * Surface Area
V=Volume (m^3)	196,744	Lake Volume[4]
A=Surface Area (m^2)	121,407	Surface Area[4]
z = mean Depth (m) = V/A	1.6	Volume / Surface Area
Q = Outflow (m^3/yr)	443,004	Inflow = Watershed Runoff + Upstream Inflows + Direct Precip = Outflow
r =Flushing Rate (yr-1) = Q/V	2.3	Outflow / Volume
Dillon and Rigler P=L(1-Rp)/(z*r) With Rp as follows:	Predicted TP Conc. (µg/L)	
Larsen and Mercier (1976) Rp=1/(1+r^(1/2))	70.9	

1 - Based on May 1, 2004 through April 30, 2005

2 - See Tab "P8EventSummary"

3 - See Tab "UpstreamDischargeSummary", Column G

4 - At Average Water Level; See Tab "GeneralInformation"

B-9 Bennett Lake 2005 in-lake steady state summary adjusted by external load reduction

Parameter	Value[1]	Comments
L=Areal Load (mg/m²/yr) From May to May	184.5	(Watershed Load + Atmospheric Load) / Surface Area
Watershed Load (mg/yr)	19,227,947	P8 Watershed Load[2] + Upstream Source Loads[3]
Atmospheric Load (mg/yr)	3,174,787	Atmospheric Deposition Rate * Surface Area = 0.2915 kg/ha/yr * Surface Area
V=Volume (m^3)	196,744	Lake Volume[4]
A=Surface Area (m^2)	121,407	Surface Area[4]
z = mean Depth (m) = V/A	1.6	Volume / Surface Area
Q = Outflow (m^3/yr)	443,004	Inflow = Watershed Runoff + Upstream Inflows + Direct Precip = Outflow
r =Flushing Rate (yr-1) = Q/V	2.3	Outflow / Volume
Dillon and Rigler P=L(1-Rp)/(z*r) With Rp as follows:	Predicted TP Conc. (µg/L)	
Larsen and Mercier (1976) Rp=1/(1+r^(1/2))	30.3	

1 - Based on May 1, 2004 through April 30, 2005

2 - See Tab "P8EventSummary". Watershed load reduced by external load reduction noted in Table B-3.

3 - See Tab "UpstreamDischargeSummary", Column G

4 - At Average Water Level; See Tab "GeneralInformation"

B-10 Bennett Lake 2005 physical parameter summary

Period		A	B	C		D	E	F	G	H
		Atmos. Dep	Water Surface Elev	Depth to Thermocline		Elevation of Thermocline	Epilimnion Volume	Surface Area	Hypolimnion Volume	Hypolimnion Area
From	To	(lbs)	(ft MSL)	(m)	(ft)	(ft MSL)	(ac-ft)	(acre)	(ac-ft)	(ac)
5/1/04	4/30/05	7.0	887.66	4.6	15.0	879.00	159.5	30.0	0.0	0.0
5/1/05	5/4/05	0.1	888.00	2.4	7.9	880.13	159.8	30.8	10.0	6.7
5/5/05	5/26/05	0.4	888.19	2.4	7.9	880.32	164.1	31.1	11.7	7.8
5/27/05	6/15/05	0.4	888.53	2.9	9.5	879.02	186.5	31.7	0.2	0.1
6/16/05	7/6/05	0.4	888.07	2.8	9.2	879.00	172.2	30.9	0.0	0.0
7/7/05	7/28/05	0.4	888.15	2.8	9.2	879.00	174.4	31.0	0.0	0.0
7/29/05	8/22/05	0.5	888.21	2.5	8.2	880.01	167.5	31.1	8.9	6.0
8/23/05	9/9/05	0.3	888.35	2.4	7.9	880.48	167.8	31.4	13.1	8.7
9/10/05	9/30/05	0.4	888.71	2.4	7.9	880.84	176.0	32.0	16.3	10.9

A - Atmospheric deposition applied at rate of 0.2915 kg/ha/yr (0.000639 lbs/ac/d) (Barr, 2005) over the surface area of the lake

B - Based on the daily water balance model. See Tab "WaterBalanceSummary", Column J

C - Estimated based on water quality profile data. See Tab "WQ Data"

D - Elevation of the Thermocline: D = B - C

E - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

F - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

G - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

H - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

B-11 Bennett Lake 2005 estimated Curlyleaf pondweed loads

Curlyleaf Pondweed survey summary

Macrophyte Area[1] (acres)	20.6
% Covered w/ Curlyleaf[1]	64%
Stem Density	150
Mat/stem	0.35
P Content	2000
Areal P load (mg/m2)	105
P Load (lbs)	12.3
Estimated Season Average Curlyleaf Release Rate Check ($mg/mg^2/d$)[2]	1.2

1 – Based on qualitative macrophyte survey

2 – Normalized over 90 days (per James et. al. 2001)

Estimated internal loading from Curlyleaf Pondweed

Sampling Dates	Cumulative P Load into Water Column (lbs)	Incremental P Load into Water Column (lbs)
4/30/05	0	0.0
5/4/05	0	0.0
5/26/05	0	0.0
6/15/05	0	0.0
7/6/05	6.07	6.1
7/28/05	11.6	5.5
8/22/05	12.2	0.6
9/9/05	12.3	0.0
9/30/05	12.3	0.0

B-12 Bennett Lake 2005 estimated uptake by Coontail

Coontail survey summary

Date Coontail uptake begins	5/1/2005
Max Coontail density (g/m^2)[1]	1324.5
Macrophyte Area (ac)	25.3
% covered w/ Coontail on uptake date	5%
Coontail Area on uptake date (ac)	1.3

1 – from LCMR, 2006; Newman, 2004

Estimated uptake by Coontail

Sampling Dates	Cumulative TP Uptake (lbs)	Incremental TP Uptake (lbs)
4/30/05	0.0	0.0
5/4/05	0.0	0.0
5/26/05	0.1	0.1
6/15/05	0.3	0.1
7/6/05	0.4	0.2
7/28/05	0.6	0.2
8/22/05	0.9	0.3
9/9/05	1.1	0.2
9/30/05	1.4	0.3

B-13 Bennett Lake 2005 summary of estimated P8 watershed runoff particle class settling from epilimnion & watershed TP loads before and after settling

			Number of Days to Settle P8 Particle Class[1,2,3]					
P8 Particle Class			P10	P30	P50	P80		
P8 Settling Velocity			vs = 0.03 ft/hr	vs = 0.3 ft/hr	vs = 1.5 ft/hr	vs = 15 ft/hr		
Sample Period		Epilimnion Depth (De)[4] (ft)	Particle Settling Time (days)	Particle Settling Time (days)	Particle Settling Time (days)	Particle Settling Time (days)	Total Watershed TP Load before Particle Settling (lbs)	Watershed TP Load after Particle Settling[2,3] (lbs)
5/1/2005	5/4/2005	15.0	20.8	2.1	0.4	0.0	0.0	0.0
5/5/2005	5/26/2005	7.9	10.9	1.1	0.2	0.0	8.5	8.2
5/27/2005	6/15/2005	7.9	10.9	1.1	0.2	0.0	7.9	7.1
6/16/2005	7/6/2005	9.5	13.2	1.3	0.3	0.0	15.2	12.7
7/7/2005	7/28/2005	9.2	12.8	1.3	0.3	0.0	14.4	12.1
7/29/2005	8/22/2005	9.2	12.8	1.3	0.3	0.0	5.3	4.4
8/23/2005	9/9/2005	8.2	11.4	1.1	0.2	0.0	15.2	11.8
9/10/2005	9/30/2005	7.9	10.9	1.1	0.2	0.0	13.0	11.7

1 Number of Days to Settle Particles = De/vs/24

2 The P0 particle class in P8 reflects the non-settleable (or dissolved) fraction of the particles.

3 The pollutant loading in P8 is based on the build-up and wash-off of particles. There are 5 particle size classes, each with a mass of pollutant associated with it (e.g. phosphorus) as well as a settling velocity. The majority of the phosphorus is associated with the P0 (or non-settleable fraction). The in-lake mass balance model tracks the mass of each particle size class (from the P8 model) and determines how long the particles will remain in the epilimnion (thus impacting observed water quality). The model considers the number of days between the water quality sampling dates and the prior storm events, and only includes the phosphorus load from those particles that would remain in the epilimnion during that period. See Tab "P8EventSummary".

4 Epilimnion Depth See Tab "PhysicalParameters"

Appendix C:
Wakefield Lake Water and Phosphorus Balance Model

C-1 Wakefield Lake 2004 climatic conditions water balance summary

	Sample Period		A	B	C	D	E	F	G	H	I	J
			Total Lake Volume at the Start of the Period (acre-ft)	Direct Precipitation (acre-ft)	Evaporation (acre-ft)	Watershed Runoff (acre-ft)	Groundwater Inflow (acre-ft)	Surface Discharge (acre-ft)	Groundwater Outflow (acre-ft)	Change in Lake Volume (acre-ft)	Total Lake Volume at the End of the Period (acre-ft)	Lake Level at End of Period (ft MSL)
				+	-	+	+	-	-			
Steady State Year (May 1, 2003 - April 30, 2004)	5/1/2003	4/29/2004	100.9	39.7	44.8	488.1	0	484.7	0	-1.6	99.3	884.72
(Oct 1, 2003 - April 30, 2004)	10/1/2003	4/29/2004	96.8	13.1	10.5	154.5	0	154.7	0	2.5	99.3	884.72
In-Lake Water Quality Phosphorus Mass Balance Calibration Period (May 1, 2004 - Sept 30, 2004)	4/30/2004	5/12/2004	99.3	1.3	2.5	12.3	0	8.1	0	3.1	102.3	884.87
	5/13/2004	6/9/2004	102.3	14.1	6.3	146.3	0	151.3	0	2.8	105.1	885.01
	6/10/2004	7/1/2004	105.1	2.3	5.1	29.3	0	36.3	0	-9.8	95.3	884.50
	7/2/2004	7/22/2004	95.3	4.2	5.1	40.2	0	37.9	0	1.3	96.6	884.58
	7/23/2004	8/10/2004	96.6	0.8	3.6	6.6	0	6.2	0	-2.3	94.3	884.44
	8/11/2004	8/30/2004	94.3	1.7	3.6	15.8	0	9.9	0	4.0	98.3	884.67
	8/31/2004	9/22/2004	98.3	7.7	4.3	81.7	0	84.5	0	0.7	99.0	884.70
	9/23/2004	9/30/2004	99.0	0.4	1.5	3.7	0	4.7	0	-2.1	96.9	884.59
Total for Growing Season (June 1, 2004 - Sept 30, 2004)	6/1/2004	9/30/2004	114.6	20.9	25.5	211.4	0	224.5	0	-17.7	96.9	884.59
Total for Water Year 2004 (Oct 1, 2003 - Sept 30, 2004)	10/1/2003	9/30/2004	96.8	45.6	42.4	490.3	0	493.4	0	0.1	96.9	884.59

Annual (2004 Water Year) Water Load to Wakefield Lake (acre-ft)	10/1/2003	9/30/2004	536	Water Load = B + D + E

A - Based on the daily water balance model (calibrated to lake level data and using the lake stage-storage-discharge curve). See Tab "WaterBalance"
B - Based on precipitation data used for the P8 modeling and the daily water balance model (Direct Precip Volume = Depth of Precip * Lake Surface Area). See Tab "P8EventSummary".
C - Based on adjusted pan evaporation data from the University of Minnesota St. Paul Campus Climatological Observatory and the daily water balance model (Evap Volume = 0.7 * Depth of Evap * Lake Surface Area). See Tab "Evap"
D - Based on the water loads from the P8 model. See Tab "P8EventSummary"
E - Groundwater Inflow estimated in the daily water balance model.
F - Surface discharge from 24-hour average rating curve. See Tab "Lake Rating Curve"
G - Groundwater Discharge estimated in the daily water balance model.
H - Change in Lake Volume = B - C + D + E - F - G
I - Total Lake Volume @ End of Period = A + G
J - Estimated lake level based on the total lake volume and the stage-storage-discharge curve. See Tab "Lake Rating Curve"

C-2 Wakefield Lake 2004 climatic conditions in-lake growing season mass balance model summary[1]

Period Start		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		Epilimnion Volume	P In-Lake @ Start of Period	Total P Watershed Runoff	P Surface Runoff (after Particulate Settling)[5]	P From SSTS	P Atmospheric	P GW	P Release from Curlyleaf Pondweed[4]	P Uptake by Coontail[4]	P Loss due to Discharge	P Remaining in lake	In-Lake P before Adjustment	Observed In-Lake P	Residual Adjustment (Internal Loading / Losses)	Residual Adjustment (Internal Loading / Losses)[6]	P In-Lake @ End of Period	Predicted In-Lake P[2]
		acre-ft	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	µg/l	µg/L	µg/l	lbs	lbs	µg/L
Steady State Total (May 1, 2003 - April 30, 2004)[3,4,7]		102.9	N/A	279.2	93.9	0	4.8	0	N/A	N/A	88.1	N/A	N/A	N/A	N/A	N/A	N/A	66.8
(Oct 1, 2003 - April 30, 2004)[3,7]		102.9	N/A	53.7	18.1	0	3.0	0	0	0.0	28.1	N/A	N/A	N/A	N/A	N/A	N/A	66.8
4/30/04	5/12/04	85.8	18.7	12.3	6.6	0	0.2	0	0	0.1	1.5	23.9	102.5	119.3	16.9	3.9	27.9	119
5/13/04	6/9/04	87.8	27.9	80.1	29.8	0	0.4	0	0	0.9	49.1	8.0	33.3	138.5	105.2	25.1	33.1	139
6/10/04	7/1/04	71.1	33.1	20.7	3.0	0	0.2	0	0	1.7	13.7	21.0	108.3	196.5	88.2	17.1	38.0	197
7/2/04	7/22/04	76.0	38.0	26.5	4.2	0	0.2	0	0	2.6	20.3	19.5	94.4	204.5	110.1	22.8	42.3	205
7/23/04	8/10/04	82.4	42.3	4.6	1.2	0	0.2	0	0	2.8	3.4	37.4	167.0	167.5	0.5	0.1	37.5	168
8/11/04	8/30/04	83.1	37.6	11.3	3.3	0	0.2	0	0	3.4	4.5	33.3	147.2	121.0	-26.2	-5.9	27.3	121
8/31/04	9/22/04	93.4	27.3	43.0	18.3	0	0.3	0	0	4.4	27.8	13.8	54.2	98.0	43.8	11.1	24.9	98
9/23/04	9/30/04	92.0	24.9	2.5	1.2	0	0.1	0	0	1.7	1.3	23.3	93.0	98.0	5.0	1.2	24.5	98[7]
Growing Season Total (June 1, 2004 - Sept 30, 2004)[8]		N/A	N/A	127.7[9]	40.8[10]	0	1.4[10]	0	0	16.9[10]	86.7[10]	N/A	N/A	N/A	N/A	60.4[11]	N/A	N/A
Total for Water Year 2004 (Oct 1, 2003 - Sept 30, 2004)[3,8]		N/A	N/A	254.8[9]	85.7	0	4.8	0	0	17.6	149.6	N/A	N/A	N/A	N/A	81.3[12]	N/A	N/A
Growing Season Average (6/1/2004 – 9/30/2004)[13]																		154

1 - Reflective of in-lake water quality model calibration conditions (2004 watershed conditions)

2 - Growing Season Average Reflects WQ data from June through September

3 - An empirical model (Dillon and Rigler (1974) with Chapra (1975)) retention coefficient) was used to predict the steady state TP concentration at the beginning of the phosphorus mass balance model developed for the period from May 1, 2003 - September 30, 2004.

4 - Phosphorus release from Curlyleaf pondweed and uptake by coontail was not estimated for the Steady State year because phosphorus mass balance modeling was not performed for the period from May 1, 2003 - April 30, 2004. Also, it was assumed that during the period from October 1 - April 30 the phosphorus loading due to Curlyleaf pondweed and uptake by coontail would be negligible due to the growth/die back cycles of these macrophytes during this season.

5 - The reported phosphorus load associated with surface runoff during the Steady State period, as well as the period from October 1, 2003 - April 30, 2004 reflects the total watershed runoff load multiplied by the ratio of watershed runoff P load after settling to the total watershed runoff P load.

6 - The individual total phosphorus adjustment values represent the net phosphorus load adjustment, including both phosphorus loads to the lake and losses such as sedimentation. Their algebraic sums year totals of these values will not match the growing season and water year totals below the data column nor the "internal loading from other sources" in Tab "PSourceSummary" which only summarizes the (positive) loads to the lake.

7 - Last P concentration observed (9/22/04) applied to the final growing season date (9/30/04) to establish a terminal boundary condition for growing season calculations.

8 - For Total Loads, total rounded to the nearest tenth of a pound for reporting purposes.

9 - Calculated from the P8 event loading for dates within the growing season (see Table A-4).

10 - Interpolated sum for the growing season (June 1, 2004 - Sept 30, 2004).

11 - Interpolated sum of positive loading values for the growing season (June 1, 2004 - Sept 30, 2004).

12 - Sum of positive loading values for the water year (Oct 1, 2003 – Sept 30, 2004).

13 - The growing season average total phosphorus concentration (µg/L) was calculated from values corresponding to observed growing season water quality concentrations in Wakefield Lake (cells highlighted in blue).

A - See Tab "PhysicalParameters". The epilimnion volume represents the predicted epilimnion volume at the end of the time period.

B - Amount of phosphorus present in lake at the beginning of the timestep (based on spring steady state or observed TP concentration and epilimnetic volume from the previous timestep).

C - Based on the Watershed TP Load before Particle Settling. See Tab "Particle Settling Summary"

D - Based on the Watershed TP Load after Particle Settling. See Tab "Particle Settling Summary"

(Continued on following page)

(Table C-2: Continued from previous page)

E - Based on estimated load from failing SSTS in the direct watershed. See Tab "Upstream_DischargeSummary"

F - Atmospheric deposition applied at rate of 0.2915 kg/ha/yr (0.000639 lbs/ac/d) over the surface area of the lake

G - Load from Groundwater Inflow. See Tab "Upstream_DischargeSummary"

H - Based on a phosphorus release rate that is applied throughout the growing season according to estimated areal coverage and density from the available macrophyte survey information. See Tab "Curlyleaf Decay Summary"

I - Based on average daily uptake rate that is applied throughout the growing season according to estimated areal coverage and density from the available macrophyte survey information. See Tab "Coontail Uptake Summary"

J - Discharge from the lake includes surface discharge and losses to groundwater multiplied by the total phosphorus concentration from the previous time period. See Tab "Upstream_DischargeSummary"

K - P Remaining in Lake = B + D + E + F + G + H - I - J

L - In-Lake P before Adj = K / A / 0.00272

M - Water quality monitoring data. See Tab "WQ Data"

N - Residual Adjustment = M - L; The Residual Adjustment is the calibration parameter used to describe the internal phosphorus loads to the lake not explicitly estimated (e.g. release from bottom sediments, resuspension due to fish activity or wind, etc.), to estimate the uptake of phosphorus from the water column by algae growth, to estimate sedimentation of phosphorus from the water column, as well as to factor in possible error in the monitoring data.

O - Residual Adj Load = N*A * 0.00272. Positive values are treated as a phosphorus source to the lakes such as sediment release while negative values are handled as a sink, such as sedimentation.

P - P In-Lake at End of Period = K + O

Q - Predicted In-Lake P is a check against the Observed In-Lake P.

C-3 Wakefield Lake 2004 climatic conditions in-lake growing season mass balance model allowable load estimate

Period Start		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
		Epilimnion Volume	P In-Lake @ Start of Period	Total P Watershed Runoff	P Surface Runoff (after Particulate Settling)[4]	P From SSTS	P Atmospheric	P GW	P Release from Curlyleaf Pondweed	P Uptake by Coontail	P Loss due to Discharge	P Remaining in lake	In-Lake P before Adjustment	Observed In-Lake P	Residual Adjustment (Internal Loading / Losses)	Residual Adjustment (Internal Loading / Losses)	P In-Lake @ End of Period	Predicted In-Lake P
		acre-ft	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	µg/l	µg/L	µg/l	lbs	lbs	µg/L
4/30/04	5/12/04	85.8	18.7[1]	7.3	2.5	0.0	0.2	0.0	0.0	0.1	1.5	19.8				1.6	21.3	91
5/13/04	6/9/04	87.8	21.3	47.6	16.0	0.0	0.4	0.0	0.0	0.9	37.6	-0.8				10.0	9.3	39
6/10/04	7/1/04	71.1	9.3	12.3	4.1	0.0	0.2	0.0	0.0	1.7	3.8	8.1				6.8	14.9	77
7/2/04	7/22/04	76.0	14.9	15.7	5.3	0.0	0.2	0.0	0.0	2.6	8.0	9.9				9.1	19.0	92
7/23/04	8/10/04	82.4	19.0	2.7	0.9	0.0	0.2	0.0	0.0	2.8	1.5	15.7				0.0	15.8	70
8/11/04	8/30/04	83.1	15.8	6.7	2.3	0.0	0.2	0.0	0.0	3.4	1.9	13.0				-2.3	10.7	47
8/31/04	9/22/04	93.4	10.7	25.6	8.6	0.0	0.3	0.0	0.0	4.4	10.9	4.3				4.4	8.8	35
9/23/04	9/30/04	92.0	8.8	1.5	0.5	0.0	0.1	0.0	0.0	1.7	0.4	7.3				0.5	7.8	31
Growing Season Total (June 1, 2004 - Sept 30, 2004)		N/A	N/A	75.9	26.9	0.0	1.4	0.0	0.0	16.9	38.6	N/A				24.1	N/A	N/A
Growing Season Average (6/1/2005 - 9/30/2005)[5]																		60

Required load reduction (lbs / growing season) to meet MPCA standard for Wakefield Lake

P Loading Source	Existing Conditions (2004)	TMDL Condition	Loading Reduction	Loading Reduction
	lbs	lbs	lbs	%
Watershed Runoff	127.7	75.9	51.8	41%[3]
Atmospheric	1.4	1.4	0	0%
Curlyleaf pondweed	--	--	--	--
Internal Loading	60.4	24.1	36.3	60%[2]
Total	**189.5**	**101.4**	**88.1**	**46%**

1 – Based on assumed initial in lake P concentration of 66.8 µg/L (see Table C-8).

2 – Internal load reduction (60%) applied to internal loading sources. Cells highlighted in yellow are the result of the noted percent reduction applied to the existing loading value. The reduction applied (60%) was chosen to represent the percent reduction achievable through methods of internal phosphorus removal and control (alum treatment).

3 – The external (watershed) load reduction applied is the reduction value required to achieve the MPCA growing season total phosphorus water quality standard (60 µg/L). The reduction value (40.6%) applied to cells highlighted in orange was calculated by solving for the external load reduction required to meet the MPCA growing season total phosphorus water quality standard after applying of the internal load reduction (see item #1).

4 – The reported phosphorus load associated with surface runoff during the steady state period reflects the total watershed runoff load multiplied by the ratio of watershed runoff P load after settling to the total watershed runoff P load.

5 – The growing season average total phosphorus concentration (µg/L) was calculated from values corresponding to observed growing season water quality concentrations in Bennett Lake (cells highlighted in blue).

C-4 Wakefield Lake 2004 water quality

Date	Water Surface Elevation (ft msl)	Secchi Disc Depth (m)	Depth to Thermocline (m)	Sample Depth (m)	Chl-a (mg/l)	D.O. (mg/l)	Temp. (^oC)	Total P (mg/L)
5/12/04	884.87	0.6	2	0-2				0.12
5/12/04	884.87		2	0		8.9	19.4	0.10
5/12/04	884.87			0.99		8.8	19.4	0.11
5/12/04	884.87			1.9				0.15
5/12/04	884.87			2		1.6	16.5	
5/12/04	884.87			2.5		1.0	14.4	
6/9/04	885.01	0.7	2	0-2				0.14
6/9/04	885.01		2	0	0.04	7.7	21.9	0.12
6/9/04	885.01			1		7.6	21.9	
6/9/04	885.01			2	0.03	2.3	20.3	0.15
6/9/04	885.01			2.7		0.6	17.2	
7/1/04	884.50	0.55	1.5	0-2				0.20
7/1/04	884.50		1.5	0	0.06	12.7	24.5	0.14
7/1/04	884.50			1		11.1	23.1	
7/1/04	884.50			1.7	0.10			0.26
7/1/04	884.50			2		0.5	17.7	
7/1/04	884.50			2		0.7	18.8	
7/22/04	884.58	0.55	1.7	0-2				0.20
7/22/04	884.58		1.7	0	0.09	10.5	27.0	0.14
7/22/04	884.58			1		9.6	27.1	
7/22/04	884.58			1.8	0.05			0.27
7/22/04	884.58			2.4		0.2	19.3	
7/22/04	884.58			2.4		0.3	20.9	
8/10/04	884.44	0.65	2.1	0-2				0.17
8/10/04	884.44		2.1	0	0.05	0.7	21.3	0.16
8/10/04	884.44			1		6.6	21.3	
8/10/04	884.44			1.5	0.06			0.18
8/10/04	884.44			2.1		0.6	21.2	
8/10/04	884.44			2.1		6.5	21.3	
8/30/04	884.67	0.6	2	0-2				0.12
8/30/04	884.67		2	0	0.06	8.3	20.3	0.12
8/30/04	884.67			0.99		7.6	20.1	
8/30/04	884.67			1.8	0.04			0.13
8/30/04	884.67			1.98		0.9	19.8	
8/30/04	884.67			1.98		1.0	19.8	
8/30/04	884.67			1.98		6.0	19.9	
9/22/04	884.70	0.8	2.5	0-2				0.10
9/22/04	884.70		2.5	0	0.05	7.3	20.2	0.09
9/22/04	884.70			1		6.9	20.1	
9/22/04	884.70			2	0.05	6.5	20.0	0.11

Date	Water Surface Elevation (ft msl)	Secchi Disc Depth (m)	Depth to Thermocline (m)	Sample Depth (m)	Chl-a (mg/l)	D.O. (mg/l)	Temp. (^oC)	Total P (mg/L)
9/22/04	884.70			2.5		4.4	19.9	
9/22/04	884.70			2.5		4.6	19.9	
9/30/04	884.59	0.8	2.5	0-2				0.10

C-5 Wakefield Lake stage storage discharge rating curve

Elevation	Area	Cumulative Storage	Discharge[1]
(ft MSL)	(ac)	(ac-ft)	(cfs)
875.6	0.0	0	0.0
880.6	12.1	30	0.0
880.9	16.4	35	0.0
882.6	16.8	63	0.0
884.3	17.2	92	0.1
884.6	17.3	97	0.2
884.8	20.5	101	0.3
884.9	20.6	103	0.4
885.0	20.8	105	0.9
885.5	21.4	115	4.5
886.0	22.1	126	8.3
887.0	23.4	149	16.8
887.6	24.2	163	21.9
888.0	24.7	173	25.9
889.0	25.8	198	35.3
891.0	28.1	252	55.5
892.8	30.3	305	75.0
893.0	30.5	311	77.6
894.0	31.7	342.0	89.0

[1] 24-hour average discharge.

C-6 Wakefield Lake historic lake level data (2003-2004)

Date	Elevation (NAVD88, feet)
1/20/2003	884.64
2/14/2003	884.37
3/13/2003	884.12
4/2/2003	884.88
4/14/2003	884.54
5/15/2003	885.05
5/30/2003	884.68
6/12/2003	884.5
6/26/2003	885.67
7/15/2003	884.97
7/30/2003	884.74
8/15/2003	884.4
9/3/2003	884.2
9/16/2003	884.94
10/1/2003	884.83
10/14/2003	884.67
10/15/2003	884.9
10/29/2003	884.72
11/14/2003	884.67
12/10/2003	884.47
1/2/2004	884.54
2/3/2004	884.12
2/26/2004	884.34
3/18/2004	885.06
4/15/2004	884.65
4/15/2004	884.7
4/22/2004	885.07
5/11/2004	885.04
5/18/2004	885.11
5/25/2004	885.06
6/14/2004	885.19
6/22/2004	884.84
7/8/2004	885.19
7/29/2004	884.83
8/10/2004	884.73
8/24/2004	884.6
9/10/2004	884.92
9/27/2004	884.87
10/15/2004	884.75
11/5/2004	884.94
11/29/2004	884.97

C-7 St. Paul Campus Monthly Pan Evaporation Data

ST. PAUL CAMPUS CLIMATOLOGICAL OBSERVATORY 21-8450-6								
Source	http://climate.umn.edu/img/wxsta/pan-evaporation.htm							
	MONTHLY PAN EVAPORATION, INCHES							
Year	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	TOTAL
2003	2.09	5.93	6.23	6.88	6.84	5.25	1.39	34.61
2004	1.91	5.41	6.3	6.63	5.14	4.91	1.27	31.57
Pan Coefficient	0.7							

C-8 Wakefield Lake 2004 in-lake steady state summary

Parameter	Value[1]	Comments
L=Areal Load (mg/m²/yr) From May to May	1546	(Watershed Load + Atmospheric Load) / Surface Area
Watershed Load (mg/yr)	126,903,306	P8 Watershed Load[2] + Upstream Source Loads[3]
Atmospheric Load (mg/yr)	2,183,386	Atmospheric Deposition Rate * Surface Area = 0.2915 kg/ha/yr * Surface Area
qs =Overflow Rate (m/yr)	7.1	Outflow / Surface Area
V=Volume (m^3)	126,869	Lake Volume[4]
A=Surface Area (m^2)	83495	Surface Area[4]
z= mean Depth (m)	1.5	Volume / Surface Area
Q=Outflow (m^3/yr)	595855	Inflow = Watershed Runoff + Upstream Inflows + Direct Precip = Outflow
r =Flushing Rate (yr-1)	4.7	Outflow / Volume
Dillon and Rigler P=L(1-Rp)/(z*r) With Rp as follows:	Predicted TP Conc (µg/L)	
Chapra (1975) Rp=16/(16+qs)	67	

1 - Based on May 1, 2003 through April 30, 2004

2 - See Tab "P8EventSummary"

3 - See Tab "UpstreamDischargeSummary", Column G

4 - At Average Water Level; See Tab "GeneralInformation"

C-9 Wakefield Lake 2004 physical parameter summary

Period		A	B	C		D	E	F	G	H
		Atmos. Dep	Water Surface Elev	Depth to Thermocline		Elevation of Thermocline	Epilimnion Volume	Surface Area	Hypolimnion Volume	Hypolimnion Area
From	To	(lbs)	(ft MSL)	(m)	(ft)	(ft MSL)	(ac-ft)	(acre)	(ac-ft)	(ac)
5/1/03	4/29/04	4.8	884.90	5.6	18.4	875.59	102.9	20.6	0.0	0.0
4/30/04	5/12/04	0.2	884.87	2.0	6.6	878.31	85.8	20.6	16.5	6.6
5/13/04	6/9/04	0.4	885.01	2.0	6.6	878.45	87.8	20.8	17.3	6.9
6/10/04	7/1/04	0.2	884.50	1.5	4.9	879.58	71.1	17.3	24.1	9.7
7/2/04	7/22/04	0.2	884.58	1.7	5.6	879.00	76.0	17.3	20.6	8.3
7/23/04	8/10/04	0.2	884.44	2.1	6.9	877.55	82.4	17.2	11.9	4.8
8/11/04	8/30/04	0.2	884.67	2.0	6.6	878.11	83.1	18.5	15.2	6.1
8/31/04	9/22/04	0.3	884.70	2.5	8.2	876.50	93.4	19.0	5.5	2.2
9/23/04	9/30/04	0.1	884.59	2.5	8.2	876.39	92.0	17.4	4.9	1.9

A - Atmospheric deposition applied at rate of 0.2915 kg/ha/yr (0.000639 lbs/ac/d) (Barr, 2005) over the surface area of the lake

B - Based on the daily water balance model. See Tab "WaterBalanceSummary", Column J

C - Estimated based on water quality profile data. See Tab "WQ Data"

D - Elevation of the Thermocline: D = B - C

E - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

F - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

G - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

H - Estimated using the lake stage-storage-discharge curve. See Tab "Lake Rating Curve"

C-10 Wakefield Lake 2005 estimated uptake by Coontail

Coontail survey summary

Date Coontail uptake begins	5/1/2004
Max Coontail density (g/m^2)[1]	1324.5
Macrophyte Area (ac)	17.6
% covered w/ Coontail on uptake date	5%
Coontail Area on uptake date (ac)	0.9

1 – from LCMR, 2006; Newman, 2004

Estimated uptake by Coontail

Sampling Dates	Cumulative TP Uptake (lbs)	Incremental TP Uptake (lbs)
4/29/04	0.00	0.0
5/12/04	0.04	0.1
6/9/04	0.46	1.0
7/1/04	1.24	2.7
7/22/04	2.44	5.4
8/10/04	3.71	8.2
8/30/04	5.23	11.5
9/22/04	7.22	15.9
9/30/04	7.97	17.6

C-11 Wakefield Lake 2004 summary of estimated P8 watershed runoff particle class settling from epilimnion & watershed TP loads before and after settling

			Number of Days to Settle P8 Particle Class[1,2,3]					
P8 Particle Class			P10	P30	P50	P80		
			0.03	0.3	1.5	15		
P8 Settling Velocity			vs = 0.03 ft/hr	vs = 0.3 ft/hr	vs = 1.5 ft/hr	vs = 15 ft/hr		
		Epilimnion Depth (De)[4]	Particle Settling Time	Particle Settling Time	Particle Settling Time	Particle Settling Time	Total Watershed TP Load before Particle Settling	Watershed TP Load after Particle Settling[2,3]
Sample Period		(ft)	(days)	(days)	(days)	(days)	(lbs)	(lbs)
4/30/2004	5/12/2004	18.4	25.6	2.6	0.5	0.1	12.3	6.6
5/13/2004	6/9/2004	6.6	9.1	0.9	0.2	0.0	80.1	29.8
6/10/2004	7/1/2004	6.6	9.1	0.9	0.2	0.0	20.7	3.0
7/2/2004	7/22/2004	4.9	6.8	0.7	0.1	0.0	26.5	4.2
7/23/2004	8/10/2004	5.6	7.7	0.8	0.2	0.0	4.6	1.2
8/11/2004	8/30/2004	6.9	9.6	1.0	0.2	0.0	11.3	3.3
8/31/2004	9/22/2004	6.6	9.1	0.9	0.2	0.0	43.0	18.3
9/23/2004	9/30/2004	8.2	11.4	1.1	0.2	0.0	2.5	1.2

1 Number of Days to Settle Particles = De/vs/24

2 The P0 particle class in P8 reflects the non-settleable (or dissolved) fraction of the particles.

3 The pollutant loading in P8 is based on the build-up and wash-off of particles. There are 5 particle size classes, each with a mass of pollutant associated with it (e.g. phosphorus) as well as a settling velocity. The majority of the phosphorus is associated with the P0 (or non-settleable fraction). The in-lake mass balance model tracks the mass of each particle size class (from the P8 model) and determines how long the particles will remain in the epilimnion (thus impacting observed water quality). The model considers the number of days between the water quality sampling dates and the prior storm events, and only includes the phosphorus load from those particles that would remain in the epilimnion during that period. See Tab "P8EventSummary".

4 Epilimnion Depth See Tab "PhysicalParameters"

Appendix D: Wakefield Lake 2D Modeling

Wakefield Lake 2D Modeling

There are three storm sewer inlets to Wakefield Lake, including discharges from the subwatersheds PHAL-03a (northwest inlet), PHAL-03b (northeast inlet), and PHAL-03c (southeast inlet, also known as the “Larpenteur Avenue storm sewer”, see Figure 3-4 of this TMDL study). However, during the development of the Wakefield Lake Strategic Lake Management Plan (Barr 2008), it was suspected that much of the runoff coming from the area drained by the Larpenteur Avenue storm sewer (including subwatersheds PHAL 03c and upstream PHAL 01, PHAL 02a and PHAL 02b) may not significantly influence the observed water quality of Wakefield Lake. Because the flows from Larpenteur Avenue enter on the southeast end of the lake directly across from the lake’s outlet on the southwest corner of the lake, it was suspected that flow may be effectively bypassing the lake (short-circuiting). Water quality in the southern part of the lake has not historically been monitored (historic monitoring location is in the center of the lake, see Figure D-1), so the impact of PHAL 03c flows on Wakefield Lake’s water quality in the southern end of the lake are unknown. However, if short-circuiting occurs, it must be accounted for as part of the in-lake modeling to appropriately quantify the watershed phosphorus loads to Wakefield Lake that influence the water quality (as observed) and to deduce the lake’s internal phosphorus loads (see Section 4.3.1.7 for additional discussion of the in-lake mass balance modeling). In order to better understand the mixing dynamics of Wakefield Lake and to estimate the contribution of the runoff from the Larpenteur Avenue storm sewer to the observed water quality in the main body of the lake, a 2-dimensional (2D) hydraulic model of inflows and mixing patterns in Wakefield Lake was developed.

We selected the Adaptive Hydraulics v4.2 (AdH) model, a 2D hydraulic model developed by the Coastal and Hydraulic Laboratory (CHL), Engineer Research and Development Center (ERDC) and the United States Army Corps of Engineers (USACE) for this analysis. AdH was selected because of its ability to determine flow vectors to visualize mixing processes and incorporate diffusion to estimate mixing within a body of water. Within the AdH 2D model, computer-estimated flow velocities are depth-averaged along the water column. It was determined that this modeling approach was appropriate for this level of investigation because the shallow nature of Wakefield Lake prevents significant temperature stratification that would affect differential flow velocities. In addition, AdH has the ability to adapt numerical meshes to efficiently compute a solution. The numerical mesh is the 2D surface, with associated elevations, used to perform the model calculations. Preprocessing of model inputs, including developing the mesh, was completed using AquaVeo’s Surface-Water Modeling System Version 11.1 (SMS).

To develop the 2D model of Wakefield Lake, we utilized updated bathymetry data collected by the RWMWD in 2013 to develop the bathymetry grid. To evaluate the hydrodynamics of the system, we used inflow data generated by the P8 water quality model for the critical water quality year (2003-2004) at the three main storm sewer inflows to the lake (on the northwest, northeast, and southeast sides of the lake). Additionally, we accounted for the outlet located on the southwest corner of the lake. We evaluated multiple scenarios to evaluate the lake mixing dynamics including:

- Constant average inflows from the P8 model for each inlet
- Constant peak inflows from the P8 model for each inlet
- Hourly hydrographs from the P8 model for each inlet, run for a period of about 6 months including the largest storm event during the critical water quality year

Although the constant inflow for an extended period of time scenarios is not realistic given the nature of storm events, the goal of these scenarios was to help isolate the relative impacts of the main factors influencing the mixing dynamics in Wakefield Lake. Some additional variables may have short term or minor impacts on mixing within the lake, but were not incorporated into the models, including:

- Mixing due to wind
- Evaporation causing the water surface elevation to drop below the outlet elevation, which would impact how flow vectors influence mixing as the water levels increase to the lake outlet elevation.
- Full stage-discharge rating curve for the lake outlet which would impact how quickly water leaves the lake. Available water level data indicates that the water surface bounce on Wakefield Lake is quite small, so the model assumed a constant water surface elevation.

While these variables would be important when doing a detailed analysis and model calibration, we assumed that these variables are not expected to significantly govern the mixing dynamics in the lake or the conclusions drawn from the model results,

To evaluate the impact of the Larpenteur Avenue flows on the observed water quality in Wakefield Lake, we utilized flow vectors and "dummy" concentrations with the flow inputs in AdH to evaluate relative impacts of the inflows on observed water quality. A concentration of 1 ppm was applied to the northwest and northeast inflows. A concentration of 100 ppm was applied to the southeast inflow (Larpentur Avenue). And based on the various flow scenarios that were evaluated, the resulting concentration around the deep hole in Wakefield Lake reflects the approximate contribution (as a percentage) of the southeast inflow.

Constant inflow scenarios were run for approximately one year of model time to generate a stable modeled concentration in the north end of the lake. Average flow and high flow scenarios based on the P8 modeling results were modeled to evaluate the expected flow dynamics during these two different flow conditions. In the average flow scenario, velocities within the lake were extremely low (less than 0.01 ft/sec) and in general, the average flows into Wakefield Lake did not develop into a consistent flow pattern. In the constant flow scenario, the final concentration in the main basin on the north end of Wakefield Lake was approximately 25-30 ppm. Since the inflow concentrations for the two northern inflow locations was 1 ppm, flow vectors indicated very little mixing through the lake, and the total flow entering the main basin in the northern portion of the lake was greater than the flow entering the southern portion of the lake, the final concentration in the main basin can be attributed to diffusion of the high concentration from the southern input into the northern portion of the lake.

In the high, constant inflow scenario, a steady flow pattern developed throughout Wakefield Lake. The final concentration in the northern portion of the lake was 1.3 ppm, so the high flows prevented mixing of the flows from the southern inlet to the lake into the northern portion of the lake and also prevented diffusion from having a significant impact on the expected water quality in the main basin of the lake. We performed this scenario primarily to establish the flow-based mixing patterns (as opposed to diffusion-based mixing patterns).

In addition to the constant inflow scenarios, we evaluated additional scenario using hourly time step hydrographs from the P8 model. As could be expected, the hydrograph scenario, provided results that were a mix of the two constant inflow scenarios. In general, concentrations in the main basin on the north end of the lake were low during and immediately after runoff events when higher flows governed the mixing patterns, but the concentrations went up during low flow or no flow periods when diffusion would govern the mixing, bringing TP from the south end to the main body of the lake.

Typically, the southeast inflows from Larpenteur Avenue have a higher peak rate and enter the lake before the flows from the other two inlets in the northern portion of the lake. This is because the watershed along Larpenteur Avenue is highly impervious and has very limited stormwater treatment that could temporarily detain flows, especially when compared to the watersheds of the northwest and northeast inlets. As such, during a storm event, flows from along Larpenteur Avenue enter Wakefield Lake before flows from other portions of the watershed. These flows begin moving north in the lake. However, by the time the flows from Larpenteur Avenue begin reaching the central portion of Wakefield Lake, the inflows from the northeast and northwest inlets begin to flow into the lake against the flows from Larpenteur Avenue, and preventing the flows from Larpenteur Avenue from fully-mixing into the main basin of the lake. Therefore, flows from along Larpenteur Avenue never directly reach the historic monitoring location in Wakefield Lake.

Figure D-1 shows the flow vectors and relative concentrations through Wakefield Lake for the storm event on June 25, 2003, demonstrating the mixing pattern discussed above in relation to the hourly inflow hydrograph scenarios. Also shown on the figure is the location of the historic water quality monitoring location in Wakefield Lake.

As a result of this hydrodynamic analysis, observed that Wakefield Lake likely does not fully-mix and that the majority of the phosphorus load from the watershed along Larpenteur Avenue does not directly influence the observed water quality. Flows from the southeast portion of the watershed primarily influences the water quality in Wakefield Lake due to diffusion of the soluble fraction of phosphorus from the southern portion of the lake to the main basin of the lake (where the historic water quality data has been collected) during the storm event and after an event (for any runoff remaining in the lake). The degree of flow-induced mixing during any given runoff event will be variable; however the primary mechanism governing the influence of the Larpenteur Avenue storm sewer runoff on the observed lake water quality in Wakefield Lake is diffusion. Based on the scenarios run in AdH, the predicted P8 watershed phosphorus loads used in the in-lake mass balance modeling were reduced to reflect the “effective” watershed load from the Larpenteur Avenue storm sewer. We assumed that only 30% of the soluble phosphorus load from the runoff coming through the Larpenteur Avenue storm sewer (southeast inlet) to Wakefield Lake actually influences the observed water quality. Because the P8 model tracks the movement of five different particle sizes (with a certain amount phosphorus associated with each particle size fraction), we were able to estimate the amount of soluble phosphorus coming from the Larpenteur Avenue Watershed and reduce the effect of the particulate loading from the Larpenteur Avenue storm sewer used in the in-lake mass balance model to represent the main body of Wakefield Lake.

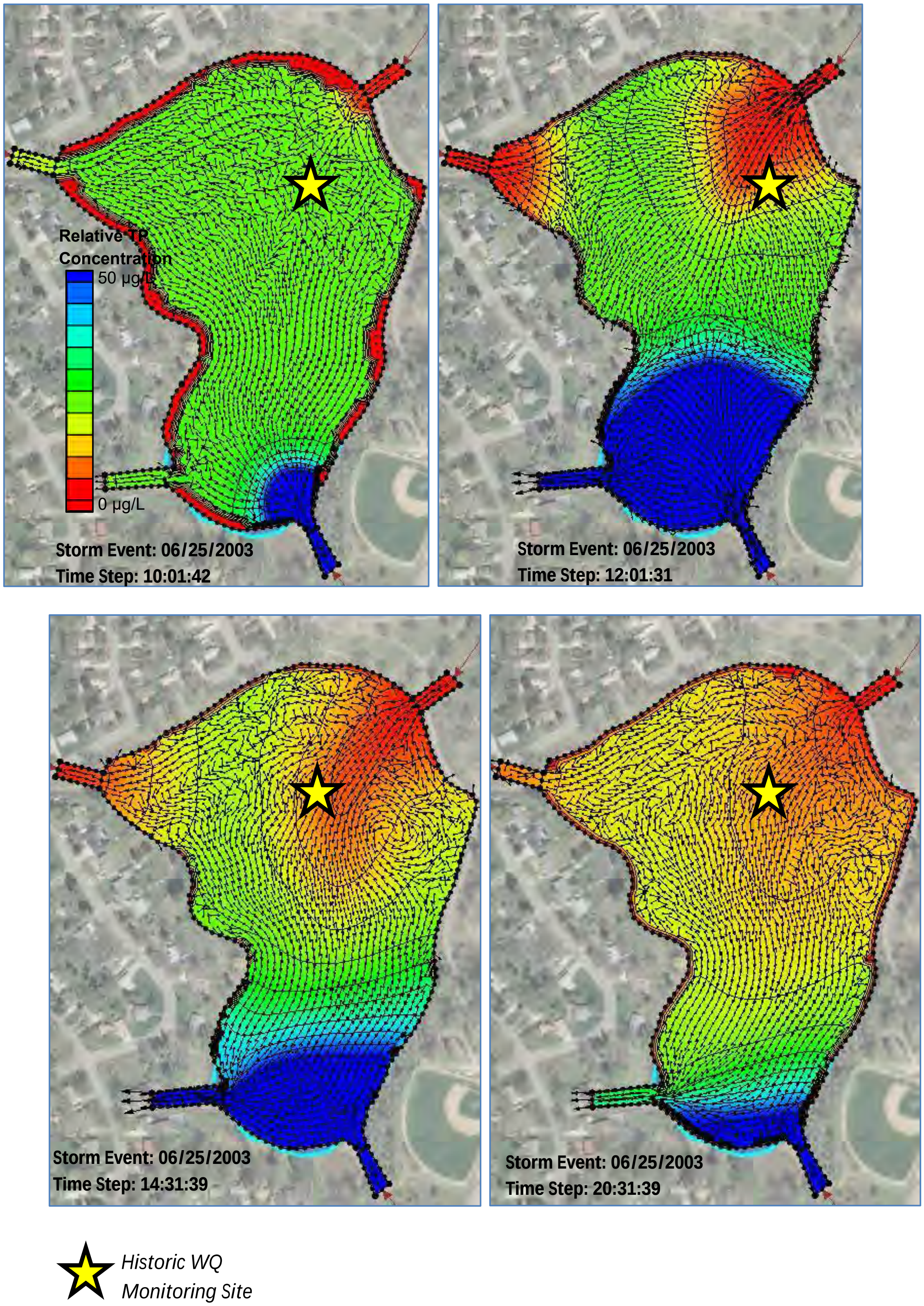

Figure D-1 Wakefield Lake 2D AdH modeling results from June 25, 2003 storm event.

Appendix E: Impaired Waterbodies by Location

E-1 Impaired lakes and streams by MS4

MS4			
MS4 Name	**MS4 ID Number**	**Impaired Lake/Stream**	**WBID**
Maplewood City	MS400032	Battle Creek Fish Creek Wakefield Lake	07010206-592 07010206-606 62-0011-00
MnDOT Metro District	MS400170	Battle Creek Fish Creek Bennett Lake	07010206-592 07010206-606 62-0048-00
North St. Paul City	MS400041	Wakefield Lake	62-0011-00
Ramsey County Public Works	MS400191	Battle Creek Fish Creek Bennett Lake Wakefield Lake	07010206-592 07010206-606 62-0048-00 62-0011-00
Roseville City	MS400047	Bennett Lake	62-0048-00
Saint Paul Municipal Storm Water	MN0061263	Battle Creek Fish Creek Wakefield Lake	07010206-592 07010206-606 62-0011-00
Washington County	MS400160	Battle Creek Fish Creek	07010206-592 07010206-606
Woodbury City	MS400128	Battle Creek Fish Creek	07010206-592 07010206-606

Watershed Restoration and Protection Strategies Report

Ramsey-Washington Metro Watershed District

April 2017
Public Review Draft

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Minnesota Pollution Control Agency

CLEAN WATER LAND & LEGACY AMENDMENT

wq-ws4-35a

*Note Regarding Legislative Charge

The science, analysis and strategy development described in this report began before accountability provisions were added to the Clean Water Legacy Act in 2013 (MS114D); thus, this report may not address all of those provisions. When this watershed is revisited (according to the 10-year cycle), the information will be updated according to the statutorily required elements of a Watershed Restoration and Protection Strategy Report.

Cover Picture Descriptions

Top picture: Gervais Mill Pond

Middle left picture: Maplewood Living Streets Project

Middle right picture: Fishing contest at WaterFest

Bottom Left picture: Maplewood Mall tree trenches

Bottom right picture: Lake Phalen shoreline restoration

Project Partners

The following organizations and agencies contributed to the development of the Ramsey-Washington Metro Watershed District Restoration and Protection Strategies Report

Barr Engineering Co.

City of Gem Lake

City of Landfall

City of Little Canada

City of Maplewood

City of North St. Paul

City of Oakdale

City of Roseville

City of Shoreview

City of St. Paul

City of Vadnais Heights

City of White Bear Lake

City of Woodbury

Metropolitan Council

Minnesota Board of Water and Soil Resources

Minnesota Department of Natural Resources

Minnesota Department of Transportation

Minnesota Pollution Control Agency

Ramsey Conservation District

Ramsey County

Ramsey-Washington Metro Watershed District

Washington Conservation District

Washington County

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Key Terms

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus, chlorophyll-*a*, or Secchi disk depth standards are not met.

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including: aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive Summary

The Ramsey-Washington Metro Watershed District (RWMWD) is located in eastern Ramsey County and western Washington County in the state of Minnesota and encompasses portions of a number of communities including White Bear Lake, Vadnais Heights, Gem Lake, Little Canada, Maplewood, Landfall, North St. Paul, St. Paul, Oakdale, Woodbury, Roseville, and Shoreview.

Battle Creek, Fish Creek, Bennett Lake and Wakefield Lake within the RWMWD are impaired for both aquatic life use and aquatic recreation use. Stormwater runoff and stream bank erosion are having negative effects on the watershed's water quality. Urban development in the watershed has resulted in runoff that carries excess phosphorus, sediment, and bacteria into bodies of water that degrades water quality and is harmful to aquatic life.

The intent of this Watershed Restoration and Protection Strategy (WRAPS) report was to develop a scientifically-based restoration and protection strategy for the RWMWD. This WRAPS summarizes past efforts to monitor water quality, identifies impaired water bodies and those in need of protection, and identifies strategies for restoring and protecting water quality in the watershed. The strategies included in this report target point and non-point sources of pollution and include reducing streambank erosion, reducing in-lake nutrients, and improving stormwater management to help improve water quality in the watershed.

What is the WRAPS Report?

The state of Minnesota has adopted a "watershed approach" to address the state's 80 "major" watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates water quality assessment, watershed analysis, civic engagement, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection. In the Twin Cities Metropolitan Area, watershed approach activities may be focused at the scale of the 33 Metro Watershed Management Organizations and Districts. This report focuses on the Ramsey-Washington Metro Watershed District (RWMWD).

As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to help state agencies, local governments, and other watershed stakeholders determine how to best proceed with restoring and protecting lakes and streams. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as a watershed plan addressing the Environmental Protection Agency's (EPA's) Nine Minimum Elements to qualify applicants for eligibility for Clean Water Act Section 319 implementation funds. This report summarizes past assessment and diagnostic work and outlines ways to prioritize actions and strategies for continued implementation.

Purpose	• Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
	• Summarize Watershed Approach work done to date including the following reports:
	  • RWMWD *Watershed Management Plan - 2017-2027 (Draft)*
	  • *Ramsey-Washington Metro Watershed District TMDL Report - 2017*
	  • *Battle Creek Stressor Identification Report - 2015*
	  • *Mississippi River-Twin Cities Monitoring and Assessment Report - 2013*
	  • *Strategic Lake Management Plans (SLMPs) and Lake Status Reports (LSR) developed for many of the lakes within the RWMWD*
	  • *Kohlman Lake TMDL Report - 2010*

Scope	• Impacts to aquatic recreation and impacts to aquatic life in streams • Impacts to aquatic recreation in lakes
Audience	• Local working groups (RWMWD, cities, etc.) • State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed Background and Description

The Ramsey-Washington Metro Watershed District (RWMWD or District) is located in eastern Ramsey County and western Washington County. The RWMWD spans a 64.8-square-mile area and includes all or part of Gem Lake, Landfall, Little Canada, Maplewood, North St. Paul, Oakdale, Roseville, Shoreview, St. Paul, Vadnais Heights, White Bear Lake, and Woodbury. Approximately 53.2 square miles of the area lie within Ramsey County; the remaining 11.6 are within Washington County. Located in the Upper Mississippi River Basin, Twin Cities (8-Digit HUC) watershed, the District is generally bounded on the west by Lexington Parkway, on the north by County Highway 96, on the east by I-694/I-494, and on the south by the Mississippi River. Topography within the District varies from steep river bluffs along the east side of the Mississippi River Valley and southeastern St. Paul, to moderately rolling land in Oakdale, Maplewood and eastern St. Paul, to gently rolling land in White Bear Lake, North St. Paul and Little Canada. The entire District is within the St. Croix Outwash Plain and Stagnations Plains of the North Central Hardwood Forest (NCHF) ecoregion.

The drainage system throughout the RWMWD is characterized by many wetlands, lakes, streams, and conveyance systems, which all eventually drain to the Mississippi River through the Mississippi River Bottomlands area. There are 18 major lakes and 5 streams within the RWMWD, including the Phalen Chain of Lakes, a significant recreational destination. Figure 1-1 depicts the RWMWD Subwatersheds, the existing land use, and the general flow direction from each subwatershed using arrows.

The RWMWD is largely extensively developed and includes a mixture of all types of urban land uses. Although some additional development is likely to occur in select locations, most changes in land use will be the result of redevelopment. Analysis of impervious surfaces within the District as part of the *Detailed Assessment of Phosphorus Sources to Ramsey-Washington Metro Watershed District (Barr 2005)* found that impervious coverage in the various subwatersheds ranged from 21% to 43% impervious, with the average being 34% impervious. Figure 1-2 shows the breakdown of each land use in terms of percent coverage throughout the District.

Additional Ramsey-Washington Metro Watershed Resources

Ramsey-Washington Metro Watershed District Website: *http://www.rwmwd.org/*

MCPA Twin Cities Metropolitan Area Chloride *TMDL* and *Management Plan*

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Twin Cities HUC 8 Watershed: *http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/dma/rwa/?cid=nrcs142p2_023595*

Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the Twin Cities HUC 8 Watershed: *http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb20.pdf*

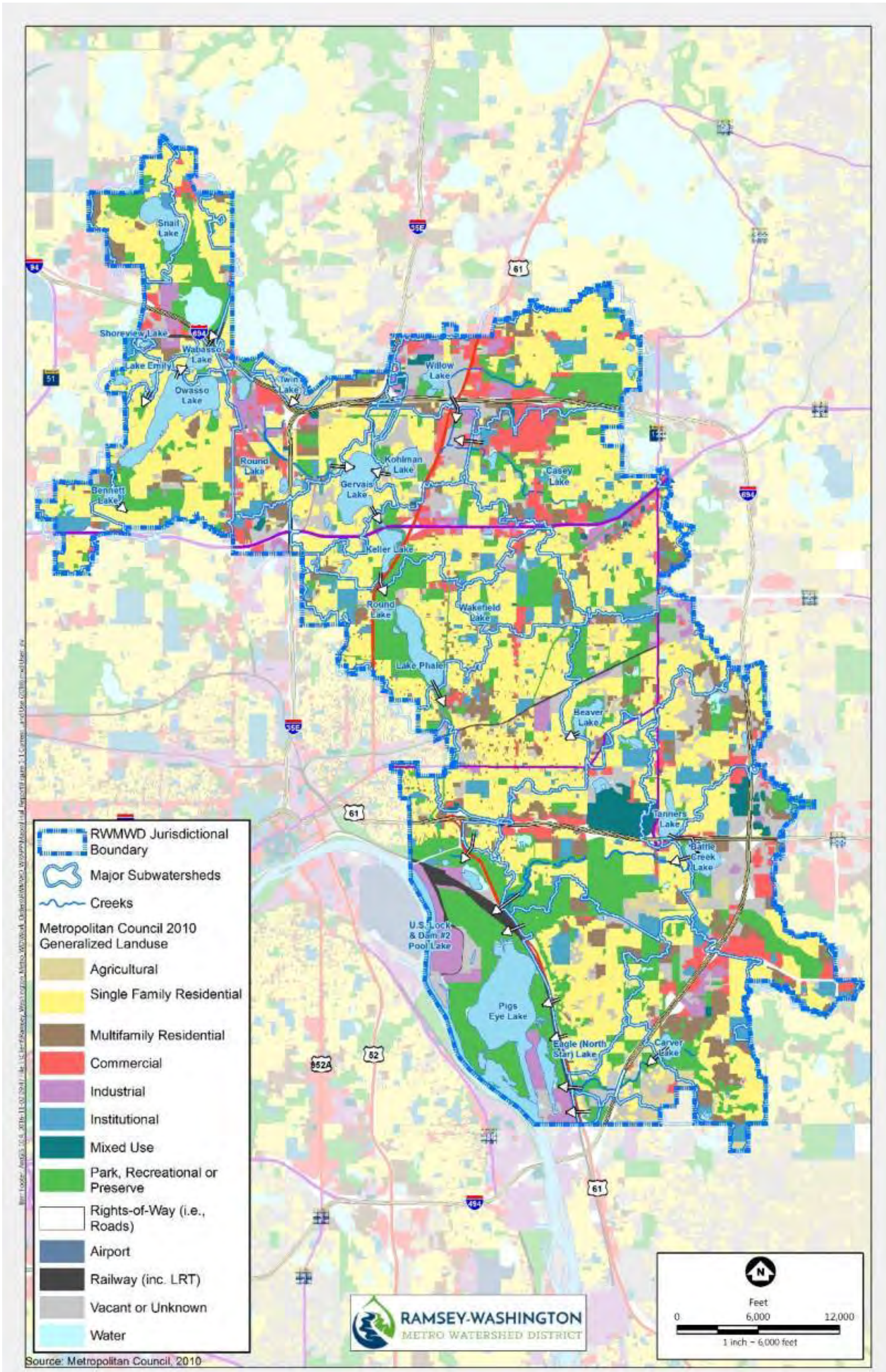


Figure 1-1 Current Land Use (2010)

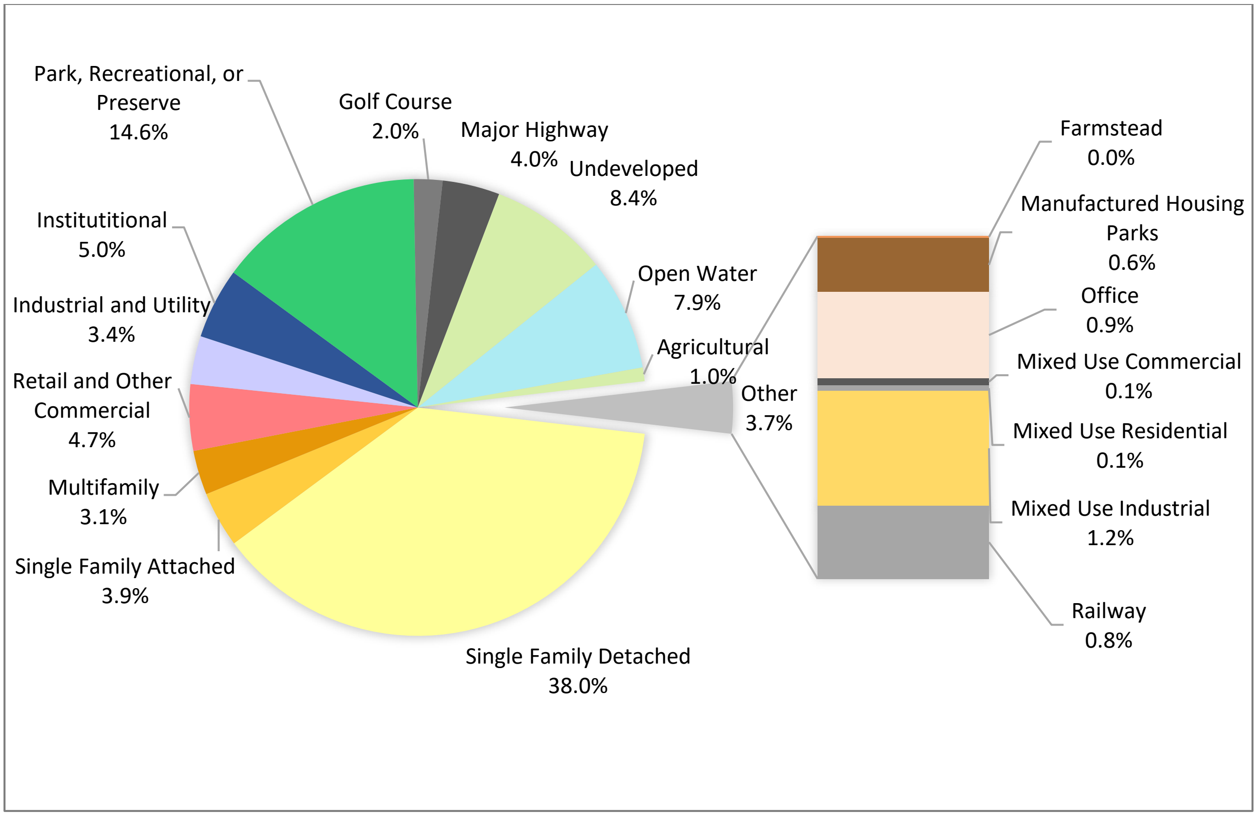


Figure 1-2 Distribution of Metropolitan Council Land Use Data (2010) in RWMWD

The *USDA-NRCS Gridded Soil Survey Geographic Database for Ramsey and Washington County (2012)* provides a comprehensive assessment of soils and soil complexes throughout the District. The soils are classified based on the infiltration capacity of the underlying soils (well drained, sandy soils are classified as “A” soils; poorly drained, clayey soils are classified as “D” soils). Soils with a higher infiltration rate have a lower runoff potential. Conversely, soils with low infiltration rate produce high runoff volumes and high peak runoff rates. According to the survey, the underlying soils in the District are predominantly classified as hydrologic soil group B, with moderate infiltration rates. However, soils in many areas of the District have been disturbed due to urban development.

Prior to the RWMWD WRAPS effort, the District had completed strategic lake management plans (SLMPs) for many District-managed lakes. The objectives of the SLMPs were to evaluate the feasibility and appropriateness of the water quality goals, determine whether each lake currently meets its water quality goals, and identify water quality improvement measures throughout the watershed that would help achieve the goals for each lake. For many other lakes, lake status reports (LSRs) had been completed that compiled all the existing data available for each lake. A list of prior SLMPs and LSRs completed for RWMWD waterbodies can be found in the *RWMWD Watershed Management Plan 2017-2027 (RWMWD 2016 (draft).*

A TMDL study was completed for Kohlman Lake in 2010. More recently (as a part of this WRAPS report), a watershed-wide TMDL report has been completed to address all of the existing impairments throughout the District, including:

- Wakefield and Bennett Lakes (excess nutrients impairment)
- Battle Creek (aquatic life impairment)
- Fish Creek (aquatic recreation impairment)

The RWMWD watershed-wide TMDL can be found on the MPCA's webpage for the RWMWD WRAPS Project.

1.1 Watershed Management Plan, Rules, and Policies

The mission of the RWMWD is to preserve and improve water resources and related ecosystems to sustain their long-term health and integrity, and contribute to the well-being and engagement of stakeholders within the community. Specifically, the RWMWD has the following goals:

- **Achieve Quality Surface Water -** Maintain or improve surface water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. Improving and protecting the quality of surface water and groundwater resources.
- **Support Sustainable Groundwater -** Consider groundwater management in decisions and collaborate with others responsible for groundwater management and protection.
- **Manage Risk of Flooding -** Reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Preserving and enhancing the quantity and quality of wetlands.
- **Achieve Healthy Ecosystems –** Manage water and related natural resources to create and preserve healthy ecosystems.
- **Inform and Empower Communities –** Inform and empower communities to become partners in improving and protecting the watershed through their own efforts.
- **Manage Organization Effectively –** Operate in a manner that achieves the District's mission while adhering to its core principles.

To support their mission and achieve these goals, the RWMWD has adopted rules, implemented policies, and developed a permitting program. These efforts are summarized below and are reflected in greater detail in the RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017) (Plan).

The strategies outlined in this WRAPS report pertain primarily to the Plan's "Achieve Surface Water Quality" and "Achieve Healthy Ecosystems" goals, but are also related to "Support Sustainable Groundwater" and "Inform and Empower Communities", especially in terms of protecting resources.

Figure 3-1 of this WRAPS report is cross- referenced with the Implementation Table in the Plan, to indicate how the strategies in this report have been incorporated into the Plan.

The RWMWD's permit program governs how land is redeveloped throughout the District, and has a direct role in the restoration and protection strategies described in this WRAPS report. Private developers and government agencies are required to apply for a grading permit for any grading or filling activity involving more than one acre of land and for any alteration to a wetland or floodplain. Permit requirements include:

1. **Rate Control** – Runoff rates shall not exceed existing runoff rates for the 2-year, 10-year, and 100-year critical storm events using Atlas 14 rainfall magnitudes.

2. **Volume Reduction** – Stormwater runoff volume reduction shall be achieved onsite in the amount of 1.1 inches of runoff from the new and newly reconstructed impervious surfaces.

3. **Water Quality** – Developments must incorporate effective nonpoint source pollution reduction BMPs to achieve 90% Total Suspended Solids (TSSs) removal from the runoff generated by a NURP water quality storm (2.5-inch rainfall) or on an annual basis.

RWMWD adopted *new development rules on April 1, 2015*. Rule changes include revisions to volume reduction requirements, credit given for filtration BMPs, and use of a stormwater reuse calculator to determine volume reduction benefits of reuse systems.

2. Watershed Conditions

Water quality in lakes, wetlands and streams is closely linked to watershed conditions and internal waterbody processes. Now that the RWMWD is almost completely urbanized, nutrient and sediment inputs (i.e., loadings) from stormwater runoff can far exceed the natural inputs to its lakes, wetlands, and streams. Stormwater runoff can carry significant amounts of phosphorus from the watershed into a waterbody. Land use changes resulting in increased imperviousness (e.g., urbanization) or land disturbance (e.g., urbanization, construction, or agricultural practices) also result in increased amounts of phosphorus carried in stormwater runoff. The increased runoff from urbanization can also lead to higher stream velocities, resulting in erosion and higher sediment loading to downstream waterbodies. In addition to watershed sources, other sources of phosphorus include atmospheric deposition, internal loading (e.g., release from anoxic sediments, algae die-off, aquatic plant die-back, and fish-disturbed sediment) and non-compliant subsurface sewage treatment systems (SSTS). Non-compliant SSTS also have the potential to add bacteria, and other pollutants to RWMWD waterbodies.

If loadings increase, it is likely that water quality degradation will accelerate, resulting in unpleasant consequences, such as profuse algae growth (algal blooms), reduced diversity of rooted aquatic plants, and fish kills.

2.1 Condition Status

There are several RWMWD water bodies that appear on the MPCA's 303(d) list, or Impaired Waters List, for a range of constituents, including: excess nutrients, chloride, mercury in fish tissue, polychlorinated biphenyls (PCBs) in fish tissue, low fish index of biotic integrity (F-IBI), and low macroinvertebrate index of biotic integrity (M-IBI) (Figure 2-1). It is important to note that this report does not cover toxic pollutants (chloride, mercury, PCBs). More information on how TMDLs for these toxic pollutants are handled is discussed later in this section.

Although there are a number of water bodies in the District listed on the *Minnesota Impaired Waters List* that either have an approved TMDL or will soon have an approved TMDL, many of the RWMWD-managed water bodies currently meet the MPCA water quality standards. However, many of these water bodies are just meeting the established standards. In order to prevent further degradation of these water bodies and future listing on the 303(d) list, the RWMWD will implement protection measures to maintain (or improve) the water quality in these resources as described in Table 3-1.

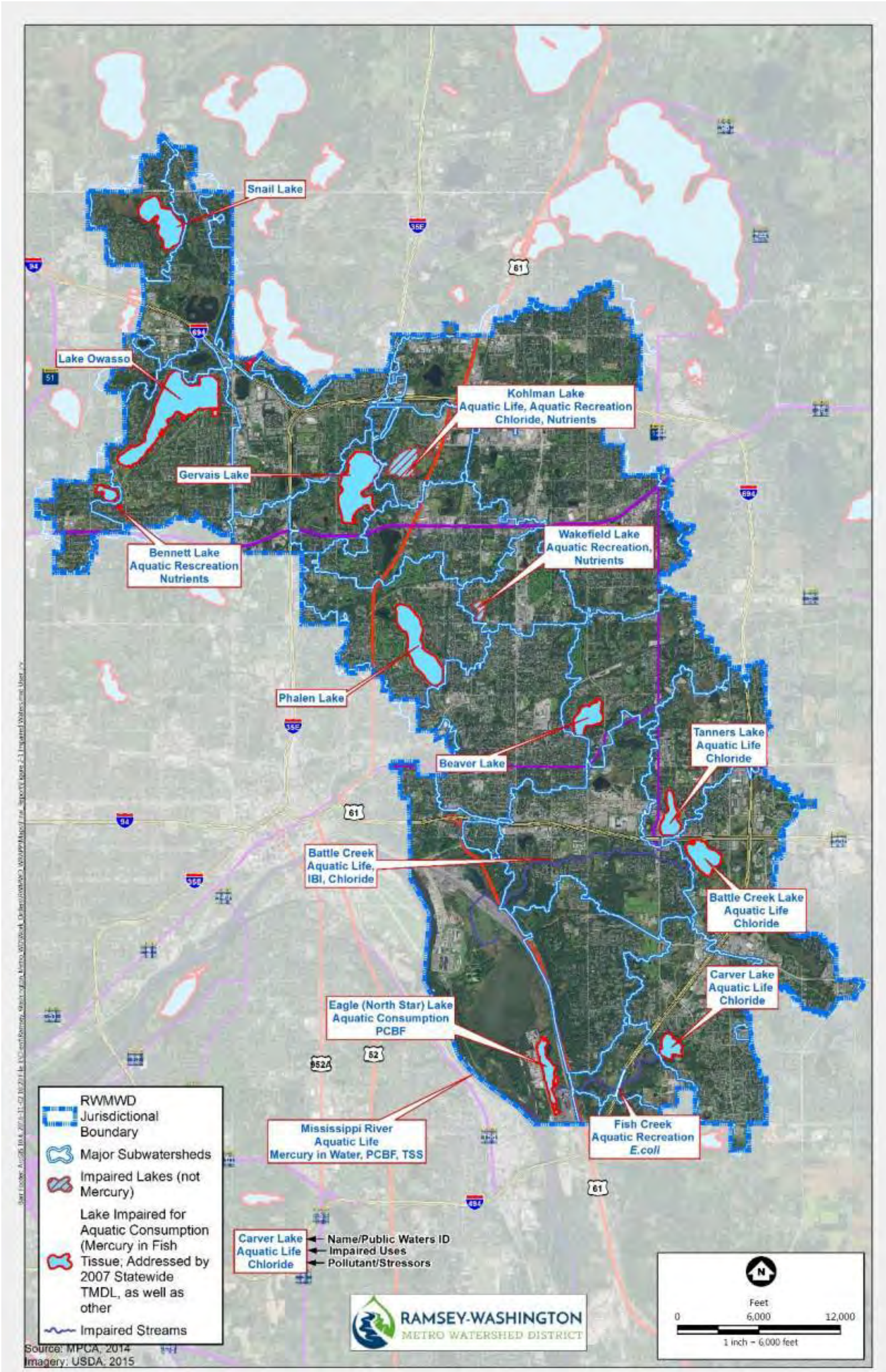


Figure 2-1 Impaired Waters

Streams

There are several small streams within the RWMWD. However, only two of the streams have sufficient data to assess the beneficial uses. These two streams are Fish Creek and Battle Creek. Table 2-1 summarizes the beneficial use data for the various streams in the RWMWD. The data included in Table 2-1 is based on data available through the [MPCA Environmental Data Access (EDA) database](), and is generally listed from upstream to downstream locations in the RWMWD.

According to the *MPCA's Minnesota Nutrient Criteria Development for Rivers (Draft, MPCA 2013)*, the TP eutrophication criteria for streams in Minnesota ranges from 50 µg TP/L to 150 µg TP/L. For streams in the Central River Nutrient Region (including Battle Creek), the criteria are that TP should remain below 100 µg TP/L (≤100 µg TP/L).

TSS standards for rivers and streams were adopted at the June 24, 2014, MPCA Citizen Board meeting. The standard that is applicable to Battle Creek, located in the Central River Nutrient Region, is 30 mg/L. Additional information about the TSS water quality standard in Minnesota (Minn. R. ch. 7050) can be found here: https://www.revisor.mn.gov/rules/?id=7050.

Battle Creek was listed for elevated concentrations of chloride on the 2008 303(d) list. During the 2012 assessment, the MPCA determined that Battle Creek should be listed on the 2014 303(d) list due to low scores on the Fish and Invertebrate Indices of Biotic Integrity (IBI). Fish Creek was also listed on the 2014 303(d) list due to elevated levels of *E. coli* bacteria.

Table 2-1 Assessment status of stream reaches in the Ramsey-Washington Metro District

HUC-10 Sub-watershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aq Rec	
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Chloride	Turbidity/TSS	Bacteria	RWMWD Nutrient Classification
City of St. Paul Mississippi River	543	Unnamed Creek (Willow Lake Outlet)	Willow Lake to Unnamed Creek	NA	NA	NA	NA	NA	NA	NA
City of St. Paul Mississippi River	758	Unnamed Creek (Kohlman Creek)	Unnamed Ditch to Beam Pond	NA	NA	NA	NA	NA	NA	At Risk[1]
City of St. Paul Mississippi River	591	Unnamed Creek (Kohlman Creek)	Beam Pond to Unnamed Creek (Willow Creek)	NA	NA	NA	NA	NA	NA	At Risk[1]

HUC-10 Sub-watershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aq Rec	
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Chloride	Turbidity/TSS	Bacteria	RWMWD Nutrient Classification
City of St. Paul Mississippi River	544	Unnamed Creek (Willow Lake Outlet)	Unnamed Creek to Kohlman Lake	NA	NA	NA	NA	NA	NA	NA
City of St. Paul Mississippi River	546	Unnamed Creek (Kohlman Lake Outlet)	Kohlman Lake to Gervais Lake	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	910	Unnamed Creek (Gervais Creek)	To Gervais Lake	NA	NA	NA	NA	NA	NA	At Risk[1]
City of St. Paul Mississippi River	609	Unnamed Creek	Gervais Lake to Keller Lake	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	611	Unnamed Creek	Keller Lake to Round Lake	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	613	Unnamed Creek	Round Lake to Phalen Lake	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	587	Unnamed Creek	Headwaters to Wakefield Lake	NA	NA	NA	NA	NA	NA	At Risk[1]
City of St. Paul Mississippi River	747	Unnamed Creek	Wakefield Lake to Phalen Lake	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	615	Unnamed Creek	Phalen Lake to Unnamed Ditch	NA	NA	NA	NA	NA	NA	Stable
City of St. Paul Mississippi River	616	Unnamed Creek	Unnamed Ditch to Mississippi River	NA	NA	NA	NA	NA	NA	NA

HUC-10 Sub-watershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life					Aq Rec	
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Chloride	Turbidity/TSS	Bacteria	RWMWD Nutrient Classification
City of St. Paul Mississippi River	606	Fish Creek	Carver Lake to Unnamed (North Star) Lake	IF	IF	IF	NA*	IF	Imp	At Risk[1]
City of St. Paul Mississippi River	592	Battle Creek	Battle Creek Lake to Pigs Eye Lake	Imp	Imp	IF	Imp	Imp	IF	Impaired[2]

*At risk for chloride impairment

Sup = found to meet the water quality standard, Imp = does not meet the water quality standard and therefore, is impaired, IF = the data collected was insufficient to make a finding, NA = not assessed

[1]Water quality monitoring data indicates that total phosphorus concentrations may exceed the State standard for TP.
[2]Impaired for excess TSS, which is associated with TP

Battle Creek

Battle Creek is currently impaired by chloride. Chloride impairments in Twin Cities Metropolitan Area (TCMA) are being handled through the MPCA's TCMA Chloride TMDL and Management Plan, which will lay out strategies for addressing chloride impacts to our surface waters for the seven-county metropolitan area. For more information on this project, see the *MPCA's TCMA Chloride Project website*.

Battle Creek was listed as impaired in 2014 for degraded fish and macroinvertebrate biological community health. The biological *Battle Creek Stressor Identification (SID) Report (Barr, 2015*) was completed in spring 2015 using the United States Environmental Protection Agency's (EPA's) Causal Analysis/Diagnosis Decision Information System (CADDIS). The SID report found that chloride and TSS are the primary stressors to the fish and macroinvertebrate assemblages within Battle Creek. Additionally, analysis of TSS water quality data found that Battle Creek is impaired by TSS based on the MPCA water quality standard for Class 2B streams in the Central River Nutrient Region. The SID study identified total phosphorus as a probably secondary stressor (likely associated with TSS loading). Therefore, the District has assigned a RWMWD nutrient water quality classification of Impaired to Battle Creek.

Fish Creek

Fish Creek was placed on the 2014 303(d) list due to elevated levels of *E. coli*. *E. coli* bacteria is used in water quality monitoring as an indicator organism to identify water that is contaminated with human or animal waste and the accompanying disease-causing organisms. Bacterial abundance in excess of the water quality standards can pose a human health risk.

Based on an average phosphorus concentration exceeding the MPCA stream eutrophication standards, the District has assigned a RWMWD nutrient water quality classification of At Risk to Fish Creek.

Willow Creek

Willow Creek has not been assessed relative to these standards by the MPCA. Due to lack of data, the District has not assigned a RWMWD nutrient water quality classification to Willow Creek (NA).

Kohlman Creek

Kohlman Creek has not been assessed relative to these standards by the MPCA. Based on water quality data collected in 2011 and available from the MPCA website, the District has assigned a RWMWD nutrient water quality classification of At Risk to Kohlman Creek.

Gervais Creek

Recent monitoring data indicates the creek likely exceeds the MPCA's stream water quality standard for total phosphorus, although the creek is not listed as impaired by nutrients. Thus, the District has assigned a RWMWD nutrient water quality classification of At Risk to Gervais Creek.

Lakes

Table 2-2 summarizes the beneficial use data for the various lakes in the RWMWD, as well as the status of TMDL for the various impairments (if applicable). The data included in Table 2-2 are based on data available through the *MPCA Environmental Data Access (EDA) Database*.

Lake impairments are based on an aquatic recreation standard centered on protecting the ability to recreate on and in Minnesota waters. This is considered a Class 2 standard. Additionally, lakes can also be listed as impaired based on aquatic life or aquatic consumption standards.

Several of the lakes are listed with impairment to aquatic recreation with a pollutant or stressor classification of Nutrient/Eutrophication Biological Indicators (excess nutrients). The eutrophication standards applied are based on the ecoregion and lake depth. *Minn. R. 7050.0222, subp. 4: Class 2B Waters* outlines the water quality criteria by ecoregion. This rule establishes the eutrophication criteria for deep and shallow lakes (shallow lakes are lakes with a maximum depth of 15 feet or a littoral area of 80% or more). The lakes included in this plan are all located within the NCHF ecoregion.

Table 2-2 Assessment status of lakes in the Ramsey-Washington Metro Watershed District

HUC-10 Sub-watershed	Lake ID	Lake	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Classification[1]
City of St. Paul-Mississippi River	82-0091	Battle Creek	Sup	Imp (Mercury FCA)	Imp (Chloride)	Statewide Mercury TMDL completed in 2007; Delisted for Nutrients in 2012; TCMA Chloride TMDL completed February, 2016	At Risk
City of St. Paul-Mississippi River	62-0016	Beaver	Sup	Imp (Mercury FCA)	IF*	Statewide Mercury TMDL completed in 2007; Delisted for Nutrients in 2012	At Risk
City of St. Paul-Mississippi River	62-0048	Bennett	Imp (Excess Nutrients)	Imp (Mercury Food Consumption Advisory)	IF*	Statewide Mercury TMDL completed in 2007; Nutrient TMDL to be completed in 2017	Impaired
City of St. Paul-Mississippi River	82-0166	Carver	Sup	Imp (Mercury FCA)	Imp (Chloride)	Statewide Mercury TMDL completed in 2007; Delisted for Nutrients in 2012; TCMA Chloride TMDL completed February, 2016	At Risk
City of St. Paul-Mississippi River	62-0237	Eagle Lake (North Star Lake)	NA	Imp (Mercury and PCB Food Consumption Advisories)	NA	Statewide Mercury TMDL completed in 2007; Target completion date for PCB TMDL is 2025.	NA
City of St. Paul-Mississippi River	62-0080	Emily[2]	IF	NA	NA		At Risk
City of St. Paul-Mississippi River	62-0007	Gervais	Sup	Imp (Mercury Food Consumption Advisory)	IF*	Statewide Mercury TMDL completed in 2007	Stable
City of St. Paul-Mississippi River	62-0010	Keller	Sup	IF	IF*	Delisted for Nutrients in 2012	Stable

HUC-10 Sub-watershed	Lake ID	Lake	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Classification[1]
City of St. Paul-Mississippi River	62-0006	Kohlman	Imp (Excess Nutrients)	IF	Imp (Chloride)	Nutrient TMDL approved in 2010; TCMA Chloride TMDL completed February 2016	Impaired
City of St. Paul-Mississippi River	62-0056	Owasso	IF	Imp (Mercury Food Consumption Advisory)	IF	Statewide Mercury TMDL completed in 2007	At Risk
City of St. Paul-Mississippi River	62-0013	Phalen	Sup	Imp (Mercury Food Consumption Advisory)	IF	Statewide Mercury TMDL completed in 2007	Stable
City of St. Paul-Mississippi River	62-0009	Round (in Little Canada)	IF	NA	NA		At Risk
City of St. Paul-Mississippi River	62-0012	Round (in Maplewood)	Sup	IF	IF	Delisted for Nutrients in 2007	Stable
City of St. Paul-Mississippi River	62-0079	Shoreview	IF	NA	NA		At Risk
City of St. Paul-Mississippi River	62-0073	Snail	Sup	Imp (Mercury Food Consumption Advisory)	IF	Statewide Mercury TMDL completed in 2007	Stable
City of St. Paul-Mississippi River	82-0115	Tanners	Sup	Imp (Mercury Food Consumption Advisory)	Imp (Chloride)	Originally listed for excess nutrients, but delisted in 2004 due to improvements; Statewide Mercury TMDL completed in 2007; TCMA Chloride TMDL completed February 2016	Stable
City of St. Paul-Mississippi River	62-0039	Twin	Sup	NA	IF		Stable

HUC-10 Sub-watershed	Lake ID	Lake	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Classification[1]
City of St. Paul-Mississippi River	62-0082	Wabasso	Sup	NA	IF*		Stable
City of St. Paul-Mississippi River	62-0011	Wakefield	Imp (Excess Nutrients)	NA	IF*	Nutrient TMDL to be completed in 2017	Impaired
City of St. Paul-Mississippi River	62-0040	Willow	NA	NA	NA		Stable

*At risk for chloride impairment.

[1]RWMWD nutrient classifications are based on the relationship between the historic average water quality (based on phosphorus concentration alone) and the MPCA water quality (phosphorus) standards.

Stable indicates water bodies with water quality that consistently meet the MPCA water quality (phosphorus) standards.

At-Risk indicate water bodies with water quality that just meets the MPCA water quality (phosphorus) standards but could potentially be listed as impaired in the future.

Impaired indicates water bodies that do not currently meet the MPCA water quality (phosphorus) standards and are currently listed as impaired.

NA indicates that there is insufficient water quality data to determine the RWMD nutrient classification.

[2]Insufficient data for classification, but available data indicates waterbody may be impaired.

Sup = found to meet the water quality standard, Imp = does not meet the water quality standard and therefore, is impaired, IF = the data collected was insufficient to make a finding, NA = not assessed

Many of the lakes listed in Table 2-2 are impaired by mercury, and one lake (Eagle Lake/North Star Lake) is listed as impaired by PCBs, due to a Minnesota Department of Health fish consumption advisory (FCA) limitation that is more restrictive than one meal per week. The mercury in Minnesota fish comes almost entirely from atmospheric deposition, with approximately 90% originating outside of Minnesota (*MPCA 2009).* Because the main source of mercury comes from outside the state and the atmospheric deposition of mercury is relatively uniform across the state, the MPCA developed a statewide TMDL, approved in 2007 and amended annually. However, beyond summarizing the lakes with mercury and PCB impairments, this RWMWD WRAPS Report does not cover toxic pollutants (mercury and PCBs). For more information on the mercury impairments see the statewide mercury TMDL at:

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html

The statewide approach for addressing PCB impairments has not yet been determined.

Several lakes are impaired by chloride (Battle Creek Lake, Carver Lake, Kohlman Lake and Tanners Lake). Chloride impairments in Twin Cities Metropolitan Area have been addressed through the *MPCA's TCMA Chloride TMDL* and *Management Plan*.

2.2 Water Quality Trends

Many of the major lakes within the RWMWD have long-term historical water quality records, due to the monitoring program supported by the District. Each year, the RWMWD performs trend analyses on the lake water quality data. The trend analyses are used to determine if the lakes in the watershed have experienced significant degradation or improvement during all (or a portion of) the years for which water quality data are available. Summer-average values (the typical averaging period was June through September to be consistent with the MPCA's method for evaluating lake water quality) were calculated and analyzed to determine water quality trends.

Long-term trends are typically determined using statistical methods (i.e., linear regression and analysis of variance). Trend analyses were run for two different time periods. The first period was for the most recent 10 years of water quality data, evaluating the same time period that the MPCA typically considers when looking at listing surface waters for water quality impairment on the 303(d) list. The second considered a period with complete water quality data for all three water quality parameters.

The Mann-Kendall/Sen's Slope Trend Test was used to determine water quality trends and their significance. To complete the trend test, the calculated summer average must be based on at least four measured values during the sampling season and at least five years of data are required. The trend was considered significant if the slope of the regression was statistically significant at the 95% confidence interval. Also, to conclude an improvement requires concurrent decreases in TP and Chlorophyll-*a* concentrations, as well as increases in Secchi disk transparences; a conclusion of degradation requires the inverse of the relationship above. Table 2-3 summarizes the most recent trend analysis information for lakes in the RWMWD.

Additionally, Metropolitan Council Environmental Services (MCES) in partnership with the RWMWD operates Watershed Outlet Monitoring Program (WOMP) stations at the outlets of Battle Creek and Fish Creek. The MCES recently compiled the long-term flow and water quality data for all of their WOMP stations throughout the Twin Cities metropolitan area and have performed trend analyses on several water quality parameters. A WOMP station is also operated on the Beltline Interceptor; however, MCES did not perform trend analyses on the Beltline Interceptor data. Table 2-4 summarizes the results of the trend analyses performed by the MCES on the streams in RWMWD.

Table 2-3 Water quality trends of the Lakes in the Ramsey-Washington Metro Watershed District

Water Resource	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 years (2003-2012)
Battle Creek Lake	1997 - 2012	Secchi Depth	Improving	Improving*
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving*	No Trend
Beaver Lake	1984 - 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend
Bennett Lake	1984 - 2012	Secchi Depth	Improving	Improving
		Total Phosphorus	Improving	Improving

Water Resource	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 years (2003-2012)
		Chlorophyll-*a*	Improving	Improving
Carver Lake	1997 - 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving*	No Trend
		Chlorophyll-*a*	No Trend	No Trend
Eagle Lake (Northstar)	--	Secchi Depth	--	--
		Total Phosphorus	--	--
		Chlorophyll-*a*	--	--
Lake Emily	1980 - 2012	Secchi Depth	Improving*	Degrading*
		Total Phosphorus	No Trend	No Trend
		Chlorophyll-*a*	No Trend	No Trend
Gervais Lake	1981 - 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend
Keller Lake	1981 - 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	Improving
		Chlorophyll-*a*	Improving	Improving*
Kohlman Lake	1981 - 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	Improving*	No Trend
Shoreview Lake	2009	Secchi Depth	--	--
		Total Phosphorus	--	--
		Chlorophyll-*a*	--	--
Lake Owasso	1948 - 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	No Trend	No Trend
Lake Phalen	1981 - 2012	Secchi Depth	Improving*	Degrading*
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving*	No Trend
Round Lake (in Maplewood)	1981 - 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend
Round Lake (in Little Canada)	--	Secchi Depth	--	--
		Total Phosphorus	--	--
		Chlorophyll-*a*	--	--
Snail Lake	1974 - 2012	Secchi Depth	Improving	Improving*
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend
Tanners Lake	1997 - 2012	Secchi Depth	Improving*	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving*	Degrading*
Twin Lake	1996 - 2012	Secchi Depth	No Trend	Improving*
		Total Phosphorus	No Trend	No Trend

Water Resource	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 years (2003-2012)
		Chlorophyll-*a*	No Trend	Improving*
Lake Wabasso	1959 - 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving*	No Trend
		Chlorophyll-*a*	No Trend	No Trend
Wakefield Lake	1984 - 2012	Secchi Depth	Improving	Improving
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	Improving*	Improving
Willow Lake	--	Secchi Depth	--	--
		Total Phosphorus	--	--
		Chlorophyll-*a*	--	--

* Trend was detectable, but was below the 95th percentile confidence interval.
-- No (or insufficient) water quality data available.
Green values indicate an improving trend in water quality for that parameter

Table 2-4 Water quality trends of the creeks in the Ramsey-Washington Metro Watershed District

Stream	Water Quality Criteria	Water Quality Trend	Percent Change
Battle Creek	Total Suspended Solids	Improving Trend	-77%
	Total Phosphorus	Improving Trend	-56%
	Nitrate	Degrading Trend	27%
Fish Creek	Total Suspended Solids	Improving Trend	-37%
	Total Phosphorus	Improving Trend	-47%
	Nitrate	Improving Trend	-21%
Gervais Creek* Kohlman Creek* Willow Creek*	Total Suspended Solids	NA	NA
	Total Phosphorus	NA	NA
	Nitrate	NA	NA

*Trend analyses have not yet been completed for Kohlman, Willow and Gervais Creeks, though data is being collected to support trend analyses in the future.

Green values indicate an improving trend in water quality for that parameter.
Red values indicate a degrading trend in water quality for that parameter.

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies the stressors, and/or sources impacting or threatening them must be identified and evaluated. Biological SID is done for streams with fish and/or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant-related (e.g. altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments are done where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings.

Stressors of Biologically-Impaired Stream Reaches

In 2014, Battle Creek was placed on the draft MPCA 303(d) impaired waters list in need of a study for impaired biota due to low F-IBI score and low M-IBI score. Battle Creek was listed on the draft 2014 303(d) list for both fish and aquatic macroinvertebrates. Other streams in RWMWD have not been assessed. As such, none of the other streams in RWMWD have been listed as having fish or macroinvertebrate (biotic) impairments and stressors have not been evaluated for these resources.

SID is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems, and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to fish and aquatic macroinvertebrates. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act (CWLA).

The purpose of SID is to explain the relationship between stressors and the degraded biological condition. It looks at causal factors – negative ones harming fish and insects, and positive ones leading to healthy biology. Stressors may be physical, chemical, or biological.

The *Battle Creek Stressor Identification Study (Barr 2015)* was initiated to find and evaluate factors, either natural or anthropogenic, which are likely responsible for the impaired condition of the fish and macroinvertebrate communities in Battle Creek. Biological, chemical, and physical data from Battle Creek were analyzed to determine candidate causes for the biological impairments. After examining many candidate causes, the stressors listed in Table 2-5 were identified as candidate causes of stress to aquatic life in Battle Creek.

Table 2-5 Primary stressors to aquatic life in biologically-impaired reaches in the Ramsey-Washington Metro Watershed

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Biological Impairment	Primary Stressor: Excess Sediment	Specific Conductance and Chloride	Dissolved Oxygen and BOD	Excess Total Phosphorus	Altered Habitat	Habitat Fragmentation	Metal Toxicity
City of Saint Paul-Mississippi River	592	Battle Creek	Battle Creek Lake to Pigs Eye Lake	Fish	●	○	●*	◐	○	◐	○
	592	Battle Creek	Battle Creek Lake to Pigs Eye Lake	Aquatic Macroinvertebrates	●	●	○	●	◐	○	○

● = probable primary stressor; ◐ = probable secondary stressor; ○ = inconclusive stressor;

●* = probably station-specific primary stressor (e.g., DO impairment immediately downstream of detention areas)

Recommendations for each of the candidate causes discussed as well as inconclusive causes identified in are presented in Table 2-6. This table additionally outlines recommended management actions and monitoring efforts related to lower priority stressors and inclusive candidate causes.

Table 2-6 Recommendations to address biological impairment in Battle Creek

Stressor	Priority	Recommendations
Candidate Causes		
Excess Sediment	High	· Create and implement TMDL for sediment loading (TSS loading). · TMDL should focus on watershed sediment loading, as well as sediment loading from the immediate stream channel.
Specific Conductance and Chloride	High	· Follow recommendations in the TCMA Chloride TMDL and Management Plan.
Dissolved Oxygen and BOD	Medium-High	· Increase longitudinal DO and BOD monitoring efforts along Battle Creek · Efforts should focus on determining (a) whether or not DO impairment is limited to stations immediately downstream of detention areas and (b) the source of DO impairment (BOD? TP? Temperature? In-stream detention? Low Flow? Chl-a? Etc.). · Consider (a) longitudinal deployment of continuous dissolved oxygen monitoring sensors and (b) additional pre-9 AM synoptic surveying efforts during the growing season. Simultaneous measurements of DO, BOD, TP, temperature, and flow will help determine potential sources of DO impairment.
Excess Total Phosphorus	Medium	· Continue longitudinal monitoring of TP concentrations. · TP monitoring should be conducted during TSS monitoring associated with sediment loading TMDL (to determine if reduced TSS loading also reduces TP loading).
Altered Habitat	Medium	· Continue MSHA surveying and request quantitative substrate measurements be taken during each survey. · Monitor survey results throughout sediment loading TMDL.

Stressor	Priority	Recommendations
Candidate Causes		
Habitat Fragmentation	Low	· Reassess biological metric impacts after other primary and secondary stressors addressed.
Metal Toxicity	Low	· Monitor concentrations of Cd, Cu, Pb, and Zn throughout sediment loading TMDL (to determine if reduced sediment loading reduces metal toxicity). · Reassess biological metric impacts after other primary and secondary stressors addressed.
Inconclusive Causes		
pH	Unknown	· Expand pH monitoring efforts along Battle Creek. · Include pH in event-based sampling at station 99UM075 (WOMP station). · Include pH in future synoptic surveys (include pH flux monitoring).
Altered Hydrology	Unknown	· Continue flow monitoring at station 99UM075, and consider installing flow monitoring stations further upstream (potentially upstream and downstream of McKnight Basin). · Continue vegetation clearing and sediment removal maintenance efforts.

Pollutant source

In general, there are two forms of pollutant sources to a waterbody: nonpoint (non-permitted) sources and point (permitted) sources. Nonpoint pollution refers to water pollution from sources such as land runoff, atmospheric deposition, drainage, seepage, and/or hydrologic modification. Point sources can be defined as any discernible, discrete conveyance (i.e., pipe, ditch, channel, etc.) from which pollutants are, or may, be discharged to a waterbody. In many situations, commercial or industrial companies that produce point source pollution require permits.

Stormwater runoff carries with it a number of contaminants affecting water quality, human health, recreation, habitat and aesthetics. The principal pollutants found in runoff include nutrients (such as phosphorus), sediments, organic materials, pathogens, hydrocarbons, metals, pesticides, chlorides, trash and debris. Additionally, non-compliant septic systems can also contribute pollutants such as nutrients and pathogens (e.g. bacteria) to resources.

Table 2-7, developed using information from the Minnesota Urban Small Sites Best Management Practice (BMP) Manual (Barr 2001), summarizes the typical sources of these pollutants and their impacts. Of these pollutants, the RWMWD recognizes that phosphorus and suspended sediment are particularly detrimental to the ecological functions and recreational use of lakes, streams, and wetlands.

Table 2-7 Principal Pollutants in Stormwater Runoff

Stormwater Pollutant	Examples of Sources	Related Impacts
Chlorides	Road salting and uncovered salt storage	Toxicity of water column and sediment
Hydrocarbons: Oil and Grease, PAHs (Naphthalenes, Pyrenes)	Industrial processes; automobile wear, emissions & fluid leaks; waste oil	Toxicity of water column and sediment, bioaccumulation in aquatic species and through food chain
Metals: Lead, Copper, Cadmium, Zinc, Mercury, Chromium, Aluminum, others	Industrial processes, normal wear of auto brake linings and tires, automobile emissions & fluid leaks, metal roofs	Toxicity of water column and sediment, bioaccumulation in aquatic species and through the food chain, fish kill
Nutrients: Nitrogen, Phosphorus	Animal waste, fertilizers, failing septic systems	Algal growth, reduced clarity, other problems associated with eutrophication (oxygen deficit, release of nutrients and metals from sediments)
Organic Materials	Leaves, grass clippings	Oxygen deficit in receiving water body, fish kill
Pathogens: Bacteria, Viruses	Animal waste, failing septic systems	Human health risks via drinking water supplies, contaminated swimming beaches
Pesticides: PCBs, Synthetic Chemicals	Pesticides (herbicides, insecticides, fungicides, rodenticides, etc.), industrial processes	Toxicity of water column and sediment, bioaccumulation in aquatic species and through the food chain, fish kill
Polycyclic Aromatic Hydrocarbons (PAHs)	Tar based pavement sealant	Carcinogenic to humans
Sediments: Suspended and Deposited	Construction sites, other disturbed and/or non-vegetated lands, eroding banks, road sanding	Increased turbidity, reduced clarity, lower dissolved oxygen, deposition of sediments, smothering of aquatic habitat including spawning sites, sediment and benthic toxicity
Trash and Debris	Litter washed through storm drain networks	Degradation of the beauty of surface waters, threat to wildlife

Based on Minnesota Urban Small Sites BMP Manual (Barr 2001).

One strategy to control point source pollution is through the issuance of permits. Point sources, or permitted sources of phosphorus, are those that require a National Pollution Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit) and are referred to as permitted sources. Examples of typical permitted sources in the District include the following:

- **Phase II Municipal Stormwater NPDES/SDS General Permit** - Includes coverage of municipal separate storm sewer systems (MS4s) which are publicly owned or operated stormwater infrastructure used solely for stormwater and often include cities, townships, and public institutions. The goal of the MS4 general permit is to improve the water quality of urban stormwater runoff and reduce pollutants in stormwater discharges.

- **Construction Stormwater NPDES/SDS General Permit** – Includes coverage of any construction activities disturbing one acre of more of soil, less than one acre of soil when part of a larger development that is more than one acre, or less than one acre when the MPCA determines the activity to pose a risk to water resources. The goal of the construction stormwater permit is to control erosion and reduce the amount of sediments and other pollutants being transported by runoff from construction sites.

- **Multi-Sector Industrial Stormwater NPDES/SDS General Permit** – Includes coverage of stormwater discharges associated with a variety of industrial activities. The goal is to reduce the amount of pollution that enters surface and ground water from industrial facilities in the form of stormwater runoff.

Table 2-8 summarizes the point (permitted) sources within the RWMWD.

Table 2-8 Point Sources in the Ramsey-Washington Metro Watershed District

HUC-10 Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
City of Saint Paul-Mississippi River	City of Gem Lake	MS400020	Municipal stormwater (MS4)	No	
City of Saint Paul-Mississippi River	City of Landfall	MS400025	Municipal stormwater (MS4)	No	
City of Saint Paul-Mississippi River	City of Little Canada	MS400029	Municipal stormwater (MS4)	No	
City of Saint Paul-Mississippi River	City of Maplewood	MS400032	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL, Wakefield TMDL, Fish Creek TMDL, Battle Creek TMDL
City of Saint Paul-Mississippi River	MnDOT	MS400170	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL, Bennett Lake TMDL, Battle Creek TMDL
City of Saint Paul-Mississippi River	City of North St. Paul	MS400041	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL, Wakefield TMDL
City of Saint Paul-Mississippi River	City of Oakdale	MS400042	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL
City of Saint Paul-Mississippi River	Ramsey County	MS400191	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL, Wakefield TMDL, Bennett Lake TMDL, Fish Creek TMDL, Battle Creek TMDL

HUC-10 Subwatershed	Point Source			Pollutant reduction needed beyond current permit conditions/limits?	Notes
	Name	Permit #	Type		
City of Saint Paul-Mississippi River	Ramsey-Washington Metro Watershed District	MS400190	Municipal stormwater (MS4)	No	
City of Saint Paul-Mississippi River	City of Roseville	MS400047	Municipal stormwater (MS4)	Yes	Bennett Lake TMDL
City of Saint Paul-Mississippi River	City of St. Paul	MN0061263	Municipal stormwater (MS4)	Yes	Wakefield TMDL, Fish Creek TMDL, Battle Creek TMDL
City of Saint Paul-Mississippi River	City of Shoreview	MS400121	Municipal stormwater (MS4)	No	
City of Saint Paul-Mississippi River	City of Vadnais Heights	MS400057	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL
City of Saint Paul-Mississippi River	Washington County	MS400160	Municipal stormwater (MS4)	Yes	Fish Creek TMDL, Battle Creek TMDL
City of Saint Paul-Mississippi River	City of White Bear Lake	MS400060	Municipal stormwater (MS4)	Yes	Kohlman Lake TMDL
City of Saint Paul-Mississippi River	City of Woodbury	MS400128	Municipal stormwater (MS4)	Yes	Fish Creek TMDL, Battle Creek TMDL

MS4s within the Battle Creek, Bennett Lake, Fish Creek, Kohlman Lake and Wakefield Lake Watersheds are shown in Figures 2-2 through Figure 2-6.

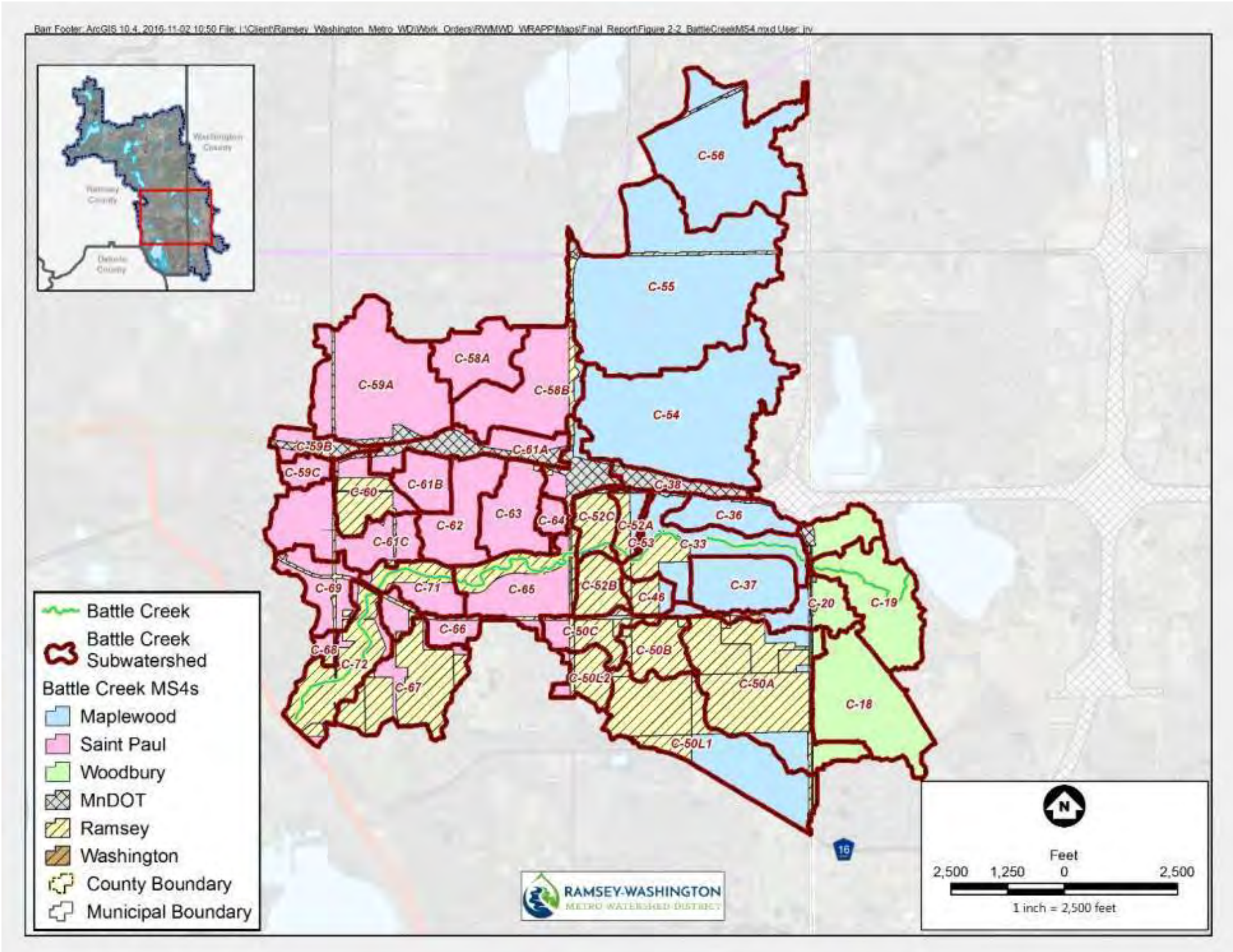


Figure 2-2 MS4s in the Battle Creek Subwatershed

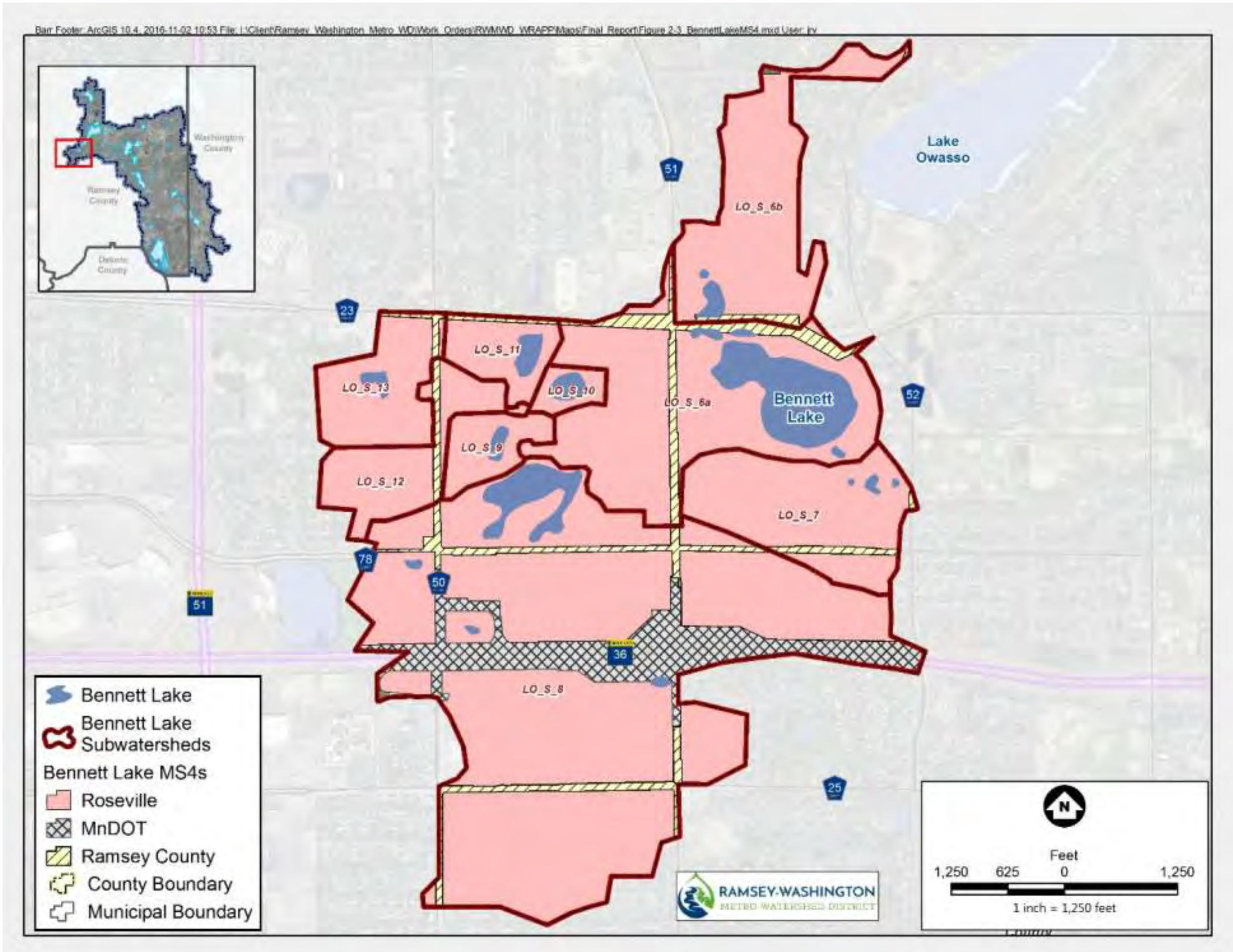


Figure 2-3 MS4s in the Bennett Lake Subwatershed

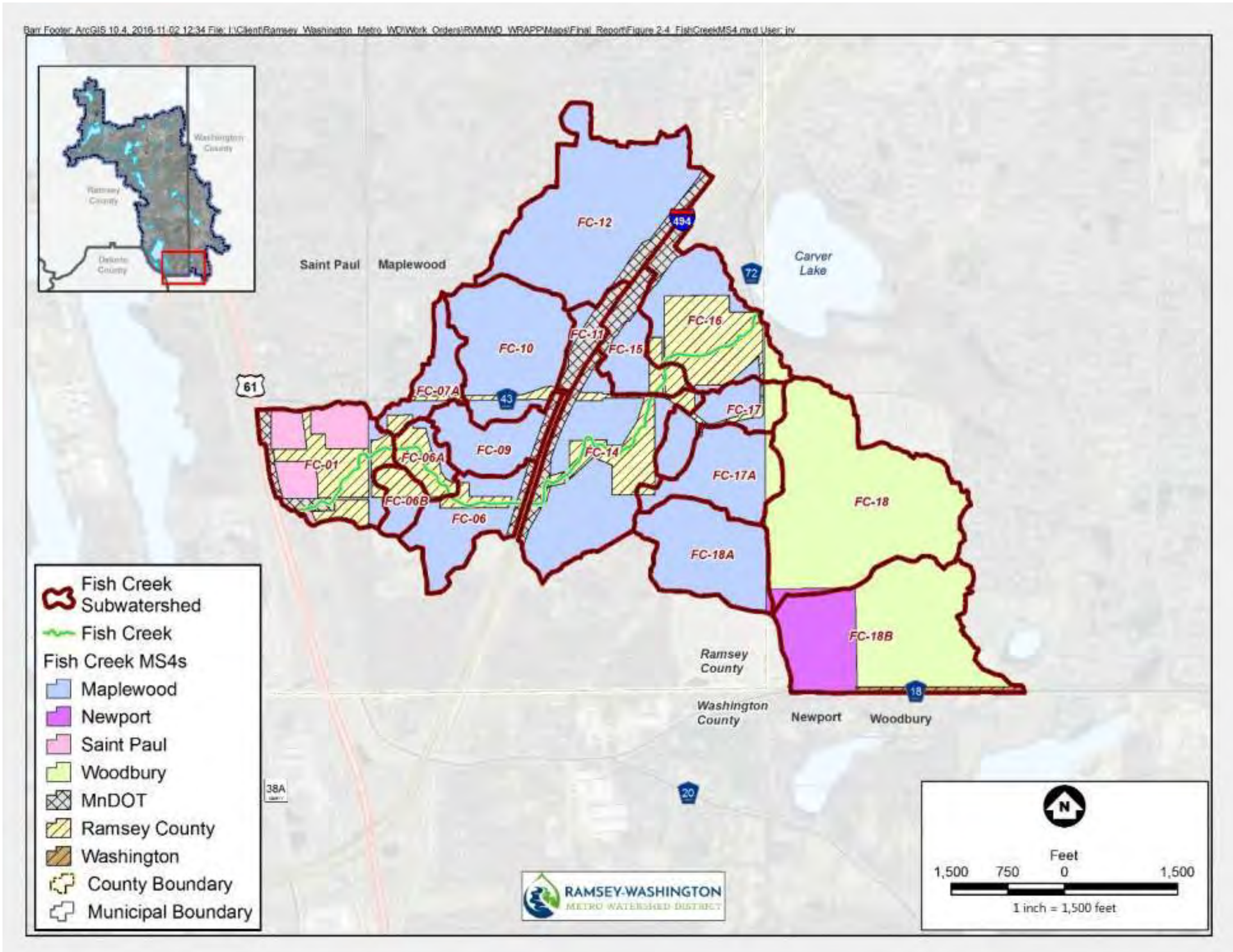


Figure 2-4 MS4s in the Fish Creek Subwatershed

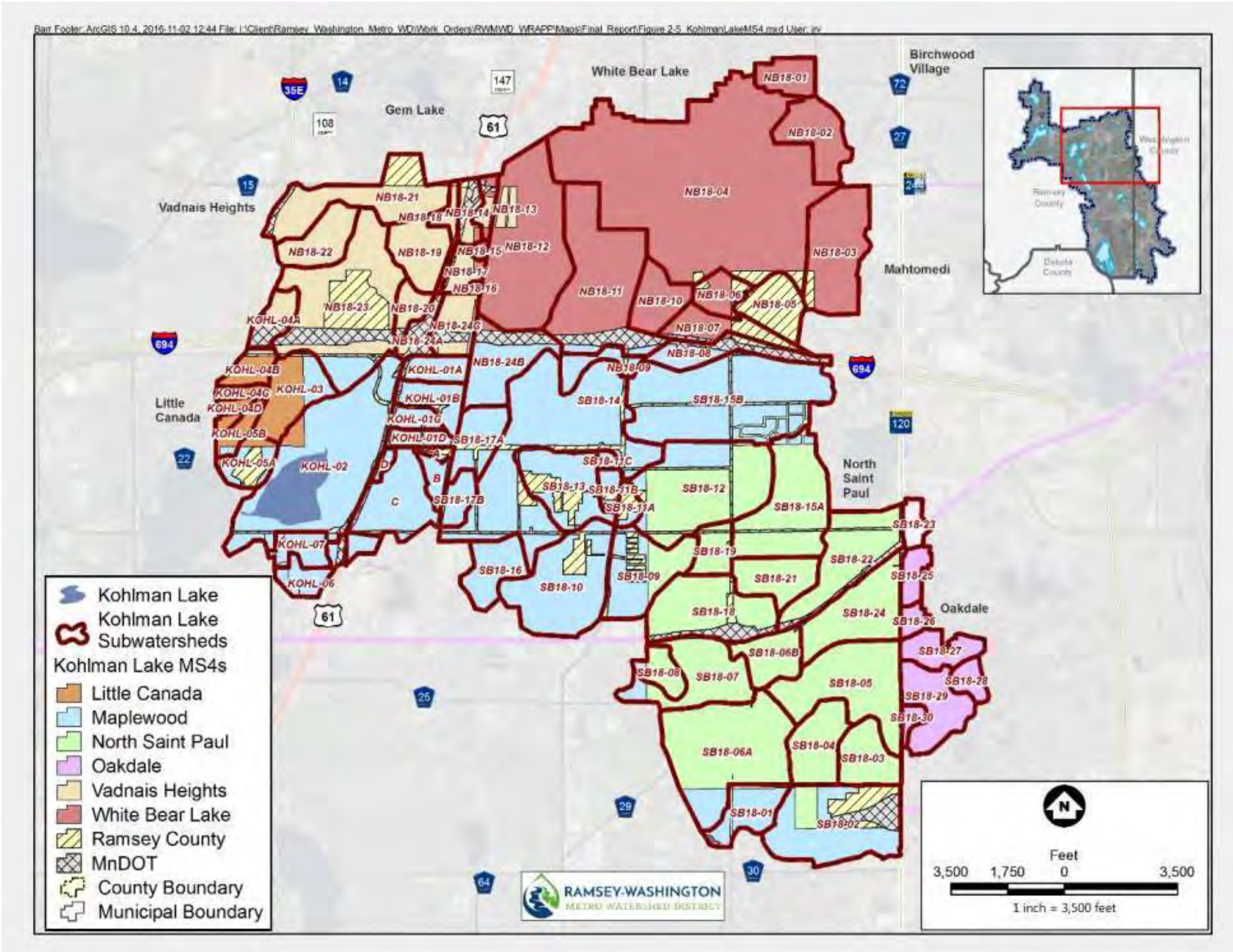


Figure 2-5 MS4s in the Kohlman Lake Subwatershed

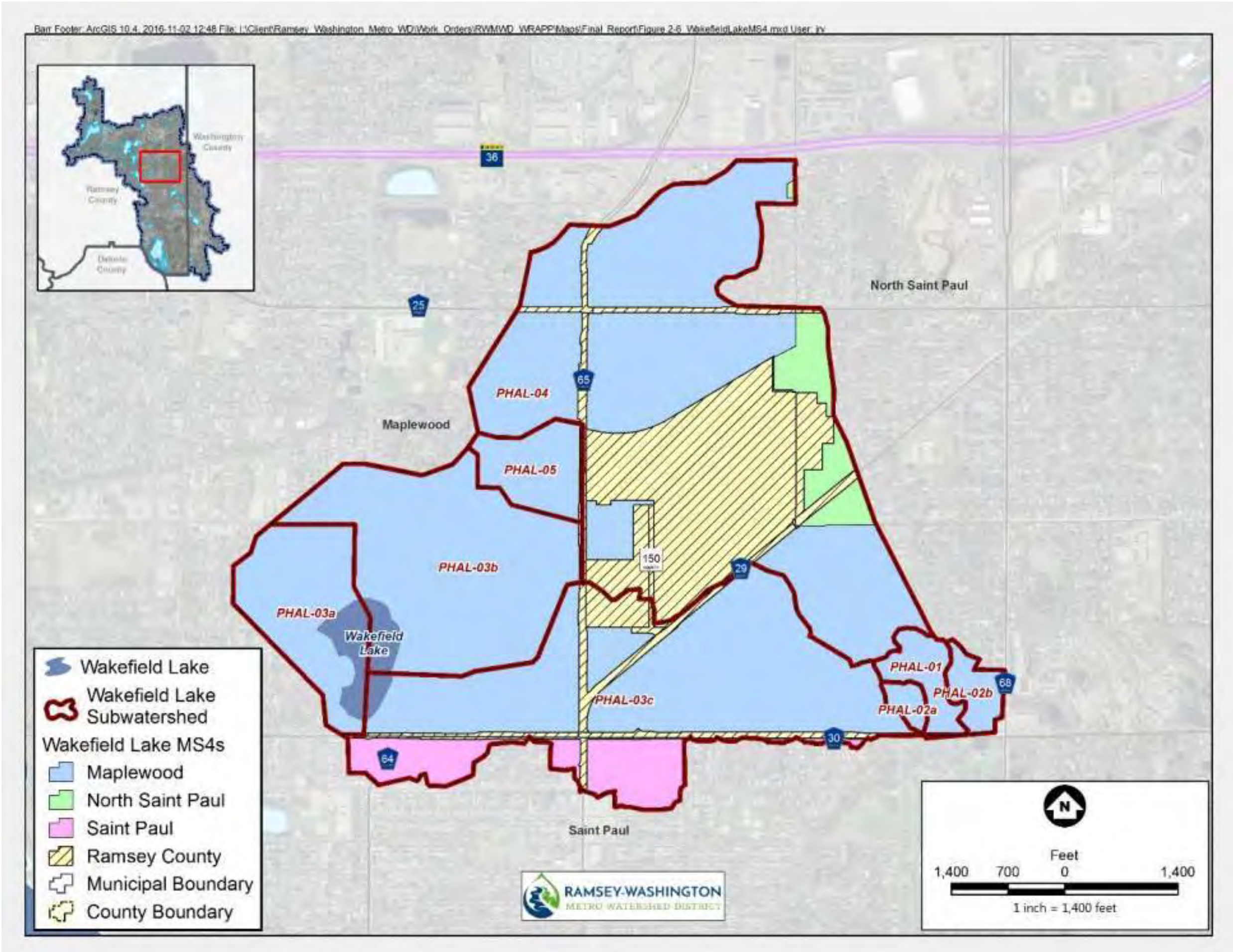


Figure 2-6 MS4s in the Wakefield Lake Subwatershed

Nonpoint (or non-permitted) sources of pollutants are those that are not regulated by the NPDES/SDS program. The following are examples of the typical non-permitted sources pollutants:

- **Atmospheric Deposition** – Pollutants deposited directly on the surface of the lake or stream during precipitation events and as dry deposition of particles in between events (e.g. particles suspended by wind that settle out)
- **Watershed Loading** – Runoff and pollutant loads from runoff from rural and/or urban portions of a watershed that are not regulated by an NPDES/SDS MS4 permit and may also include discharges from upstream lakes and water resources
- **Erosion** –Loss of soil and attached pollutants from the land surface, along ravines and other drainage ways, as well as stream banks
- **Failing SSTS** – In rural areas not served by sanitary sewer systems, failing SSTS on lakeshore properties and in other locations in the watershed can contribute to various impairments, such as excess nutrients and bacteria
- **Internal Sources** – There are a variety of potential sources of phosphorus that can come from within the lake - examples include release of phosphorus bound to lake bottom sediments during anoxic conditions, the senescence of certain aquatic vegetation (e.g., curlyleaf pondweed) during the growing season, the activity of benthivorous fish such as carp, suspension of bottom sediments due to wind and/or boat traffic, and groundwater interaction

To begin understanding the impact of both point and nonpoint sources of pollution on the water quality in the resources in the RWMWD, water quality analyses were performed on several water bodies and streams within the watershed as part of the WRAPS process.

A summary of the various contributions of pollutants to the RWMWD lakes and streams are summarized in Table 2-9. The estimated contributions are typically summarized as a percentage based on the estimating loadings for the lakes from the watershed and in-lake modeling completed for this WRAPS report, in past RWMWD studies, and from the flow and load duration and source assessments completed for Battle Creek (TSS) and Fish Creek (bacteria).

A population source inventory and assumed bacteria availability was used to estimate the sources of bacteria loading to Fish Creek. The analysis indicated that runoff from urban areas mobilizing bacteria from improperly managed pet waste is the main source of *E. coli* loading during wet-weather conditions, and failing subsurface septic treatment systems (SSTSs) and sanitary sewer exfiltration are the main sources of loading during dry-weather conditions.

Table 2-9 Nonpoint and Point (MS4) Sources in the Ramsey-Washington Metro Watershed District

HUC-10 Subwater-shed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources									
			Fertilizer & manure run-off	Livestock overgrazing in riparian	Human Source (e.g., Failing septic systems, sanitary sewer, exfiltration)systems	Wildlife	Poor riparian vegetation cover	Upland soil erosion	Urban Stormwater Runoff	Internal Sources (e.g., Sediment, stream corridor)	Upstream Waterbodies	Atmospheric Deposition
City of Saint Paul-Mississippi River	District-Wide	Chloride	--	--	--	--	--	--	100%	--	--	--
	Battle Creek[5] (592)	TSS	--	--	--	--	--	--	42%	46%	12%	--
	Battle Creek Lake (82-0091)[1]	TP	--	--	--	--	--	--	68%	18%	12%	2%
	Beaver Lake (62-0016)[1]	TP	--	--	--	--	--	--	51%	47%	--	2%
	Bennett Lake (62-0048)[2]	TP	--	--	--	--	--	--	43%	56%	--	1%
	Carver Lake (82-0166)[1]	TP	--	--	--	--	--	--	79%	19%	--	2%
	Fish Creek (606)[3]	Bacteria	--	--	53%	2%	--	--	45%	--	--	--
	Gervais Lake[2] (62-0007)	TP	--	--	--	--	--	--	24%	~0%	76%	NA
	Keller Lake (62-0010)[1]	TP	--	--	--	--	--	--	42%	8%	49%	1%
	Kohlman Lake (62-0006)[2]	TP	--	--	--	--	--	--	76%	23%	--	15%
	Lake Emily (62-0080)[2]	TP	--	--	--	--	--	--	37%	42%	20%	2%
	Lake Owasso (62-0056)[2]	TP	--	--	--	--	--	--	31%	63%	--	6%
	Lake Phalen[2] (62-0013)	TP	--	--	--	--	--	--	68%	~0%	32%	NA
	Lake Wabasso (62-0082)[2]	TP	--	--	--	--	--	--	13%	62%	3%	22%
	Round Lake, Little Canada (62-0009)	TP	--	--	--	--	--	--	NA	NA	--	NA
	Round Lake, Maplewood (62-0012)[1]	TP	--	--	--	--	--	--	87%	10%	--	3%
	Shoreview Lake (62-0079)[4]	TP	--	--	--	--	--	--	NA	NA	--	NA
	Snail Lake (62-0073)[2]	TP	--	--	--	--	--	--	30%	11%	51%	8%
	Tanners Lake (82-0115)	TP	--	--	--	--	--	--	NA	NA	--	NA

HUC-10 Subwater-shed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources									
			Fertilizer & manure run-off	Livestock overgrazing in riparian	Human Source (e.g., Failing septic systems, sanitary sewer, exfiltration)systems	Wildlife	Poor riparian vegetation cover	Upland soil erosion	Urban Stormwater Runoff	Internal Sources (e.g., Sediment, stream corridor)	Upstream Waterbodies	Atmospheric Deposition
	Twin Lake (62-0039)	TP	--	--	--	--	--	--	NA	NA	--	NA
	Wakefield Lake (62-0011)[2]	TP	--	--	--	--	--	--	67%	32%	--	1%
	Willow Lake (62-0040)[4]	TP	--	--	--	--	--	--	NA	NA	--	NA

NA = Not Assessed
[1] Values based on the water year
[2] Values based on the growing season
[3] Values based on available *E. Coli* organisms generated per month
[4]Likely sources of pollutants based on knowledge of the resource and its watershed. Official water quality study has not been performed.
[5] Values based on annual loading average of last 10-years of data
[6]All sources of urban stormwater runoff in RWMWD are permitted MS4 sources.

2.4 TMDL Summary

The *RWMWD TMDL Study (draft, Barr 2016)* addresses the aquatic life and aquatic recreation impairments in Battle Creek and Fish Creek, and nutrient impairments in Bennett Lake and Wakefield Lake. The goal of this TMDL report is to quantify the pollutant reductions needed to meet the Minnesota Pollution Control Agency’s (MPCA’s) water quality standards for all four RWMWD water bodies. This TMDL was established in accordance with Section 303(d) of the Clean Water Act and provides the wasteload allocations (WLAs) and load allocations (LAs) for the impaired water resources. The results of this effort are shown in the Table 2-10 and Table 2-11 below.

Table 2-10 Allocations Summary for all Lake TMDLs in the RWMWD

Lake (ID)	Pollutant	Allocations (lbs/GS[1])								Percent Reduction[1]
		Wasteload Allocation (WLA)							MOS	
		WWTPs	Construction & Industrial SW	MnDOT (MS400170)	MS4s	Internal Load	Upstream Lakes	Atmosphere	Margin of Safety (MOS)	
Bennett Lake (62-0048)	TP	--	0.9	1.6	20.1	18.1	--	2.3	4.8	74%
Wakefield Lake (62-0011)	TP	--	1.6	--	93.1	12.1	--	1.4	12	43%

[1] GS = Growing Season [June 1 through September 30]

Table 2-11 Allocation summary for all stream TMDLs in the RWMWD

Stream/Reach (AUID)	Pollutant	Flow Zone	*E. coli* allocations (billions org./day)							Percent Reduction[1]
			TP & TSS Allocations (lbs/day)							
			WLA				LA		MOS	
			WWTPs	Construction & Industrial SW	MnDOT (MS400170)	MS4 Communities	Non-MS4 Watershed Load	Upstream Reach(es)	MOS	
Battle Creek (592)	TSS	Very High	--	31	82	1,763	2,551	--	492	91%
		High	--	12	32	679	982	--	189	88%
		Mid	--	7	17	371	537	--	104	86%
		Low	--	2	6	133	193	--	37	66%
		Very Low	--	0	1	12	17	--	3	73%
Fish Creek (606)	*E. coli*	Very High	--	--	2.3	37.3	0.6	--	4.5	0%
		High	--	--	1.2	20.1	0.3	--	2.4	22%
		Mid	--	--	0.8	13.4	0.2	--	1.6	0%
		Low	--	--	0.3	4.6	0.1	--	0.6	26%
		Very Low	--	--	0.1	0.9	0.0	--	0.1	62%

Details concerning implementation strategies that could achieve these reductions can be found in the RWMWD TMDL Study *Report* and are reflected in the strategies described in Table 3-1 of this WRAPS report.

2.5 Protection Considerations

In addition to the topics and resource-specific items discussed in the preceding sections, the RWMWD also considers areas with specific protection considerations such as stormwater management, land use changes, recreational assets, AIS, non-compliant septic systems, the presence of natural communities or rare species, groundwater sensitivity to pollution, or areas that seem appropriate for targeted infiltration for the purpose of groundwater recharge.

Land Use Changes and Stormwater

Land use and land cover play a major role in determining what happens to precipitation in the hydrologic cycle. Vegetation intercepts precipitation, slows its movement, and returns moisture to the atmosphere via transpiration. Trees and native grasses, with their extensive root systems, encourage far more water to soak into the soil than pastures or lawns, which have very shallow roots and are more likely to allow water to run off quickly if the soil is compacted or saturated. Therefore, areas in the watershed that are forested or contain native grasses will have a greater capacity to infiltrate water than those areas that are cultivated or covered by lawns.

Although the RWMWD is largely developed, there are always many areas of the watershed that are redeveloping at any given time. These proposed redevelopments can cause significant land use changes (for better or worse). Land redevelopment is an opportunity to dramatically change how stormwater runoff moves in the local watershed. In the past, the changes began during construction, when clearing and grading of the site results in less infiltration, higher rates and volumes of stormwater runoff, and increased erosion. As construction continued, natural surfaces became covered with asphalt, concrete, and other materials that are impervious and prevent infiltration of water into the soil. Impervious surfaces greatly increase the rate at which water runs off the landscape and enters waterbodies, and can alter the hydrologic cycle. An increase in surface runoff to streams can result in bank erosion, increased pollutant loads, and increased temperatures.

As such, the quality and quantity of surface water is greatly influenced by stormwater runoff. As redevelopment continues in the RWMWD, nutrient and sediment inputs (i.e., loadings) from stormwater runoff can far exceed the natural inputs to a lake, pond, or stream. To accomplish the RWMWD goals for maintaining and improving water quality and managing water quantity, stormwater runoff must be carefully and closely managed.

The RWMWD manages stormwater runoff by carrying out its regulatory and permit program, which includes preventive measures so that negative effects of stormwater runoff are addressed (and prevented) at the time of development or redevelopment, and not after problems develop. The RWMWD has adopted rules that outline requirements in relation to:

- Stormwater Management (including a volume reduction rule)
- Flood Control
- Wetland Management
- Erosion and Sediment Control
- Illicit Discharge and Connection

The RWMWD permit program is designed to allow contractors and developers to work with District staff to address and prevent issues related to development. Staff are active in a project from the early planning stages until the site has been permanently stabilized. Additionally, long-term maintenance agreements are required through this process. The RWMWD actively encourages developers to use new, innovative stormwater management technologies.

Also, the RWMWD has an active cost share program that provides funding assistance to individuals and organizations that wish to implement stormwater management features on their properties. The proportion of funding that is provided for proposed projects depends on the project's location in the watershed. Those in "Impaired" watersheds receive higher levels of funding than those that are not.

The RWMWD carries out an extensive monitoring program for its lakes and streams in order to assess their water quality and determine what protection measures need to be used to improve or maintain water quality.

Recreational Assets

The city of St. Paul's historic Phalen-Keller Regional Park attracts over 1 million visitors annually, making it one of the most visited Regional Parks in the Twin Cities Metropolitan Region. The park and its facilities are heavily used throughout the year. People from local neighborhoods, as well as from across the region, participate in many different activities and events throughout its nearly 750 acres.

Roseville's Central Park, which encompasses the entirety of Bennett Lake, is a popular spot for biking, walking, fishing, picnicking and events at the Frank Rog Amphitheater.

Maplewood's Wakefield Park is a community park that encompasses the southern portion of Wakefield Lake's shoreline. The park attracts local visitors to its playground and athletic fields.

Aquatic Invasive Species

Watershed management has historically focused on water quality as a function of land use activities and the resulting increase in loading of nutrients, sediment, and other chemicals. Changes in the ecology of aquatic plants, animals, and microorganisms may also result in the degradation of aquatic environments and negatively impact aesthetics, recreation, and environmental quality. Therefore, the RWMWD conducts aquatic plant surveys to assess and prioritize the waterbodies within the watershed. Also, the RWMWD has actively managed the carp population in the Phalen Chain of Lakes since 2009, and plans to embark on carp management strategies in the waterbodies tributary to the Grass Lake wetland in the future.

The term "invasive species" describes plants, animals, or microorganisms within lakes and streams that are non-native and that: (1) cause or may cause economic or environmental harm or harm to human health; or (2) threaten or may threaten natural resources or the use of natural resources in the state (Minn. Stat. ch. 84D.01). Aquatic invasive species (AIS) is a term given to invasive species that inhabit lakes, wetlands, rivers, or streams and overrun or inhibit the growth of native species. AIS pose a threat to natural resources and local economies that depend on them.

Under direction from the Minnesota Legislature, the Minnesota Department of Natural Resources (DNR) established the Invasive Species Program in 1991. The program is designed to implement actions to prevent the spread of invasive species and manage invasive aquatic plants and wild animals (Minn. Stat. 84D).

As part of its Invasive Species Program, the DNR maintains a list of waters infested with specific AIS (*DNR Designation of Infested Waters, 2015 as amended*). The DNR list includes several RWMWD waterbodies as infested with Eurasian watermilfoil, including Beaver Lake, Gervais Lake (Gervais Mill Pond), Keller Lake (Spoon Lake), Kohlman Lake, Lake Owasso, Lake Phalen, Snail Lake and Lake Wabasso. The DNR's list of AIS infested waterbodies does not include all known AIS occurrences within the RWMWD. In addition, the RWMWD has identified the presence of the following AIS in or in the riparian areas of RWMWD waterbodies:

- Eurasian watermilfoil (*Myriophyllum spicatum*)
- Purple loosestrife (*Lythrum salicaria*)
- Curlyleaf pondweed (*Potamogeton crispus*)
- Yellow iris (*Iris pseudacorus*)
- Narrowleaf cattail (*Typha angustifolia*)
- Hybrid cattail (*Typha glauca*)
- Reed canary grass (*Phalaris arundinacea*)
- Common carp (*Cyprinus carpio*)

Of these species, curlyleaf pondweed (CLP) is of special concern due to its shifted life cycle, ability to displace native vegetation, and having the potential as a source of internal phosphorus loading during the growing season. Curlyleaf and Eurasian watermilfoil have been managed as needed in Kohlman Lake since 2008. Common carp are also of great concern in the Phalen Chain of Lakes and in waterbodies tributary to the Grass Lake area, in that they negatively affect water quality and displace native populations of fish.

In addition, many shallow RWMWD lakes suffer from an overabundance of filamentous green algae (FGA). FGA forms dense, sometime noxious, green mats that interfere with recreation, and can affect water oxygen levels through respiration. Residents commonly complain about FGA in their lakes, wetlands and ponds, and lake managers have traditionally had few tools to manage this annoyance. RWMWD has recently launched a macrophyte harvesting study on Kohlman Lake that aims to assess whether physically removing FGA might help not only to reduce FGA mats, but also remove substantial quantities of phosphorus at a reasonable cost as well. Results from this study will be available in spring, 2017.

To date, zebra mussels have not been detected in any RWMWD lakes. However, it is important to note that zebra mussels have been found in neighboring Sucker, Vadnais and White Bear Lakes. Zebra mussels can cause problems for lakeshore residents and recreationists by clogging water intakes and attaching to motors and possibly clogging cooling water areas. Zebra mussels can also attach to native mussels, killing them.

Common carp are also present in many District lakes. Common carp are typically spread between lakes by the accidental inclusion and later release of live bait, but can also migrate through natural or built channels as adults. Carp feeding techniques disrupt shallow-rooted plants, which can reduce water clarity and stir up the bottom sediments, which can potentially release phosphorus bound in sediments, leading to increased algal blooms and decline in native aquatic plants.

In 2009, the Watershed partnered with the University of Minnesota's Sorensen Lab on an applied research project to investigate carp in the Phalen Chain of Lakes. The main objectives were to:

1. Determine the abundance of carp in the Phalen Chain of Lakes;
2. Identify spawning areas;
3. Better understand what influences carp recruitment (maturing from an egg to an adult).

   The watershed funded this work along with the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

Since 2009, the District has made substantial progress in understanding the carp population and ecology in the Phalen Chain. Through research and management, the District has:

- Reduced the adult carp density by over 60%, from 158 pounds per acre to 55 pounds per acre (average biomass for Kohlman, Gervais, and Keller)
- Located the key spawning areas in the Chain and are actively working to eliminate carp in these systems (e.g., Casey Lake, Markham Pond, and Kohlman Basin).
- Installed a carp barrier in Kohlman Creek that will reduce the number of adult carp migrating into the Kohlman Basin wetlands during spring spawning.

The RWMWD limits its management of AIS to instances where the AIS have a demonstrated negative effect on water quality. Planned AIS management actions for the major RWMWD waterbodies are described in the *RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017).* The RWMWD partners with Ramsey and Washington counties to monitor and help prevent the spread of AIS in the RWMWD.

Natural Communities and Rare Species

Through its Natural Heritage and Nongame Research Program (NHNRP), the DNR collects, manages, and interprets information about rare natural features, native plants and plant communities, and nongame animals, including endangered, threatened, and special concern species. As part of the NHNRP, the DNR maintains the Natural Heritage Information System (NHIS) as a statewide database of these resources. The DNR limits publication of spatial attributes and locations of these items to protect rare features or species from damage or collection.

Numerous locations throughout the RWMWD Watershed are identified as part of the DNR's NHIS indicating the presence of the species found in Table 2-12.

Table 2-12 NHIS Database Species in RWMWD

Common Name	Category
Colonial Waterbird Nesting Site	Animal Assemblage
Ebonyshell	Invertebrate Animal
Fawnsfoot	Invertebrate Animal
Hickorynut	Invertebrate Animal
Monkeyface	Invertebrate Animal
Rock Pocketbook	Invertebrate Animal
Wartyback	Invertebrate Animal
Proglacial River Composite (Quaternary)	Other (Ecological)
Alder - (Maple - Loosestrife) Swamp	Terrestrial Community - Other Classification
Dry Sand - Gravel Prairie (Southern)	Terrestrial Community - Other Classification
Lake Bed	Terrestrial Community - Other Classification
Mesic Prairie (Southern)	Terrestrial Community - Other Classification
Native Plant Community, Undetermined Class	Terrestrial Community - Other Classification
Northern Mixed Cattail Marsh	Terrestrial Community - Other Classification
Prairie Rich Fen	Terrestrial Community - Other Classification
Red Oak - Sugar Maple - Basswood - (Bitternut Hickory) Forest	Terrestrial Community - Other Classification
Red Oak - White Oak Forest	Terrestrial Community - Other Classification
Sand Beach (Inland Lake)	Terrestrial Community - Other Classification
Seepage Meadow/Carr	Terrestrial Community - Other Classification
Tamarack Swamp (Southern)	Terrestrial Community - Other Classification
Wet Prairie (Southern)	Terrestrial Community - Other Classification
Willow - Dogwood Shrub Swamp	Terrestrial Community - Other Classification
Autumn Fimbristylis	Vascular Plant
Black Huckleberry	Vascular Plant
Clinton's Bulrush	Vascular Plant
Club-spur Orchid	Vascular Plant
Cowbane	Vascular Plant
Half Bristly Bramble	Vascular Plant

Common Name	Category
Kitten-tails	Vascular Plant
Tall Nut-rush	Vascular Plant
Tooth-cup	Vascular Plant
Tubercled Rein-orchid	Vascular Plant
White Wild Indigo	Vascular Plant
Yellow Pimpernel	Vascular Plant
Bald Eagle	Vertebrate Animal
Black Buffalo	Vertebrate Animal
Blanding's Turtle	Vertebrate Animal
Blue Sucker	Vertebrate Animal
Lake Sturgeon	Vertebrate Animal
Least Darter	Vertebrate Animal
Paddlefish	Vertebrate Animal
Pugnose Shiner	Vertebrate Animal
Red-shouldered Hawk	Vertebrate Animal
Western Foxsnake	Vertebrate Animal

There is one “scientific and natural area” identified by the DNR within the RWMWD. This site is the Pig’s Eye Island Heron Rookery scientific and natural area. This site is owned by the city of St. Paul and is one of the largest nesting sites for colonial waterbirds within the state of Minnesota.

Tamarack Swamp, a wetland found in the southeast portion of the subwatershed upstream of Battle Creek Lake, is the largest and most ecologically diverse wetland in the District. The wetland is named for the tamarack tree, a cold-climate conifer found in far northern latitudes, but generally quite rare in this part of the state.

RWMWD also actively manages many other important habitat areas, as described in the Natural Resources portion of its website (*http://www.rwmwd.org/*). Figure 2-7 shows the managed habitat areas throughout the RWMWD.

These special areas and the species that inhabit them get special attention in District projects and programs, particularly in actions that pertain to the District’s “Achieve Healthy Ecosystems” goal.

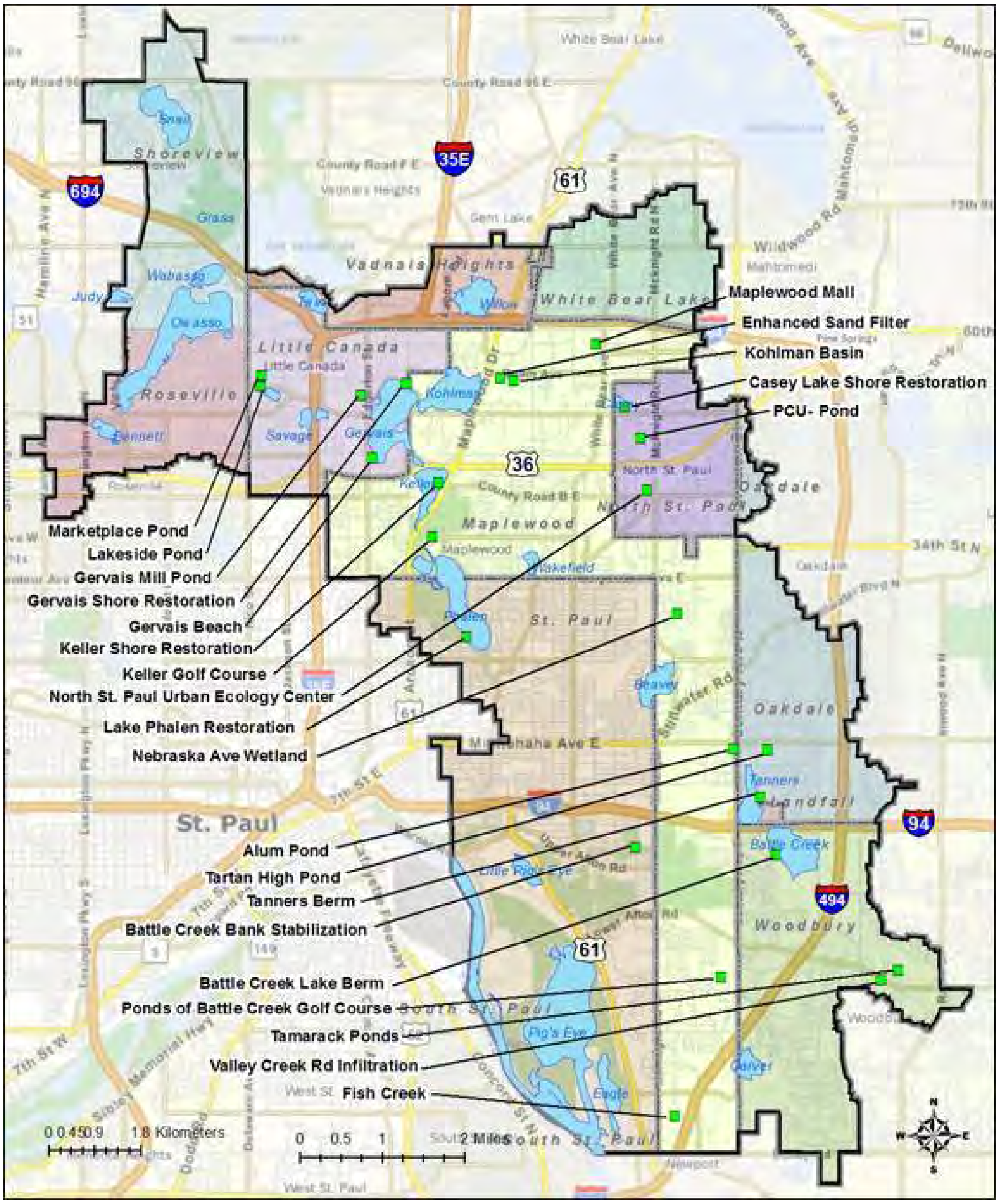


Figure 2-7 Managed habitat areas throughout the RWMWD

Groundwater/Surface Water Interaction

Understanding how changes in the groundwater system may affect water levels, stream flow, and water quality is an important component of long-term planning and protection of water resources in the RWMWD. How well connected, or disconnected, surface waters are to the groundwater system affects how they may respond to seasonal changes (such as drought), long-term climate change, or groundwater pumping. In addition, understanding the connection between groundwater and surface waters throughout the RWMWD can help inform how best to target infiltration practices to promote groundwater recharge, or to avoid infiltration in sensitive groundwater areas.

To better the RWMWD's understanding of these connections across the watershed, the RWMWD Groundwater/Surface Water Interaction Study was completed in 2015 (Barr 2015). This study evaluated how groundwater and surface water interact across the District and identified surface waters that may be susceptible to changes in groundwater levels. The second part of the study identified areas for focused groundwater recharge to replenish stressed aquifers while also achieving stream-flow volume reductions and water quality improvements and avoiding groundwater pollution.

To evaluate groundwater/surface water interaction across the District, publicly available data sets were compiled and further analyzed. A number of different agencies and organizations collect groundwater, surface water, and other environmental data throughout the District for many different purposes.

Some of the major datasets compiled and used for this study include:

- Surficial and bedrock geology
- Lake bathymetric data
- Surface typography and morphology
- Observation well data
- Well records and boring logs
- Soil survey data
- Data from the Twin Cities Metropolitan Area Groundwater Flow Model (Metro Model 3)
- Water use and projected demand

Figure 2-8 shows areas that may be suitable for focused groundwater recharge across the RWMWD. In the figure, higher scores indicate areas more suitable for infiltration to achieve District goals involving stormwater volume reduction and groundwater recharge, while lower scores indicate areas that are less suitable for infiltration to achieve District goals.

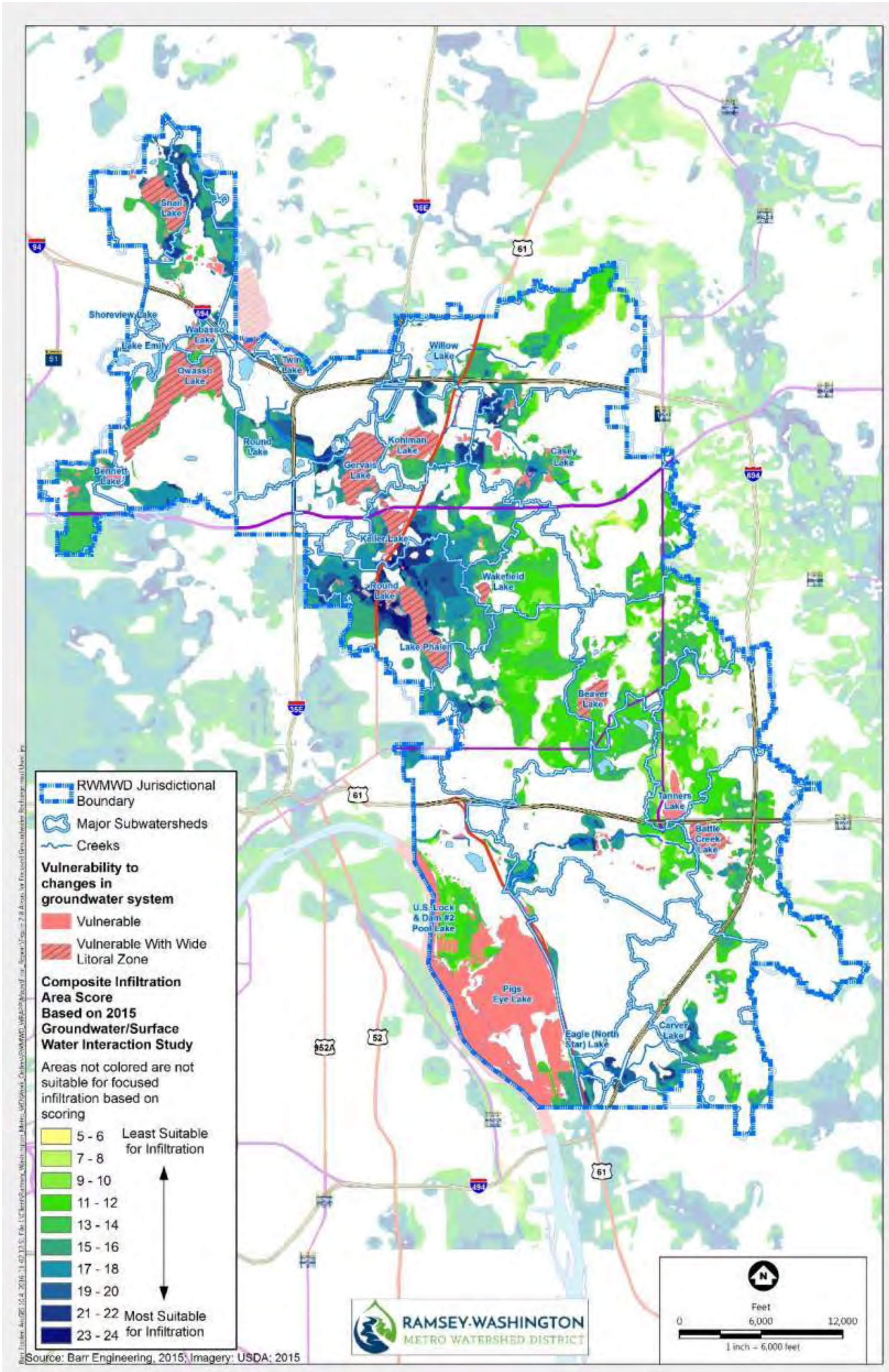


Figure 2-8 Areas for Focused Groundwater Recharge

3. Prioritizing and Implementing Restoration and Protection

The CWLA requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, and identify point sources and nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of this WRAPS report provides the results of such prioritization and strategy development. Because some of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed, it is imperative to create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement best management practices. Thus, effective ongoing civic engagement is fully a part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgement based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management - an iterative approach of implementation, evaluation and course correction.

There are issues that are not addressed in the strategies tables, like limited local capacity and funding that can greatly affect the outcomes of this report. If resources, like staff or funding, are limited or nonexistent in the project area, it is likely that the strategies and goals laid out in this report will take longer to achieve. Therefore, it is important that as these actions are undertaken that all levels (federal government, state government, local government, non-profits, and landowners) continue to find ways to support local entities and individuals to ensure the waterbodies in the RWMWD are restored and protected.

In implementing this WRAPS report, the RWMWD will rely upon the following sources of funding and technical support:

- RWMWD tax levies
- Cost sharing opportunities with partners
- Grants and loans from federal, state and local sources
- State agencies (technical support)
- University of Minnesota (technical support)

Grants are an important funding source for RWMWD projects and programs. The District will continue to apply for grants whenever possible to reduce the portion of project and program cost borne by the District. Historically, the District has been able to secure grant funding for a majority of its ecological restoration projects. Grant funds are also often available for research projects.

Grant programs are available at the local (e.g., county, MCES), state, and federal level. Several District projects have been funded by the Clean Water Fund (CWF) grant program implemented by the Board of Water and Soil Resources (BWSR). The District recognizes that many grant programs are funded through public tax dollars. When possible, the District prefers to seek state and federal grant programs in order to spread the indirect expense across a wider tax base, thereby reducing the direct and indirect cost to the residents of the watershed.

Detailed information on the planning level costs to implement this WRAPS report and other District efforts is included in the *RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017).*

3.1 Targeting of Geographic Areas

To improve and/or maintain water quality in the RWMWD, it is important to identify nonpoint sources of pollution and prioritize and geographically locate restoration and protection areas within the RWMWD. This section describes the strategies and tools the RWMWD uses to prioritize waterbodies and target geographic areas for water quality improvement.

State, Basin and Regional Scale

The Minnesota Nutrient Reduction Strategy was developed in response to concern about excessive nutrient levels that pose a substantial threat to Minnesota's lakes and rivers, as well as downstream waters including the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico. In recent decades, nutrient issues downstream of Minnesota have reached critical levels, including the effect of nutrients in the Gulf of Mexico, which resulted in a dead zone, eutrophication issues in Lake Winnipeg, and algal blooms in the Great Lakes. Several state-level initiatives and actions highlighted the need for a statewide strategy that ties separate but related activities together to further progress in making nutrient reductions. Minnesota conducted both nitrogen and phosphorus assessments to identify nutrient source contributions. The main nutrient sources to the Mississippi River are phosphorus (P) from agricultural cropland runoff, wastewater, and streambank erosion, and nitrogen (N) from agricultural tile drainage and water leaving cropland via groundwater. The associated Phase I milestones for the Mississippi River Basin for N and P are 20% and 35% reductions respectively from baseline by 2025. Additional milestones call for 30% (N) and 45% (P) by 2035 and 45% reduction from baseline in N by 2045. The primary tools the State will use to achieve these reductions are the 10-year cycle of watershed assessments and WRAPS studies to: identify high-loading areas and critical management areas; enhanced phosphorus and nitrogen reduction strategies for wastewater effluent; facilitating implementation of agricultural BMPs targeted at increasing fertilizer use efficiency, reducing field erosion, and treating tile drainage water; and continued implementation of the SW discharge permitting system for MS4s.

While there is very little agricultural land and no wastewater effluent in the RWMWD, areas with high loads of phosphorus have been identified through the diagnostic feasibility studies described later in this section of this WRAPS report. In addition, streambank erosion is identified during annual inspections, and repairs/stabilizations are implemented each year as necessary.

The Nitrogen in Minnesota Surface Waters Strategy was developed in response to a concern for human health when elevated nitrogen levels reach drinking water supplies. The 10 mg/l nitrate-N drinking water standard established for surface and groundwater drinking water sources and for cold water streams is exceeded in numerous wells and streams in the state. The purpose of this study was to provide an assessment of the science concerning N in Minnesota waters so that the results could be used for current and future planning efforts, thereby resulting in meaningful goals, priorities, and solutions.

More specifically, the purpose of this project was to characterize N loading to Minnesota's surface waters, and assess conditions, trends, sources, pathways, and potential BMPs to achieve nitrogen reductions in our waters. The nitrogen study contains a spreadsheet tool called the nitrogen best management practice (NBMP) tool (NBMP is described in more detail in the *Nitrogen in Minnesota Surface Waters Report Chapter F1* (Wall 2013)).

The *Twin Cities Metropolitan Area Chloride Management Plan* (CMP) was developed to address the increasing concentrations of chloride found in Minnesota's waters in urban areas as well as across the state. The CMP provides the framework to assist local communities in reducing chloride concentrations in both the state's ground and surface waters through protection and restoration efforts. The CMP contains a variety of BMPs that reduce salt use while still maintaining safe conditions for the public. The chloride reduction strategy outlined in the CMP uses a performance-based approach that does not have specific numerical requirements, but focuses on implementing BMPs and tracking trends in chloride concentrations. The primary recommended strategies for reducing chloride concentrations in the CMP, which apply to the District, include: (1) a shift to using more liquid deicing chemical products rather the granular ones, (2) improved physical snow and ice removal, (3) use of practices that prevent the formation of a bond between snow/ice and the pavement, (4) strategies that eliminate salt waste, (5) training for winter maintenance professionals, and (6) education for the public and elected officials.

RWMWD

Non-Compliant Septic Systems

Although much of the RWMWD is served by sanitary sewer, some residential sites within the RWMWD are served by septic systems. Septic systems or SSTS that are not properly designed or maintained can allow untreated or partially treated sewage to flow into surface waters. Human waste can be a source of bacteria loading and nutrients to surface waters, especially during dry and low flow periods. Non-compliant septic systems are especially critical in areas with high groundwater levels, which makes the groundwater more susceptible to pollution.

For septic systems in Ramsey County, the cities are the primary regulatory authority. The Washington County Department of Public Health and Environment is the primary regulatory authority for all SSTS in the RWMWD that are located in Washington County. The current *Washington County Groundwater Plan* has identified SSTS financial assistance as a priority, and the County has several opportunities for financial assistance to upgrade or fix noncompliant SSTS systems. Since Fish Creek has a bacterial impairment, critical areas for this subwatershed were identified in a bacterial source assessment, discussed in greater detail below.

Water Quality Diagnostic Studies to Target Implementation Efforts

The primary way by which the RWMWD defines its implementation program is through the completion of water quality diagnostic feasibility studies. At this time, most of the managed water bodies in RWMWD have had such a study, including the identification of critical areas and recommended projects for implementation. These recommended projects have been incorporated into the Implementation section of the *RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017).* Those items that relate only to water quality considerations are presented in Table 3-1 of this WRAPS report.

As part of this WRAPS report, the RWMWD performed water quality studies and analyses of several lakes within the district: Battle Creek Lake, Beaver Lake, Carver Lake, Keller Lake, Lake Emily, Snail Lake, Lake Owasso, and Lake Wabasso including development of TMDLs for Wakefield Lake, Bennett Lake, Battle Creek and Fish Creek. Lakes that have shown declining water quality in recent years or have the potential to be listed on the impaired waters list (such as Lake Emily) were also targeted during this WRAPS report.

The goal of these water quality studies was to understand the impact of both point and nonpoint sources of pollution on the water quality in the resources in the RWMWD and identify restoration and protection strategies. Watershed and in-lake water quality modeling for the lakes was used to identify and quantify pollutant sources and to identify, target, and prioritize water quality improvement actions.

The water quality analysis included compilation of all historic water quality and lake level data, outlet rating curves, updates to existing and/or development of new watershed pollutant loading models, and development of in-lake water quality mass balance models for each lake to identify and quantify the contributing sources of nutrients (phosphorus) to the water body. Water quality models were developed for each lake's critical water quality conditions (or the worst observed water quality conditions in the past 10 years).

The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) Urban Catchment (computer) Model was used to estimate watershed runoff and total phosphorus loads from each lake's tributary watershed. P8 is a useful diagnostic tool for evaluating and designing watershed improvements and BMPs because it can estimate the treatment effect of several different kinds of potential BMPs. P8 tracks stormwater runoff as it carries phosphorus across watersheds and incorporates the treatment effect of detention ponds, infiltration basins, etc. on the phosphorus and sediment loads that ultimately reach downstream water bodies. P8 accounts for phosphorus attached to a range of particulate sizes, each with their own settling velocity, tracking their removal by treatment features accordingly.

In-lake water quality modeling for the RWMWD lakes was accomplished through the creation of a mass balance models that track both the flow of water and phosphorus through the lakes, the growing season (as defined by the MPCA). The in-lake mass balance models included both a calibrated water balance as well as a phosphorus balance. The key input parameters for the in-lake mass balance models included the stage-storage-discharge relationship developed for the lakes, direct precipitation and evaporation data, groundwater exchange, the water and total phosphorus loads from the lake's watershed as predicted by the P8 model, and through quantification of other sources that are not captured in the watershed modeling (e.g. loads from upstream lakes not in the P8 models). Water quality monitoring data is also used in the in-lake mass balance modeling.

To estimate the internal phosphorus loading from other sources or losses (e.g., sediment release, fish, etc.), the predicted phosphorus concentration in the lake epilimnion was compared to the observed in-lake water quality data on each monitoring event. The magnitude of the internal phosphorus load to the lake's surface waters was deduced by comparing the observed water quality in the lake to the water quality predicted by the in-lake model. To verify the deduced internal loads, the estimated were verified with other available data such as water quality profile information, sediment core data, macrophyte survey information, and fishery information.

The in-lake model results summarizing the growing season (June to September) internal and external (nonpoint) sources of water and phosphorus for each RWMWD lake are summarized in Table 2-8.

Additionally, a bacteria source assessment and load duration analyses were performed for Fish Creek as part of the TMDL development to help identify bacteria sources to the creek and identify and prioritize water quality improvement strategies. Data analysis indicated that bacteria levels were elevated under moist, dry, and low flow conditions. The source assessment concluded that the primary source of bacteria to the creek is from improperly management pet waste mobilized by stormwater runoff. Pollutant source assessments were not conducted for other streams in the RWMWD as they are currently not listed as impaired. Table 2-9 shows the relative sources of bacteria to Fish Creek under average flow conditions.

The *Battle Creek SID Report completed in spring 2015 (Barr 2015)* found that TSS was the primary stressor to fish and macroinvertebrates in the stream, and that TSS concentrations were over the MPCA standard for Class 2B streams in the Central River Nutrient Region. A P8 model was developed for the direct watershed to Battle Creek (downstream of Battle Creek Lake) to help understand and quantify the TSS loading from the watershed along with a flow and load duration analysis for the establishment of the Battle Creek TMDL. Water quality modeling in the Battle Creek Watershed was compared to annual loading rates predicted by the Metropolitan Council from TSS data collected at the Battle Creek WOMP station. The comparison of water quality modeling results to predicted annual loading indicates that the elevated TSS concentrations in the stream are caused nearly equally by TSS mobilized by watershed runoff and TSS sourced from the stream corridor Table 2-9.

All of this monitoring and modeling has helped RWMWD target its efforts in managing different parts of the watershed to the benefit of downstream water bodies, especially with respect to the RWMWD's efforts with their CIP Program and Cost Share Program. The Cost Share Program targets projects in what the RWMWD calls its "Priority" areas by offering a higher percentage of funding in critical areas. Figure 3-1 is a flow chart that demonstrates how the level of RWMWD funding is determined.

A CWF Accelerated Implementation grant in 2014 allowed the District to develop an inventory and methodology for assessing commercial and school properties for possible retrofit projects through the RWMWD Cost Share Program. This methodology has been used to greatly increase the number of schools and commercial properties that have participated in the program. CWF Community Partners grants in 2013 and 2015 have helped the RWMWD to reach out to churches throughout the District as well.

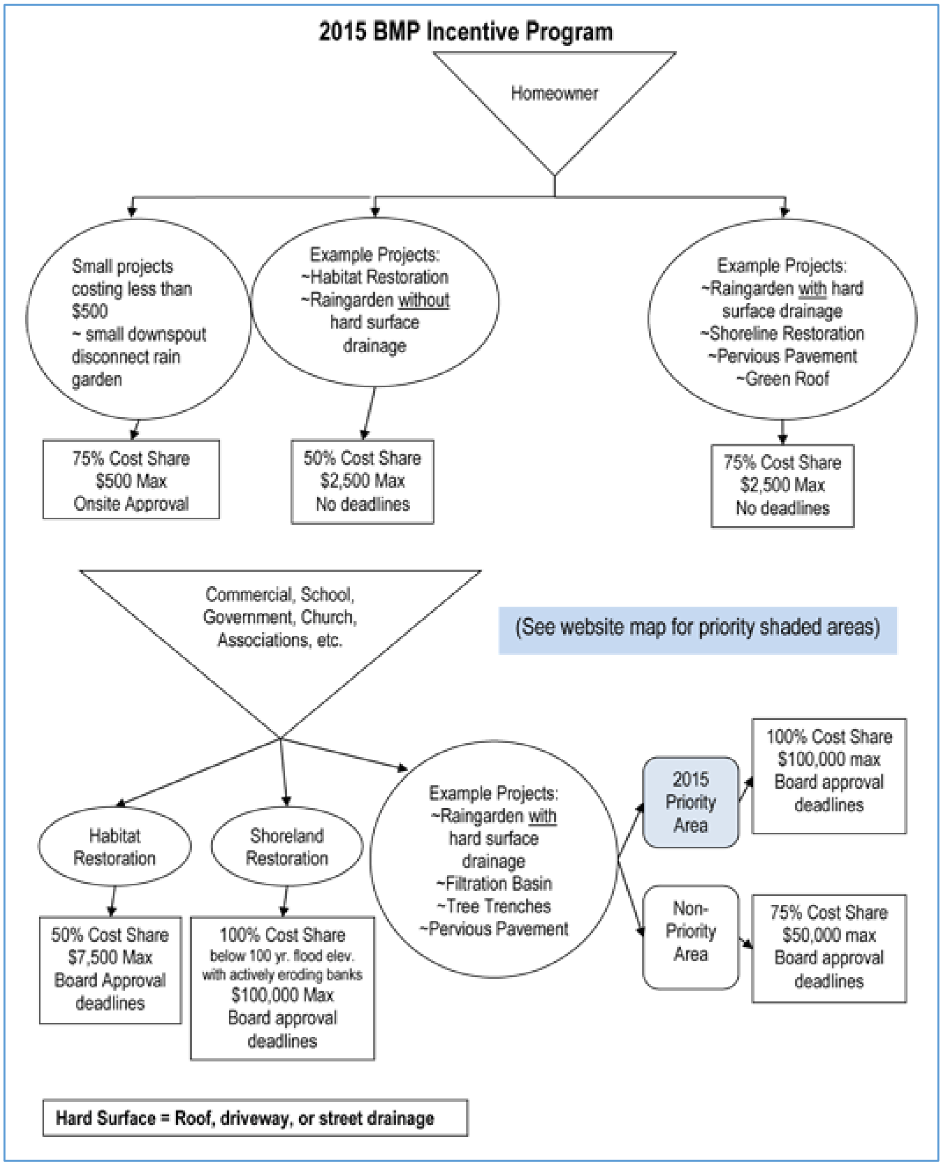


Figure 3-1 Flow chart of RWMWD's fiscal involvement with cost share projects

Project Tracking

The RWMWD maintains a detailed cost benefit database of all of the projects that have resulted from the RWMWD Cost Share, CIP, and Permit Programs. This database contains information for each project such as location in the watershed, size, capital and maintenance costs (not for permitted projects), pollutant removals, stormwater volume reductions, and more, allowing the District to track its progress toward cost-efficiency and stormwater pollutant reduction goals for each waterbody.

The RWMWD has a long history of proactively finding projects and partnerships that work to improve the water quality of its resources.

Cost Share Program

Since the inception of the District's cost share program in 2007, over 300 cost share projects have been implemented. The level of the RWMWD's fiscal involvement in each project depends upon where the project is located. "Priority Areas" are those that are within a subwatershed that drains to an impaired waterbody. Figure 3-2 shows the proliferation of cost share projects in the District implemented through 2015.

Capital Improvement Projects Program

Capital improvement projects are long term/permanent solutions to flood control and water quality problems that the RWMWD implements and maintains. The locations and types of projects are chosen based on monitoring and modeling results. Figure 3-3 shows the proliferation of the 42 capital improvement projects that the RWMWD has implemented from its inception in 1975 through 2015.

RWMWD Permit Program

The RWMWD Permit Program, described in Section 2.5 of this WRAPS report is also serving to change the watershed to benefit waterbodies in the RWMWD. Since the RWMWD's inception in 1975, over 1,640 permitted projects have responded to the District's development/redevelopment rules. Since the inception of the RWMWD permit program's volume reduction rule in 2007, over 170 development/redevelopment projects have been permitted throughout the RWMWD. Figure 3-4 shows the proliferation of development/redevelopment projects that the RWMWD has permitted through its rules from April 1976 (the start of the RWMWD's permit program) to October 2015.

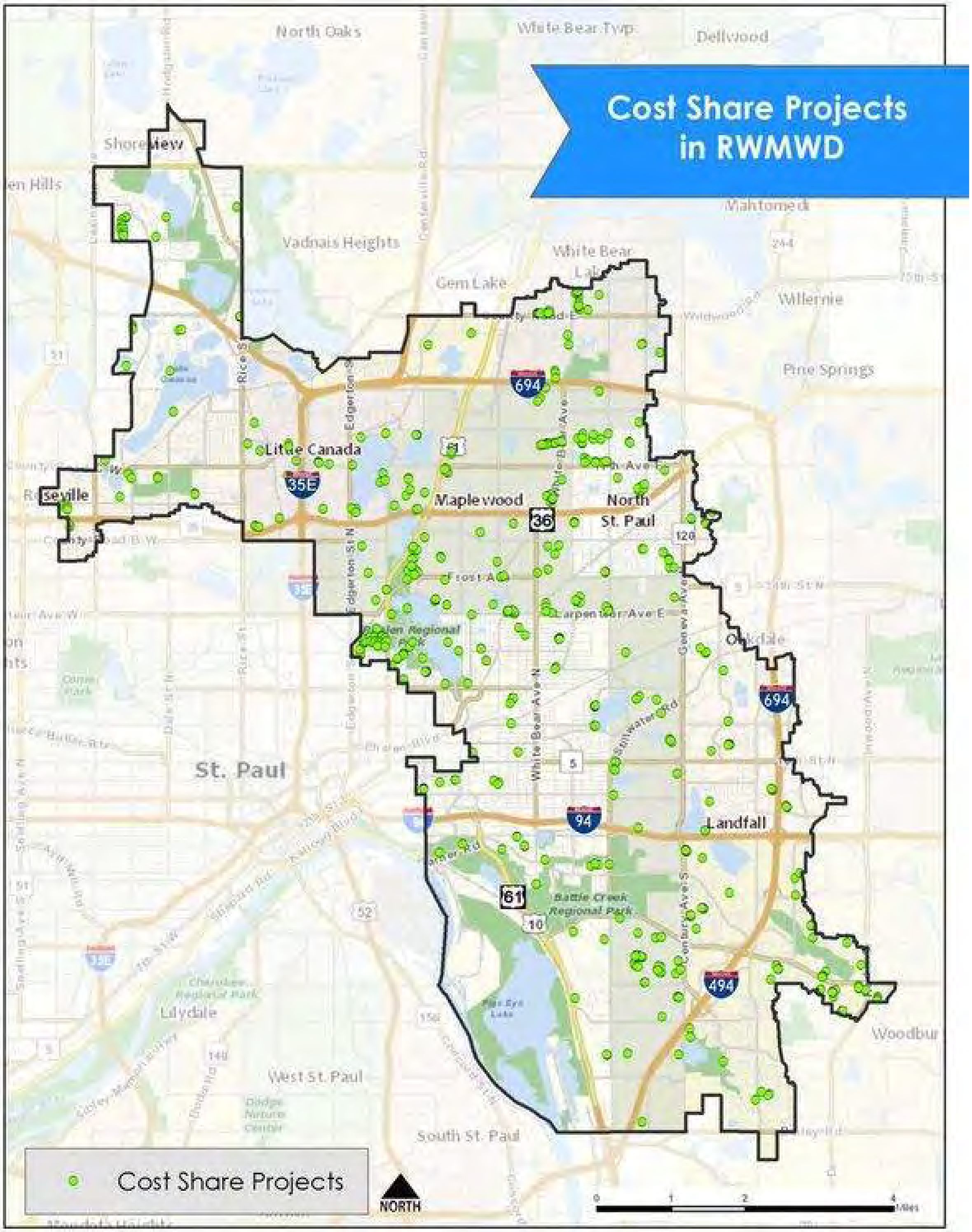


Figure 3-2 Cost Share Projects in RWMWD through 2015

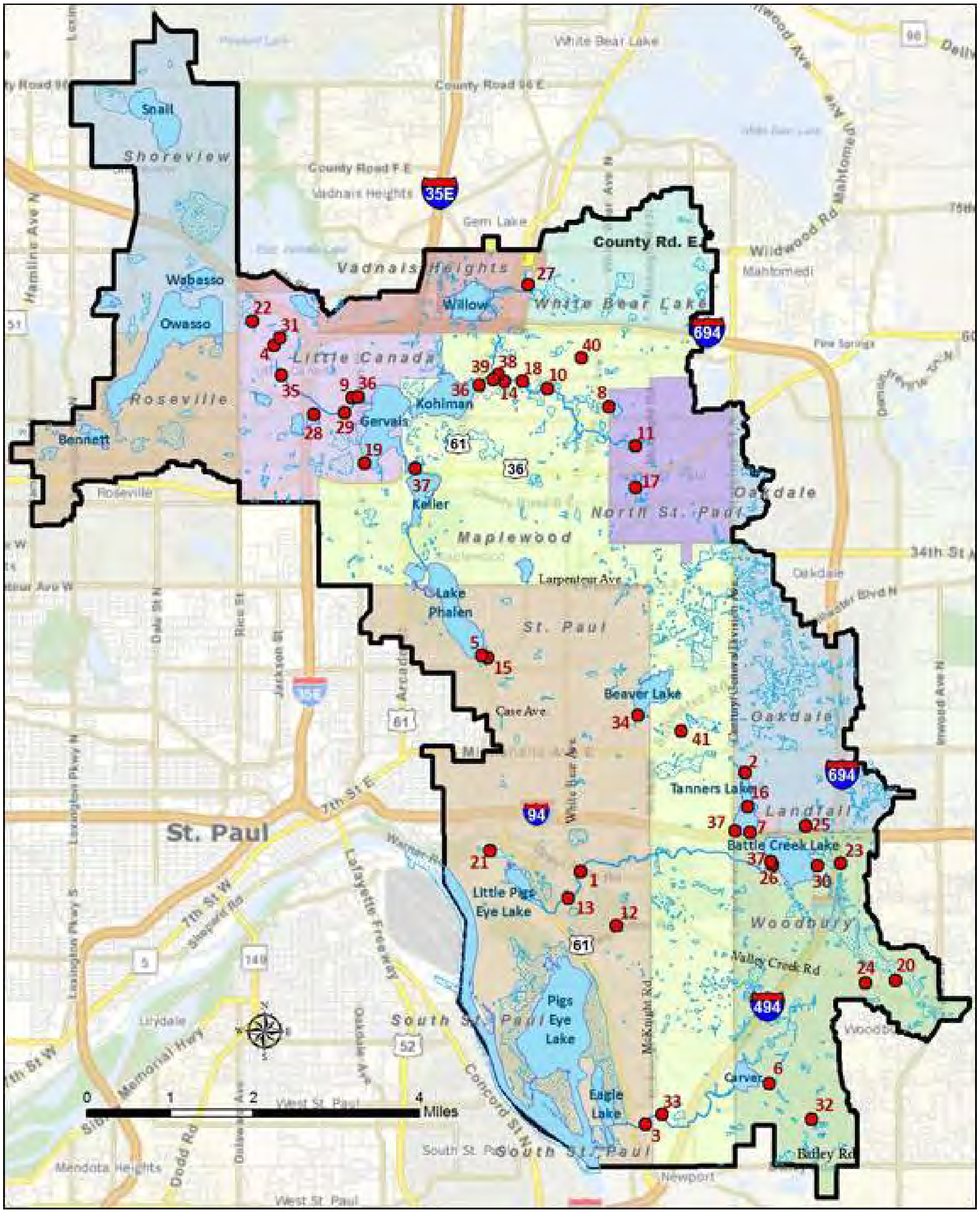


Figure 3-3 RWMWD Capital Improvement Projects through 2015

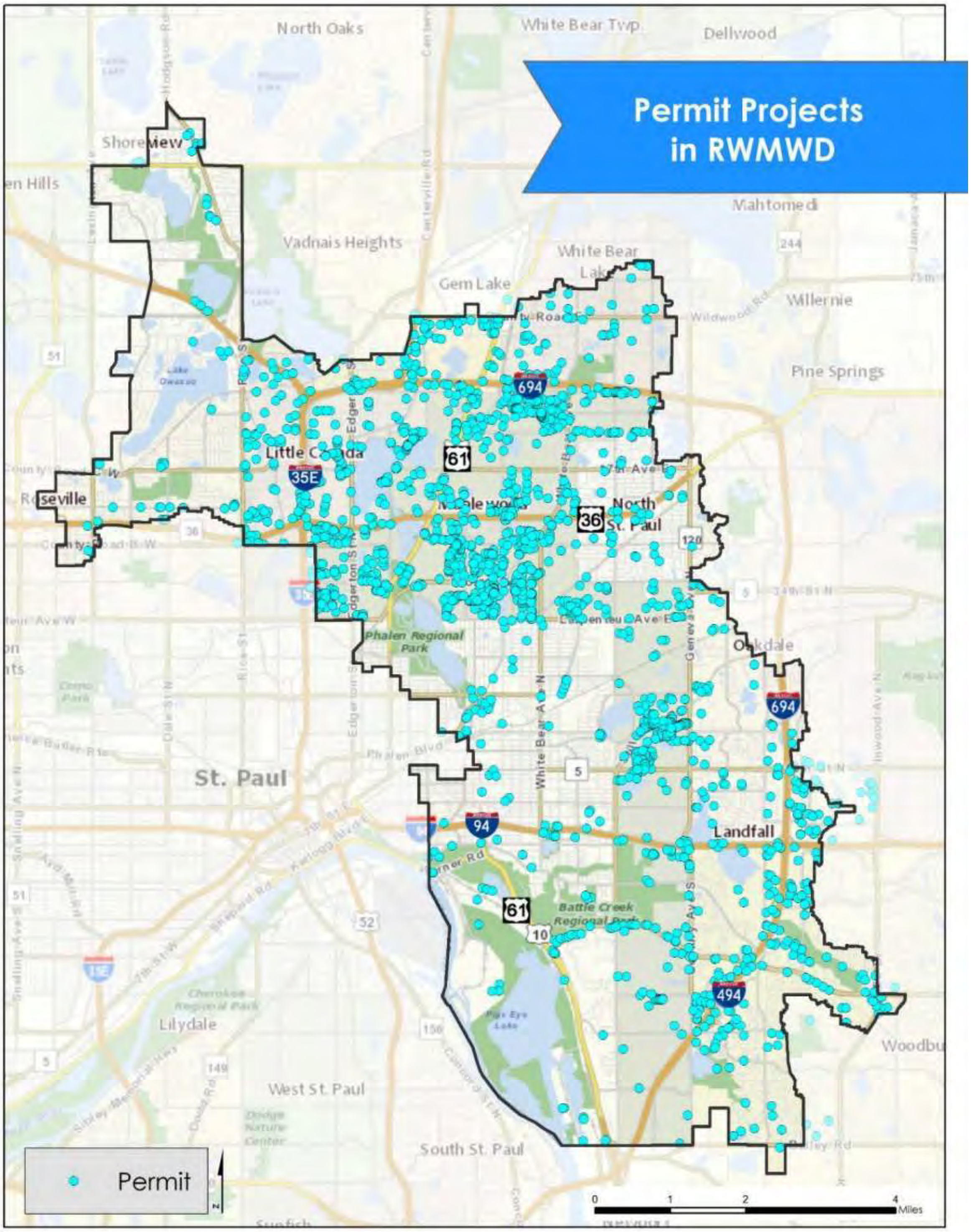
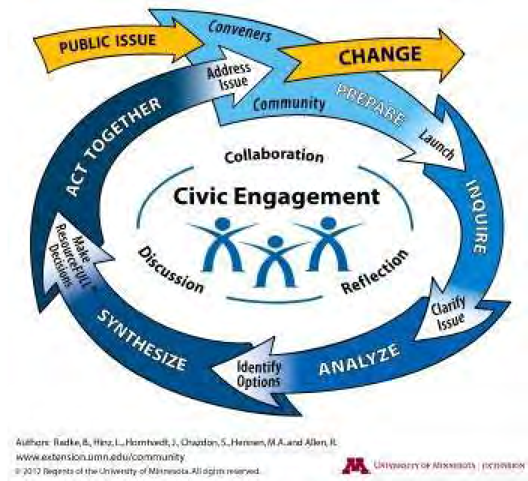


Figure 3-4 RWMWD Permitted Projects through 2015

3.2 Civic Engagement

A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. The University of Minnesota Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." A resourceFULL decision is one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available at: http://www1.extension.umn.edu/community/civic-engagement/.



Public education and public involvement are critical to the RWMWD accomplishing its mission to protect and manage its water resources. It is through education and involvement efforts that the RWMWD increases the public's understanding of water resource management and issues in the watershed, and fosters long-term public commitment to protecting these resources through individual or group actions.

Accomplishments and Future Plans

Government Collaboration

The RWMWD is one of several units of government that are directly or indirectly responsible for managing water resources – both water quality and water quantity. Other entities with a role in water quality protection include, but are not limited to:

- RWMWD cities
- Washington Conservation District and Ramsey Conservation District
- Minnesota Department of Natural Resources
- Minnesota Pollution Control Agency
- Minnesota Board of Water and Soil Resources
- Minnesota Department of Health
- Washington County and Ramsey County

Part of the RWMWD's mission is to promote communication and collaboration with its residents, communities and governmental units.

Public Involvement and Education

Past and current RWMWD public education and public involvement efforts include the following:

Website—(*www.rwmwd.org*) The District website contains information on all RWMWD program areas and projects over the history of the watershed. It is the location to share upcoming events and make announcements. The public can also get connected to the RWMWD blog, e-newsletter and various social media sites.

Citizen Advisory Committee (CAC)—The CAC is appointed by the Board of Managers to provide input to the board and staff on program design, implementation, and evaluation. The CAC duties and tasks will be defined by District staff in consultation with the CAC membership.

Technical Advisory Committee (TAC)—The District plans a monthly meeting of public works, engineering and environmental staff from each city, county and conservation district. The group meets to discuss upcoming projects and programs as well as education efforts and trainings needs. The MS4 permit and SWPPP is a topic that is discussed throughout the year also. The TAC also plays a large role in the development of the District' watershed management plan and subsequent yearly budget process.

Public Involvement and Education Program—RWMWD's Public Involvement and Education Program's role is to inform citizens and involve them in in stewardship actions that enhance the community's awareness about water issues, and increase its capacity to help protect local water and natural resources. The PIE program engages the community in addressing local water issues through partnerships with cities and their staff, neighborhoods, developers, other natural resources and stormwater agencies and professionals, nature centers, businesses, churches, schools, colleges, lake associations and the general public. The PIE program supports stormwater, habitat enhancement/restoration and outreach projects by training, recruiting and engaging volunteers from schools, churches and the Master Gardener, Master Naturalist and Master Water Stewards programs in these initiatives. The PIE program also develops and facilitates training activities, workshops and classes for the public, cities, schools and churches and directs the use of social media, the District's website, the Ripple Effect blog/newsletter and videos to inform and increase citizen and community stewardship about local water quality and natural resources issues.

BMP Incentive Program— The RWMWD BMP Incentive Program offers financial, educational, and technical assistance to public and private landowners to protect and improve water and natural resources within our watershed. Assistance is available to homeowners, government agencies, churches, schools, homeowner associations, and commercial sites implementing programs and projects that support one or more of the following:

- Promote actions that prevent flooding or lessens the effect of drought
- Protect and restore clean water by capturing pollutants in rainwater runoff
- Increase the watershed's ability to store water
- Preserve and restore native plant and wildlife communities, especially lakes, rivers and wetlands
- Protect and preserve groundwater quality and quantity

- Educate and engage citizens in water & natural resources protection

2017-2027 Watershed Management Plan, Planning Process – During the early months of development of the RWMWD Watershed Management Plan update, this WRAPS report, and the TMDL report, nearly 100 residents came together in a series of three Community Conversations within RWMWD between mid-September and early October 2013. The Community Conversations were held on the following dates:

- 9/17/2013 at Maplewood Community Center
- 9/26/2013 at Woodbury City Hall
- 10/3/2013 at Shoreview Community Center

The goal of these Community Conversations was two-fold. The first goal was to teach residents about the history of the District, how the budget is established, and the major District initiatives and recent accomplishments. The second goal of the Community Conversations was to solicit input from participants. These gatherings were designed to begin the public input process in updating the District's Watershed Management Plan and to help brainstorm ideas for implementation to improve water quality, as well as to achieve other RWMWD goals.

At each Community Conversation, people reflected on how they value and interact with the District's lakes, wetlands and creeks, identified many of their concerns, and offered potential solutions to the identified watershed issues through a "brain-sprinting" exercise. In the first round of the exercise, the participants generated an expanded list of issues/concerns in the watershed such as invasive species, animal habitats, stormwater and other pollutants, water quality, water levels, aquatic vegetation (macrophytes), increased development/impervious surfaces and the need for education and maintenance. A second round of small group interchanges in the exercise then precipitated insights and suggestions to address the problems and make improvements. Each night the discussions culminated in a large group sharing of what the participants valued in the watershed and a summary of the key issues and ideas for improvement.

The culmination of all of these community meetings was a "Community Confluence" Event held on January 30, 2014. Members of the public, government agencies, city and county staff were invited to hear the results from the three community conversations meetings, and to review eight posters that represented a series of goal "themes" and ideas and/or issues that pertained to those themes. These themes were developed from the feedback received during the Community Conversations meetings. A ninth poster titled "What Did We Miss?" was included for citizens to write-in additional ideas and issues that they thought were not represented in the other eight posters.

Figure 3-5 shows some of the results of the brainstorming exercises shared at the Community Confluence event.

Figure 3-5 Word cloud representation of citizens' "Ideas for Improvements in the Watershed", summarized across all three Community Confluence meetings. Larger phrases were used more often in citizen responses

In addition to the Community Conversations and Confluence meetings described above, TAC meetings were regularly held throughout the creation of the new plan, to discuss the Plan's contents, especially implementation strategies, and priorities for the District's cost share program.

RWMWD TMDL Process – Several meetings were held between various stakeholders in the watershed, and other applicable local and state agencies. Public meetings were also held. The goal of this process was to discuss the development and conclusions of the *RWMWD TMDL Study (draft, Barr 2016)*, obtain input from, review results with, and take comments from those interested and affected parties.

Future Plans

During the next phase of the *RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017)*, the District's goal surrounding public involvement and education ("Inform and Empower Communities") is described as follows:

The RWMWD will inform and empower communities to become partners in improving and protecting the watershed through their own efforts.

Many actions and signs of success for the next ten years of public involvement and education are described in the *Plans' Strategic Overview*.

Public Notice for Comments

An opportunity for public comment on this draft WRAPS report was provided via a public notice in the State Register from XX to XX.

3.3 Restoration and Protection Strategies

The mission of the RWMWD is to preserve and improve water resources and related ecosystems to sustain their long-term health and integrity, and contribute to the well-being and engagement of stakeholders within the community. The activities the RWMWD intends to undertake to achieve this mission are reflected in the RWMWD Watershed Management Plan 2017-2027 (RWMWD 2016), and those activities supporting water quality are summarized in this section of this WRAPS report.

Water quality improvement projects and management activities implemented by the RWMWD are based on feasibility, prioritization, and available funding. Prioritization will be based on the RWMWD management classification (Impaired, Protect-At Risk, Protect-Stable) for water quality improvement projects identified during diagnostic feasibility studies. The RWMWD will place the highest implementation priority on water quality improvement projects that target “Impaired” waterbodies. However, the RWMWD will also give higher priority to water quality improvement projects that are the most effective at achieving water quality goals. Additionally, the RWMWD is open to partnering with other agencies (e.g. cities, county) to implement water quality improvement projects as these opportunities arise. More information on the RWMWD’s approach to implementing projects and programs can be found in the Implementation Section of the Plan.

Specific strategies have been developed to restore the impaired waters within the RWMWD and for protecting/maintaining the quality of the waters within the watershed that are not impaired. The watershed-wide and the subwatershed-based implementation strategy table that follows outlines the strategies and actions that could be capable of improving water quality. The table was developed by reviewing the specific conditions affecting each of the waterbodies, targeting geographic areas through modeling and monitoring procedures, and collecting input from watershed stakeholders. These implementation items relate directly to the implementation items in the RWMWD Watershed Management Plan 2017-2027 (RWMWD 2017), as indicated in the Table 3-1.

RWMWD is unique in that it is a permitted MS4 and a watershed district. Because the RWMWD owns and operates a conveyance system (Beltline and Battle Creek Interceptors), they must maintain and comply with the requirements of the MS4 General Permit (See Section 2.3). Since they are also a watershed district, they are the local unit of government that manages water resources within the RWMWD Watershed jurisdiction. Watershed districts within the Twin Cities Metropolitan Area must follow the guidance of both the Watershed Act (Minn. Stat. 103D) and the Metropolitan Surface Water Management Act (Minn. Stat. 103B). Minn. Stat. §§ 103B and 103D, require watershed district to prepare watershed management plans and follow the plan requirements of Minn. R. 8410. Because of their role as a watershed district, RWMWD will be taking primary responsibility for the majority of the implementation strategies listed in Table 3-1. Examples of BMPs and actions that the District will take to implement these strategies are shown in Table 3-2.

It is important to note that loading reduced from some implementation actions listed in Table 3-1 is creditable to the LA and some to the WLA. Examples of non-WLA-creditable projects include strategies aimed at reducing in-lake loading (e.g., alum treatment, aquatic plant management). For clarification on a particular project’s applicability to a WLA, a project proposer should contact the MPCA Stormwater Program.

Lastly, the RWMWD and other cities, townships, and property owners have already implemented numerous stormwater runoff management projects and water quality improvement projects. In addition, hundreds of water quality improvement projects have been constructed in RWMWD as part of RWMWD-permitted projects. After implementation of the projects, it is essential that these projects be operated and maintained so that they continually provide their intended benefits.

Table 3-1 Strategies and actions proposed for the Ramsey-Washington Metro Watershed District

Table 3-1: Strategies and Actions Proposed for the Ramsey-Washington Metro Watershed District

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 3-3)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility[1]																					Estimated Year to Achieve Water Quality Target	RWMWD Watershed Management Plan Implementation Item ID
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				Watershed District	Ramsey Co. SWCD	Washington Co. SWCD	Gem Lake	Landfall	Little Canada	Maplewood	North St. Paul	Oakdale	St. Paul	Shoreview	Roseville	Vadnais Heights	White Bear Lake	Woodbury	Ramsey County	Washington County	MPCA	DNR	MDH	MnDOT		
	All	Ramsey and Washington Counties	All Conventional Pollutants	--	--	Inform and empower communities	Implement public information and education programs directed at multiple audience groups that includes; education events, K-12 watershed education, public education and outreach, city collaboration and support, and metro education support.	Ongoing	P																					Ongoing	DW-11
							Implement tours, workshops, trainings and other events to increase MS4 and community participation and awareness of watershed issues.	Ongoing	P																					Ongoing	DW-21
				--	--	Support sustainable groundwater	Collaborate to address groundwater issues, including identification of data gaps and areas of vulnerability, and develop management strategies and tools	Ongoing	S			A	A	A	A	A	A	A	A	A	A	A	A	S	S	S	P	S	A	Ongoing	DW-10
							Maintain an inventory of RWMWD infiltration projects and share information with agencies with groundwater jurisdiction.	Ongoing	P																					Ongoing	DW-17
				--	--	Inspect and maintain stormwater facilities	Inspect and maintain stormwater facilities and natural areas, and consider opportunities to collaborate with others to support maintenance activities.	Ongoing	P			S	S	S	S	S	S	S	S	S	S	S	S	S	S				S	Ongoing	DW-5
				--	--	Inspect and maintain creeks	Inspect stability of creek channel and banks and implement structural improvements and habitat restoration projects to address identified stream bank erosion, gully erosion and other stream degradation problems.	Biennial inspections, improvements as needed	P																					Ongoing	DW-1
				--	--	Inspect and maintain natural areas	Inspect, monitor and maintain restoration sites, shorelines and natural areas.	Ongoing	P	A	A	S	S	S	S	S	S	S	S	S	S	S	S	S	S		S		S	Ongoing	DW-8
				--	--	Monitor lake and stream water quality	Monitor water quality of lakes and creeks to assess trends and evaluate achievement of water quality goals. Monitor subwatershed outlets to measure performance of pollutant reduction measures.	Ongoing	P																	P				Ongoing	DW-2 DW-3
				--	--	Monitor lake levels	Monitor lake levels within the District.	Ongoing	P																					Ongoing	DW-18
				--	--	Manage risk of flooding	Collaboratively Identify, assess, and address potential flooding problems.	Ongoing	P			P	P	P	P	P	P	P	P	P	P	P	P	P	P		P		P	Ongoing	DW-9
				--	--	Support research	Implement or support research projects, monitoring, and other activities to better understand factors affecting District water quality and seek opportunities to incorporate information into District projects and programs.	Ongoing	P																					Ongoing	DW-12
				--	--	Support implementation of water quality BMPs	Implement the District's BMP Cost Share Program to assist citizens, cities, institutions, local agencies and businesses in implementing water quality improvements throughout the District.	Ongoing	P																					Ongoing	DW-6
				--	--	Implement policies and rules	Implement, track, and update (as necessary) District rules and permitting program. Develop and implement methods/programs for measuring, tracking and reporting progress toward District goals. Administer the Minnesota Wetland Conservation Act (RWMWD is the Local Unit of Government).	Ongoing	P																					Ongoing	DW-7 DW-20
			Invasive Species	--	--	Manage Invasive Species	Collaboratively manage invasive species that threaten water resources and associated upland habitats.	Ongoing	S	A	A	S	S	S	S	S	S	S	S	S	S	S	S	S	S		P		S	Ongoing	DW-14
							Implement the District's macrophyte and filamentous green algae monitoring program and assess data for trends, creating and implementing macrophyte management plans where necessary to improve lake water quality.	Ongoing	P																		P			Ongoing	DW-4
			Parameters cited in permit	--	--	Permit Compliance	Ensure construction and industrial stormwater permittees comply with general permits	Ongoing				S	S	S	S	S	S	S	S	S	S	S	S	S	S	P			S	Ongoing	
							Ensure MS4s comply with permits	Ongoing	S			S	S	S	S	S	S	S	S	S	S	S	S	S	S	P			S	Ongoing	DW-15
			Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	A			P	Ongoing	DW-11
	Battle Creek (Assessment ID: 07010206-592)	St. Paul, Ramsey and Washington counties	TSS	Loads vary by flow regime; 71 mg/L seasonal average	86% reduction 30 mg/L seasonal average	Protect/stabilize banks/bluffs	Look for opportunities to stabilize areas in Battle Creek Regional Park and along streambanks	Ongoing	P															P						Ongoing	BC-2 BC-3
						Remove accumulated sediment	Continue removal of accumulated sediment from creek, as needed.	Ongoing	A															P						Ongoing	BC-3
						Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TSS load to Battle Creek. 86% of reduction of TSS from baseline watershed levels (Baseline year: 2007)	Battle Creek subwatershed feasibility study in 2016/2017 to search for feasible projects.	P	S	S				P			P					P	P	P				P	2026	BC-3
			Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A				P			P					P	P	P	A			P	Ongoing	DW-11
	Kohlman Lake (62-0006-00)	Maplewood, Ramsey County	Phosphorus (TP)	1233 lbs TP seasonal load (June through September, critical year at the time the TMDL was written in 2007); 111 ppb seasonal conc (June through September, 10 year average at the time the TMDL was written in 2007) 74 ppb seasonal conc (June through September, 2003-2012 average)	769 lbs TP seasonal load (June through September, critical year); 60 ppb seasonal conc (June through September, 10-year average)	Reduce in-lake loading	80% Reduction of internal load	First round of rough fish management complete, continue as needed	P																		S			Ongoing	KL-4
								Curlyleaf Pondweed Management per DNR Invasive Aquatic Plant Management permit	P																		S			Ongoing	KL-3
								Initial round of alum treatments complete, continue as needed, assess other options by 2020.	P																		S			Ongoing	KL-2
						Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Kohlman Lake. 209 pounds (or 22%) reduction from baseline watershed levels (Baseline Year: 2002) targeted at Kohlman Creek Subwatershed	Ongoing	P	A	A	P		P	P	P	P				P	P		P	P				P	2027	KC-1 KC-3 KL-1
			Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A	P		P	P	P	P				P	P		P		A			P	Ongoing	DW-11
	Bennett Lake	Roseville, Ramsey County	Phosphorus (TP)	143.3 lbs TP seasonal load (June through September, critical year)	43.7 lbs TP seasonal load (June through September, critical year);	Reduce in-lake loading	80% Reduction of internal load	Monitor carp in Lake Owasso-Central Park Wetlands-Bennett Lake, and manage carp populations if deemed necessary (2019-2026)	P																		S			Ongoing	BeL-6 BeL-7
								Develop a plan for macrophyte management (including curlyleaf pondweed) of Bennett Lake by 2020.	P																		S			Ongoing	BeL-5

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 3-3)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility[1]																					Estimated Year to Achieve Water Quality Target	RWMWD Watershed Management Plan Implementation Item ID
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				Watershed District	Ramsey Co. SWCD	Washington Co. SWCD	Gem Lake	Landfall	Little Canada	Maplewood	North St. Paul	Oakdale	St. Paul	Shoreview	Roseville	Vadnais Heights	White Bear Lake	Woodbury	Ramsey County	Washington County	MPCA	DNR	MDH	MnDOT		
City of Saint Paul-Mississippi River (701020608)	(62-0048-00)	Roseville, Ramsey County	Phosphorus (TP)	138 ppb seasonal conc (June through September, 2003-2012 average)	60 ppb seasonal conc (June through September, 10-year average)			Assess options for inactivation of sediment TP release by 2020.	P																		S			Ongoing	BeL-3
						Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Bennett Lake. 42.7 pounds (or 61%) reduction from baseline watershed levels (Baseline Year: 2005)	Bennett Lake subwatershed feasibility study in 2016/2017 to search for feasible projects.	P	A										P				P					P	2026	BeL-1 BeL-2 BeL-4
	Wakefield Lake (62-0011-P)	Maplewood, Ramsey County	Phosphorus (TP)	186 lbs TP seasonal load (June through September, critical year); 106 ppb seasonal conc (June through September, 10-year average)	103 lbs TP seasonal load (June through September, critical year) 60 ppb seasonal conc (June through September, 10-year average)	Reduce in-lake loading	80% Reduction of internal load	Develop a plan for macrophyte management (including curlyleaf pondweed) of Wakefield Lake by 2020.	P																		S			Ongoing	WL-4
								Assess options for inactivation of sediment release of TP by 2020.	P																		S			TBD	WL-3
						Improve stormwater management to reduce runoff of TP	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Wakefield Lake.	Spent lime filter planned to be constructed in 2017 by RWMWD on Maplewood property	P	A					P	P		P						P						2020	WL-1 WL-2
	Fish Creek (Assessment ID: 07010206-606)	Maplewood, Ramsey County	E. coli	197 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean; 36% reduction (Baseline Year: 2011)	Address non-compliant septic systems	Inspect and replace (or fund through cost share programs) non-functional or noncompliant SSTS	Inspections of 20 SSTS and replacement of failing septic systems.	A						P			P						S						2026	DW-6 DW-11 DW-15
						Educate citizens about proper disposal of pet waste	Leverage the education and outreach programs run by District staff and other agencies to provide educational materials for distribution.	Methodology in place to disseminate information by 2020	P	S	S				P			P					P	P	P	P				Ongoing	FC-1
	Lake Emily (62-0080)	Shoreview, Ramsey County	Total Phosphorus (TP)	98 ppb seasonal conc (June through September, 10 year average)	60 ppb seasonal conc (June through September, 10-year average)	Reduce in-lake loading	Reduction of internal load, if necessary	Assess options for inactivation of sediment release of TP by 2020.	P																		S			TBD	LE-4
						Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Lake Emily.	Lake Emily subwatershed feasibility study in 2016 to search for feasible projects.	P	S									S					S						2026	LE-1 LE-2 LE-3
	Carver Lake (82-0166-P)	Woodbury, Washington County	Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A				P								P	P	P	A				Ongoing	DW-11
			Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Carver Lake.	Ongoing	P	S	S				S								S	S	S				S	Ongoing	CL-1 DW-6
	Owasso Lake (62-0056)	Shoreview, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Owasso Lake.	Owasso Lake subwatershed feasibility study in 2018 to search for feasible projects.	P	S									S	S				S						2026	LO-1 LO-3 LO-4
						Reduce in-lake loading	Inactivation of sediment phosphorus release, if necessary	Assess options for inactivation of sediment release of TP by 2020.	P																		S			TBD	LO-5 LO-8
							Rough fish management, if necessary	Monitor carp in Lake Owasso-Central Park Wetlands-Bennett Lake, and manage carp populations if deemed necessary (2019-2026)	P																		S			2026	LO-6 LO-7
	Gervais Lake (62-0007)	Little Canada, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Gervais Lake.	Ongoing	P	S				S	S									S					S	Ongoing	GC-2, DW-6
	Battle Creek Lake (82-0091)	Woodbury, Washington County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Battle Creek Lake.	Battle Creek Lake subwatershed feasibility study in 2018 to search for feasible projects.	P		S		S				S						S		S				S	2026	BCL-3 BCL-4
						Reduce in-lake loading	Reduction of internal load, if necessary	Assess options for inactivation of sediment release of TP by 2020.	P																		S			TBD	BCL-2 BCL-5
			Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A		P				P						P		P	A			P	Ongoing	DW-11
	Round Lake (Little Canada) (62-0009)	Little Canada, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Round Lake (Little Canada)	Ongoing	P	S				S										S						Ongoing	DW-6
	Beaver Lake (62-0016)	St. Paul, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Beaver Lake	Ongoing	P	S	S				S		S	S						S	S					Ongoing	BL-1 BL-4
						Reduce in-lake loading	Inactivation of sediment phosphorus release, if necessary	Assess options for inactivation of sediment release of TP by 2020.	P																		S			TBD	BL-2 BL-3
	Keller Lake (62-0010)	Maplewood, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Keller Lake.	Ongoing	P	S				S	S									S						Ongoing	DW-6
						Reduce in-lake loading	Rough fish management, if necessary	First round of rough fish management complete, continue as needed	P																		S			Ongoing	KeL-2
			Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be	40 ppb seasonal conc	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6

HUC-10 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see Table 3-3)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility[1]																					Estimated Year to Achieve Water Quality Target	RWMWD Watershed Management Plan Implementation Item ID
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				Watershed District	Ramsey Co. SWCD	Washington Co. SWCD	Gem Lake	Landfall	Little Canada	Maplewood	North St. Paul	Oakdale	St. Paul	Shoreview	Roseville	Vadnais Heights	White Bear Lake	Woodbury	Ramsey County	Washington County	MPCA	DNR	MDH	MnDOT		
	Tanners Lake (82-0115-P)	Oakdale and Landfall, Washington County	Phosphorus (TP)	"Stable"	(June through September, 10-year average)	Improve stormwater management	Implement feasible water quality projects that decrease the TP load to Tanners Lake.	Ongoing	P	S	S		S		S		S						S	S	S				S	Ongoing	TaL-2 TaL-3
			Chloride	--	<230 mg/L	Improve road salt management	Promote and adopt strategies in the TCMA Chloride Management Plan http://www.pca.state.mn.us/r0pgb86	Ongoing	A	A	A		P		P		P						P	P	P	A			P	Ongoing	DW-11
	Round Lake (Maplewood) (62-0012)	Maplewood, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Round Lake (Maplewood)	Ongoing	P	S					S									S						Ongoing	LP-3 DW-6
	Lake Wabasso (62-0082)	Shoreview, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Lake Wabasso	Ongoing	S	S									S					S						Ongoing	DW-6
	Snail Lake (62-0073)	Shoreview, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Snail Lake	Ongoing	P	S									S					S						Ongoing	DW-6
	Shoreview Lake (62-0079)	Shoreview, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, but thought to be "At Risk" of not meeting them in the future	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Shoreview Lake	Shoreview Lake subwatershed feasibility study in 2017 to search for feasible projects.	P	S									S					S						2026	ShL-1 ShL-2
	Eagle Lake (Northstar)	St. Paul, Ramsey County	Phosphorus (TP)	--	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Eagle Lake (Northstar)	Ongoing	P	S								S						S						Ongoing	DW-6
	Twin Lake (62-0039)	Little Canada, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Twin Lake.	Ongoing	P	S				S							S			S						Ongoing	DW-6
	Lake Phalen (62-0013)	St. Paul, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	40 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Lake Phalen	Ongoing	P	S					S			S						S						Ongoing	LP-2 DW-6
	Willow Lake (62-0040)	Vadnais Heights, Ramsey County	Phosphorus (TP)	Currently meeting state TP standards, and currently considered to be "Stable"	60 ppb seasonal conc (June through September, 10-year average)	Improve stormwater management	Implement BMP Cost Share Program	Ongoing	P																					Ongoing	DW-6
							Implement feasible water quality projects that decrease the TP load to Willow Lake.	Ongoing	P	S		S									S			S					S	Ongoing	DW-6

[1] P – Primary; S – Secondary; A – Assist

Restoration

Protection

Entire watershed

Table 3-2 Key for Strategies Column

Table 3-2: Key for Strategies Column in Table 3-2

Parameter (including non-pollutant stressors)	Strategy Key	
	Strategy Description	Example BMPs and Actions
All Conventional Pollutants	**Inform and empower communities:** Implement public information and education programs directed at multiple audience groups that includes; education events, K-12 watershed education, public education and outreach, city collaboration and support, and metro education support. Implement tours, workshops, trainings and other events to increase MS4 and community participation and awareness of watershed issues.	WaterFest School projects sponsored by the RWMWD The RWMWD's Ripple Effect Newsletter Master Water Stewards program LEAP Program and Annual Volunteer Recognition Ceremony MS4/RWMWD Forum Meetings Annual Watershed Tour hosted by RWMWD Hosted workshops and sharing of training and other informational material
	Support sustainable groundwater: Collaborate to address groundwater issues, including identification of data gaps and areas of vulnerability, and develop management strategies and tools	Implement county groundwater plans Groundwater data collection and reporting Study the connection between surface water and groundwater throughout the District Maintain an inventory of infiltration projects and share information with agencies with groundwater jurisdiction.
	Inspect and maintain stormwater facilities: Inspect and maintain stormwater facilities and natural areas, and consider opportunities to collaborate with others to support maintenance activities.	RWMWD annual inspection and maintenance program Pond prioritization study to help MS4s prioritize pond assessment and dredging activities
	Inspect and maintain creeks: Inspect stability of creek channel and banks and implement structural improvements and habitat restoration projects to address identified stream bank erosion, gully erosion and other stream degradation problems.	Shoreline stabilization projects Native revegetation of buffers Removal of accumulated sediment
	Inspect and maintain natural areas: Inspect, monitor and maintain restoration sites, shorelines and natural areas.	Native revegetation of buffers and riparian natural areas.
	Monitor lake and stream water quality: Monitor water quality of lakes and creeks to assess trends and evaluate achievement of water quality goals. Monitor subwatershed outlets to measure performance of pollutant reduction measures.	Analysis of data trends and status of water quality Evaluation of progress in improving water quality
	Monitor lake levels	Monitor lake levels within the District and share information with MS4s
	Manage risk of flooding: Collaboratively Identify, assess, and address potential flooding problems.	Share RWMWD Atlas 14 modeling results with MS4s Monitor areas of concern Plan for improvements to infrastructure
	Support research: Implement or support research projects, monitoring, and other activities to better understand factors affecting District water quality and seek opportunities to incorporate information into District projects and programs.	Spent lime filter BMP (RWMWD) Macrophyte harvesting study (RWMWD)
	Support implementation of water quality BMPs: Implement the BMP Cost Share Programs to assist citizens, cities, institutions, local agencies and businesses in implementing water quality improvements throughout the District.	Retrofit projects in commercial, school and church properties Collaboration between MS4s and RWMWD to help water quality projects go "above and beyond" permit requirements.
	Implement policies and rules: Implement RWMWD rules and policies and the rules and policies of other agencies.	Implement, track, and update (as necessary) District rules and permitting program. Administer the Minnesota Wetland Conservation Act (RWMWD is the Local Unit of Government). Conform to MS4 NPDES permit requirements Implement SWPPPs
	Permit Compliance	Ensure construction and industrial stormwater permittees comply with general permits Ensure NPDES compliance Ensure MS4s comply with permits
Invasive Species	**Manage Invasive Species:** Collaboratively manage invasive species that threaten water resources and associated upland habitats.	Implement the District's (and others') macrophyte and filamentous green algae monitoring program and assess data for trends, creating and implementing macrophyte management plans where necessary to improve lake water quality. Mechanical harvesting Lake drawdown Herbicide treatments
Chloride	**Improve road salt management:** Promote and adopt strategies in the TCMA Chloride Management Plan	http://www.pca.state.mn.us/r0pgb86
Total Suspended Solids (TSS)	**Protect and stabilize banks and bluffs**	Annual inspections of streambanks to assess erosion that requires stabilization Stabilization of stream banks with regrading and/or revegetation
	Remove accumulated sediment: Remove sediment that has deposited in the creek bed when it alters flow or habitat for macroinvertebrates or fish	Remove accumulated sediment from creek beds as needed to maintain flow and ecological function.
	Improve stormwater management: Decrease the TSS load to downstream waterbodies through the implementation of BMPs that remove sediment, reduce stormwater volume, or both.	Implement BMP Cost Share Program (District or other) to promote the proliferation of projects that reduce TSS loads to downstream waterbodies Implement feasible water quality projects that decrease the TSS loads to downstream waterbodies.
Phosphorus (TP)	**Reduce in-lake loading**	Rough fish (carp) monitoring and management Macrophyte (curlyleaf pondweed) management Inactivation of sediment phosphorus release (alum or other) Lake drawdown Dredging
	Improve stormwater management	Implement BMP Cost Share Program (District or other) to promote the proliferation of projects that reduce TP loads to downstream waterbodies Implement feasible water quality projects that decrease the TP load to lakes
E. coli	**Address non-compliant septic systems**	Inspect and replace (or fund through cost share programs) non-functional or noncompliant SSTS
	Educate citizens about proper disposal of pet waste	Leverage the education and outreach programs run by District staff and other agencies to provide educational materials about proper disposal of pet waste to limit exposure to rainfall.

4. Monitoring Plan

The purpose of the RWMWD's monitoring program is to collect chemical and biological information on District water resources. This data is used to assess the health of the resources and determine if additional management activities are necessary. Monitoring has also been implemented to evaluate the effectiveness of completed projects.

The RWMWD has a comprehensive monitoring program and the district has collected a large amount of water quality data over its history. The district has also collected lake level, stream flow and lake biological data. In addition, other agencies have collected data for RWMWD waterbodies, including the MPCA and the Metropolitan Council. The amount of data currently available varies by waterbody.

Continued water quality data collection is necessary for the RWMWD to track water quality improvement or degradation, detect trends, better understand water quality processes, and ultimately determine if there are water quality problems (e.g., impaired uses). This information is critical for RWMWD to identify and prioritize water quality improvement projects, and to determine appropriate methods for preventing water quality degradation. Detection of trends, specifically improvements, is critical to determining the effectiveness of actions implemented by the RWMWD.

This section of this WRAPS report describes waterbody monitoring programs currently utilized by the RWMWD:

RWMWD Water Quality Monitoring

The District's Water Quality Monitoring Program tracks water quality and quantity in District lakes and streams. The program collects data on District lakes every two to three weeks from June through September. Measurements include water clarity (Secchi depth), conductivity, pH, and dissolved oxygen every meter of depth in the deepest part of the lake. In addition, water samples are collected for analysis of chloride, phosphorus and chlorophyll-*a* concentrations. Chlorides are also typically monitored in mid-February and at ice-out.

For lakes in Ramsey County, the District and the Ramsey County Environmental Services Office collaborate. For these lakes, the County collects and analyzes the samples from May through October, plus winter chloride monitoring. The District pays the staff and lab costs, and reports the results. The Washington County lakes and special interest wetlands are monitored by District staff. The District also monitors water levels of Battle Creek Lake, Carver Lake, Tanners Lake and Spoon Lake (Keller Lake) every two weeks and after major storm events. The RWMWD website's *Lake Monitoring Page* summarizes the water quality monitoring data that has been collected and compiled for each RWMWD lake and stream.

Aquatic Plant Monitoring

This program monitors the presence and abundance of aquatic plants in RWMWD waterbodies, usually focusing on management of both native and invasive aquatic plants and FGA.

Phytoplankton and Zooplankton Monitoring

This program monitors the microbiotic communities in certain RWMWD waterbodies on an as-needed basis. The monitoring results track the relative distributions of phytoplankton and zooplankton and identify the presence of phytotoxins.

Stream Water Quality Monitoring

The RWMWD stream monitoring program is part of a larger monitoring effort carried out by the MCES. The WOMP is coordinated by MCES, and includes three locations within the RWMWD: Fish Creek, Battle Creek, and the outlet of the Beltline Interceptor storm sewer. These sites have been monitored since 1995, and collect water quality and stream flow data. Links to the Met Council Stream Monitoring program and reports for District streams may be found on the *Stream Monitoring Page*.

In addition, the RWMWD has historically monitored the outlets of Kohlman Creek, Gervais Creek, and Willow Creek. Since then, the RWMWD has installed permanent stations monitoring flow and water quality on all Kohlman and Gervais Creeks.

BMP Effectiveness Monitoring

The RWMWD monitors BMPs to evaluate the effectiveness of District water quality improvement projects. This monitoring can include flow monitoring as well as water quality, often at the inflow to and outflow from the various BMPs, to evaluate the performance of the system. The period for which a given project is monitored after construction can vary; however, this performance evaluation is typically conducted for a minimum of one growing season. Results from BMP monitoring are tracked in the RWMWD's cost benefit database of all permit, cost share and CIP projects.

The RWMWD intends to continue each of these monitoring programs into the future, collecting additional data that will help evaluate the effectiveness of implemented projects on the overall water quality of the resources in the District.

5. References and Further Information

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Ramsey-Washington Metro Watershed District. 2007 (as amended). *Ramsey-Washington Metro Watershed District 2006-2016 Watershed Management Plan*.

Ramsey-Washington Metro Watershed District. 2017. *Ramsey-Washington Metro Watershed District Watershed Management Plan 2017-2027*.

Washington County Groundwater Plan. https://www.co.washington.mn.us/DocumentCenter/View/794.

Ramsey-Washington Metro Watershed District Reports

All Ramsey-Washington Metro Watershed District reports referenced in this WRAPS report are available at the RWMWD watershed webpage:

https://www.pca.state.mn.us/water/tmdl/ramsey-washington-metro-watershed-district-watershed-restoration-and-protection-strategy

Or the RWMWD website:

http://www.rwmwd.org/

Or by contacting the RWMWD directly.

Appendix C

Zoning Ordinances and Overlay Districts

Contains the Following Ordinances:

1) Chapter 51. Discharges to the Storm Sewer System
2) Chapter 52. Stormwater Runoff
3) Chapter 68. River Corridor Overlay Districts
4) Chapter 91. Water Code – Miscellaneous Provisions

Chapter 51. - Allowable Discharges to the Storm Sewer System

Sec. 51.01. - Purpose.

This chapter is adopted in accordance with the city's national pollutant discharge elimination system (NPDES) municipal separate storm sewer (MS4) permit which authorizes the discharge of stormwater to surface water. Pursuant to permit regulations, the city is required to control the introduction of non-stormwater discharges to the city's municipal separate storm sewer system.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.02. - Definitions.

For the purposes of this chapter, the terms used in this chapter have the meanings defined as follows:

City. "City" means the City of Saint Paul and its officials, employees, or duly authorized agents.

Clean Water Act. The Federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.) and subsequent amendments thereto.

Groundwater. Water contained below the surface of the earth in the saturated zone including, without limitation, all waters whether under confined, unconfined, or perched conditions, in near surface unconsolidated sediment or in rock formations deeper underground.

MPCA. The Minnesota Pollution Control Agency.

MS4 (Municipal Separate Storm Sewer System). The system of conveyances including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels or storm drains that is: owned and operated by the city, or other public entity, and designed or used for collecting or conveying stormwater, and which is not used for collecting or conveying sewage.

National pollutant discharge elimination system (NPDES) stormwater discharge permit. A permit issued under the Clean Water Act (Section 301, 318, 402, and 405) and United States Code of Federal Regulations Title 33, Section 1317, 1328, 1342, and 1345 authorizing the discharge of pollutants to water of the United States.

Non-stormwater discharge. Any substance not composed entirely of stormwater.

Prohibited discharge. Any introduction of non-stormwater discharge to the city's municipal separate storm sewer system or to surface waters within the city, unless specifically exempted under section 51.03(b) of this chapter.

Person. "Person" means any individual, association, organization, partnership, firm, corporation, or other entity recognized by law, acting as either the owner or as the owner's agent.

Pollutant. Any substance which, when introduced as non-stormwater, has potential to or does any of the following:

(1) Interferes with state designated water uses;

(2) Obstructs or causes damage to waters of the state;

(3) Changes water color, odor, or usability as a drinking water source through causes not attributable to natural stream processes affecting surface water; or

(4) Adds an unnatural surface film on the water;

(5) Adversely changes other chemical, biological, thermal, or physical condition, in any surface water or stream channel; or

(6) Harms human life, aquatic life, or terrestrial life.

Stormwater. Defined under Minnesota Rule 7077.0105, subpart 41(b), and means precipitation runoff, stormwater runoff, snow melt runoff, and any other surface runoff or drainage.

Surface water. Ponds, lakes, rivers, streams, and wetlands.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.03. - Non-stormwater discharges.

(a) No person shall cause any non-stormwater discharges to enter the city's municipal separate storm sewer system, or to any surface waters within the city, unless specifically exempted under paragraph (b) of this section.

(b) The following allowable discharges are exempted from this section:

(1) Non-stormwater that is authorized by an NPDES point source permit obtained from the MPCA;

(2) Fire fighting activities and fire suppression systems;

(3) Dye testing for which the city has received written notification prior to the time of the test;

(4) Water line flushing or other potable water sources;

(5) Landscape irrigation or lawn watering;

(6) Diverted stream flows;

(7) Rising groundwater;

(8) Groundwater infiltration to storm drains;

(9) Uncontaminated pumped groundwater;

(10) Foundation or footing drains (but not including active groundwater dewatering systems);

(11) Air conditioning condensation;

(12) Springs;

(13) Non-commercial washing of vehicles;

(14) Natural riparian habitat and wetland flows;

(15) Dechlorinated swimming pool water;

(16) Street wash water discharges;

(17) Activities undertaken by the city, or by written authority of the city, deemed necessary to protect public health, welfare, or safety; and,

(18) Any other water source not containing a pollutant.

(c) No person shall intentionally dispose of substances including, but not limited to, grass, leaves, dirt, or landscape material into the city's municipal separate storm sewer system or to any surface waters within the city.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.04. - Prohibited MS4 connections.

No person shall construct, use, or maintain any connection to intentionally convey non-stormwater to the city's municipal separate storm sewer system. This prohibition expressly includes, without limitation, connections made in the past regardless of whether the connection was permissible under law or practices applicable or prevailing at the time of connection. A person is considered to be in violation of this chapter if the person connects a line conveying non-stormwater to the storm sewer system, or allows such a connection to continue.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.05. - Suspension of storm sewer system access, emergencies.

The city may, without prior notice, suspend MS4 discharge access to a person where it is determined that suspension is necessary to stop an actual or threatened discharge that presents or may present imminent and substantial danger to the environment, or to the health or welfare of persons, or to the MS4 or public waters. If the violator fails to comply with a suspension order issued in an emergency, the city may take any step deemed necessary to prevent or minimize damage to the storm sewer system or public waters, or to minimize danger to persons.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.06. - Access, administrative search warrants.

If access to any part of a premises from which stormwater is discharged has been refused and, upon a demonstration of probable cause to believe that there may be a violation of this chapter, or that there is a need to inspect and/or sample as part of a routine inspection and sampling program designed to verify compliance with this chapter or any order issued hereunder, or to protect the overall public health, safety, and welfare of the community, the city may seek an administrative search warrant from a court of competent jurisdiction.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.07. - Criminal violation, enforcement.

Any person failing to comply with or violating any section of this chapter shall be guilty of a misdemeanor and, upon conviction thereof, may be punished by fine, by imprisonment, or both, as provided under section 1.05 of this Code. All city approvals and permits shall be suspended until the violation(s) of this chapter are corrected. Nothing in this section shall preclude the city from concurrently seeking the enforcement of the provisions of this chapter in a court of competent jurisdiction by civil action to enjoin any continuing violation(s).

(Ord 13-6, § 1, 2-13-13)

Sec. 51.08. - Each day a separate offense.

A separate offense shall be deemed committed upon each day during or when a violation occurs or continues.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.09. - Public nuisance.

A violation of this chapter is a public nuisance subject to abatement pursuant to City Code chapter 45. When the city finds that a person has violated or failed to meet a requirement of this section, the person is deemed to have created a public nuisance per se subject to an injunction or any other appropriate remedy to prevent activities which would create further violations or compel a person to perform an abatement or remediation of the violation which the city may seek from a court of competent jurisdiction. All city approvals and permits shall be suspended until abatement of the nuisance condition(s). Nothing in this section shall preclude the city from concurrently seeking the enforcement of the provisions of this chapter by criminal prosecution.

(Ord 13-6, § 1, 2-13-13)

Sec. 51.10. - Administration.

The departments of safety and inspections or public works, as the case may be, shall as determined, be responsible for the administration, implementation, and enforcement of the provisions of this chapter.

(Ord 13-6, § 1, 2-13-13)

Chapter 52. - Stormwater Runoff

Contents

Sec. 52.01. – Purpose.

The purpose of this chapter is to control stormwater pollution associated with land disturbance and post construction runoff in the city. It establishes standards and specifications for practices and planning activities, which minimize stormwater pollution, soil erosion and sedimentation.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.02. – Scope.

Any person, firm, sole proprietorship, partnership, corporation, state agency, or political subdivision proposing a land disturbance activity, including projects that are part of a common plan of development or sale identified in parts (a) or (b) below shall submit a stormwater pollution control plan to the city for approval as outlined in section 52.05. No land shall be disturbed until the plan, conforming to the standards set forth herein, is approved by the city.

(a) Land disturbing activities greater than 10,000 square feet shall:

1. Meet the detention standard specified in section 52.05(b) except activity related to public roads and public and private utilities; and

2. Provide effective erosion and sediment control BMPs appropriate to the site conditions and anticipated construction activity.

(b) Construction activity of one-acre or more shall also meet the pollution control standard in section 52.05(c).

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.03. – Exemptions.

The following activities shall be exempt from all of the requirements of this ordinance:

(a) Emergency work necessary to protect life, limb, or property.

(b) Applicants required to obtain an equivalent stormwater permit from a Watershed District specified in section 52.05(c).

(c) Applicants obtaining a building permit for either a single family or dual family dwelling unit.

Sec. 52.04. – Definitions.

For the purposes of this chapter, the terms used in this chapter have the meanings defined as follows:

(a) *Applicant* means any person or entity that applies for a building permit, subdivision approval, or a permit to allow construction activities. Applicant also means that person's agents, employees, and others acting under this person's direction.

(b) *Best management practices (BMPs)* mean the erosion and sediment control and water quality management practices that are the most effective and practicable means of controlling, preventing, and minimizing degradation of surface water, including avoidance of impacts, construction phasing, minimizing the length of time soil areas are exposed, prohibitions, and other management practices published by state or designated area-wide planning agencies. Individual BMPs are described in the current versions of the "Minnesota Stormwater Manual."

(c) *Common plan of development means a contiguous area where multiple separate and distinct land-disturbing* activities may be taking place at different times, on different schedules, but under one proposed plan.

(d) *Dewatering* means the removal of water for construction activity. It can be a discharge of appropriated surface or groundwater to dry and/or solidify a construction site. It may require state department of natural resources permits to be appropriated and if contaminated may require other MPCA permits to be discharged.

(e) *Discharge* means the release, conveyance, channeling, runoff, or drainage, of stormwater, including snowmelt, from a construction site.

(f) *Erosion* means the wearing away of the ground surface as a result of the movement of wind, water, ice, and/or construction activities.

(g) *Erosion control* means methods employed to prevent erosion including, but not limited to soil stabilization practices, limited grading, mulch, temporary or permanent cover, and construction phasing.

(h) *Final stabilization* means that all soil disturbing activities at the site have been completed and a uniform, evenly distributed perennial vegetative cover with a density of seventy (70) percent of the cover for unpaved areas and areas not covered by permanent structures has been established, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

(i) *Impervious surface* means a constructed hard surface that prevents or retards the entry of water into the soil. Examples include rooftops, sidewalks, patios, driveways, parking lots, storage areas, and concrete, asphalt, or gravel roads.

(j) *Land disturbance activity* means any activity that changes the volume or peak discharge rate of stormwater runoff from the land surface. This may include the grading, digging, cutting, scraping, or excavating of soil, placement of fill materials, paving, construction, substantial removal of vegetation, or any activity that bares soil or rock or involves the diversion or piping of any natural or fabricated watercourse.

(k) *MPCA* means the Minnesota Pollution Control Agency.

(l) *NPDES* means the national pollutant discharge elimination system, the program for issuing, modifying, and enforcing permits under the Federal Clean Water Act.

(m) *Owner* means the person or party possessing the title of the land on which the construction activity will occur; or if the construction activity is for a lease holder, the party or individual identified as the lease holder; or the contracting government agency responsible for the construction activity.

(n) *Permanent cover* means final stabilization. Examples include grass, gravel, asphalt, and concrete.

(o) *Runoff* means rainfall, snowmelt, or irrigation water flowing over the ground surface.

(p) *Sediment control* means the methods employed to prevent sediment from leaving the site. Sediment control practices include, but are not limited to, silt fences, sediment traps, earth dikes, drainage swales, check dams, subsurface drains, pipe slope drains, storm drain inlet protection, and temporary or permanent sedimentation basins.

(q) *Stabilization* means covering the exposed ground surface with appropriate materials such as mulch, staked sod, riprap, wood fiber blanket, or other material that prevents erosion from occurring. Sowing grass seed is not considered stabilization.

(r) *Standard plates* mean general drawings having or showing similar characteristics or qualities that are representative of a construction practice or activity.

(s) *Stormwater runoff* includes precipitation runoff, snow melt runoff, and any other surface runoff and drainage. "Stormwater" does not include construction site dewatering.

(t) *Stormwater pollution control plan* means a plan, prepared by the applicant, for stormwater discharge that includes a combination of drawings, calculations, and narrative which together demonstrates conformance with the provisions of Chapter 52.

(u) *Surface waters* means all streams, lakes, ponds, marshes, wetlands, reservoirs, springs, rivers, drainage systems, waterways, watercourses, and irrigation systems

(v) *Temporary erosion protection* means short term methods employed to prevent erosion. Examples of temporary cover include: straw, erosion control blankets, wood chips, and erosion netting.

(w) *Wetlands* as defined in Minnesota Rules 7050.0130, subpart F, "wetlands," are those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.05. - Stormwater pollution control plan.

The stormwater pollution control plan contains minimum standards for construction activity. Additional standards, requirements, and provisions may be found within the city's public works policy document, zoning code for subdivisions, and parking lots.

(a) *General stormwater pollution control plan submittal requirements:*

1. The name, address and telephone number of the following individuals:
    a. Owner,
    b. Applicant,
    c. Person responsible for the preparation of the stormwater pollution control plan,
    d. On-site person responsible for implementation, inspection and maintenance of the requirements of the stormwater pollution control plan,
    e. Person responsible for the long term operation and maintenance of the permanent stormwater management system.
2. A project description that includes the nature and purpose of the construction activity, the amount of grading, utilities, and building construction involved and the location of the project.

3. Construction phasing that includes time frames and schedules for the project's various aspects including erosion and sediment control practices.
4. A map of the existing site conditions that includes existing topography, property information, steep slopes, existing drainage systems/patterns, type of soils, waterways, wetlands, vegetative cover and one hundred-year flood plain boundaries.
5. A site construction plan that includes the location of the proposed construction activity and the plan for the maintenance and inspection of the stormwater pollution control measures, including the plan for disposal of collected sediment and floating debris.
6. Location of temporary and permanent stormwater pollution control measures.
7. Standard plates and/or specifications for all stormwater pollution control measures.
8. Location of streams, lakes or wetlands which may be impacted by the construction activity.
9. Provisions for preventing sediment damage to adjacent properties and other designated areas such as streams, wetlands and lakes.
10. A plan to stabilize utility construction areas as soon as possible.
11. A plan for permanent stabilization including how the site will be stabilized after construction is completed, including specifications and schedules.
12. A plan for removal of temporary erosion and sediment control measures at the end of the project.
13. Calculations that were made for the design of such items as rate control, sediment basins, wet detention basins, diversions, waterways, infiltration zones and other applicable practices.
14. Documentation to demonstrate that the stormwater pollution controls were designed by a professional engineer licensed in the state. Constructed controls must be certified by a professional engineer.
15. Hydrologic models and design methodologies used for the determining runoff characteristics and analyzing stormwater management structures must be approved by the city. Plans, specifications and computations for stormwater management facilities submitted for review must be sealed and signed by a licensed professional engineer. All computations must appear in the plans submitted for review, unless otherwise approved by the City.

(b) *Erosion and sediment control requirements:*

1. Applicant shall provide a map of the existing and proposed site conditions that includes topography, property information, steep slopes, drainage systems/patterns, type of soils, surface waters, vegetative cover and one hundred-year flood plain boundaries.

2. Applicant shall provide a site construction plan that includes a combination of notes and symbols identifying the proposed construction activity erosion and sediment control BMPs.

   a. Construction activities identified in section 52.02(a) must include provisions addressing perimeter containment, inlet protection, site entrance/egress management, soil stabilization, and recovery of sediment discharged or tracked off-site. Where additional BMPs are needed, they will be specified at the discretion of the city.

   b. Construction activities identified in section 52.02(b) must provide a level of erosion and sediment control equivalent to that required by Minnesota’s NPDES General Stormwater Permit for Construction Activity.

(c) *Stormwater infrastructure for detention.*

1. Construction activities that meet the criteria of 52.02(a) must include provisions to reduce the rate of stormwater discharge. Stormwater discharge into public storm sewers shall be controlled, reviewed, and approved in accordance with the department of public works policy. Required information to be submitted as part of the stormwater pollution control plan is available from the department of public works. Peak stormwater discharge rates from the site for all storms up to and including the critical 100-year frequency will not exceed:

   $Q = 1.64 \times A$

   where Q = the maximum acceptable discharge rate in cubic feet per second and A = the site area in acres.

   Discharge of all stormwater runoff and surface water shall be in a fashion so as to preclude drainage onto adjacent property or toward buildings.

2. Applicant shall provide a site construction plan in conformance with section 52.05 which identifies the location and elevation of all emergency overflow (EOF) area, and the low floor elevation for new construction must be a minimum of one (1) foot above the critical one hundred-year flood elevation.

(d) *Stormwater infrastructure for pollution control.*

1. Construction activities that meet the criteria of 52.02(b) shall prohibit stormwater discharge from the site for 1.1 inches of runoff from all new or redeveloped impervious surface, notwithstanding those applicants required to obtain an equivalent stormwater permit from a Watershed District, which are exempt. All provisions to reduce the volume of stormwater discharge shall be based on the MPCA Minimal Impact Design Standards (MIDS) Calculator and conform to the current version of the “Minnesota Stormwater Manual.”

2. Construction activities that meet the criteria of 52.02(b) and have site constraints which limit full compliance with the standard are allowed to follow the MPCA MIDS Design Sequence Flowchart of flexible treatment options. All constraints and treatment options explored must be included within the applicant’s Stormwater Pollution Control Plan.

(e) *Inspection and maintenance of the stormwater pollution control plan's measures.*

1. The applicant must routinely inspect the construction site once every seven (7) days during active construction and within twenty-four (24) hours after a storm event greater than one-half (0.50) inches in twenty-four (24) hours.

2. The city's inspection staff is authorized to perform inspection and enforce provisions of this article as may be required, to ensure that erosion and sediment control measures are properly installed and maintained. If the applicant fails to maintain proper erosion control measures on site and/or perform necessary remedial action, as directed by the inspector, the inspector may take such enforcement action as may be required to achieve compliance. Enforcement may be, but is not limited to, stopping all construction work at the site, until necessary remedial actions have been completed and erosion and sediment controls are in compliance with the approved plans.

3. For sites that require permanent stormwater infrastructure, a certification letter shall be submitted after the facilities have been installed to affirm that construction has been completed in accordance with the approved stormwater pollution control plan. At a minimum, certification shall include a set of as-built drawings comparing the approved stormwater management plan with what was constructed. Other information shall be submitted as required by the approving agency.

4. It shall be the responsibility of the applicant to obtain any necessary easements or other property interests to allow access to the stormwater management facilities for inspection

and maintenance purposes.

5. All stormwater pollution control infrastructure must be designed to minimize the need of maintenance, to provide easy vehicle and personnel access for maintenance purposes and be structurally sound. These facilities must have a plan of operation and maintenance that ensures continued effective removal of the pollutants carried in stormwater runoff.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.06. - Review.

The city shall review the stormwater pollution control plan pursuant to the provisions of Minnesota Statute Sec. 15.99.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.07. - Modification of plan.

An approved stormwater pollution control plan may be modified upon submission of a written application for modification to the city, and after written approval by the city. In reviewing such an application, the city may require additional reports and data.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.08. - Financial securities.

The city may require financial security, in the form of either bond, letter of credit, or cash escrow, for the performance of the work described in the approved stormwater pollution control plan and any related remedial work. This security must be available prior to commencing the project.

(a) *Action against the financial security.* The city may act against the financial security if any of the conditions listed below exist. The city shall use funds from this security to finance any corrective or remedial work undertaken by the city or a contractor under contract to the city and to reimburse the city for all direct cost incurred in the process of remedial work including, but not limited to, staff time and attorneys' fees.

1. The applicant ceases construction activities and/or filling and abandons the work site prior to completion of the stormwater pollution control plan.

2. The applicant fails to conform to the stormwater pollution control plan as approved by the city, or to related supplementary instructions.

3. The techniques utilized under the stormwater pollution control plan fail within one (1) year of installation.

4. The applicant fails to reimburse the city for corrective action taken under section 52.09

5. Emergency action is taken under section 52.09

(b) *Returning the financial security.* Any unspent amount of the financial security deposited with the city for faithful performance of the stormwater pollution control plan and any stormwater and pollution control plan related remedial work must be released not more than one (1) full year after the completion of the installation of all such measures and the establishment of final stabilization.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.09. - Failure of the stormwater pollution control plan.

(a) *Notification by the city.* The city shall notify the applicant, when the City has determined that any of the conditions set forth in 52.08(a) exist. The initial contact will be to the party or parties listed on the stormwater pollution control plan as contacts. Except during an emergency action, the city at its discretion may begin corrective work forty-eight (48) hours after notification by the city. Such notification should be in writing, but if it is verbal, a written notification should follow as quickly as practical. If after making a good faith effort to notify the responsible party or parties, the city has been unable to establish contact, the city may proceed with corrective work.

(b) *Emergency action.* If circumstances exist that pose an immediate danger to the public health, safety and welfare, the city, upon making this determination, may take immediate action to abate said circumstances for the purpose of restoring the site to a safe condition. The city shall, as part of this action, make reasonable effort to contact and give notice to the applicant of the decision to institute this emergency procedure. Any cost to the city associated with this emergency action is recoverable from the applicant or the applicant's financial security.

(c) *Erosion off-site.* If erosion breaches the perimeter of the site, the applicant shall immediately develop a cleanup and restoration plan, obtain the right-of-entry from the adjoining property owner, and implement the cleanup and restoration plan within forty-eight (48) hours of obtaining the adjoining property owner's permission. In no case, unless written approval is received from the city, shall more than seven (7) calendar days go by without corrective action being taken. If, in the discretion of the city, the applicant does not repair the damage caused by the erosion, the city may do the remedial work required and charge the cost to the applicant.

(d) *Erosion into streets, right-of-ways, wetlands or water bodies.* If eroded soils (including tracked soils from construction activities) enter or appear likely to enter streets, right-of-ways, wetlands, or other water bodies, prevention strategies, cleanup and repair must be immediate. The applicant shall provide all traffic control and flagging required to protect the traveling public during the cleanup operations and secure required right-of-way permits from the department of public works.

(e) *Failure to do corrective work.* When an applicant fails to conform to any provision of sections 52.08 or 52.09 within the time stipulated, the city may take the following actions:

1. Withhold the scheduling of inspections and/or the issuance of a certificate of occupancy.

2. Revoke any permit issued by the city to the applicant for the site in question.

3. Direct the correction of the deficiency by city forces or by a separate contract.

4. All costs incurred by the city in correcting stormwater pollution control deficiencies must be reimbursed by the applicant. If payment is not made within thirty (30) days after costs are incurred by the city, payment will be made from the applicant's financial securities as described in section 52.08

5. If a financial security as described in section 52.08 was not required by the city, or if there is an insufficient financial amount in the applicant's financial securities to cover the costs incurred by the city, then the city in its discretion is authorized to either certify the remaining amount to the property taxes or to assess the remaining amount against the property.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.10. - Enforcement.

The city shall be responsible for enforcing this chapter. Any person, firm, or corporation failing to comply with or violating any of these regulations, shall be deemed guilty of a misdemeanor and be subject to a fine or imprisonment or both. All land use and building permits must be suspended until the applicant has corrected the violation. Each day that a separate violation exists shall constitute a separate offense.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.11. - Right of entry and inspection.

The applicant shall allow the city and their authorized representatives, upon presentation of credentials to:

(a) Enter upon the permitted site for the purpose of obtaining information, examining records, conducting investigations or surveys or for the purpose of correcting deficiencies in stormwater pollution control.

(b) Bring such equipment upon the permitted site as is necessary.

(c) Examine and copy any books, papers, records, or memoranda pertaining to activities or records required to be kept under the terms and conditions of this permitted site.

(d) Inspect the stormwater pollution control measures.

(e) Sample and monitor any items or activities pertaining to stormwater pollution control measures.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.12. - Record retention.

The stormwater pollution control plan and all changes to it must be kept at the site during construction. The applicant must keep the stormwater pollution control plan, along with the following additional records, on file for three (3) years after completion of the construction project:

(a) Any other permits required for the project;

(b) Records of all inspections and maintenance conducted during construction;

(c) All permanent operation and maintenance agreements that have been implemented, including all right-of-way, contracts, covenants and other binding requirements regarding perpetual maintenance and;

(d) All required calculations for design of the temporary and permanent stormwater management systems.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.13. - Abrogation and greater restrictions.

This chapter is not intended to repeal, abrogate, or impair any existing easements, covenants, or deed restrictions. However, where this chapter imposes greater restrictions, the provisions of this chapter shall prevail.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.14. - Other statutes, rules and ordinances.

The applicant shall comply with all federal and state statutes and local ordinances including the current version of the MPCA's general permit to discharge stormwater associated with construction activity under the NPDES and the requirements of the applicable watershed district or watershed management organization.

(C.F. No. 04-267, § 1, 4-7-04)

Sec. 52.15. - Severability.

The provisions of this chapter are severable, and if any provisions of this chapter, or application of any provisions of this chapter to any circumstance, are held invalid, the application of such provisions to other circumstances and the remainder of this chapter shall not be affected.

(C.F. No. 04-267, § 1, 4-7-04)

Chapter 68. - Zoning Code—River Corridor Overlay Districts[4]

Footnotes:

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Editor's note—C.F. No. 03-241, § 2, adopted March 26, 2003, amended the Code by, in effect, repealing former ch. 65, and adding similar provisions as a new ch. 68. Ord. No. 03-241, § 3, renumbered former ch. 68 as a new ch. 65. Former ch. 65 derived from Ord. No. 16876, adopted January 28, 1982; Ord. No. 16931, adopted June 15, 1982; Ord. No. 16956, adopted September 9, 1982; Ord. No. 17116, adopted March 22, 1984; Ord. No. 17502, adopted October 13, 1987; C.F. No. 91-531, adopted May 6, 1993; Ord. No. 93-1718, adopted December 14, 1993; Ord. No. 95-1140, adopted October 18, 1995; and Ord. No. 95-1444, adopted January 17, 1996.

ARTICLE I. - 68.100. GENERAL PROVISIONS

Sec. 68.101. - Intent and purpose.

(a) The River Corridor Overlay District and its subclassifications, RC1, RC2, RC3, RC4, are map overlay districts, designed to provide comprehensive floodplain and river bluff management for the city in accordance with the policies of Minnesota Statutes (Chapters 103 and 116G), Minnesota Regulations (MEQC 54) and Governor's Executive Order No. 79-19.

(b) It is the purpose of this chapter:

(1) To protect and preserve the Mississippi River Corridor as a unique and valuable resource for the benefit of the health, safety and welfare of the citizens of the city and the state;

(2) To prevent and mitigate irreversible damage to the Mississippi River Corridor;

(3) To protect and preserve the Mississippi River Corridor as an essential element in the federal, state, regional and local recreation, transportation, sewer and water systems;

(4) To maintain the river corridor's value and utility for residential, commercial, industrial and public purposes;

(5) To protect and preserve the Saint Paul Mississippi River Corridor's biological and ecological functions;

(6) To preserve and enhance the Saint Paul Mississippi River Corridor's aesthetic, cultural, scientific and historic functions;

(7) To guide development of the floodplain so as to minimize loss of life, threats to health, and private and public economic loss caused by flooding; and

(8) To guide floodplain development in order to lessen the adverse effects of floods, but not to reduce or eliminate flooding.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.102. - Establishment.

(a) This chapter shall apply to all lands within the city shown on the river corridor overlay zoning district maps as being located within the boundaries of the RC1 River Corridor Floodway District, RC2 River

Corridor Flood Fringe District, RC3 River Corridor Urban Open Space District and RC4 River Corridor Urban Diversified District.

(b) The river corridor overlay zoning district maps accompanying this river corridor code, together with all matters attached thereto, are hereby adopted by reference and made a part of this code as if the matters and information set forth therein were fully described herein. The attached material shall include:

(1) The flood insurance study for the city prepared by the Federal Emergency Management Agency (FEMA), dated April 2, 2003; and

(2) The Flood Insurance Rate Map, dated April 2, 2003.

(c) The RC1 Floodway District shall include those areas designated as floodway and Zone AE without a floodway designation on the Flood Insurance Rate Map. The RC2 Flood Fringe District shall include those areas designated as Zone AE and outside of the floodway on the Flood Insurance Rate Map.

(d) Within these districts all uses not allowed as permitted uses or as permitted uses subject to special conditions shall be and are hereby prohibited. Legal nonconforming structures or uses existing on the effective date of this chapter or amendment thereto will be permitted to continue as provided in section 62.102 and section 65.900.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.103. - Compliance.

(a) *Permit required.* A permit issued by the zoning administrator in conformance with the provisions of this chapter shall be secured prior to the erection, addition, or alteration of any building, structure, or portion thereof; prior to the use or change of use of a building, structure or land; prior to the change or extension of a nonconforming use; and prior to the placement of fill, excavation of materials, or the storage of materials or equipment within the flood plain.

(b) *Compliance of uses or occupations required.* No use or occupation of any lands, for any purpose whatsoever, shall hereafter be permitted within the River Corridor District without full compliance with the terms of this chapter and other applicable laws.

(c) *Compliance of structures, fill, etc.* No structure, fill, material or object shall hereafter be placed on or removed from lands within the River Corridor District, and no structures or other object shall hereafter be located, used, constructed, extended, converted or altered within the district without full compliance with this chapter and other applicable laws.

(d) *Submission of site plan.* A site plan shall be submitted to and approved by the planning commission in accordance with section 62.108 before a permit is issued for any development on property wholly or partially located within the River Corridor District. For any development in the RC1 and RC2 districts, the site plan shall include the regulatory flood protection elevation; the proposed elevation of fill; the proposed elevation of the lowest floor of new structures, altered structures and additions to existing structures; and the proposed elevation to which structures will be floodproofed.

(e) *Review of building permits for adequate floodproofing.* All building permits for structures proposed to be floodproofed in the RC1 and RC2 districts shall be reviewed to determine whether the structures will be adequately floodproofed.

(f) *Certification.* Before a certificate of occupancy is issued for any development in the RC1 and RC2 districts, the applicant shall submit to the zoning administrator certification by a registered professional engineer, registered architect, registered landscape architect or registered land surveyor that the finished fill and building elevations were accomplished in compliance with the provisions of this chapter. Finished fill and building elevations shall be verified by ground surveys. Floodproofing measures shall be certified by a registered professional engineer or registered architect.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE II. - 68.200. RIVER CORRIDOR OVERLAY DISTRICTS

Division 1. - 68.210. RC1 River Corridor Floodway Overlay District

Sec. 68.211. - Permitted uses.

(a) The following uses shall be permitted within the RC1 Floodway District to the extent that they are not prohibited by any other provision of the zoning code or other ordinances. The uses are subject to the conditions of the underlying zoning district, to the standards for permitted uses in the Floodway District, section 68.212 and to the River Corridor Standards and Criteria, section 68.212.

(1) Nonstructural industrial-commercial uses, such as open-loading areas, parking areas, interior service roads, airport service roads and airport runways.

(2) Public and private recreational uses such as golf courses, tennis courts, driving ranges, archery ranges, picnic and camp grounds, boat launching and beaching areas or ramps, swimming areas, parks, playgrounds, wildlife and nature preserves, game farms, fish hatcheries, and hiking, bicycling, horseback or recreational vehicle areas and trails, and other open space uses.

(3) Accessory residential uses such as lawns, gardens, parking areas and play areas.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.212. - Standards for permitted uses in the RC1 Floodway District.

(a) The use shall not obstruct flood flows to the point that it increases the one (1) percent chance flood elevation and shall not involve structures, fill, obstruction, excavations or storage of materials or equipment.

(b) The use shall have a low flood damage potential.

(c) The use shall not adversely affect the hydraulic capacity of the channel or floodway or any tributary to the main stream or of any ditch or other drainage facility or system.

(d) No use shall be permitted which is likely to cause pollution of waters, as defined in Minnesota Statutes, Section 115.01, unless adequate safeguards, approved by the state pollution control agency, are provided.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.213. - Conditional uses.

The following uses shall be permitted within the RC1 Floodway District to the extent they are not prohibited by any other provision of the zoning code or other ordinances. The uses shall be permitted only upon the application and issuance of a conditional use permit by the planning commission. The uses are subject to the conditions of the underlying zoning district, to the standards for conditional uses in the Floodway District, section 68.214 below, and to the River Corridor Standards and Criteria, section 68.400 below.

(a) Railroads, highways, streets, alleys, access roads, bridges, sewers, utilities, utility transmission lines and pipe lines.

(b) Marinas, boat rentals, docks, piers, mooring anchors, wharves, water-control structures and navigation facilities.

(c) Storage yards or areas for equipment, machinery or bulk materials.

(d) Structures accessory to permitted uses, section 68.212, or conditional uses of this section.

(e) Placement of fill.

(f) Structural works for flood control such as levees, dikes and floodwalls constructed to any height where the intent is to protect individual structures.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.214. - Standards for conditional uses in the RC1 Floodway District.

(a) No structure (temporary or permanent), fill deposit (including fill for roads and levees), obstruction, storage of materials or equipment, or other use may be allowed which will cause an increase in the height of the regional flood or cause an increase in flood damages in the reach or reaches affected.

(b) Fill shall be protected from erosion by vegetative cover, mulching, riprap or other acceptable method.

(c) Accessory structures shall not be designed for human habitation.

(d) Accessory structures shall be constructed and placed on the building site so as to offer the minimum obstruction to the flow of floodwaters.

   (1) Whenever possible, structures shall be constructed with the longitudinal axis parallel to the direction of flood flow; and

   (2) So far as practicable, structures shall be placed approximately on the same flood flow lines as those of adjoining structures.

(e) All accessory structures must be elevated on fill so that the lowest floor, including basement floor, is at or above the regulatory flood protection elevation. The finished fill elevation for accessory structures shall be no lower than one (1) foot below the regulatory flood protection elevation and the fill shall extend at such elevation at least fifteen (15) feet beyond the outside limits of the structure erected thereon.

(f) As an alternative to elevation on fill, accessory structures may be structurally dry floodproofed in accordance with the FP-1 or FP-2 floodproofing classification in the state building code or floodproofed to the FP-3 or FP-4 floodproofing classification in the state building code, provided the accessory structure constitutes a minimal investment, does not exceed five hundred (500) square feet in size and for a detached garage, the detached garage must be used solely for parking of vehicles and limited storage. All floodproofed accessory structures must meet the following additional standards, as appropriate:

   (1) The structure must be adequately anchored to prevent flotation, collapse or lateral movement of the structure and shall be designed to equalize hydrostatic flood forces on exterior walls; and

   (2) Any mechanical and utility equipment in a structure must be elevated to or above the regulatory flood protection elevation or properly floodproofed.

(g) Storage of materials or equipment may be allowed if readily removable from the area within the time available after a flood warning and in accordance with a plan approved by the planning commission.

(h) Structural works for flood control that will change the course, current or cross-section of protected wetlands, or public waters shall be subject to the provisions of Minnesota Statutes, Chapter 103.G. Community-wide structural works for flood control intended to remove areas from the regulatory floodplain shall not be allowed in the floodway.

(i) A levee, dike or floodwall constructed in the floodway shall not cause an increase to the regional flood and the technical analysis must assume equal conveyance or storage loss on both sides of a stream.

(j) No use shall be permitted which is likely to cause pollution of waters, as defined in Minnesota Statutes, Section 115.01, unless adequate safeguards, approved by the state pollution-control agency, are provided.

(C.F. No. 03-241, § 2, 3-26-03)

Division 2. - 68.220. RC2 River Corridor Flood Fringe Overlay District

Sec. 68.221. - Permitted uses.

Permitted uses in the RC2 Flood Fringe Overlay District shall be those uses of land or structures listed as permitted uses in the underlying zoning district, except that mining, extraction operations, the disposal of waste materials and landfills shall not be permitted. The uses are subject to the conditions of the underlying zoning district, to the standards for permitted uses in the Flood Fringe District, section 68.222 below, to the Standards for All Flood Fringe Uses, section 68.225 below, and River Corridor Standards and Criteria, section 68.400 below.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.222. - Standards for permitted uses in the RC2 Flood Fringe District.

(a) All structures, including accessory structures, must be elevated on fill so that the lowest floor including basement floor is at or above the regulatory flood protection elevation. The finished fill elevation for structures shall be not lower than one foot below the regulatory flood protection elevation and the fill shall extend at such elevation at least 15 feet beyond the outside limits of the structure erected thereon.

(b) As an alternative to elevation on fill, accessory structures that constitute a minimal investment and that do not exceed 500 square feet for the outside dimension at ground level may be internally floodproofed in accordance with section 68.214(f).

(c) The storage of any materials or equipment shall be elevated on fill to the regulatory flood protection elevation.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.223. - Conditional uses.

The following uses shall be permitted within the RC2 Flood Fringe District to the extent they are not prohibited by any other provision of the zoning code or other ordinances, except that mining, extraction operations, the disposal of waste materials and landfills shall not be permitted. The use shall be permitted only upon the application and issuance of a conditional use permit by the planning commission. The uses are subject to the conditions of the underlying zoning district, to the standards for conditional uses in the Flood Fringe District, section 68.224 below, to the Standards for All Flood Fringe Uses, section 68.224 below, and to the River Corridor Standards and Criteria, section 68.400.

(a) Any structure that is not elevated on fill or floodproofed in accordance with section 68.222(a) or (b) above.

(b) Any use of land that does not comply with the standards in section 68.222(c).

(c) Sewage treatment plants.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.224. - Standards for conditional uses in the RC2 Flood Fringe District.

(a) Alternative elevation methods other than the use of fill may be utilized to elevate a structure's lowest floor above the regulatory flood protection elevation. These alternative methods may include the use of stilts, pilings, parallel walls or above grade, enclosed areas such as crawl spaces or tuck-under garages. The base or floor of an enclosed area shall be considered above grade and not a structure's basement or lowest floor if: 1) the enclosed area is above grade on at least one (1) side of the structure; 2) is designed to internally flood and is constructed with flood-resistant materials; and 3) is used solely for parking of vehicles, building access or storage. The above-noted alternative elevation methods are subject to the following additional standards:

(1) *Design and certification.* The structure's design and as-built condition must be certified by a registered professional engineer or architect as being in compliance with the general design standards of the State Building Code and, specifically, that all electrical, heating, ventilation, plumbing and air conditioning equipment and other service facilities must be at or above the regulatory flood protection elevation or be designed to prevent floodwater from entering or accumulating within these components during times of flooding.

(2) *Specific standards for above grade, enclosed areas.* Above grade, fully enclosed areas such as crawl spaces or tuck-under garages must be designed to internally flood and the design plans must stipulate:

a. The minimum area of openings in the walls where internal flooding is to be used as a floodproofing technique. When openings are placed in a structure's walls to provide for entry of floodwaters to equalize pressures, the bottom of all openings shall be no higher than one (1) foot above grade. There shall be a minimum of two openings and the openings shall be placed on at least two walls of the structure. Openings may be equipped with screens, louvers, valves or other coverings or devices, provided that they permit the automatic entry and exit of floodwaters.

b. That the enclosed area will be designed of flood-resistant materials in accordance with the FP-3 or FP-4 classifications in the State Building Code and shall be used solely for building access, parking of vehicles or storage.

(b) Basements, as defined by section 60.203.B for this river corridor code, shall be subject to the following:

(1) Residential basement construction shall not be allowed below the regulatory flood protection elevation except as authorized in subsection (f) of this section.

(2) Nonresidential basements may be allowed below the regulatory flood-protection elevation, provided the basement is protected in accordance with subsection (c) or (f) of this section.

(c) All areas of nonresidential structures including basements to be placed below the regulatory flood protection elevation shall be structurally dry floodproofed in accordance with the FP-1 or FP-2 floodproofing classifications in the State Building Code. This shall require making the structure watertight, with the walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy. Structures floodproofed to the FP-3 or FP-4 classification shall not be permitted.

(d) The storage or processing of materials that are, in times of flooding, flammable, explosive or potentially injurious to human, animal or plant life is prohibited. Storage of other materials or equipment may be allowed if readily removable from the area within the time available after a flood warning and in accordance with a plan approved by the planning commission, or if elevated above the regulatory flood protection elevation by alternative methods which meet the requirements of subsection (a) above.

(e) No new construction, addition or modification to existing sewage treatment plants shall be permitted within the floodplain unless emergency plans and procedures for action to be taken in the event of flooding are prepared, filed with and approved by the Minnesota Pollution Control Agency. The emergency plans and procedures must provide for measures to prevent introduction of any pollutant or toxic materials into the floodwaters.

(f) When the Federal Emergency Management Agency has issued a conditional letter of map revision-fill (CLOMR-F) for vacant parcels of land elevated by fill to the one (1) percent chance flood elevation, the area elevated by fill remains subject to the provisions of this chapter. A structure may be placed on the area elevated by fill with the lowest floor below the regulatory flood protection elevation provided the structure meets the following provisions:

(1) No floor level or portion of a structure that is below the regulatory flood protection elevation shall be used as habitable space or for storage of any property, materials, or equipment that might constitute a safety hazard when contacted by floodwaters. Habitable space shall be defined as any space in a structure used for living, sleeping, eating or cooking. Bathrooms, toilet compartments, closets, halls, storage rooms, laundry or utility space, and similar areas are not considered habitable space.

(2) For residential and nonresidential structures, the basement floor may be placed below the regulatory flood protection elevation subject to the following standards:

a. The top of the immediate floor above any basement area shall be placed at or above the regulatory flood protection elevation.

b. Any area of the structure placed below the regulatory flood protection elevation shall meet the "reasonably safe from flooding" standards in the Federal Emergency Management Agency (FEMA) publication entitled "Ensuring that Structures Build on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding," Technical Bulletin 10-01, a copy of which is hereby adopted by reference and made part of this chapter. In accordance with the provisions of this chapter, and specifically section 68.504(g), the applicant shall submit documentation that the structure is designed and built in accordance with either the "Simplified Approach" or "Engineered Basement Option" found in FEMA Technical Bulletin 10-01.

c. If the ground surrounding the lowest adjacent grade to the structure is not at or above the regulatory flood protection elevation, then any portion of the structure that is below the regulatory flood protection elevation must be floodproofed consistent with any of the FP-1 through FP-4 floodproofing classifications found in the State Building Code.

(C.F. No. 03-241, § 2, 3-26-03; C.F. No. 03-1028, § 1, 4-7-04)

Sec. 68.225. - Standards for all RC2 Flood Fringe Uses.

(a) *Vehicular access.* All new principal structures must have vehicular access at or above an elevation not more than two (2) feet below the regulatory flood protection elevation. If a modification to this requirement is granted, the planning commission must specify limitations on the period of use or occupancy of the structure for times of flooding and only after determining that adequate flood warning time and local flood emergency response procedures exist.

(b) *Commercial uses.* Accessory land uses, such as yards, railroad tracks and parking lots may be at elevations lower than the regulatory flood protection elevation. However, a permit for such facilities to be used by the employees or the general public shall not be granted in the absence of a flood warning system that provides adequate time for evacuation if the area would be inundated to a depth greater than two (2) feet or be subject to flood velocities greater than four (4) feet per second upon occurrence of the regional flood.

(c) *Manufacturing and industrial uses.* Measures shall be taken to minimize interference with normal plant operations. Certain accessory land uses such as yards and parking lots may be at lower elevation subject to requirements set out in subdivision (b) above. In considering permit applications, due consideration shall be given to needs of an industry whose business requires that it be located in floodplain areas.

(d) *Standards pertaining to fill.* Fill shall be properly compacted and the slopes shall be properly protected by the use of riprap, vegetative cover or other acceptable method. The Federal Emergency Management Agency (FEMA) has established criteria for removing the special flood hazard area designation for certain structures properly elevated on fill above the one (1) percent chance flood elevation. FEMA's requirements incorporate specific fill compaction and side slope protection standards for multistructure or multilot developments. These standards should be investigated prior to the initiation of site preparation if a change of special flood hazard area designation will be requested.

(e) *Developments not to affect hydraulic capacities.* Floodplain developments shall not adversely affect the hydraulic capacity of the channel and adjoining floodplain of any tributary watercourse or drainage system where a floodway or other encroachment limit has not been specified on the official zoning map.

(f) *Manufactured homes.* Manufactured homes must meet all the density, setback, flood protection and other requirements for residential use of the zoning code and all requirements of the housing and building code. All manufactured homes must be securely anchored to an adequately anchored foundation system that resists flotation, collapse and lateral movement. Methods of anchoring may include, but are not limited to, use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable state or local anchoring requirements for resisting wind forces.

(g) *Travel trailers.* Travel trailers shall not be used for living quarters, and are exempt from the provisions of this ordinance if they have current licenses required for highway use, are highway ready meaning on wheels or the internal jacking system, are attached to the site only by quick disconnect type utilities commonly used in campgrounds and trailer parks, and the travel trailer/travel vehicle has no permanent structural type additions attached to it. Travel trailers and travel vehicles lose this exemption when development occurs on the parcel exceeding $500 dollars for a structural addition to the travel trailer/travel vehicle or and accessory structure such as a garage or storage building. The travel trailer/travel vehicle and all additions and accessory structures will then be treated as a new structure and shall be subject to the elevation/flood proofing requirements and use of land restrictions specified in this ordinance. No new commercial travel trailer or travel vehicle parks shall be allowed in the RC1 floodway or RC2 flood fringe overlay districts.

(h) *Pollution of waters.* No use shall be permitted which is likely to cause pollution of waters, as defined in Minnesota Statutes, Section 115.01, unless adequate safeguards, approved by the state pollution control agency, are provided.

(C.F. No. 03-241, § 2, 3-26-03; C.F. No. 03-1028, § 1, 4-7-04)

Division 3. - 68.230. RC3 River Corridor Urban Open Overlay District

Sec. 68.231. - Intent.

It is intended that lands and waters within this district shall be managed to conserve and protect the existing and potential recreational, scenic, natural and historic resources. Open space provided in the open river corridor is for public use and the protection of unique natural and scenic resources. The existing transportation role of the river in this district will be protected.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.232. - Permitted uses.

In the RC3 River Corridor Urban Open Overlay District, use of the land, location and erection of new buildings or structures, and the alteration, enlargement and moving of existing buildings or structures from other locations or districts shall conform to those specified uses and standards of the corresponding underlying district as established in section 60.303 to the extent that they are not prohibited by any other provision of the zoning code. In addition, permitted uses shall be subject to the following applicable standards and those in section 68.400 et seq.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.233. - Standards for permitted uses in the RC3 Urban Open District.

(a) Development shall be limited to forty (40) feet in height.

(b) The development of new and expansion of existing commercial and industrial uses shall only be on lands which are on the landward side of blufflines.

(c) Mining and extraction operations shall not be permitted.

(d) No use shall be permitted which is likely to cause pollution of water, as defined in Minnesota Statutes, Section 115.01, unless adequate safeguards, approved by the state pollution control agency, are provided.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.234. - Conditional uses.

(a) Conditional uses are those specified by the corresponding underlying district as established in section 60.303 to the extent that they are not prohibited by any other provision of the zoning code. They are subject to standards specified in the corresponding underlying district section and to those specified in sections 68.233 and 68.400 et seq.

(b) Such uses will be permitted only upon application and issuance of a conditional use permit by the planning commission.

(C.F. No. 03-241, § 2, 3-26-03)

Division 4. - 68.240. RC4 River Corridor Urban Diversified Overlay District

Sec. 68.241. - Intent.

It is intended that the lands and waters in this district be used and developed to maintain the present diversity of commercial, industrial, residential and public uses of the lands, including the existing transportation use of the river; to protect historical sites and areas, natural scenic and environmental resources; and to expand public access to and enjoyment of the river. New commercial, industrial, residential and other uses are permitted if they are compatible with these goals.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.242. - Permitted uses.

In the RC4 River Corridor Urban Diversified overlay district, use of the land, location and erection of new buildings or structures and the alteration, enlargement and moving of existing buildings or structures from other locations or districts shall conform to those specified uses and standards of the corresponding underlying district as established in section 60.303 to the extent that they are not prohibited by any other provision of the zoning code. In addition, permitted uses shall be subject to the standards specified in section 68.400 et seq.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.243. - Standards for permitted uses in the RC4 Urban Diversified District.

No use shall be permitted which is likely to cause pollution of waters, as defined in Minnesota Statutes, Section 115.01, unless adequate safeguards, approved by the state pollution control agency, are provided.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.244. - Conditional uses.

(a) Conditional uses are those specified by the corresponding underlying district as established in section 60.303 to the extent that they are not prohibited by any other provision of the zoning code. They are subject to standards specified in the corresponding underlying district section and to those specified in section 68.400 et seq.

(b) Such uses will be permitted only upon application and issuance of a conditional use permit by the planning commission.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE III. - 68.300. PUBLIC UTILITIES, RAILROADS, ROADS AND BRIDGES

Sec. 68.301. - Public utilities, railroads, roads and bridges.

(a) *Public utilities.* All public utilities and facilities such as gas, electrical, sewer and water supply systems to be located in the floodplain shall be floodproofed in accordance with the state building code or elevated to above the regulatory flood protection elevation.

(b) *Public transportation facilities.* Railroad tracks, roads and bridges to be located within the floodplain shall comply with sections 68.210 and 68.220 of this chapter. Elevation to the regulatory flood protection elevation may be required by the planning commission where the failure or interruption of these transportation facilities would result in danger to the public health or safety or where such facilities are essential to the orderly functioning of the area. Minor or auxiliary roads or railroads may be constructed at a lower elevation where failure or interruption of transportation services would not endanger the public health or safety.

(c) *On-site sewage treatment and water supply systems.* Where public utilities are not provided:

(1) On-site water supply systems must be designed to minimize or eliminate infiltration of floodwaters into the systems; and

(2) New or replacement on-site sewage treatment systems must be designed to minimize or eliminate infiltration of floodwaters into the systems and discharges from the systems into floodwaters and they shall not be subject to impairment or contamination during times of flooding.

Any sewage treatment system designed in accordance with the state's current statewide standards for on-site sewage treatment systems shall be determined to be in compliance with this section.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE IV. - 68.400. RIVER CORRIDOR STANDARDS AND CRITERIA

Sec. 68.401. - Objectives.

The objective of standards and criteria is to maintain the aesthetic integrity and natural environment of the river corridor in conformance to the St. Paul Mississippi River Corridor Plan by reducing the effects of poorly planned shoreline and bluffline development; providing sufficient setback for sanitary facilities; preventing pollution of surface and groundwater; minimizing flood damage; preventing soil erosion; and implementing metropolitan plans, policies and standards.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.402. - Protection of shorelands, floodplains, wetlands and bluffs.

(a) *Generally.* Development shall be conducted so that the smallest practical area of land be developed at any one time and that each area be subjected to as little erosion or flood damage as possible during and after development.

(b) *Placement of structures.*

(1) The following minimum setbacks for each class of public waters as described in Minnesota Regulations NR-82 shall apply to all structures except those specified as exceptions in subsection (7) below.

a. For natural environment waters at least two hundred (200) feet from the normal high water mark for lots not served by public sewer and at least one hundred fifty (150) feet from the ordinary high water mark for lots served by public sewers.

b. For general development waters at least seventy-five (75) feet from the normal high water mark for lots not served by public sewer and at least fifty (50) feet from the ordinary high water mark for lots served by public sewer.

(2) No commercial or industrial development shall be permitted on slopes greater than twelve (12) percent.

(3) No residential development shall be permitted on slopes greater than eighteen (18) percent.

(4) Bluff development shall take place at least forty (40) feet landward of all blufflines.

(5) Transportation, utility and other transmission service facilities and corridors shall avoid:

a. Steep slopes;

b. Intrusions into or over streams, valleys and open exposures of water;

c. Intrusions into ridge crests and high points;

d. Creating tunnel vistas;

e. Wetlands;

f. Forests by running along fringe rather than through them. If necessary, to route through forests, utilize open areas in order to minimize cutting;

g. Soils susceptible to erosion, which would create sedimentation and pollution problems;

h. Areas of unstable soils which would be subject to extensive slippages;

i. Areas with high water tables; and

j. Open space recreation areas.

(6) At river crossing points, public facilities, crossing corridors and other rights-of-way shall be consolidated, so that the smallest area possible is devoted to crossing.

(7) Exceptions:

a. Location of piers and docks shall be controlled by applicable state and local regulations.

b. Commercial, industrial or permitted open space uses requiring location on public waters may be closer to such waters than the setbacks specified in the standard set out in subsection (3) above.

(c) *Grading and filling.*

(1) A minimum amount of filling shall be allowed when necessary, but in no case shall the following restrictions on filling be exceeded. Furthermore, fill opportunities shall be fairly apportioned to riparian landowners. The developer shall evaluate ownership patterns, configuration and the bottom profile of each wetland basin before fill opportunities are apportioned.

(2) Grading and filling in shoreland areas (when allowable) or any other substantial alteration of the natural topography shall be controlled in accordance with the following criteria:

a. The smallest amount of bare ground shall be exposed for as short a time as feasible.

b. Temporary ground cover shall be used.

c. Methods to prevent erosion and trap sediment shall be employed.

d. Fill shall be stabilized.

(3) Only fill free of chemical pollutants and organic wastes shall be used.

(4) Total filling shall not cause the total natural flood storage capacity of the wetland to fall below the natural volume of runoff from the wetland and watershed generated by a 100-year storm, as defined by the National Weather Service.

(5) Solid waste disposal and landfill shall not be permitted in the River Corridor District.

(6) Development shall fit existing topography and vegetation with a minimum of clearing and grading.

(7) No rehabilitation slopes shall be steeper than eighteen (18) percent slope.

(8) Dredging of a shoreland or wetland shall be allowed only when it will not have adverse effect upon the wetland. Dredging when allowed shall be limited as follows:

a. It shall be located in the areas of minimum vegetation.

b. It shall not significantly change the water flow characteristics.

c. The size of the dredged area shall be limited to the absolute minimum.

d. Deposit of dredged material shall not result in a change in the current flow, or in destruction of vegetation or fish spawning areas, or in water pollution.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.403. - Protection of wildlife and vegetation.

Development shall be conducted so as to avoid intrusion into animal and plant habitats.

(a) No alteration of the natural environment or removal of vegetation shall be permitted when such alteration or removal would diminish the ability of dependent wildlife to survive in the River Corridor.

(b) No wetland or bluffline vegetation shall be removed or altered except that required for the placement of structures.

(c) Clear cutting shall be prohibited except as necessary for placing approved public roads, utilities, structures and parking areas.

(d) Natural vegetation shall be restored after any construction project.

(e) Watering areas necessary for plant survival shall be maintained or provided.

(f) Development shall not cause extreme fluctuations of water levels or unnatural changes in water temperature, water quality, water currents or movements which may have an adverse impact on endangered or unique species of birds or wildlife.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.404. - Protection of water quality.

(a) *Generally.* Development shall occur so that surface and subsurface water is not adversely affected by contaminants. Water quality should meet or exceed state standards.

(b) *Contamination.*

(1) Development shall not be permitted on wet soils, very shallow soils, soils with high shrink-swell or frost action potential unless it is shown that appropriate construction techniques capable of overcoming the restrictive condition will be utilized.

(2) Septic tanks and soil absorption systems shall not be permitted where public sewer systems are available. In areas where public sewers are not available, system shall be set back from the normal high water mark in accordance with the class of public waters as prescribed in Minnesota Regulations NR-82:

a. On natural environment waters, at least one hundred fifty (150) feet.

b. On general development waters, at least fifty (50) feet.

(3) Private wells shall be placed in areas not subject to flooding and up slope from any source of contamination. Wells already existing in areas subject to flooding shall be floodproofed in accordance with accepted engineering standards as defined in the Uniform State Building Code.

(4) Commercial or industrial land uses requiring the storage or production of materials or wastes that may create a pollution hazard for groundwater or surface water shall be prohibited unless the quality of both the groundwater and surface waters can conform to all applicable state and federal standards, criteria, rules and regulations.

(c) *Runoff.*

(1) The phases of development shall be planned so that only areas which are actively being developed are exposed. Other areas shall have cover of vegetation or mulch.

(2) Natural vegetation in shoreland and bluff areas shall be preserved to retard surface runoff and soil erosion and to utilize excess nutrients.

(3) Sediment shall be retained within the development site area either by filtering runoff as it flows through the development area or by detaining sediment-laden runoff in a sediment basin so that the soil particles settle out.

(4) Water released to a drainage system shall be directed in such a manner as to travel over natural areas rather than across established surfaces.

(5) Stormwater runoff may be directed to wetlands only when free of silt, debris and chemical pollutants and only at rates which will not disturb vegetation or increase turbidity.

(6) Development which takes place near slopes greater than twelve (12) percent shall not result in increased runoff onto those slopes sufficient to damage vegetation or structures thereon.

(7) Plans shall be submitted to the planning commission for any development placed landward from dikes, floodwalls or levees which is below the flood protection elevation of the dikes, floodwalls or levees. The plans must provide measures to ensure that floodwaters do not back up onto the development from stormwater drainage systems.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE V. - 68.500. CONDITIONAL USE PERMITS

Sec. 68.501. - Application.

Applications for conditional use permits shall be submitted and reviewed according to the provisions in section 64.300. The planning administrator shall determine whether to require any or all of the following six (6) items of information to be supplied by the applicant as a prerequisite to the consideration of the application:

(a) Plans in triplicate drawn to scale, prepared by and signed by a registered engineer, architect and/or land surveyor as applicable, showing the nature, location, dimensions and elevation of the land; existing surface contours, structures, streets and utilities; proposed surface contours, structures, fill and the location and elevations of proposed streets, water supply, sanitary facilities and other utilities showing the relationship of the above to the channel and to the designated River Corridor District limits.

(b) Specifications for building construction and materials, floodproofing, filling, dredging, grading, channel improvements, storage of materials, water supply and sanitary facilities.

(c) Typical valley cross-sections of areas to be occupied by the proposed development showing the channel of the stream, elevation of land areas, high water information, vegetation and soil types.

(d) Plan (surface view) of the proposed development showing the proposed use or uses of the area and structures and providing location, relationships and spatial arrangements of those uses and related structures to pertinent elevations, fill, storage location, utilities and other features.

(e) Profile showing the slope of the bottom of the channel and flow lines of the stream.

(f) A written evaluation by a registered engineer or other expert person or agency of the proposed project in relationship to flood heights and velocities, the seriousness of flood damage to the use, the adequacy of plans for flood protection and other technical matters.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.502. - Other permits.

Applicable conditional use permits for lands in the designated River Corridor District must be obtained prior to application for all other permits required by law and ordinance. Conditional use permits for River Corridor areas are supplementary to other zoning and building permits.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.503. - Factors considered.

In addition to the general standards and requirements in section 61.500 and all other relevant factors specified in other sections of this chapter, in reviewing conditional use permit applications, the planning commission or planning administrator shall consider the following:

(a) The relationship of the proposed use to the comprehensive plan and floodplain management program for the city.

(b) The importance of the services provided by the proposed facility to the community.

(c) The ability of the existing topography, soils and geology to support and accommodate the proposed use.

(d) The compatibility of the proposed use with existing characteristics of biologic and other natural communities.

(e) The proposed water supply and sanitation systems and the ability of those systems to prevent disease, contamination and unsanitary conditions.

(f) The requirements of the facility for a river-dependent location, if applicable.

(g) The safety of access to the property for ordinary vehicles.

(h) The susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual owner.

(i) The dangers to life and property due to increased flood heights or velocities caused by encroachments.

(j) The expected heights, velocity, duration, rate of rise, and sediment transport of the floodwaters expected at the site.

(k) The danger that materials may be swept onto other lands or downstream to the injury of others.

(l) The availability of alternative locations or configurations for the proposed use.

(m) Such other factors as are relevant to the purposes of this chapter.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.504. - Conditions imposed.

The planning commission or planning administrator may attach such conditions to the granting of conditional use permits as each deems necessary to fulfill the purposes of this chapter. Such conditions may include, but are not limited to, the following:

(a) Modifications of design, site planning or site treatment.

(b) Requirements for implementation of erosion and sediment control, vegetation management, wildlife management and other protective measures.

(c) Modifications of waste disposal and water supply facilities or operations.

(d) Limitations on period of use and operation, a flood warning system and an evacuation plan.

(e) Imposition of operational controls, sureties and deed restrictions.

(f) Requirements for construction of channel improvements, modifications, dredging, dikes, levees and other protective measures.

(g) Floodproofing measures shall be designed consistent with state-established floodproofing standards and with the flood protection elevation for the particular area including flood velocities, duration and rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the regulatory flood. The commission shall require that the applicant submit a plan or documents certified by a registered professional engineer or architect that the floodproofing measures are consistent with the regulatory flood elevation and associated flood factors for the particular area. The floodproofing measures that may be required include, but are not limited to, the following:

    (1) Anchorage to resist flotation and lateral movement.

    (2) Installation of watertight doors, bulkheads and shutters, or similar methods of construction.

    (3) Reinforcement of walls to resist water pressure.

    (4) Use of paints, membranes or mortars to reduce seepage of water through walls.

    (5) Addition of mass or weight to structures to resist flotation.

    (6) Installation of pumps to lower water levels in structures.

    (7) Construction of water supply and waste treatment systems to prevent the entrance of floodwaters.

    (8) Installation of pumping facilities or comparable practice for subsurface drainage systems for buildings to relieve external foundation wall and basement floor pressures.

    (9) Construction to resist rupture or collapse caused by water pressure or floating debris.

    (10) Installation of valves or controls on sanitary and storm drainage which will permit the drains to be closed to prevent backup of sewage and stormwaters into the buildings or structures. Gravity draining of basements may be eliminated by mechanical devices.

    (11) Location of all electrical equipment, circuits and installed electrical appliances such that they are not subject to the regional flood.

    (12) Location of any structural storage facilities for chemicals, explosives, buoyant materials, flammable liquids or other toxic materials, which could be hazardous to public health, safety and welfare, above the flood protection elevation or provision of adequate floodproofing to prevent flotation of or damage to storage containers which could result in the escape of toxic materials into floodwaters.

(h) Specifications for building construction and materials, filling and grading, water supply, sanitary facilities, utilities and other work or construction to be submitted to the city division of housing and building code enforcement for review and approval prior to any development.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE VI. - 68.600. VARIANCES

Sec. 68.601. - Variances.

(a) Applications for variance to the provisions of this chapter may be filed as provided in section 61.600. The burden of proof shall rest with the applicant to demonstrate conclusively that such variance will not result in a hazard to life or property and will not adversely affect the safety, use or stability of a public way, slope or drainage channel, or the natural environment; such proof may include soils, geology and hydrology reports which shall be signed by registered professional engineers. Variances shall be consistent with the general purposes of the standards contained in this chapter and state law and the intent of applicable state and national laws and programs. Although variances may be used to modify permissible methods of flood protection, no variance shall have the effect of allowing in any district uses prohibited in that district, permit a lower degree of flood protection than the flood protection elevation for the particular area, or permit a lesser degree of flood protection than required by state law.

(b) Notwithstanding any other provision of this river corridor code, variances may be granted for the repair or rehabilitation of historic structures upon a determination that the repair or rehabilitation will not preclude the structure's continued designation as a historic structure, the variance is the minimum necessary to preserve the historic character and design of the structure and the repair or rehabilitation will not cause an increase in the height of the regional flood or increase the flood damage potential of the structure.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE VII. - 68.700. NONCONFORMING STRUCTURES

Sec. 68.701. - Floodplain nonconforming structures.

Nonconforming use of structures and land and nonconforming structures shall be subject to the regulations in this section as well as provisions of chapter 62, Nonconforming Lots, Uses and Structures. A structure which was lawful before the passage or amendment of this chapter but which is not in conformity with the provisions of this chapter may be continued subject to the following conditions:

(a) No structure shall be expanded, changed, enlarged or altered in a way which increases its nonconformity.

(b) Any alteration or addition to a nonconforming structure which would result in increasing the flood damage potential of that structure or use shall be protected to the regulatory flood protection elevation in accordance with any of the elevation on fill or floodproofing techniques (i.e., FP-1 through FP-4, floodproofing classifications) allowable in the state building code, except as further restricted in subsection c. below.

(c) The cost of any structural alterations or additions to any nonconforming structure over the life of the structure shall not exceed fifty (50) percent of the market value of the structure unless the conditions of this section are satisfied. The cost of all structural alterations and additions constructed since January 28, 1982, must be calculated into today's current cost which will include all costs such as construction materials and a reasonable cost placed on all manpower or labor. If the current cost of all previous and proposed alterations and additions exceeds fifty (50) percent of the current market value of the structure, then the structure must meet the standards of Section 68.210 or 68.220 of this chapter for new structures depending upon whether the structure is in the floodway or flood fringe, respectively.

(d) When the use of a nonconforming structure is discontinued or ceases to exist for three hundred sixty-five (365) days, the nonconforming structure shall not thereafter be reused until the nonconforming is made conforming to the flood protection measures of this chapter, unless the planning commission, pursuant to a public hearing, finds that the nonconforming structure cannot reasonable or economically be made into a conforming structure and that reuse of the nonconforming structure is consistent with the public health, safety, morals and general welfare of the community and is consistent with the reasonable use and enjoyment of adjacent property.

(e) If any nonconforming structure is destroyed by any means, including floods, to an extent of fifty (50) percent or more of its market value at the time of destruction, it shall not be reconstructed except in conformity with the provisions of this chapter. The applicable provisions for establishing new structures in Section 68.210 or 68.220 will apply depending upon whether the structure is in the floodway or flood fringe, respectively.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE VIII. - 68.800. AMENDMENTS

Sec. 68.801. - Amendments.

(a) All amendments shall be made in the manner set forth in Minnesota Statutes, Section 462.357. The floodplain designations established by this chapter shall not be removed from floodplain areas unless it can be shown that the designation is in error or that the areas are filled to an elevation at or above the flood protection elevation and are contiguous to other lands lying outside the floodplain district. Special exceptions to this rule may be permitted by the Commissioner of Natural Resources if he determines that, through other measure, lands are adequately protected for the intended use.

(b) All amendments to this chapter, including amendments to the River Corridor Overlay Districts maps, must be submitted to and approved by the Commissioner of Natural Resources prior to adoption. Changes to the flood plain boundaries must meet the Federal Emergency Management Agency's (FEMA) technical conditions and criteria and must receive prior FEMA approval before adoption. The Commissioner of Natural Resources must be given ten (10) days' written notice of all hearings to consider an amendment to this chapter and such notice shall include a draft of the ordinance amendment or technical study under consideration.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.802. - Areas protected by dikes, levies and floodwalls.

Areas which the Federal Emergency Management Agency has removed from the floodplain through a revision to the flood insurance rate map or a letter of map revision because the areas are protected by a dike, levee or floodwall shall be exempt from the flood protection regulations of this code after said FEMA action has been adopted as a formal amendment to this chapter.

(C.F. No. 03-241, § 2, 3-26-03)

ARTICLE IX. - 68.900. ADMINISTRATION

Sec. 68.901. - Administration.

(a) *Record of elevation of lowest floor and floodproofing.* The zoning administrator shall maintain a record of the elevation of the lowest floor (including basement) of all new structures, altered structures or additions to existing structures in the floodplain. The zoning administrator shall also maintain a record of the elevation to which all new structures and alterations or additions to structures are floodproofed.

(b) *State and federal permits.* Applicants for special condition use permits, modifications and site plan review approval are responsible for obtaining all necessary state and federal permits.

(c) *Warning and disclaimer of liability.* This chapter does not imply that areas outside the floodplain districts or land uses permitted within such districts will be free from flooding or flood damages. This chapter shall not create liability on the part of the City of Saint Paul or any officer or employee thereof for any flood damages that result from reliance on this chapter or any administrative decision lawfully made thereunder.

(d) *Severability.* If any section, clause, provision or portion of this chapter is adjudged unconstitutional or invalid by a court of competent jurisdiction, the remainder of this chapter shall not be affected thereby.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.902. - Notify commissioner of natural resources.

A copy of the application for a conditional use permit or variance shall be submitted to the commissioner of natural resources sufficiently in advance so that the commissioner will receive at least ten (10) days' notice of the hearing. A copy of all decisions granting conditional use permits or variances shall be forwarded to the commissioner of natural resources within ten (10) days of such action.

(C.F. No. 03-241, § 2, 3-26-03)

Sec. 68.903. - Notice of increased insurance costs.

Applicants for a conditional use permit or variance to construct a structure below the regulatory flood protection elevation shall be notified that:

(1) The issuance of a conditional use permit or variance to construct a structure below the regulatory flood protection elevation may result in increased premium rates for flood insurance up to amounts as high as twenty-five dollars ($25.00) for one hundred dollars ($100.00) of insurance coverage; and

(2) Such construction below the regulatory flood protection elevation increases risks to life and property. Such notification shall be maintained with a record of the conditional use permit or variance. The planning or zoning administrator shall report such conditional use permits or variances issued in the biennial report submitted to the administrator of the National Flood Insurance Program.

(C.F. No. 03-241, § 2, 3-26-03)

Chapter 91. - Water Code—Miscellaneous Provisions

Sec. 91.01. - Resale of water.

No consumer, except with the written consent of the board of water commissioners previously obtained, will be allowed to furnish water to other persons or property or to suffer such other persons to take it themselves. Violations of this regulation may cause the supply to be shut off.

(Code 1956, § 252.01)

Sec. 91.02. - Water charges to one person only.

Where two (2) or more tenants are in one building or two (2) or more buildings are on one lot or enclosure, the water consumption will be charged to one person only, who must pay the full rate for the whole property, and no reduction will be made on the plea that some of the tenants do not use the water or on account of some of the fixtures not being used or portions of the premises vacant.

(Code 1956, § 252.02)

Sec. 91.03. - Water conservation.

Plumbing fixtures installed in any new building or any retrofitted building shall be of water conserving type and shall meet requirements of the state building code. The board of water commissioners may implement a plan to promote and encourage replacement of nonconserving faucets, shower heads and toilets.

All automatic lawn sprinkler systems connected to the public water system must be equipped with water conserving devices. However, systems which were installed prior to the effective date of this chapter may continue in operation at their current locations.

No person shall allow water to be wasted through any faucet or fixture or keep water running longer than necessary. The board of water commissioners shall discourage any wastage of water and may, when in its judgment deemed necessary, turn off any water service and require remedial action as it may in its judgment be deemed proper and necessary.

(Code 1956, § 252.03; C.F. No. 93-905, § 16, 7-15-93; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.04. - Right to make inspections.

Inspectors of the water utility, or any person authorized by the board of water commissioners, shall have free access at all reasonable hours to all parts of every building for the purpose of reading, inspecting, removing or replacing meters, remote meter reading receptacles and connecting cable, examining water fixtures and observing the manner in which water is used.

(Code 1956, § 252.04; Ord. No. 17267, § 4, 8-1385)

Sec. 91.05. - Sprinkling restrictions.

The use of water for lawn sprinkling purposes shall at all times be subject to the express condition that the board of water commissioners may, at any time when in its opinion the condition of the public water supply demands it, limit the time during each day when water may be used for sprinkling purposes; and the board may forbid the use of water for lawn sprinkling for any period not exceeding thirty (30) days at one time.

(Code 1956, § 252.06)

Sec. 91.06. - No claim against the board for breaks or shutoffs.

The board of water commissioners may at any time shut off the water for the purpose of extending, replacing, repairing or cleaning mains and appurtenances, and said board shall not be held liable for any damage arising therefrom. No claim shall be made against the board by reason of the breaking of any water main, service pipe or connection.

(Code 1956, § 252.07)

Sec. 91.07. - Service outside city limits.

The board of water commissioners may furnish water to places outside of the boundaries of the City of Saint Paul where such service will not affect the city's supply, under such rules and regulations as are approved by the board.

(Code 1956, § 252.08)

Sec. 91.08. - Order to turn off.

If so ordered by the owner of the premises or authorized agent, the water utility will turn off the water, except that water will not be turned off for the purpose of eviction.

(Code 1956, § 252.09)

Sec. 91.09. - Order to remove meter.

On the request of the owner or authorized agent, the water will be shut off and the meter will be removed and any fixed charge stopped as of the date of removal. Removal of any remote meter reading device and connecting cable shall be at the discretion of the water utility.

(Code 1956, § 252.10; Ord. No. 17267, § 4, 8-13-85; C.F. No. 93-905, § 17, 7-15-93; Ord. No. 11-99, § 1, 10-26-11)

Sec. 91.10. - Reserved.

Editor's note— C.F. No. 93-905, § 18, adopted July 15, 1993, deleted in its entirety, in effect repealed, § 91.10, which pertained to service charge—when stopped and derived from § 252.11 of the city's 1956 Code.

Sec. 91.11. - Request for re-establishment of service.

After service has been shut off for any reason except repairs or nonpayment, it shall not be reestablished unless requested by the owner or the owner's authorized agent.

(Code 1956, § 252.12; C.F. No. 93-905, § 19, 7-15-93)

Sec. 91.12. - Shutoff for nonpayment or violation of rules.

For violation of any rule or for nonpayment of any and all charges, including water bills and/or sewer service charges, when due, the board may discontinue service and shut off the water supply, in accordance with Chapter 46 of the Saint Paul Legislative Code. The board shall not discontinue service to a tenant because of a delinquent account owed or incurred by a prior customer at the service address. The board shall not knowingly bill a tenant for a delinquent account owed or incurred by a prior customer at the service address.

(Code 1956, § 252.13; Ord. No. 17497, § 1, 10-7-87; C.F. No. 02-501, § 1, 7-3-02)

Sec. 91.13. - Turn-on service charge.

(a) When water has been turned off for nonpayment of charges due, for any infraction of rules or upon request of the owner or authorized agent, the water may not be turned on again until a turn-on service charge in the amount of $50.00 has been paid or arrangements for payment have been made and approved by the water utility.

(b) If a water utility truck is dispatched to a property during established working hours for the purpose of turning off the water service for nonpayment of delinquent charges and the owner or tenant pays the delinquent charges rather than have the water service terminated, a collection service fee equal in amount to the current turn-on service charge shall be charged even though the water service is not actually shut off.

(c) Whenever water has been turned off for nonpayment of charges due or for infraction of the rules, all outstanding charges must be paid or arrangements for payment must be made and approved by the water utility, in addition to the turn-on service charge or collection service fee, before water is turned on again. Water service will only be turned on during established working hours.

(Code 1956, § 252.14; Ord. No. 17724, § 8, 4-24-90; C.F. No. 93-1589, § 5, 11-9-93; C.F. No. 97-1419, § 5, 12-22-97; C.F. No. 01-1192, § 2, 12-5-01; C.F. No. 03-892, § 3, 11-5-03; Ord 12-67, § 1, 11-14-12)

Sec. 91.14. - Unpaid service charges.

The property owner is responsible for all charges for water service and sewer service against the property. If the owner desires to have bills sent to a tenant, the water utility will do so. This does not, however, relieve the property owner of the responsibility for payment of the charges. All charges for water and sewer service are a continuing lien against the property until they are paid. The utility may annually certify delinquent water and sewer charges to the county auditor to be collected with the real estate taxes for the property on the date specified by the county taxing authority. An administrative fee of fifteen dollars ($15.00), or as otherwise set by resolution of the board of water commissioners, and twelve (12) months of interest, at an interest rate determined by the city, will be added to the delinquent water and sewer charges at the time these charges are certified to the county auditor. Charges so collected shall be remitted to the city treasurer in the same manner as assessments for local improvements.

(Code 1956, § 252.15; Ord. No. 17497, § 2, 10-7-87; C.F. No. 93-905, § 20, 7-15-93; C.F. No. 02-501, § 2, 7-3-02; C.F. No. 02-814, § 1, 10-2-02; C.F. No. 03-727, § 1, 9-3-03; Ord 15-52, § 1, 10-14-15)

Sec. 91.15. - Permanent mains.

Petitions for the extension of permanent street mains shall be made to the board of water commissioners upon proper forms. Petitions will not be granted until the street surface has been graded to the grade established by the city council and certified to by the department of public works, or until a future grade line is established by the department of public works, and the future grade line as certified does not vary by more than two (2) feet of fill or six (6) inches of cut from the existing grade line.

(Code 1956, § 252.17)

Sec. 91.16. - Private mains.

(a) The board shall have the authority to enter into private main agreements in such cases where a private water main is deemed necessary. The board shall determine the terms of the private main agreement.

(b) For private mains in streets which have not been officially graded (formerly called temporary mains), the private main shall be the property of the board, and all repairs shall be paid for by the water users supplied by such main.

Private mains which are located in officially graded streets and in other streets which meet the criteria for ungraded streets established in section 91.15 (permanent mains) shall be owned by the board and maintained at water utility expense.

(Code 1956, § 252.18; C.F. No. 93-905, § 22, 7-15-93)

Sec. 91.17. - Private water facilities, maintenance.

Private water facilities located on private property shall at all times be maintained by the owner in accordance with water utility standards at the owner's sole expense. If the owner fails to provide said maintenance, the water utility may, upon due notice, shut off water service thereto until the maintenance is completed. "Private water facilities" includes all hydrants, mains, service connections, main and service connection valve boxes, and their related appurtenances.

(C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.18. - Official house number.

Water will not be turned on nor service continued unless the official house number is conspicuously shown on the property in accordance with the records of the water utility. Temporary official numbers will be accepted on new buildings.

(Code 1956, § 252.19; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.19. - Bills to property supplied.

Unless a request for a special mailing address is placed on file in the water utility office, all bills and charges will be addressed to the property supplied. The property owner shall be responsible for payment of all bills and service charges against the property supplied.

(Code 1956, § 252.20; C.F. No. 93-905, § 22, 7-15-93; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.20. - Water bills not split.

If more than one (1) tenant is supplied by a street service, the property owner must apportion the charges to each tenant, if the owner desires such apportionment. The water utility will not adjudicate charges.

(Code 1956, § 252.21; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.21. - Board may make additional rules.

The board of water commissioners may make such further rules and regulations, subject to approval by the city council, as may be necessary for the preservation and protection of the water system.

(Code 1956, § 252.22; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.22. - Failure to receive bills.

Failure to receive a bill will not relieve the property owner of responsibility for payment.

(Code 1956, § 252.23; C.F. No. 93-905, § 23, 7-15-93; C.F. No. 97-1419, § 5, 12-22-97; C.F. No. 1048, § 5, 11-28-07)

Sec. 91.23. - Miscellaneous charges.

The board of water commissioners may charge the actual costs, including labor, equipment, materials and overhead, incurred for nonrequired services performed at the request of others, such services to include, but not be limited to, hydrant flow tests, relocations of hydrants, relocation of water mains or connections, inspection and other similar services.

(Ord. No. 17001, 2-24-83; C.F. No. 97-1419, § 5, 12-22-97)

Sec. 91.24. - Special purpose lateral mains.

The board may, at its discretion, install special purpose lateral mains within street rights-of-way from the public main in the street to the property line. Special purpose lateral mains may be used for connections to private water mains, hydrants, and multiple street service connections. Charges for special purpose lateral mains shall be in accordance with charges for street service connections and fire services, sections 87.13 and 87.16. Special purpose lateral mains shall be maintained by the water utility as part of the public water main system.

(Ord. No. 17001, 2-24-83; Ord. No. 17724, § 9, 4-24-90; C.F. No. 97-1419, § 5, 12-22-97; C.F. No. 03-892, § 3, 11-5-03)

APPENDIX D

Wetland Management Plan

City of St. Paul

Wetland Management Plan

September 2008

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SECTION I – EXECUTIVE SUMMARY

Wetlands provide many benefits and therefore are important resources to a city. Wetlands provide critical habitat for many types of birds, mammals, amphibians, reptiles, invertebrates, and plants. Wetlands can also act to improve water quality and provide water quantity control by storing water during storm events. Wetlands allow for groundwater interactions, whether it is recharge or discharge. Additionally, wetlands provide aesthetic value, nature observation areas, and areas for education and scientific research. Because of the importance of wetlands and the role wetlands play within a community, they must be considered during development review and city-wide planning in order to balance protection of the wetlands and development and growth in the City. Since the City of St. Paul is fully developed, protecting and restoring the remaining wetlands and their functions is a high priority.

The City of St. Paul Wetland Management Plan (WMP) has been developed as part of the implementation of the Surface Water Management Plan and provides an overall approach for the protection and management of wetlands within the City. The WMP will be adopted by the City and is to be used in conjunction with the Surface Water Management Plan.

The WMP provides an approach for the protection and management of wetlands within the City. The WMP provides greater flexibility and control over wetland management and protection, identifies regional wetland mitigation sites, identifies potential wetland restoration areas, and provides management strategies for different types of wetlands.

Section II contains an introduction to the WMP. It includes the intent of the Plan and a general description of the water resources within the City.

Section III discusses the regulatory framework for wetlands within the City. This section provides details of the role of the City as the Local Government Unit (LGU) for the Wetland Conservation Act (WCA) and provides a brief overview of other agency jurisdiction over wetlands.

Section IV contains the methods used to assess the wetland functions and values and classify the wetlands within the City. A wetland function is defined as a physical, chemical, or biological process or attribute of a wetland. A wetland value is the extent to which a wetland function is perceived as beneficial to an individual, municipality, or other entity. Wetlands were assessed using the Minnesota Rapid Assessment Method (MnRAM) 3.1. This method incorporates objective and categorical information collected on wetlands to evaluate overall wetland health, vulnerability, and social value. No wetlands were delineated as part of this Plan. Absence of a wetland in the WMP does not indicate that a wetland does not exist.

Section V discusses the results of the functions and values assessment and the wetland management strategies for the wetlands. Wetlands were given scores for each function that was evaluated. Approximately 152 wetlands within the City were evaluated as part of this Plan. Detailed information about each wetland can be found in **Appendix B**. The wetland management classifications include Preserve, Manage 1, Manage 2, Manage 3, and Storm Water Pond as outlined below:

Preserve (P): Wetlands that were placed into the Preserve category generally provided the highest functions for vegetative diversity and wildlife habitat.

Manage 1 (M1): Wetlands that were placed into the Manage 1 category generally provided high functions for vegetative diversity and wildlife habitat with some functions for water quality protection and flood attenuation.

Manage 2 (M2): Wetlands that were placed into the Manage 2 category generally provided some functions for vegetative diversity and wildlife habitat with high functions for water quality protection and flood attenuation.

Manage 3 (M3): Wetlands that were placed into the Manage 3 category generally provided the highest functions for water quality protection and flood attenuation.

Storm Water Pond: Water bodies that were created for the purpose of treating and/or storing storm water runoff were designated as storm ponds. While these areas may have taken on wetland characteristics, they are not considered jurisdictional wetlands based on the Wetland Conservation Act.

These classifications allow the City to actively protect, and manage wetlands, plan for future development and redevelopment, and identify programs and policies for wetland management.

Section VI contains an implementation program for this Plan. **Section VII** provides information on enforcement, appeals, and amendment procedures for this Plan and wetland assessments.

A number of appendices are also included which provide supplemental information to the Plan.

SECTION II - INTRODUCTION

A. Purpose of the Plan

The City of St. Paul Wetland Management Plan has been developed to provide the City with additional information about its wetland resources and to develop policies related to wetland management. The WMP was created as part of the implementation of the Surface Water Management Plan and provides an overall approach for the protection and management of wetlands within the City. The WMP provides greater flexibility and control over wetland management and protection, identifies potential wetland restoration areas, identifies regional wetland mitigation sites, and provides management strategies for different types of wetlands. The WMP designates wetland priorities and defines the City's long-term goals for wetland management. The objectives of this plan are to:

- Identify, classify, and create an inventory of wetlands within the City
- Identify wetland functions and resources important to the City
- Identify existing storm water ponds
- Identify potential wetland restoration and mitigation sites
- Manage wetland resources towards improvement of their functions and values
- Develop a long-term wetland management strategy
- Focus limited resources in the most effective direction
- Provide technical information and baseline data regarding the functions and values of wetlands within the City
- Provide advance information for developers and the City about the quality of wetlands within the site
- Achieve no net loss in the quantity and quality of St. Paul's wetlands
- Provide identification of wetland priorities
- Create a detailed GIS database about the wetlands that can be used by City Staff and residents

Additionally, the City anticipates examining the jurisdictional status of wetland management in the City. This will be completed as part of an overall process of reviewing City policy related to wetlands and storm water management that is anticipated to begin in 2009.

B. Background Information

The City of St Paul is approximately 56 square miles in size and is located in southern Ramsey County (see **Figure 1**). The City is bordered by Minneapolis, Lauderdale, Falcon Heights, Roseville, Maplewood, Newport, South St. Paul, West St. Paul, Mendota Heights, Lilydale, and Mendota. The Mississippi River flows through the southern portion of the City.

There are approximately 152 wetlands within the city limits of St. Paul. Lakes and other natural resources of special interest within the City are listed below. Although many of these natural features were not included in the scope of this study, they represent important resources for the City and its residents. These resources provide recreational and educational benefits to the residents of St. Paul and are also invaluable ecological resources providing habitat and breeding grounds for resident and migratory wildlife.

Mississippi River
Battle Creek
Como Lake
Loeb Lake
Lake Phalen
Frost Lake
Beaver Lake
Crosby Lake
Burlington Pond
Mallard Marsh
Pickerel Lake
Pig's Eye Lake
Little Pig's Eye Lake
Suburban Pond
Upper Lake

Although many wetlands within the City have been altered or impacted by past and present land uses, several high quality, biologically diverse, wetlands were documented during the wetland inventory. Most of these wetlands were associated with the side-hill seeps occurring along the bluff line located in Battle Creek Regional Park.

SECTION III – WETLAND REGULATIONS

The existing wetland regulatory framework in Minnesota involves a number of federal, state, and local agencies including the US Army Corps of Engineers, Department of Natural Resources, Pollution Control Agency, Watershed Districts, and the Local Government Units. A brief discussion of the role of each wetland regulatory agency is included in this section.

A. US Army Corps of Engineers

The US Army Corps of Engineers (COE) regulates the discharge of dredged or fill materials to wetlands and other water bodies through Section 404 of the Clean Water Act provided there is a surface water connection to navigable waters. Any impact to navigable waters or wetlands that are connected to navigable waters, including filling, draining, or excavation, may require a permit from the COE. Wetland delineations are also subject to COE approval. Depending on the size and extent of the wetland impact, the Minnesota Pollution Control Agency may be involved in certifying the COE permit. For more information about the COE regulations, the area COE Project Manager can be contacted at (651) 290-5360 or information can be obtained from the COE website at www.mvp.usace.army.mil.

B. Department of Natural Resources

The Department of Natural Resources (DNR) has jurisdiction over Public Waters and Wetlands as depicted on the DNR Public Waters and Wetland maps (see **Figure 2**). The DNR has jurisdiction over Public Water and Wetlands below the Ordinary High Water (OHW) elevation or below the top-of-bank for streams. The OHW is determined by the DNR. Any impact to a Public Water or Wetland may require a permit from the DNR. The DNR Area Hydrologist can be contacted for more information at (651) 772-7910 or information can be obtained from the DNR website at www.dnr.state.mn.us/waters.

C. Pollution Control Agency

Minnesota Pollution Control Agency (MPCA) water quality standards applicable to wetland protection are contained in Minnesota Rules 7050. Water quality standards are applicable to all wetlands of the state and sequence mitigation requirements of Minn. Rule 7050.0186 apply to all wetland alterations that are permitted or certified by the MPCA as described below.

The National Pollutant Discharge Elimination System (NPDES)/SDS permit program is a delegated federal permit issued under the responsibilities and authorities contained in Minnesota Statutes Chapter 115. Minnesota Rule 7050.0186 sequencing requirements to avoid, minimize, and mitigate wetland impacts are required to be satisfied in the issuance of MPCA/SDS permits, including issuance of the general Construction Storm Water NPDES permits. If a project includes a physical wetland alteration caused by draining, filling, excavation, or inundation of the wetland and that impact is not addressed in either the US Army Corps of Engineers 404 permit, the Department of Natural Resources permit, or the Wetland Conservation Act permit, then mitigation compliance with MN Rule 7050.0186 must be demonstrated. For the purposes of the MPCA NPDES permit, *de minimis* determinations by another permitting agency that address the project impacts are recognized by the MPCA. However, a non-jurisdictional determination by another permitting agency does not address project impacts and therefore does require the project proposer to demonstrate that they meet the NPDES permit conditions and Minnesota Rule 7050.0186.

In the past, 7050.0186 requirements were often applied during the issuance of Section 401 Water Quality Certification which is part of the issuance process of the US Corps of Engineers 404 permit. The 401 Water Quality Certification program is an element of the Federal Clean Water Act and has been delegated to the MPCA. Under this program, the MPCA reviewed all federal permits including Clean Water Act Section 404 permit applications for compliance with state water quality standards primarily contained in Minnesota Rule 7050. The MPCA can approve, deny, or waive 401 certification. If denied, the federal permit, usually the US Corps of Engineers 404 permit, cannot be issued. The MPCA is currently not implementing the Section 401 program on a regular basis and nearly all certifications are being waived. This action does not eliminate, waive, or vary the applicant's responsibility of complying with all water quality standards and requirements contained in Minnesota Rules 7050. In addition, this waiver action does not waive MPCA's authority to take necessary actions, including enforcement actions, to ensure that the applicant and the project's construction, installation, and operation comply with water quality standards and all other applicable MPCA statutes and rules regarding water quality.

D. Watershed Districts and Watershed Management Organizations (WMO)

The City of St. Paul resides within four Watershed Districts or Management Organizations shown in **Figure 3.**

- Capitol Region Watershed District (CRWD): www.capitolregionwd.org
- Ramsey-Washington Metro Watershed District (RWMWD): www.rwmwd.org
- Lower Mississippi River Watershed Management Organization (LMRWMO)
- Mississippi Watershed Management Organization (MWMO): www.mwmo.org

Each watershed district has developed a watershed management plan that incorporates policies concerning wetland management within the watershed. The MWMO and the LMWMO leave administration of the WCA as the responsibility of the cities as acting Local Government Units (LGUs). The CRWD and the RWMWD have additional wetland regulations that vary from the WCA and additional approvals are needed from these Watershed Districts for projects that impact wetlands. These rules concerning wetland management by the corresponding watershed district are available on each organization's web site listed above. The goal of St. Paul's WMP is to work in conjunction with these existing policies.

E. Local Government Unit – Wetland Conservation Act

The Wetland Conservation Act (WCA) is a State law that first passed in 1991 and has been subsequently amended (Minn. Laws CH 354, Minn. Statute 103G.222-2373 and other scattered sections). The Board of Water and Soil Resources (BWSR) publishes MN Rule 8420 in accordance with the WCA laws. BWSR's role is to assist the Local Government Units (LGUs) in the implementation of WCA and to be a member of the Technical Evaluation Panel (TEP).

The intent of the WCA is to achieve a "no net loss" of wetland quantity, quality and biological diversity in Minnesota. Therefore, the WCA prohibits filling, draining, and excavation of wetlands in some areas unless the activity is exempt or wetlands are replaced by restoration or creation of wetland of at least equal functions and values.

The WCA is administered by Local Government Units (LGUs). The City of St. Paul is the LGU for the WCA within the City's boundaries. The City can issue or deny permits depending on whether or not the project is in conformance with the WCA or the requirements of this Plan. The WCA exemptions are discussed in Minn. Rules 8420 and are included by reference to this Plan. The procedures for wetland impact application, sequencing, and replacement are outlined within the WCA. Additionally, the City anticipates examining the jurisdictional status of wetland management in the City. This will be completed as part of an overall process of reviewing City policy related to wetlands and storm water management that is anticipated to begin in 2009.

SECTION IV – WETLAND EVALUATION AND CLASSIFICATION METHODS

Approximately 152 wetlands were evaluated and classified within the City of St. Paul. The methods used to accomplish these tasks are described in this section.

A. Background Information

Aerial photography of the City was obtained to provide a base map for the Wetland Management Plan. Additional mapping from Metropolitan Mosquito Control, the DNR, the National Wetland Inventory, and RWMWD were also reviewed. These sources were reviewed and compiled into one map in order to determine the potential locations of all wetlands within the City.

After potential wetland locations were identified in the office and by City Staff, these locations were field verified for their presence. The presence or absence of a wetland was determined using the criteria for wetland delineation as set forth in the 1987 Manual for Delineating and Identifying Jurisdictional Wetlands (US Corps of Engineers, 1987). The majority of wetlands found below the bluff line within the Mississippi River floodplain were beyond the scope of this study and therefore were not assessed and are not included as part of this wetland management plan.

It is important to note that wetland edges were not delineated as part of the preparation of this Plan. A wetland delineation will need to be conducted as part of any potential impact or development activity near the wetland. In addition, the absence of a wetland from this Plan does not indicate that a wetland is not present on the site. Extreme efforts were taken to ensure that all wetlands within the City were evaluated as part of the development of this Plan; however, the unintentional omission of a particular wetland does not grant permission to impact that wetland before going through the proper regulatory process.

B. Wetland Function and Value Assessment

After background information about the location of a potential wetland was obtained and the wetland was field verified, a function and value assessment was completed for each wetland and a photograph of the wetland was taken for reference.

Functions and values of each wetland were evaluated using the Minnesota Routine Assessment Method Version 3.1. A wetland function is defined as a physical, chemical, or biological process or attribute of a wetland. A wetland value is the extent to which a wetland function is perceived as beneficial to an individual, municipality, or other entity. The assessment evaluated the values of the following functions:

- Vegetative Diversity / Integrity
- Fish and Wildlife Habitat
- Water Quality Protection
- Flood / Storm Water Attenuation
- Shoreline Protection
- Aesthetics, Recreation, and Education

A copy of the MnRAM Version 3.1 assessment method is included in **Appendix C** along with guidance on MnRAM. After the functions and values assessment was completed for the wetlands, the wetlands were placed into different management categories using a modified version of BWSR's Wetland Management Classification Process (see **Appendix C)**. The deviations from this method are described below:

- The evaluation for aesthetics was not included in placing wetlands into management categories. This function was determined by the City to not be as significant in determining a wetland's function as the other functions of the wetlands.

- Sixteen wetlands were assigned a different classification than what was produced using the Wetland Management Classification Process. This change in management classification was based on the historical use of these wetlands for storm water management as well as the requirements of the City of St. Paul in future storm water management. Table 3 in **Appendix C** outlines which wetlands were amended and the classification change that occurred.

C. GIS Database for WMP

Information generated by the functions and values assessments was compiled into a GIS map and database. This database can be used by the City, developers, and the public for plan reviews, storm water planning, and general information. This database will be updated as necessary when new wetlands are created or wetlands are re-evaluated. The wetland classification map (**Figure 4**) is included in **Appendix A.**

SECTION V – WETLAND ASSESSMENT RESULTS AND MANAGEMENT STRATEGIES

A. Wetland Inventory Results

Approximately 152 wetlands within the City were evaluated using MnRAM 3.1. Wetlands were numbered based on the wetland numbering system outlined in MnRAM where wetlands are numerically numbered based on which section they are located. For example, wetland number 62-029-22-19-182A is wetland number 182 located in section 19 of County 62, Township 29, Range 22. The designation "A" refers to the wetland's assessment number; in this case the first assessment. The second time this wetland is assessed, its number will be 62-029-22-19-182B. The approximate boundaries of the assessed wetlands are shown on **Figure 4.**

While an attempt was made to evaluate all of the wetlands within the City, access to some wetlands was unavailable. The MnRAM 3.1 assessment will need to be undertaken at the property owner' expense if and when their land develops or redevelops.

Upon completion of the field work and after further review, a number of assessed wetlands were identified as either constructed storm water ponds or were reevaluated and found to be non wetland. These are not included as assessed wetlands in the inventory results. The storm water ponds identified during the inventory are shown on **Figure 4**.

B. Wetland Management Categories and Strategies

Based on the MnRAM 3.1 wetland function and value assessment conducted during 2007/2008, five different management categories were developed as follows:

Preserve (P): Wetlands that were placed into the Preserve category generally provided the highest functions for vegetative diversity and wildlife habitat. There are approximately 89 acres of P wetlands in the City.

Manage 1 (M1): Wetlands that were placed into the Manage 1 category generally provided high functions for vegetative diversity and wildlife habitat with some functions for water quality protection and flood attenuation. There are approximately 34 acres of M1 wetlands in the City.

Manage 2 (M2): Wetlands that were placed into the Manage 2 category generally provided some functions for vegetative diversity and wildlife habitat with high functions for water quality protection and flood attenuation. There are approximately 82 acres of M2 wetlands in the City.

Manage 3 (M3): Wetlands that were placed into the Manage 3 category generally provided the highest functions for water quality protection and flood attenuation. Many of these wetlands serve storm water storage and treatment functions. There are approximately 9 acres of M3 wetlands in the City.

Storm Water Pond: Water bodies that were created in upland areas for the purpose of treating and/or storing storm water runoff were put into the Storm Water Pond category. There are approximately 35 acres of Storm Water Ponds in the City. These water bodies are not within the jurisdiction of the Wetland Conservation Act.

Each management category has a different management strategy based on the wetland functions and values. These management strategies are outlined below.

1. Wetland buffers

Buffers are an upland area adjacent to a wetland that is covered with vegetation that experiences little to no human impact such as mowing or fertilizing. Buffers are effective management tools for protecting wetland systems. Vegetated buffers provide cover and nesting habitat for wildlife, reduce erosion around the wetland, provide vegetative diversity, and reduce the amount of pollutants in overland overflow runoff prior to discharge to the wetland.

The CRWD and RWMWD have implemented wetland buffer requirements within their respective watersheds as follows:

Table 1. Buffer requirements of the CRWD and RWMWD

Management Class	CRWD	RWMWD
Preserve / A	25 feet	Minimum 37.5 feet; average 75 feet
Manage 1 / B	25 feet	Minimum 25 feet; average 50 feet
Manage 2 / C	25 feet	Minimum 12 feet; average 25 feet
Manage 3	25 feet	NA
Water Quality Ponds	NA	10 feet

As part of this Wetland Management Plan, the City adopts buffer requirements around existing wetlands for all new or redevelopment as follows, except where a watershed district has more restrictive buffer requirements in place:

Table 2. Buffer requirements* of the City of St. Paul

Management Class	City Buffer Requirement
Preserve	25 feet
Manage 1	25 feet
Manage 2	25 feet
Manage 3	25 feet

** Buffers shall not preclude maintenance for sediment removal or construction of BMP's adjacent to these wetlands.*

Due to the fully developed nature of the City, implementing buffers on previously developed private property is very difficult. A buffer of any width will be encouraged through education efforts around existing wetlands that are not experiencing development or redevelopment. Additionally, the City will maintain these buffer widths within City-owned property to the extent that land is available for this use. However, the City does not anticipate remove existing trails or roads to accomplish the full buffer width as this would be cost prohibitive and result in safety and traffic issues. Storm water ponds or other Best Management Practices (BMP's) will be allowed within the designated buffer.

Additionally, an easement around the water body and buffer will be required if none exists at the time of work.

2. Storm Water Management

Wetlands have the ability to provide storm water treatment and decrease the risks of downstream flooding. The nutrients and sediment present in storm water runoff can have a detrimental impact on some wetlands. However, other wetlands are not as sensitive to storm water impacts and may provide an overall benefit to the community by providing storm water treatment functions.

The CRWD and RWMWD require 90% removal of sediment and 60% removal of phosphorus prior to discharge to Preserve/A, Manage 1/B, and Manage 2/C wetlands. The CRWD also requires this removal for Manage 3 wetlands. The RWMWD requires no pretreatment to Water Quality Ponds, as these areas act as water treatment areas. The City will not require any pretreatment prior to discharge to storm water ponds as these areas are designated storm water management areas and are not regulated by this Plan. Wetland areas will continue to be used for rate control or to meet original design performance standards, as many wetlands are currently functioning to provide rate control within the City. As part of the City's storm water management initiatives in the next few years, the City will investigate local or regional BMP's that are reasonable and practical to implement.

3. Wetland Mitigation and Sequencing

The Wetland Conservation Act (WCA) guidelines serve as a baseline for the evaluation of impacts and associated wetland mitigation and replacement plans. Any wetland impact within the City is required to follow the avoidance and sequencing outlined within the WCA. Storm water ponds are exempt from this activity as they are not regulated by the WCA. The CRWD and RWMWD have additional requirements that will need to be followed within their jurisdiction.

For wetland mitigation, the City will require wetland replacement for any impacts to Preserve, Manage 1, and Manage 2 wetlands occur with the City boundaries. Consideration should be given to the restoration or wetland mitigation areas identified within this Plan for mitigation, when feasible. Storm water ponds are not under the jurisdiction of the WCA as they were constructed in upland areas. Therefore, no mitigation is required for impacts to storm water ponds.

4. Public Ditch Systems and Creek Maintenance

There are a variety of public ditch systems and creek systems throughout the City. Maintenance of these public ditches will continue to be through the ditch authority. Removal of deadfall, streambank stabilization, and other projects to maintain these public ditches will be allowed to be completed and will be regulated under applicable State laws. Additionally, deadfall removal and streambank stabilization will be allowed along any creek, if needed.

C. New Wetlands and Wetlands not Assessed

New wetlands include wetlands created as part of a wetland mitigation/creation project that did not exist at the time this plan was adopted. Wetland areas not intentionally created such as those created by culvert blockage, beavers, etc. as outlined in Minn. Rules 8420.0122 shall not become part of this plan. City Staff will initially place newly created wetlands in the management category of the wetland that is being replaced or as otherwise determined by Staff. Newly created wetlands for mitigation are required to have a buffer commensurate with the width required for the wetland impacted.

City Staff will review the newly created wetlands at least five years after creation/restoration to determine if the wetland meets the functions and values of the management category of the wetland that it replaced. The annual wetland monitoring reports as required by the Wetland Conservation Act will also be used in this evaluation. The City will determine if additional work is needed or if the management goal has been met or is attainable in the near future.

All known wetlands within the study area were evaluated with the exception of those areas where permission to access the site was not granted or the site could not be accessed due to safety issues. The absence of a wetland from this plan does not mean that a wetland is not present on the site. Extreme efforts were taken to ensure that all wetlands within the study site were evaluated as part of the development of this plan; however, the unintentional omission of a particular wetland does not grant permission to impact that wetland before going through the proper regulatory process. It is important to note that wetland edges were not delineated as part of this project. A wetland delineation will need to be performed as part of any potential impact of development or redevelopment activity near the wetlands.

If an existing wetland was not evaluated as part of this plan, the MnRAM 3.1 assessment contained within **Appendix C** will need to be completed by the applicant and submitted to the City for review and classification. Based on this assessment, the City Staff will place the wetland into a management category.

SECTION VI – IMPLEMENTATION PROGRAM

As part of this Wetland Management Plan, several programs and projects have been identified to protect wetlands as the City continues to experience development pressure. The following lists programs and/or projects that have been identified by this Plan.

1. **Public Education:** Wetlands and buffers provide a wide variety of benefits to wildlife, water quality, and the public. The goal of the City is to continue to educate its citizens about the importance of wetlands and wetland buffers, and to encourage voluntary stewardship of wetland resources through public education. Multi-level education can be achieved through schools, community workshops, local newspapers, special interest groups, City sponsored workshops, the City's newsletter, information on the City's web-page, and use of interpretive signage throughout the park and trail system in St. Paul. The WMP serves as a general resource tool for the City to reference when implementing wetland education programs.

2. **Potential Restorable Wetlands:** Some wetlands within the plan have been identified as having the potential to restore or enhance. These wetlands are shown on **Figure 5.** The City will pursue grant funding and other resources to restore these areas through a combination of in-wetland enhancements and/or upstream BMPs.

3. **Potential Mitigation Areas**: Some potential mitigation areas have been identified and are shown on **Figure 5.** As projects that impact wetlands occur in the City, the City will encourage project proposers to use these sites for mitigation.

4. **Water Quality Projects:** A number of wetlands were identified as needing additional storm water treatment. These areas will be prioritized by the City and the City will pursue grant funding and other resources to implement BMPs within the wetland's subwatershed.

SECTION VII – ENFORCEMENT, AMENDMENT, APPEALS

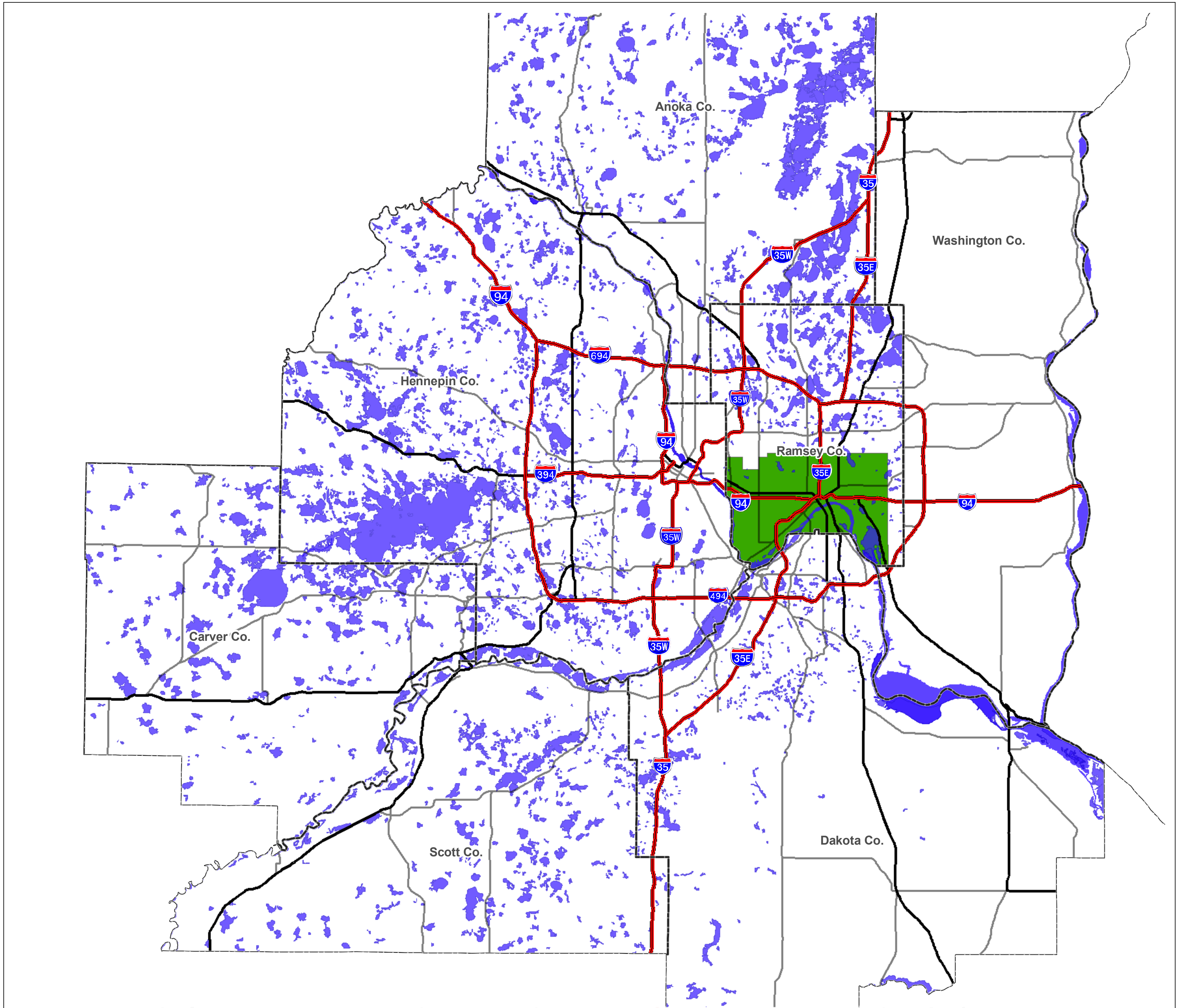
It is the intent to have this WMP adopted by the City. Once adopted, significant changes to this Plan shall be made known to the following parties:

- X The Mayor, City Council, and City Staff
- X Planning Commission
- X Watershed Management Organizations and Watershed Districts
- X Metropolitan Council
- X Board of Water and Soil Resources

Minor changes to the Plan including the addition of newly classified wetlands can be made by the City without outside review. Revision to the management strategies shall be considered a major change.

The management classification of a wetland within the Plan can be appealed by the landowner, project proposer, or other interested party. This appeal must be submitted in writing to the City and include documentation supporting the reasons for placing a wetland into a different management category. This written appeal must be submitted to the City prior to or along with the wetland impact permit application. A fee, as set by the City, will be required for each wetland being appealed. The appeal will be reviewed by City Staff and the Technical Evaluation Panel. A decision will be made regarding the appeal within 60 days of receipt of the appropriate documentation from the appellant if the appeal is submitted during the growing season. If the appeal is submitted outside of the growing season, a decision will be made within 60 days after the start of the growing season. The appellant will be notified in writing of the panel's decision. If not specifically stated in this Plan, the appeal process in Minnesota Rules 8420 will apply.

The City's decision regarding the wetland impact permit application can be appealed by a project proposer. This appeal must be made to BWSR within 30 days after the date on which the decision of the City is mailed to those required to receive notification of the decision. Minn. Rules 8420.0250 can be consulted for further information. Enforcement will be in conformance with the City Code and Minnesota Rules 8420.



SAINT PAUL

City of St. Paul
Wetland Management Plan

Figure I Location Map

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WSB & Associates, Inc.

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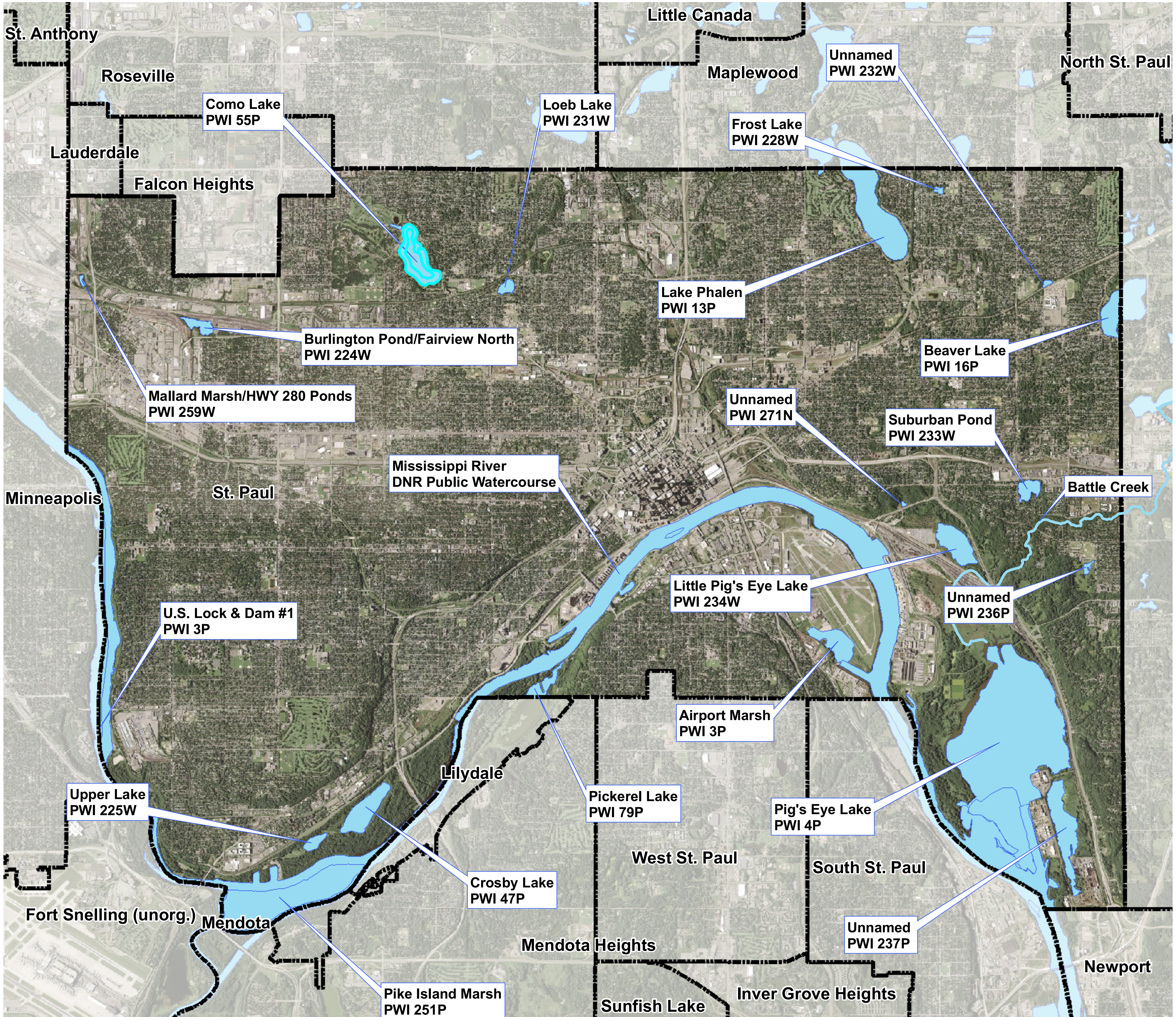

SAINT PAUL

City of St. Paul

Wetland Management Plan

Figure II DNR Public Waters/Wetlands Map

N
W E
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0 2,500 5,000 10,000 Feet

Legend

MnDNR PUBLIC WATERS/WETLANDS

WSB & Associates, Inc.

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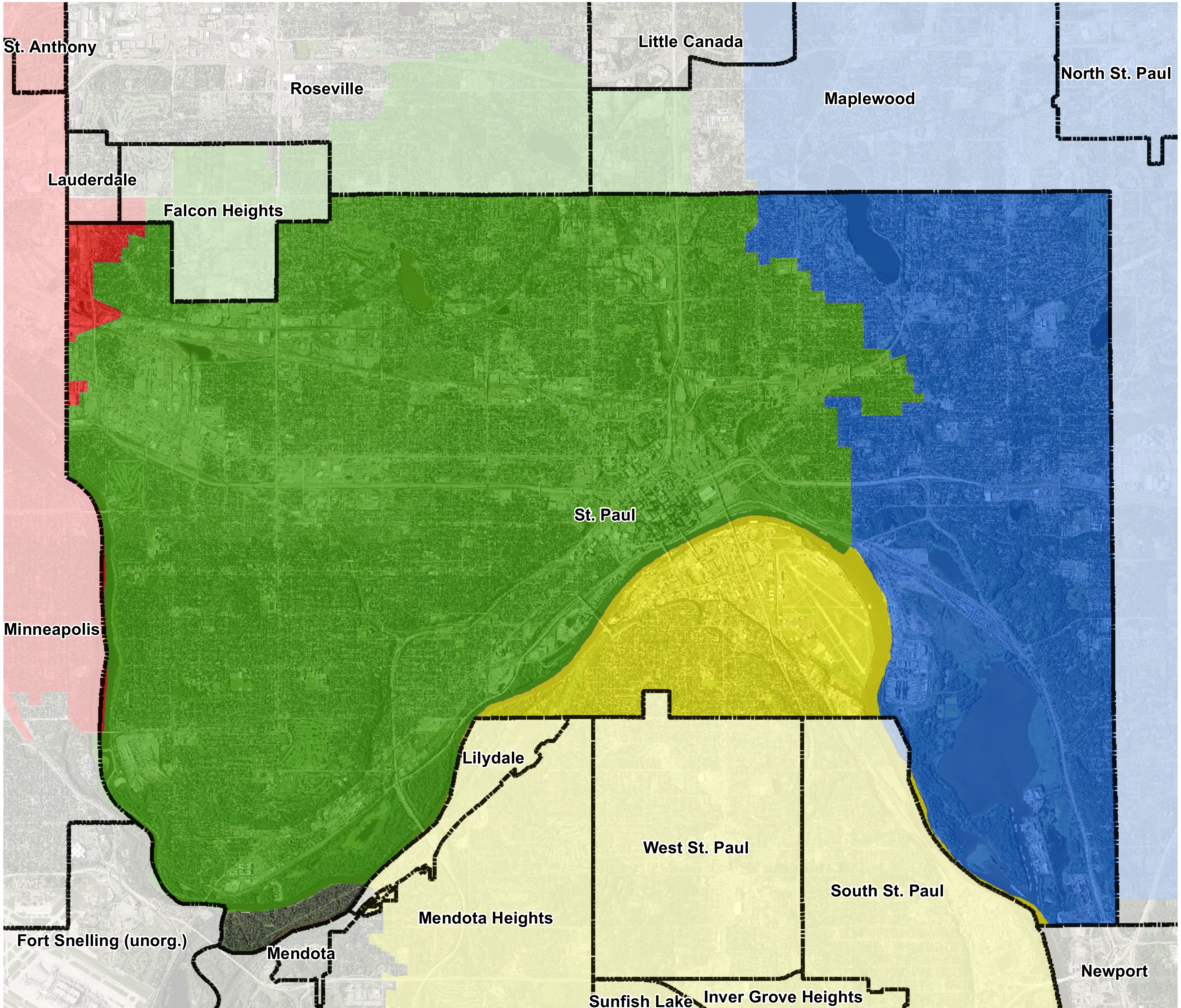

City of St. Paul
Wetland Management Plan

Figure III Watershed District & Management Organizations Boundary Map

N
W E
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0 2,500 5,000 10,000
Feet

Legend

- CAPITOL REGION WD (CRWD)
- LOWER MISSISSIPPI RIVER WMO (LMRWMO)
- MISSISSIPPI WMO (MWMO)
- RAMSEY/WASHINGTON/METRO WD (RWMWD)

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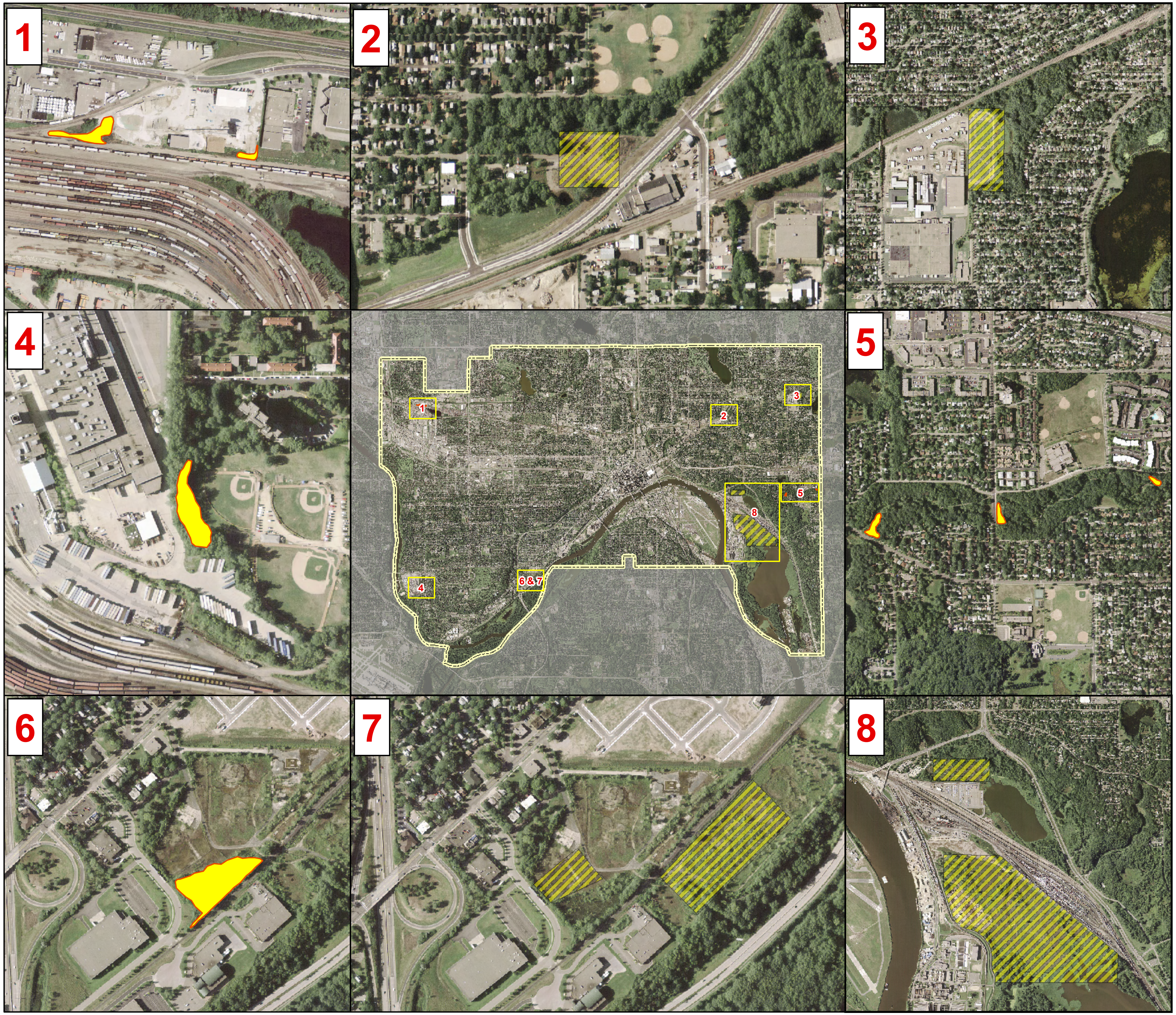
City of St. Paul

Wetland Management Plan

Figure IV

Management Classifications

Wetland boundaries shown are approximate. The boundaries shown on this map were not delineated and do not represent the actual extent of the wetland. Efforts were taken to ensure that all wetlands within the study site were evaluated; however, the unintentional omission of a wetland does not grant permission to impact a wetland before going through the proper permitting process.



City of St. Paul
WETLAND MANAGEMENT PLAN

FIGURE V RESTORATION AND MITIGATION AREAS

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LEGEND

- Potential Restoration Areas
- Potential Mitigation Areas
- City Boundary

WSB & Associates, Inc.

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Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-22-02-139-A	Battle Creek	20.30412	PEMH	Type 4	Deep Marsh	100	0.1				
62-028-22-02-139-A						100		Low	Low	Low	☐
62-028-22-02-140-A	Battle Creek	0.681219	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-140-A						100		Low	Low	Low	☐
62-028-22-02-141-A	Battle Creek	0.408189	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-141-A						100		Low	Low	Low	☐
62-028-22-02-142-A	Battle Creek	0.132937	PEMB	Type 2	Sedge Meadow	100	0.5				
62-028-22-02-142-A						100		Moderate	Moderate	Moderate	☐
62-028-22-02-143-A	Battle Creek	0.215575	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-143-A						100		Low	Low	Low	☐
62-028-22-02-144-A	Battle Creek	0.052948	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-144-A						100		Low	Low	Low	☐
62-028-22-02-145-A	Battle Creek	0.055010	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-145-A						100		Low	Low	Low	☐
62-028-22-02-146-A	Blufflands	4.480529	PUBH	Type 5	Shallow, Open Water Communities	60	0.1				
62-028-22-02-146-A	Blufflands	4.480529	PEMF	Type 3	Shallow Marsh	40	0.5				
62-028-22-02-146-A						100		Moderate	Low	Low	☐
62-028-22-02-147-A	Blufflands	0.063279	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-147-A						100		Low	Low	Low	☐
62-028-22-02-148-A	Blufflands	0.782393	PEMC	Type 2	Sedge Meadow	0	0.5				

** Denotes incomplete calculation data.*

Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
						Vegetative Diversity/Integrity					
62-028-22-02-148-A								Moderate	Moderate	Not Applicable	☐
62-028-22-02-150-A	Blufflands	0.199212	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-150-A						100		Low	Low	Low	☐
62-028-22-02-151-A	Blufflands	0.086541	PEMC	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-02-151-A						100		Low	Low	Low	☐
62-028-22-02-172-A	Battle Creek	0.106131	PEMF	Type 3	Shallow Marsh	100	0.1				
62-028-22-02-172-A						100		Low	Low	Low	☐
62-028-22-02-173-A	Battle Creek	0.250623	PEMF	Type 3	Shallow Marsh	100	0.1				
62-028-22-02-173-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-02-195-A	Blufflands	0.402074	PSS1B	Type 6	Shrub Carr	100	0.1				
62-028-22-02-195-A						100		Low	Low	Low	☐
62-028-22-03-168-A	Beltline Stormsewer	0.128862	PUBF	Type 5	Shallow, Open Water Communities	100	0.1				
62-028-22-03-168-A						100		Low	Low	Low	☐
62-028-22-03-169-A	Battle Creek	0.118053	PEMC	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-03-169-A						100		Low	Low	Low	☐
62-028-22-03-170-A	Battle Creek	0.052859	PUBF	Type 5	Shallow, Open Water Communities	100	0.1				
62-028-22-03-170-A						100		Low	Low	Low	☐
62-028-22-03-171-A	Battle Creek	0.087032	PUBF	Type 5	Shallow, Open Water Communities	100	0.1				
62-028-22-03-171-A						100		Exceptional	Exceptional	Exceptional	☐

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
			Community			Vegetative Diversity/Integrity					
62-028-22-03-174-A	Pigs Eye	0.166499	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-03-174-A						100		Low	Low	Low	☐
62-028-22-03-175-A	Pigs Eye	12.69111	PEMF	Type 3	Shallow Marsh	70	0.1				
62-028-22-03-175-A	Pigs Eye	12.69111	PSS1C	Type 6	Shrub Carr	30	0.1				
62-028-22-03-175-A						100		Low	Low	Low	☐
62-028-22-03-176-A	Pigs Eye	1.293888	PEMF	Type 3	Shallow Marsh	10	0.1				
62-028-22-03-176-A	Pigs Eye	1.293888	PSS1C	Type 5	Shallow, Open Water Communities	90	0.1				
62-028-22-03-176-A						100		Low	Low	Low	☐
62-028-22-03-177-A	Pigs Eye	0.855519	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-03-177-A						100		Low	Low	Low	☐
62-028-22-03-178-A	Pigs Eye	0.254034	PEMB	Type 2	Fresh (Wet) Meadow	100	0.5				
62-028-22-03-178-A						100		Moderate	Moderate	Moderate	☐
62-028-22-03-179-A	Pigs Eye	0.901527	PFO1B	Type 7	Hardwood Swamp	100	1				
62-028-22-03-179-A						100		High	High	High	☐
62-028-22-03-181-A	Pigs Eye	8.831292	PEMC	Type 3	Shallow Marsh	60	0.1				
62-028-22-03-181-A	Pigs Eye	8.831292	PSS1C	Type 6	Shrub Carr	40	0.1				
62-028-22-03-181-A						100		Low	Low	Low	☐
62-028-22-03-182-A	Griffith Pt Douglas	2.481039	PEMB	Type 2	Sedge Meadow	100	0.5				
62-028-22-03-182-A						100		Moderate	Moderate	Moderate	☐
62-028-22-03-183-A	Griffith Pt Douglas	17.68052	PEMF	Type 3	Shallow Marsh	100	0.1				

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-22-03-183-A						100		Low	Low	Low	☐
62-028-22-03-191-A	Pigs Eye	0.295562	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-22-03-191-A						100		High	High	High	☐
62-028-22-03-192-A	Pigs Eye	0.204077	PFO1B	Type 7	Hardwood Swamp	100	1				
62-028-22-03-192-A						100		High	High	High	☐
62-028-22-03-193-A	Pigs Eye	0.193859	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-03-193-A						100		Low	Low	Low	☐
62-028-22-03-194-A	Pigs Eye	0.325928	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-03-194-A						100		Low	Low	Low	☐
62-028-22-04-099-A	Pigs Eye	0.206584	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-22-04-099-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-04-100-A	Pigs Eye	0.230807	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-22-04-100-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-04-101-A	Pigs Eye	0.284962	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-22-04-101-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-04-102-A	Pigs Eye	0.401948	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-22-04-102-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-04-103-A	Pigs Eye	1.523533	PFO1B	Type 7	Hardwood Swamp	20	0.5				
62-028-22-04-103-A	Pigs Eye	1.523533	PUBG	Type 5	Shallow, Open Water Communities	60	0.5				
62-028-22-04-103-A	Pigs Eye	1.523533	PEMF	Type 4	Deep Marsh	20	0.5				

Column group "Vegetative Diversity/Integrity" spans Community through Weighted Average Wetland Rating.

**** Denotes incomplete calculation data.***

Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity								
			Community								
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-22-04-103-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-22-04-180-A	Pigs Eye	0.203717	PUBH	Type 5	Shallow, Open Water Communities	100	0.1				
62-028-22-04-180-A						100		Low	Low	Low	☐
62-028-22-05-094-A	Downtown	0.510607	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-05-094-A						100		Low	Low	Low	☐
62-028-22-10-189-A	Blufflands	0.287912	PEMC	Type 3	Shallow Marsh	65	0.1				
62-028-22-10-189-A	Blufflands	0.287912	PEMB	Type 2	Fresh (Wet) Meadow	35	0.1				
62-028-22-10-189-A						100		Low	Low	Low	☐
62-028-22-10-190-A	Blufflands	0.071428	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-028-22-10-190-A						100		Low	Low	Low	☐
62-028-22-11-149-A	Blufflands	0.348957	PUBF	Type 5	Shallow, Open Water Communities	80	0.1				
62-028-22-11-149-A	Blufflands	0.348957	PEMB	Type 2	Fresh (Wet) Meadow	20	0.1				
62-028-22-11-149-A						100		Low	Low	Low	☐
62-028-22-11-152-A	Blufflands	0.330242	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-11-152-A						100		Low	Low	Low	☐
62-028-22-11-153-A	Blufflands	0.582062	PUBF	Type 5	Shallow, Open Water Communities	85	0.1				
62-028-22-11-153-A	Blufflands	0.582062	PEMB	Type 2	Fresh (Wet) Meadow	15	0.1				
62-028-22-11-153-A						100		Low	Low	Low	☐
62-028-22-11-154-A	Blufflands	0.267699	PEMB	Type 2	Sedge Meadow	0	0.5				

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Vegetative Diversity/Integrity: Community: Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-22-11-154-A								Moderate	Moderate	Not Applicable	
62-028-22-11-155-A	Blufflands	0.051143	PEMB	Type 2	Fresh (Wet) Meadow	0	0.1				
62-028-22-11-155-A								Low	Low	Not Applicable	
62-028-22-11-156-A	Blufflands	0.126785	PEMB	Type 2	Fresh (Wet) Meadow	0	0.1				
62-028-22-11-156-A								Low	Low	Not Applicable	
62-028-22-11-157-A	Blufflands	0.158708	PEMB	Type 2	Fresh (Wet) Meadow	85	0.1				
62-028-22-11-157-A	Blufflands	0.158708	PEMC	Type 3	Shallow Marsh	15	0.1				
62-028-22-11-157-A						100		Low	Low	Low	
62-028-22-11-158-A	Blufflands	0.053235	PEMC	Type 2	Sedge Meadow	0	0.5				
62-028-22-11-158-A								Moderate	Moderate	Not Applicable	
62-028-22-11-159-A	Blufflands	0.061708	PEMA	Type 1	Seasonally Flooded Basin	100	0.5				
62-028-22-11-159-A						100		Moderate	Moderate	Moderate	
62-028-22-11-160-A	Blufflands	0.943021	PUBF	Type 5	Shallow, Open Water Communities	85	0.1				
62-028-22-11-160-A	Blufflands	0.943021	PEMB	Type 2	Fresh (Wet) Meadow	15	0.1				
62-028-22-11-160-A						100		Low	Low	Low	
62-028-22-11-161-A	Blufflands	0.386368	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-22-11-161-A						100		Low	Low	Low	
62-028-22-11-162-A	Blufflands	0.793750	PEMF	Type 3	Shallow Marsh	100	0.1				
62-028-22-11-162-A						100		Low	Low	Low	
62-028-22-11-163-A	Blufflands	0.188708	PEMC	Type 3	Shallow Marsh	75	0.1				

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Vegetative Diversity/Integrity: Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-22-11-163-A	Blufflands	0.188708	PEMB	Type 2	Fresh (Wet) Meadow	25	0.1				
62-028-22-11-163-A						100		Low	Low	Low	☐
62-028-22-11-164-A	Blufflands	0.177907	PEMF	Type 3	Shallow Marsh	100	0.1				
62-028-22-11-164-A						100		Low	Low	Low	☐
62-028-22-11-167-A	Blufflands	4.886536	PFO1B	Type 7	Hardwood Swamp	100	0.5				
62-028-22-11-167-A						100		Moderate	Moderate	Moderate	☐
62-028-22-14-165-A	Blufflands	0.228035	PEMF	Type 3	Shallow Marsh	100	0.1				
62-028-22-14-165-A						100		Low	Low	Low	☐
62-028-22-14-166-A	Blufflands	0.07816	PUBF	Type 5	Shallow, Open Water Communities	60	0.1				
62-028-22-14-166-A	Blufflands	0.07816	PEMB	Type 2	Fresh (Wet) Meadow	40	0.1				
62-028-22-14-166-A						100		Low	Low	Low	☐
62-028-23-09-028-A	Mississippi River Blvd	1.651892	PEMF	Type 4	Deep Marsh	25	0.5				
62-028-23-09-028-A	Mississippi River Blvd	1.651892	PUBFx	Type 5	Shallow, Open Water Communities	65	0.5				
62-028-23-09-028-A	Mississippi River Blvd	1.651892	PEMA	Type 1	Seasonally Flooded Basin	100	0.5				
62-028-23-09-028-A						190		Moderate	Moderate	High	☐
62-028-23-09-029-A	Mississippi River Blvd	0.639888	PFO1A	Type 7	Hardwood Swamp	100	0.5				
62-028-23-09-029-A						100		Moderate	Moderate	Moderate	☐
62-028-23-12-188-A	Urban	0.217242	PFO1B	Type 7	Hardwood Swamp	100	0.5				
62-028-23-12-188-A						100		Exceptional	Exceptional	Exceptional	☐

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Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-23-14-045-A	Crosby	2.035057	PEMF	Type 3	Shallow Marsh	80	0.1				
62-028-23-14-045-A	Crosby	2.035057	PSS1C	Type 6	Shrub Carr	20	0.1				
62-028-23-14-045-A						100		Low	Low	Low	☐
62-028-23-14-046-A	Crosby	0.157386	PSS1C	Type 6	Shallow Marsh	100	0.1				
62-028-23-14-046-A						100		Low	Low	Low	☐
62-028-23-14-047-A	Crosby	0.134412	PEMC	Type 3	Shallow Marsh	100	0.1				
62-028-23-14-047-A						100		Low	Low	Low	☐
62-028-23-14-048-A	Crosby	0.682516	PEMC	Type 3	Shallow Marsh	80	0.5				
62-028-23-14-048-A	Crosby	0.682516	PFO1B	Type 7	Hardwood Swamp	20	0.5				
62-028-23-14-048-A						100		Moderate	Moderate	Moderate	☐
62-028-23-14-109-A	Crosby	0.061977	PFO1A	Type 7	Hardwood Swamp	80	0.1				
62-028-23-14-109-A	Crosby	0.061977	PEMA	Type 1	Fresh (Wet) Meadow	20	0.1				
62-028-23-14-109-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-15-043-A	Crosby	0.382093	PFO1A	Type 7	Floodplain Forest	100	0.5				
62-028-23-15-043-A						100		Moderate	Moderate	Moderate	☐
62-028-23-15-044-A	Davern	1.196871	PFO1B	Type 7	Floodplain Forest	40	0.5				
62-028-23-15-044-A	Davern	1.196871	PEMA	Type 1	Seasonally Flooded Basin	60	1				
62-028-23-15-044-A						100		High	High	High	☐
62-028-23-17-014-A	Hidden Falls	0.463513	PEMB	Type 2	Fresh (Wet) Meadow	60	0.5				
62-028-23-17-014-A	Hidden Falls	0.463513	PFO1C	Type 7	Shallow, Open Water Communities	40	0.1				

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Wetland Community Summary
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			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-028-23-17-014-A						100		Moderate	Low	Moderate	☐
62-028-23-17-015-A	Davern	7.490337	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-23-17-015-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-17-016-A	Hidden Falls	0.098814	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-23-17-016-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-17-017-A	Hidden Falls	0.031378	PFO1A	Type 7	Hardwood Swamp	100	1				
62-028-23-17-017-A						100		High	High	High	☐
62-028-23-17-018-A	Hidden Falls	0.016891	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-23-17-018-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-17-019-A	Davern	0.067955	PFO1A	Type 7	Hardwood Swamp	100	0.1				
62-028-23-17-019-A						100		Low	Low	Low	☐
62-028-23-20-020-A	Davern	0.052635	PFO1A	Type 7	Hardwood Swamp	100	1				
62-028-23-20-020-A						100		High	High	High	☐
62-028-23-20-021-A	Davern	0.376514	PFO1A	Type 7	Hardwood Swamp	100	1				
62-028-23-20-021-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-022-A	Davern	0.196019	PFO1A	Type 7	Hardwood Swamp	100	1				
62-028-23-21-022-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-023-A	Davern	0.082664	PFO1C	Type 7	Hardwood Swamp	100	1				
62-028-23-21-023-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-024-A	Davern	5.380334	PFO1A	Type 7	Hardwood Swamp	70	1				

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Wetland Community Summary
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Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
			Vegetative Diversity/Integrity								
			Community								
62-028-23-21-024-A	Davern	5.380334	PEMA	Type 1	Fresh (Wet) Meadow	20	0.1				
62-028-23-21-024-A	Davern	5.380334	PEMA	Type 1	Wet to Wet-Mesic Prairie	10	0.5				
62-028-23-21-024-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-025-A	Crosby	1.373124	PFO1A	Type 7	Hardwood Swamp	100	0.1				
62-028-23-21-025-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-026-A	Crosby	3.749081	PEMF	Type 4	Deep Marsh	25	1				
62-028-23-21-026-A	Crosby	3.749081	PUBF	Type 5	Shallow, Open Water Communities	75	0.1				
62-028-23-21-026-A						100		Exceptional	Exceptional	Exceptional	☐
62-028-23-21-027-A	Crosby	2.394543	PFO1A	Type 7	Hardwood Swamp	100	1				
62-028-23-21-027-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-19-059-A	Trout Brook	0.803894	PEMC	Type 3	Shallow Marsh	75	0.5				
62-029-22-19-059-A	Trout Brook	0.803894	PSS1B	Type 6	Shrub Carr	25	0.5				
62-029-22-19-059-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-060-A	Trout Brook	1.148368	PEMC	Type 3	Shallow Marsh	75	0.1				
62-029-22-19-060-A	Trout Brook	1.148368	PFO1A	Type 7	Hardwood Swamp	25	0.1				
62-029-22-19-060-A						100		Low	Low	Low	☐
62-029-22-19-061-A	Trout Brook	0.125113	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-19-061-A						100		Low	Low	Low	☐
62-029-22-19-062-A	Trout Brook	0.454050	PEMC	Type 3	Shallow Marsh	55	0.5				

**** Denotes incomplete calculation data.***

Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Vegetative Diversity/Integrity: Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-19-062-A	Trout Brook	0.454050	PUBF	Type 5	Shallow, Open Water Communities	45	0.5				
62-029-22-19-062-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-063-A	Trout Brook	0.86304	PEMC	Type 3	Shallow Marsh	55	0.1				
62-029-22-19-063-A	Trout Brook	0.86304	PSS1C	Type 6	Shrub Carr	45	0.5				
62-029-22-19-063-A						100		Moderate	Low	Low	☐
62-029-22-19-064-A	Trout Brook	0.255263	PSS1C	Type 6	Shrub Carr	100	0.1				
62-029-22-19-064-A						100		Low	Low	Low	☐
62-029-22-19-065-A	Trout Brook	0.136168	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				
62-029-22-19-065-A						100		Low	Low	Low	☐
62-029-22-19-066-A	Trout Brook	2.063706	PEMB	Type 2	Fresh (Wet) Meadow	60	0.5				
62-029-22-19-066-A	Trout Brook	2.063706	PEMC	Type 3	Shallow Marsh	40	0.5				
62-029-22-19-066-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-067-A	Trout Brook	10.40949	PEMC	Type 3	Shallow Marsh	50	0.5				
62-029-22-19-067-A	Trout Brook	10.40949	PSS1C	Type 6	Shrub Carr	20	0.5				
62-029-22-19-067-A	Trout Brook	10.40949	PEMF	Type 4	Deep Marsh	30	0.5				
62-029-22-19-067-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-068-A	Trout Brook	0.084279	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				
62-029-22-19-068-A						100		Low	Low	Low	☐
62-029-22-19-069-A	Trout Brook	0.016225	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				
62-029-22-19-069-A						100		Low	Low	Low	☐

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
						Vegetative Diversity/Integrity					
62-029-22-19-070-A	Trout Brook	0.177399	PEMB	Type 2	Fresh (Wet) Meadow	100	0.5				
62-029-22-19-070-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-071-A	Trout Brook	0.501796	PEMB	Type 2	Fresh (Wet) Meadow	100	0.5				
62-029-22-19-071-A						100		Moderate	Moderate	Moderate	☐
62-029-22-19-072-A	Trout Brook	0.067791	PEMF	Type 4	Deep Marsh	70	0.5				
62-029-22-19-072-A	Trout Brook	0.067791	PEMC	Type 3	Shallow Marsh	30	0.1				
62-029-22-19-072-A						100		Moderate	Low	Moderate	☐
62-029-22-20-077-A	Trout Brook	1.028237	PEMC	Type 3	Shallow Marsh	40	0.1				
62-029-22-20-077-A	Trout Brook	1.028237	PUBG	Type 5	Shallow, Open Water Communities	60	0.1				
62-029-22-20-077-A						100		Low	Low	Low	☐
62-029-22-20-078-A	Trout Brook	0.336117	PEMFx	Type 4	Deep Marsh	100	0.1				
62-029-22-20-078-A						100		Low	Low	Low	☐
62-029-22-20-079-A	Trout Brook	0.141749	PEMA	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-22-20-079-A						100		Low	Low	Low	☐
62-029-22-20-080-A	Trout Brook	0.037744	PEMA	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-22-20-080-A						100		Low	Low	Low	☐
62-029-22-20-081-A	Trout Brook	1.881719	PEMF	Type 4	Deep Marsh	70	0.1				
62-029-22-20-081-A	Trout Brook	1.881719	PEMC	Type 3	Shallow Marsh	30	0.1				
62-029-22-20-081-A						100		Low	Low	Low	☐
62-029-22-20-082-A	Trout Brook	0.61675	PEMF	Type 4	Deep Marsh	90	0.1				

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Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity								
			Community								
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-20-082-A	Trout Brook	0.61675	PEMC	Type 3	Shallow Marsh	10	0.1				
62-029-22-20-082-A						100		Low	Low	Low	☐
62-029-22-20-083-A	Trout Brook	0.117557	PFO1A	Type 7	Seasonally Flooded Basin	100	0.1				
62-029-22-20-083-A						100		Low	Low	Low	☐
62-029-22-20-084-A	Trout Brook	0.045456	PEMA	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-22-20-084-A						100		Low	Low	Low	☐
62-029-22-20-085-A	Trout Brook	0.021011	PFO1A	Type 7	Seasonally Flooded Basin	100	0.1				
62-029-22-20-085-A						100		Low	Low	Low	☐
62-029-22-20-086-A	Trout Brook	0.051714	PFO1A	Type 7	Seasonally Flooded Basin	100	0.1				
62-029-22-20-086-A						100		Low	Low	Low	☐
62-029-22-20-087-A	Trout Brook	0.052566	PFO1A	Type 7	Seasonally Flooded Basin	100	0.1				
62-029-22-20-087-A						100		Low	Low	Low	☐
62-029-22-21-089-A	Lake Phalen	5.293864	PSS1F	Type 6	Shrub Carr	40	1				
62-029-22-21-089-A	Lake Phalen	5.293864	PUBG	Type 5	Shallow, Open Water Communities	40	1				
62-029-22-21-089-A	Lake Phalen	5.293864	PEMA	Type 1	Fresh (Wet) Meadow	20	0.1				
62-029-22-21-089-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-21-090-A	Beltline Stormsewer	1.350041	PEMC	Type 3	Shallow Marsh	60	0.5				
62-029-22-21-090-A	Beltline Stormsewer	1.350041	PEMF	Type 4	Deep Marsh	40	1				
62-029-22-21-090-A						100		High	High	High	☐
62-029-22-21-091-A	Lake Phalen	0.551443	PEMC	Type 3	Shallow Marsh	60	0.5				

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Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity								
			Community								
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-21-091-A	Lake Phalen	0.551443	PUBFx	Type 4	Deep Marsh	40	0.1				
62-029-22-21-091-A						100		Moderate	Low	Moderate	☐
62-029-22-22-104-A	Lake Phalen	4.350023	PFO1C	Type 7	Hardwood Swamp	20	1				
62-029-22-22-104-A	Lake Phalen	4.350023	PEMF	Type 4	Deep Marsh	80	0.5				
62-029-22-22-104-A						100		High	High	Moderate	☐
62-029-22-22-105-A	Lake Phalen	0.195868	PFO1A	Type 7	Hardwood Swamp	100	0.5				
62-029-22-22-105-A						100		Moderate	Moderate	Moderate	☐
62-029-22-22-106-A	Beltline Stormsewer	0.854898	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-22-106-A						100		Low	Low	Low	☐
62-029-22-22-107-A	Beltline Stormsewer	2.110253	PFO1B	Type 7	Hardwood Swamp	80	0.5				
62-029-22-22-107-A	Beltline Stormsewer	2.110253	PEMC	Type 3	Shallow Marsh	20	0.5				
62-029-22-22-107-A						100		Moderate	Moderate	Moderate	☐
62-029-22-22-110-A	Beltline Stormsewer	4.512286	PSS1B	Type 6	Shrub Carr	10	0.1				
62-029-22-22-110-A	Beltline Stormsewer	4.512286	PEMF	Type 3	Shallow Marsh	30	0.1				
62-029-22-22-110-A	Beltline Stormsewer	4.512286	PEMB	Type 2	Fresh (Wet) Meadow	60	0.1				
62-029-22-22-110-A						100		Low	Low	Low	☐
62-029-22-22-111-A	Beltline Stormsewer	0.352036	PEMB	Type 2	Sedge Meadow	25	0.5				
62-029-22-22-111-A	Beltline Stormsewer	0.352036	PUBF	Type 5	Shallow, Open Water Communities	75	0.1				
62-029-22-22-111-A						100		Moderate	Low	Low	☐
62-029-22-22-112-A	Beltline Stormsewer	0.512709	PEMC	Type 3	Shallow Marsh	60	0.1				

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
			Vegetative Diversity/Integrity								
			Community								
62-029-22-22-112-A	Beltline Stormsewer	0.512709	PEMB	Type 2	Fresh (Wet) Meadow	40	0.1				
62-029-22-22-112-A						100		Low	Low	Low	☐
62-029-22-23-123-A	Beltline Stormsewer	5.420329	PEMF	Type 3	Shallow Marsh	40	1				
62-029-22-23-123-A	Beltline Stormsewer	5.420329	PEMC	Type 2	Sedge Meadow	40	1				
62-029-22-23-123-A	Beltline Stormsewer	5.420329	PSS1B	Type 6	Shrub Carr	20	0.5				
62-029-22-23-123-A						100		High	High	High	☐
62-029-22-23-124-A	Beltline Stormsewer	1.140569	PEMF	Type 3	Shallow Marsh	100	0.1				
62-029-22-23-124-A						100		Low	Low	Low	☐
62-029-22-23-127-A	Beltline Stormsewer	4.950738	PSS1B	Type 6	Shrub Carr	70	1				
62-029-22-23-127-A	Beltline Stormsewer	4.950738	PEMC	Type 3	Shallow Marsh	30	0.5				
62-029-22-23-127-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-23-128-A	Beltline Stormsewer	0.388261	PEMF	Type 3	Shallow Marsh	100	0.1				
62-029-22-23-128-A						100		Low	Low	Low	☐
62-029-22-23-129-A	Beltline Stormsewer	0.100111	PFO1B	Type 7	Hardwood Swamp	100	0.1				
62-029-22-23-129-A						100		Low	Low	Low	☐
62-029-22-26-125-A	Beltline Stormsewer	2.949119	PEMG	Type 4	Deep Marsh	100	0.1				
62-029-22-26-125-A						100		Low	Low	Low	☐
62-029-22-26-126-A	Beltline Stormsewer	0.140960	PEMC	Type 5	Shallow, Open Water Communities	40	0.1				
62-029-22-26-126-A	Beltline Stormsewer	0.140960	PEMB	Type 2	Fresh (Wet) Meadow	60	0.1				
62-029-22-26-126-A						100		Low	Low	Low	☐

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
						Vegetative Diversity/Integrity					
62-029-22-26-130-A	Beaver Lake	0.583294	PEMF	Type 3	Shallow Marsh	100	0.1				
62-029-22-26-130-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-26-131-A	Beaver Lake	4.929774	PEMF	Type 3	Shallow Marsh	80	0.1				
62-029-22-26-131-A	Beaver Lake	4.929774	PSS1C	Type 6	Shrub Carr	20	0.1				
62-029-22-26-131-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-26-132-A	Beaver Lake	3.496448	PEMG	Type 4	Deep Marsh	0	0.1				
62-029-22-26-132-A								Low	Low	Not Applicable	☐
62-029-22-26-133-A	Beltline Stormsewer	1.084644	PEMC	Type 3	Shallow Marsh	80	0.1				
62-029-22-26-133-A	Beltline Stormsewer	1.084644	PEMB	Type 2	Fresh (Wet) Meadow	20	0.1				
62-029-22-26-133-A						100		Low	Low	Low	☐
62-029-22-26-134-A	Beltline Stormsewer	0.644192	PSS1B	Type 6	Shrub Carr	100	0.1				
62-029-22-26-134-A						100		Low	Low	Low	☐
62-029-22-27-113-A	Beltline Stormsewer	2.360211	PEMF	Type 5	Shallow, Open Water Communities	80	0.5				
62-029-22-27-113-A	Beltline Stormsewer	2.360211	PEMC	Type 3	Shallow Marsh	20	0.5				
62-029-22-27-113-A						100		Moderate	Moderate	Moderate	☐
62-029-22-27-114-A	Beltline Stormsewer	0.172741	PEMC	Type 3	Shallow Marsh	50	0.1				
62-029-22-27-114-A	Beltline Stormsewer	0.172741	PSS1B	Type 6	Shrub Carr	50	0.5				
62-029-22-27-114-A						100		Moderate	Low	Low	☐
62-029-22-27-115-A	Beltline Stormsewer	0.588865	PSS1B	Type 6	Shrub Carr	100	0.5				
62-029-22-27-115-A						100		Moderate	Moderate	Moderate	☐

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Vegetative Diversity/Integrity: Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-27-116-A	Beltline Stormsewer	0.694579	PSS1C	Type 6	Shrub Carr	100	0.5				
62-029-22-27-116-A						100		Moderate	Moderate	Moderate	
62-029-22-27-117-A	Beltline Stormsewer	1.300666	PEMB	Type 2	Fresh (Wet) Meadow	70	0.1				
62-029-22-27-117-A	Beltline Stormsewer	1.300666	PEMC	Type 3	Shallow Marsh	30	0.1				
62-029-22-27-117-A						100		Low	Low	Low	
62-029-22-27-118-A	Beltline Stormsewer	0.309165	PSS1B	Type 6	Alder Thicket	100	0.1				
62-029-22-27-118-A						100		Low	Low	Low	
62-029-22-27-119-A	Beltline Stormsewer	0.408042	PSS1B	Type 6	Shrub Carr	100	0.1				
62-029-22-27-119-A						100		Low	Low	Low	
62-029-22-28-096-A	Phalen Creek	1.231432	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				
62-029-22-28-096-A						100		Low	Low	Low	
62-029-22-28-097-A	Phalen Creek	0.115279	PEMCx	Type 3	Shallow Marsh	100	0.1				
62-029-22-28-097-A						100		Low	Low	Low	
62-029-22-29-088-A	Trout Brook	0.179503	PEMC	Type 3	Shallow Marsh	100	0.5				
62-029-22-29-088-A						100		Moderate	Moderate	Moderate	
62-029-22-29-092-A	Phalen Creek	0.060027	PEMA	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-22-29-092-A						100		Low	Low	Low	
62-029-22-30-073-A	Trout Brook	3.921484	PUBG	Type 5	Shallow, Open Water Communities	70	0.5				
62-029-22-30-073-A	Trout Brook	3.921484	PEMC	Type 3	Shallow Marsh	30	0.1				
62-029-22-30-073-A						100		Moderate	Low	Moderate	

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Wetland Community Summary
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Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
						Vegetative Diversity/Integrity					
62-029-22-30-074-A	Trout Brook	0.112991	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-30-074-A						100		Low	Low	Low	☐
62-029-22-30-075-A	Trout Brook	0.193911	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-30-075-A						100		Low	Low	Low	☐
62-029-22-30-076-A	Trout Brook	0.956227	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-30-076-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-32-093-A	Phalen Creek	4.005232	PSS1C	Type 6	Shrub Carr	20	1				
62-029-22-32-093-A	Phalen Creek	4.005232	PUBG	Type 5	Shallow, Open Water Communities	30	2				
62-029-22-32-093-A	Phalen Creek	4.005232	PEMF	Type 4	Deep Marsh	50	1				
62-029-22-32-093-A						100		Exceptional	Exceptional	Exceptional	☐
62-029-22-32-095-A	Trout Brook	0.390895	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-32-095-A						100		Low	Low	Low	☐
62-029-22-32-184-A	Trout Brook	0.366292	PEMF	Type 3	Shallow Marsh	80	0.5				
62-029-22-32-184-A	Trout Brook	0.366292	PEMB	Type 2	Fresh (Wet) Meadow	20	1				
62-029-22-32-184-A						100		High	High	Moderate	☐
62-029-22-32-185-A	Trout Brook	0.415313	PEMF	Type 3	Shallow Marsh	80	0.5				
62-029-22-32-185-A	Trout Brook	0.415313	PEMB	Type 2	Fresh (Wet) Meadow	20	1				
62-029-22-32-185-A						100		High	High	Moderate	☐
62-029-22-32-186-A	Trout Brook	0.309051	PEMF	Type 3	Shallow Marsh	80	0.5				
62-029-22-32-186-A	Trout Brook	0.309051	PEMB	Type 2	Fresh (Wet) Meadow	20	1				

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			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-32-186-A						100		High	High	Moderate	☐
62-029-22-32-187-A	Trout Brook	0.373906	PEMF	Type 3	Shallow Marsh	100	0.5				
62-029-22-32-187-A						100		Moderate	Moderate	Moderate	☐
62-029-22-33-098-A	Griffith Pt Douglas	1.707818	PFO1A	Type 7	Hardwood Swamp	100	0.1				
62-029-22-33-098-A						100		Low	Low	Low	☐
62-029-22-34-120-A	Beltline Stormsewer	0.160209	PEMC	Type 3	Shallow Marsh	60	0.1				
62-029-22-34-120-A	Beltline Stormsewer	0.160209	PEMB	Type 2	Fresh (Wet) Meadow	40	0.1				
62-029-22-34-120-A						100		Low	Low	Low	☐
62-029-22-34-121-A	Beltline Stormsewer	0.049365	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-22-34-121-A						100		Low	Low	Low	☐
62-029-22-34-122-A	Beltline Stormsewer	1.934372	PEMC	Type 3	Shallow Marsh	15	0.1				
62-029-22-34-122-A	Beltline Stormsewer	1.934372	PEMB	Type 2	Fresh (Wet) Meadow	85	0.1				
62-029-22-34-122-A						100		Low	Low	Low	☐
62-029-22-35-135-A	Battle Creek	0.754592	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-029-22-35-135-A						100		Low	Low	Low	☐
62-029-22-35-136-A	Battle Creek	0.128048	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-029-22-35-136-A						100		Low	Low	Low	☐
62-029-22-35-137-A	Battle Creek	0.328662	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				
62-029-22-35-137-A						100		Low	Low	Low	☐
62-029-22-35-138-A	Battle Creek	0.545200	PEMA	Type 1	Fresh (Wet) Meadow	100	0.1				

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Wetland Community Summary
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			Vegetative Diversity/Integrity									
			Community								
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-22-35-138-A						100		Low	Low	Low	☐
62-029-23-20-001-A	St. Anthony Falls	0.144368	PEMA	Type 1	Fresh (Wet) Meadow	100	0.5				
62-029-23-20-001-A						100		Moderate	Moderate	Moderate	☐
62-029-23-20-003-A	St. Anthony Falls	1.568139	PEMF	Type 4	Deep Marsh	50	0.5				
62-029-23-20-003-A	St. Anthony Falls	1.568139	PUBF	Type 5	Shallow, Open Water Communities	50	0.1				
62-029-23-20-003-A						100		Moderate	Low	Low	☐
62-029-23-20-007-A	St. Anthony Falls	0.107178	PEMA	Type 1	Fresh (Wet) Meadow	60	0.1				
62-029-23-20-007-A	St. Anthony Falls	0.107178	PEMC	Type 3	Shallow Marsh	40	0.1				
62-029-23-20-007-A						100		Low	Low	Low	☐
62-029-23-20-008-A	St. Anthony Falls	0.107847	PEMA	Type 1	Fresh (Wet) Meadow	20	0.5				
62-029-23-20-008-A	St. Anthony Falls	0.107847	PEMC	Type 3	Shallow Marsh	80	1				
62-029-23-20-008-A						100		High	High	High	☐
62-029-23-22-038-A	Lake Como	0.127637	PEMC	Type 3	Shallow Marsh	100	1				
62-029-23-22-038-A						100		High	High	High	☐
62-029-23-23-041-A	Trout Brook	67.71685	PEMF	Type 4	Deep Marsh	50	0.5				
62-029-23-23-041-A	Trout Brook	67.71685	PSS1C	Type 6	Shrub Carr	50	1				
62-029-23-23-041-A						100		High	High	High	☐
62-029-23-23-042-A	Lake Como	0.230095	PEMC	Type 3	Shallow Marsh	60	0.5				
62-029-23-23-042-A	Lake Como	0.230095	PSS1C	Type 6	Shrub Carr	40	1				
62-029-23-23-042-A						100		High	High	High	☐

*** Denotes incomplete calculation data.***

Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
			Community			Vegetative Diversity/Integrity					
62-029-23-24-049-A	Trout Brook	9.506479	PEMF	Type 4	Deep Marsh	30	0.5				
62-029-23-24-049-A	Trout Brook	9.506479	PUBG	Type 5	Shallow, Open Water Communities	50	0.5				
62-029-23-24-049-A	Trout Brook	9.506479	PFO1B	Type 7	Hardwood Swamp	20	0.1				
62-029-23-24-049-A						100		Moderate	Moderate	Moderate	☐
62-029-23-24-050-A	Trout Brook	1.440061	PEMB	Type 2	Fresh (Wet) Meadow	100	0.1				
62-029-23-24-050-A						100		Low	Low	Low	☐
62-029-23-24-053-A	Trout Brook	1.092011	PEMC	Type 3	Shallow Marsh	80	0.5				
62-029-23-24-053-A	Trout Brook	1.092011	PSS1C	Type 6	Shrub Carr	20	0.5				
62-029-23-24-053-A						100		Moderate	Moderate	Moderate	☐
62-029-23-24-054-A	Trout Brook	0.017388	PEMA	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-23-24-054-A						100		Low	Low	Low	☐
62-029-23-24-055-A	Trout Brook	0.268491	PSS1Ad	Type 6	Shrub Carr	100	0.1				
62-029-23-24-055-A						100		Low	Low	Low	☐
62-029-23-25-051-A	Trout Brook	9.604103	PEMF	Type 4	Deep Marsh	50	0.5				
62-029-23-25-051-A	Trout Brook	9.604103	PSS1C	Type 6	Shrub Carr	50	1				
62-029-23-25-051-A						100		High	High	High	☐
62-029-23-25-052-A	Trout Brook	0.124821	PEMC	Type 3	Shallow Marsh	80	0.5				
62-029-23-25-052-A	Trout Brook	0.124821	PSS1C	Type 6	Shrub Carr	20	1				
62-029-23-25-052-A						100		High	High	Moderate	☐
62-029-23-25-056-A	Trout Brook	1.357364	PEMC	Type 3	Shallow Marsh	100	0.1				

** Denotes incomplete calculation data.*

Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-23-25-056-A						100		Low	Low	Low	☐
62-029-23-25-057-A	Trout Brook	0.453868	PEMC	Type 3	Shallow Marsh	70	0.1				
62-029-23-25-057-A	Trout Brook	0.453868	PFO1B	Type 7	Hardwood Swamp	30	0.1				
62-029-23-25-057-A						100		Low	Low	Low	☐
62-029-23-25-058-A	Trout Brook	1.033397	PEMC	Type 3	Shallow Marsh	80	0.1				
62-029-23-25-058-A	Trout Brook	1.033397	PFO1B	Type 7	Hardwood Swamp	20	0.1				
62-029-23-25-058-A						100		Low	Low	Low	☐
62-029-23-27-039-A	Lake Como	0.043147	PFO1A	Type 1	Seasonally Flooded Basin	100	0.5				
62-029-23-27-039-A						100		Moderate	Moderate	Moderate	☐
62-029-23-27-040-A	Lake Como	0.040366	PEMC	Type 3	Shallow Marsh	100	0.1				
62-029-23-27-040-A						100		Low	Low	Low	☐
62-029-23-28-030-A	St. Anthony Falls	0.03841	PEMA	Type 6	Seasonally Flooded Basin	100	0.1				
62-029-23-28-030-A						100		Low	Low	Low	☐
62-029-23-28-031-A	St. Anthony Falls	0.282899	PFO1A	Type 7	Hardwood Swamp	100	0.5				
62-029-23-28-031-A						100		Moderate	Moderate	Moderate	☐
62-029-23-28-032-A	St. Anthony Falls	16.18565	PUBG	Type 5	Shallow, Open Water Communities	70	0.1				
62-029-23-28-032-A	St. Anthony Falls	16.18565	PEMF	Type 4	Deep Marsh	20	0.5				
62-029-23-28-032-A	St. Anthony Falls	16.18565	PEMA	Type 1	Seasonally Flooded Basin	10	0.1				
62-029-23-28-032-A						100		Moderate	Low	Low	☐

** Denotes incomplete calculation data.*

Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-23-28-033-A	St. Anthony Falls	0.882153	PUBG	Type 5	Shallow, Open Water Communities	70	0.1				
62-029-23-28-033-A	St. Anthony Falls	0.882153	PEMC	Type 3	Shallow Marsh	20	0.5				
62-029-23-28-033-A						90		Moderate	Low	Low	☐
62-029-23-28-034-A	St. Anthony Falls	1.439739	PEMF	Type 4	Deep Marsh	70	0.1				
62-029-23-28-034-A	St. Anthony Falls	1.439739	PEMC	Type 3	Shallow Marsh	20	0.1				
62-029-23-28-034-A						90		Low	Low	Low	☐
62-029-23-28-035-A	St. Anthony Falls	0.165274	PEMA	Type 1	Seasonally Flooded Basin	100	0.5				
62-029-23-28-035-A						100		Moderate	Moderate	Moderate	☐
62-029-23-28-036-A	St. Anthony Falls	0.076049	PEMC	Type 3	Shallow Marsh	75	0.1				
62-029-23-28-036-A	St. Anthony Falls	0.076049	PSS1Ad	Type 6	Shrub Carr	25	0.1				
62-029-23-28-036-A						100		Low	Low	Low	☐
62-029-23-28-037-A	St. Anthony Falls	0.18949	PFO1A	Type 1	Seasonally Flooded Basin	100	0.1				
62-029-23-28-037-A						100		Low	Low	Low	☐
62-029-23-28-108-A	St. Anthony Falls	0.286241	PEMC	Type 3	Shallow Marsh	60	0.1				
62-029-23-28-108-A	St. Anthony Falls	0.286241	PEMF	Type 4	Deep Marsh	40	0.5				
62-029-23-28-108-A						100		Moderate	Low	Low	☐
62-029-23-29-002-A	St. Anthony Falls	0.316661	PSS1Ad	Type 6	Shrub Carr	100	0.5				
62-029-23-29-002-A						100		Moderate	Moderate	Moderate	☐
62-029-23-29-004-A	St. Anthony Falls	0.898615	PEMA	Type 1	Seasonally Flooded Basin	60	0.5				
62-029-23-29-004-A	St. Anthony Falls	0.898615	PEMC	Type 3	Shallow Marsh	40	0.5				

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Wetland Community Summary
Saint Paul Wetland Assessment

Wetland ID	Subwatershed	Wetland Size (acres)	Community: Cowardin Classification	Community: Circular 39	Community: Plant Community	Vegetative Diversity/Integrity: Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-23-29-004-A						100		Moderate	Moderate	Moderate	☐
62-029-23-29-005-A	St. Anthony Falls	0.339965	PEMA	Type 1	Seasonally Flooded Basin	100	0.5				
62-029-23-29-005-A						100		Moderate	Moderate	Moderate	☐
62-029-23-29-006-A	St. Anthony Falls	2.121833	PEMF	Type 4	Deep Marsh	40	0.5				
62-029-23-29-006-A	St. Anthony Falls	2.121833	PEMG	Type 5	Shallow, Open Water Communities	60	0.5				
62-029-23-29-006-A						100		Moderate	Moderate	Moderate	☐
62-029-23-29-009-A	St. Anthony Falls	0.196759	PFO1A	Type 7	Fresh (Wet) Meadow	100	0.1				
62-029-23-29-009-A						100		Low	Low	Low	☐
62-029-23-29-010-A	St. Anthony Falls	0.123771	PUBFx	Type 5	Shallow, Open Water Communities	100	0.1				
62-029-23-29-010-A						100		Low	Low	Low	☐
62-029-23-29-011-A	St. Anthony Falls	0.950598	PEMC	Type 3	Shallow Marsh	60	0.1				
62-029-23-29-011-A	St. Anthony Falls	0.950598	PUBF	Type 5	Shallow, Open Water Communities	25	0.1				
62-029-23-29-011-A	St. Anthony Falls	0.950598	PSS1C	Type 6	Shrub Carr	15	0.1				
62-029-23-29-011-A						100		Low	Low	Low	☐
62-029-23-29-012-A	St. Anthony Falls	0.104868	PEMF	Type 4	Deep Marsh	40	0.5				
62-029-23-29-012-A	St. Anthony Falls	0.104868	PEMG	Type 5	Shallow, Open Water Communities	60	0.5				
62-029-23-29-012-A						100		Moderate	Moderate	Moderate	☐
62-029-23-29-013-A	St. Anthony Falls	0.825295	PUBG	Type 5	Shallow, Open Water Communities	90	0.1				

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Wetland Community Summary
Saint Paul Wetland Assessment

			Vegetative Diversity/Integrity									
			Community									
Wetland ID	Subwatershed	Wetland Size (acres)	Cowardin Classification	Circular 39	Plant Community	Wetland Proportion	Individual Community Rating	Highest Wetland Rating	Average Wetland Rating	Weighted Average Wetland Rating	*
62-029-23-29-013-A	St. Anthony Falls	0.825295	PFO1C	Type 7	Floodplain Forest	10	0.5				
62-029-23-29-013-A						100		Moderate	Low	Low	☐

*** Denotes incomplete calculation data.***

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-028-22-02-139-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Moderate	Moderate	Moderate	Low	Not Applicable
62-028-22-02-140-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-028-22-02-141-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-028-22-02-142-A	Floodplain (outside waterbody banks)	High	High	Moderate	High	Not Applicable
62-028-22-02-143-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-028-22-02-144-A	Floodplain (outside waterbody banks)	High	High	Moderate	Moderate	Not Applicable
62-028-22-02-145-A	Floodplain (outside waterbody banks)	High	High	Moderate	Moderate	Not Applicable
62-028-22-02-146-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-02-147-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-02-148-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-02-150-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-02-151-A	Depressional/Isolated (no discernable inlets or outlets)	High	Moderate	Moderate	Moderate	Not Applicable
62-028-22-02-172-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	High	Moderate	Moderate	Moderate	High
62-028-22-02-173-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	High	Moderate	Moderate	Exceptional	High
62-028-22-02-195-A	Depressional/Isolated (no discernable inlets or outlets)	Not Applicable	Low	Moderate	Low	Not Applicable
62-028-22-03-168-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-028-22-03-169-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-028-22-03-170-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-028-22-03-171-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Exceptional	Not Applicable
62-028-22-03-174-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Moderate	Not Applicable
62-028-22-03-175-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-03-176-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-03-177-A	Slope	High	Moderate	Moderate	Moderate	Not Applicable
62-028-22-03-178-A	Slope	High	Moderate	Moderate	High	Not Applicable
62-028-22-03-179-A	Slope	High	Moderate	Moderate	High	Not Applicable
62-028-22-03-181-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Low	Not Applicable
62-028-22-03-182-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-03-183-A	Lacustrine Fringe (edge of deepwater areas)/Shoreland	Moderate	High	High	Low	High
62-028-22-03-191-A	Slope	High	Moderate	Moderate	High	Not Applicable
62-028-22-03-192-A	Slope	High	Moderate	Moderate	High	Not Applicable
62-028-22-03-193-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Moderate	Not Applicable
62-028-22-03-194-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-028-22-04-099-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable
62-028-22-04-100-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable
62-028-22-04-101-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable
62-028-22-04-102-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable

Wetland Functional Assessment Summary
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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-028-22-04-103-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	High	High	High	Exceptional	Not Applicable
62-028-22-04-180-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Moderate	Not Applicable
62-028-22-05-094-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	Moderate	High	High	Low	Not Applicable
62-028-22-10-189-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-10-190-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-11-149-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-11-152-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	Moderate	Moderate	Low	Not Applicable
62-028-22-11-153-A	Depressional/Isolated (no discernable inlets or outlets)	High	Moderate	Moderate	Moderate	Not Applicable
62-028-22-11-154-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Moderate	Not Applicable
62-028-22-11-155-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-11-156-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-11-157-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-11-158-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-11-159-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-028-22-11-160-A	Depressional/Isolated (no discernable inlets or outlets)	High	Moderate	Moderate	Moderate	Not Applicable
62-028-22-11-161-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-028-22-11-162-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-11-163-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-028-22-11-164-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-028-22-11-167-A	Slope	High	Moderate	Moderate	High	Not Applicable
62-028-22-14-165-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Low	Not Applicable
62-028-22-14-166-A	Depressional/Isolated (no discernable inlets or outlets)	High	Moderate	Moderate	Moderate	Not Applicable
62-028-23-09-028-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	High	Not Applicable
62-028-23-09-029-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-028-23-12-188-A	Slope	High	Moderate	Moderate	Exceptional	Not Applicable
62-028-23-14-045-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Low	Not Applicable
62-028-23-14-046-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	High	Moderate	Not Applicable
62-028-23-14-047-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Moderate	Not Applicable
62-028-23-14-048-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	High	Moderate	Not Applicable
62-028-23-14-109-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	Moderate	High	High	High	Not Applicable
62-028-23-15-043-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-028-23-15-044-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-028-23-17-014-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-028-23-17-015-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable
62-028-23-17-016-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-17-017-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	Moderate	Moderate	High	High	Not Applicable

Wetland Functional Assessment Summary
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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-028-23-17-018-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-17-019-A	Slope, Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-028-23-20-020-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	High	Not Applicable
62-028-23-20-021-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-21-022-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-21-023-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-21-024-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	Exceptional	Not Applicable
62-028-23-21-025-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	High	High	Not Applicable
62-028-23-21-026-A	Riverine (within the river/stream banks), Floodplain (outside waterbody banks)	High	High	High	High	Moderate
62-028-23-21-027-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	Moderate	High	Exceptional	Not Applicable
62-029-22-19-059-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	High	Moderate	Not Applicable
62-029-22-19-060-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable
62-029-22-19-061-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-22-19-062-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-19-063-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-064-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	High	Low	Not Applicable
62-029-22-19-065-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Low	Not Applicable
62-029-22-19-066-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-22-19-067-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-068-A	Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-069-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-070-A	Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-071-A	Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-029-22-19-072-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-20-077-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-22-20-078-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-22-20-079-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	Moderate	Low	Not Applicable
62-029-22-20-080-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-22-20-081-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Low	Not Applicable
62-029-22-20-082-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Low	Not Applicable
62-029-22-20-083-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-20-084-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-20-085-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-20-086-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-20-087-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-22-21-089-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Riverine (within the river/stream banks), Lacustrine Fringe (edge of deepwater areas)/Shoreland	High	Moderate	High	Exceptional	High
62-029-22-21-090-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	High	High	High	High	Not Applicable
62-029-22-21-091-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-22-22-104-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	High	High	High	Moderate	Not Applicable
62-029-22-22-105-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	Moderate	High	High	Moderate	Not Applicable
62-029-22-22-106-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-22-22-107-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-22-110-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Moderate	High	High	Moderate	Not Applicable
62-029-22-22-111-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Moderate	Moderate	Not Applicable
62-029-22-22-112-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-23-123-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	High	High	High	High	Not Applicable
62-029-22-23-124-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-23-127-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Exceptional	Not Applicable
62-029-22-23-128-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	High	High	High	Moderate	Not Applicable
62-029-22-23-129-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-029-22-26-125-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-029-22-26-126-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Low	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-22-26-130-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	Moderate	Exceptional	Not Applicable
62-029-22-26-131-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	High	Not Applicable
62-029-22-26-132-A	Lacustrine Fringe (edge of deepwater areas)/Shoreland	Moderate	High	Moderate	Low	Moderate
62-029-22-26-133-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Moderate	Low	Not Applicable
62-029-22-26-134-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-27-113-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-27-114-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-27-115-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	High	Not Applicable
62-029-22-27-116-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Riverine (within the river/stream banks)	Moderate	Moderate	High	Moderate	Not Applicable
62-029-22-27-117-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	Moderate	Moderate	Low	Not Applicable
62-029-22-27-118-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	Moderate	Not Applicable
62-029-22-27-119-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-28-096-A	Depressional/Isolated (no discernable inlets or outlets)	Low	Moderate	Moderate	Low	Not Applicable
62-029-22-28-097-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Low	Not Applicable
62-029-22-29-088-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Low	High	High	Moderate	Not Applicable
62-029-22-29-092-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-30-073-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Moderate	Not Applicable
62-029-22-30-074-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Low	High	Moderate	Low	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-22-30-075-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-22-30-076-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	High	Not Applicable
62-029-22-32-093-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Riverine (within the river/stream banks)	High	High	High	Exceptional	Not Applicable
62-029-22-32-095-A	Depressional/Isolated (no discernable inlets or outlets), Floodplain (outside waterbody banks)	Moderate	High	High	Low	Not Applicable
62-029-22-32-184-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-029-22-32-185-A	inlet present from upstream wetland and seepage areas, no discernable outlet	High	High	Moderate	High	Not Applicable
62-029-22-32-186-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	High	High	Moderate	High	Not Applicable
62-029-22-32-187-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	High	High	High	High	Not Applicable
62-029-22-33-098-A	Depressional/Isolated (no discernable inlets or outlets)	High	High	High	High	Not Applicable
62-029-22-34-120-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	Moderate	Low	Not Applicable
62-029-22-34-121-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-029-22-34-122-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-22-35-135-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-35-136-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-35-137-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-22-35-138-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-20-001-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-20-003-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-23-20-007-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable
62-029-23-20-008-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-23-22-038-A	Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)	Moderate	High	High	High	Not Applicable
62-029-23-23-041-A	Lacustrine Fringe (edge of deepwater areas)/Shoreland	Moderate	High	High	Moderate	High
62-029-23-23-042-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Lacustrine Fringe (edge of deepwater areas)/Shoreland	Moderate	High	High	Moderate	Not Applicable
62-029-23-24-049-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-24-050-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Low	Not Applicable
62-029-23-24-053-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-24-054-A	Depressional/Isolated (no discernable inlets or outlets)	Low	Moderate	Moderate	Low	Not Applicable
62-029-23-24-055-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-25-051-A	Lacustrine Fringe (edge of deepwater areas)/Shoreland	High	High	High	High	High
62-029-23-25-052-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet), Lacustrine Fringe (edge of deepwater areas)/Shoreland	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-25-056-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-23-25-057-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-23-25-058-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-23-27-039-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-27-040-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable

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Wetland ID	Hydrogeomorphology	Hydrologic Regime	Flood Storage	Downstream Water Quality	Wetland Water Quality	Shoreline Protection
62-029-23-28-030-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-28-031-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-28-032-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	Moderate	Moderate	Moderate	Not Applicable
62-029-23-28-033-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-28-034-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	High	Moderate	Low	Not Applicable
62-029-23-28-035-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	High	Moderate	Not Applicable
62-029-23-28-036-A	Depressional/Isolated (no discernable inlets or outlets)	Low	Moderate	Moderate	Low	Not Applicable
62-029-23-28-037-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-28-108-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-23-29-002-A	Depressional/Isolated (no discernable inlets or outlets)	Low	Moderate	Moderate	Moderate	Not Applicable
62-029-23-29-004-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Moderate	Moderate	Not Applicable
62-029-23-29-005-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Moderate	Moderate	Not Applicable
62-029-23-29-006-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable
62-029-23-29-009-A	Depressional/Isolated (no discernable inlets or outlets)	Moderate	High	Moderate	Moderate	Not Applicable
62-029-23-29-010-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Low	Moderate	Low	Low	Not Applicable
62-029-23-29-011-A	Depressional/Isolated (no discernable inlets or outlets)	Low	High	Moderate	Low	Not Applicable
62-029-23-29-012-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	High	Moderate	Not Applicable

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Wetland ID	*Hydrogeomorphology*	*Hydrologic Regime*	*Flood Storage*	*Downstream Water Quality*	*Wetland Water Quality*	*Shoreline Protection*
62-029-23-29-013-A	Depressional/Flow-through (apparent inlet and outlet), Depressional/Flow-through (apparent inlet and outlet)	Moderate	High	Moderate	Moderate	Not Applicable

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Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-028-22-02-139-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-028-22-02-140-A	Moderate	Moderate	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	High	Moderate	Moderate
62-028-22-02-141-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	High	Moderate	Moderate
62-028-22-02-142-A	High	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-02-143-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	High	Moderate	Moderate
62-028-22-02-144-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-145-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-146-A	Moderate	Moderate	Moderate	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-147-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-148-A	High	High	High	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-02-150-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate

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Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-028-22-02-151-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-172-A	Moderate	Moderate	Low	High	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-02-173-A	Exceptional	Moderate	Low	High	Not Applicable	Recharge	Not Applicable	Exceptional	Moderate
62-028-22-02-195-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	Low	High
62-028-22-03-168-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-169-A	Moderate	Not Applicable	Moderate	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-170-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-171-A	High	High	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Moderate
62-028-22-03-174-A	Moderate	Moderate	Low	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-175-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-176-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-177-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-178-A	High	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Moderate
62-028-22-03-179-A	Exceptional	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	High	Exceptional

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Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-028-22-03-181-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-028-22-03-182-A	High	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	High	Exceptional
62-028-22-03-183-A	Moderate	High	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-028-22-03-191-A	Exceptional	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-03-192-A	Exceptional	Not Applicable	Not Applicable	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-03-193-A	Moderate	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-03-194-A	Moderate	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-04-099-A	Exceptional	Not Applicable	High	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-028-22-04-100-A	Exceptional	Not Applicable	High	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-028-22-04-101-A	Exceptional	Not Applicable	High	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-028-22-04-102-A	Exceptional	Not Applicable	High	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-028-22-04-103-A	High	High	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Moderate
62-028-22-04-180-A	Moderate	High	Low	Low	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate

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Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-028-22-05-094-A	Moderate	Not Applicable	Low	High	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-028-22-10-189-A	Moderate	Moderate	Low	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-10-190-A	Moderate	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-149-A	Moderate	Moderate	High	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Moderate
62-028-22-11-152-A	Moderate	Moderate	Low	Low	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-028-22-11-153-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-154-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Exceptional
62-028-22-11-155-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	High	Moderate
62-028-22-11-156-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	High	Moderate
62-028-22-11-157-A	High	Moderate	High	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-158-A	High	High	High	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Exceptional
62-028-22-11-159-A	High	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-11-160-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-161-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate

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Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-028-22-11-162-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-163-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-164-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-22-11-167-A	High	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-22-14-165-A	Moderate	Low	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-028-22-14-166-A	Moderate	Moderate	Moderate	Low	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-23-09-028-A	High	Moderate	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	High	Moderate
62-028-23-09-029-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-028-23-12-188-A	Exceptional	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-14-045-A	Low	Low	Low	Moderate	Not Applicable	Recharge	Moderate	Low	Moderate
62-028-23-14-046-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-23-14-047-A	Low	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-23-14-048-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-028-23-14-109-A	Exceptional	Not Applicable	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-028-23-15-043-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-028-23-15-044-A	High	Not Applicable	Moderate	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Exceptional
62-028-23-17-014-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Moderate	Moderate	Moderate
62-028-23-17-015-A	Exceptional	Not Applicable	Moderate	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-17-016-A	Exceptional	Not Applicable	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-17-017-A	High	Not Applicable	Moderate	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-23-17-018-A	Exceptional	Not Applicable	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-17-019-A	Moderate	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-028-23-20-020-A	High	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	High	Exceptional
62-028-23-20-021-A	Exceptional	Not Applicable	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-21-022-A	Exceptional	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-21-023-A	Exceptional	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-21-024-A	Exceptional	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Exceptional	Exceptional
62-028-23-21-025-A	Exceptional	Not Applicable	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-028-23-21-026-A	Exceptional	Moderate	Not Applicable	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Moderate

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-028-23-21-027-A	Exceptional	Not Applicable	Moderate	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Exceptional
62-029-22-19-059-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-060-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-19-061-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-19-062-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-063-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	High
62-029-22-19-064-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	High
62-029-22-19-065-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-19-066-A	Moderate	Moderate	Low	High	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-067-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-068-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-069-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-070-A	High	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-071-A	High	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-19-072-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-029-22-20-077-A	Low	Not Applicable	Moderate	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-20-078-A	Moderate	Not Applicable	Moderate	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-20-079-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Exceptional
62-029-22-20-080-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Exceptional
62-029-22-20-081-A	Moderate	Not Applicable	Low	High	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-20-082-A	Moderate	Not Applicable	Low	High	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-20-083-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-20-084-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-20-085-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-20-086-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-20-087-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-21-089-A	Exceptional	High	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	High
62-029-22-21-090-A	Moderate	Moderate	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	High	High
62-029-22-21-091-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-22-104-A	Moderate	Moderate	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-22-105-A	Moderate	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-22-106-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-22-107-A	Moderate	Moderate	Moderate	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-22-110-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-029-22-22-111-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Exceptional
62-029-22-22-112-A	Moderate	Moderate	Low	Low	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-23-123-A	Exceptional	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	High
62-029-22-23-124-A	Moderate	Moderate	Low	Low	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-23-127-A	Exceptional	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	High
62-029-22-23-128-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-23-129-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Exceptional
62-029-22-26-125-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-26-126-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-029-22-26-130-A	Exceptional	Moderate	Low	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	Moderate
62-029-22-26-131-A	Exceptional	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	Moderate

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-029-22-26-132-A	Moderate	High	Low	High	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-029-22-26-133-A	Low	Low	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-26-134-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-22-27-113-A	Moderate	Moderate	Not Applicable	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-27-114-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-22-27-115-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	High	High
62-029-22-27-116-A	Moderate	Moderate	Moderate	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	High
62-029-22-27-117-A	Moderate	Low	Low	Low	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-27-118-A	Moderate	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-22-27-119-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-22-28-096-A	Low	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Moderate	Low	Moderate
62-029-22-28-097-A	Moderate	Not Applicable	Low	Low	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-29-088-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-29-092-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-22-30-073-A	Moderate	Moderate	Moderate	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-22-30-074-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-30-075-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Stormwater Treatment Needs	Wetland Stormwater Sensitivity
62-029-22-30-076-A	Exceptional	Not Applicable	Low	Low	Not Applicable	Recharge	Not Applicable	High	Moderate
62-029-22-32-093-A	Exceptional	High	Moderate	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Exceptional	High
62-029-22-32-095-A	Moderate	Not Applicable	Low	High	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-32-184-A	Exceptional	High	Moderate	High	Not Applicable	Recharge	Not Applicable	High	High
62-029-22-32-185-A	Exceptional	High	Moderate	High	Not Applicable	Recharge	Not Applicable	High	High
62-029-22-32-186-A	Exceptional	High	Moderate	High	Not Applicable	Recharge	Not Applicable	High	High
62-029-22-32-187-A	High	Moderate	Moderate	High	Not Applicable	Recharge	Not Applicable	High	Moderate
62-029-22-33-098-A	Moderate	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	High	Exceptional
62-029-22-34-120-A	Low	Low	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-22-34-121-A	Moderate	Moderate	Not Applicable	High	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-34-122-A	Moderate	Moderate	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-35-135-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-35-136-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-35-137-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-22-35-138-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-20-001-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-20-003-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-20-007-A	Low	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-23-20-008-A	Moderate	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-23-22-038-A	High	Not Applicable	Low	Exceptional	Not Applicable	Recharge	Not Applicable	High	High

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-029-23-23-041-A	Moderate	High	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	High
62-029-23-23-042-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-23-24-049-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-23-24-050-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-23-24-053-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-23-24-054-A	Low	Not Applicable	Not Applicable	Low	Not Applicable	Recharge	Not Applicable	Low	Exceptional
62-029-23-24-055-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-23-25-051-A	Moderate	High	Low	Exceptional	Not Applicable	Combination Discharge, Recharge	Not Applicable	High	High
62-029-23-25-052-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-23-25-056-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-23-25-057-A	Low	Low	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-029-23-25-058-A	Moderate	Low	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-029-23-27-039-A	High	Not Applicable	Not Applicable	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-27-040-A	Low	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-23-28-030-A	Low	Not Applicable	Not Applicable	High	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional

Wetland Functional Assessment Summary
Saint Paul Wetland Assessment

Wetland ID	Wildlife Habitat	Fishery Habitat	Amphibian Habitat	Aesthetics, Recreation, Education	Commercial	Ground-Water Interaction	Additional Information: Wetland Restoration Potential	Additional Information: Stormwater Treatment Needs	Additional Information: Wetland Stormwater Sensitivity
62-029-23-28-031-A	Moderate	Not Applicable	Moderate	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-28-032-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-23-28-033-A	Moderate	Moderate	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Moderate	Moderate
62-029-23-28-034-A	Moderate	Low	Low	Moderate	Not Applicable	Combination Discharge, Recharge	Not Applicable	Low	Moderate
62-029-23-28-035-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-28-036-A	Low	Not Applicable	Low	Low	Not Applicable	Recharge	Low	Low	Moderate
62-029-23-28-037-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-28-108-A	Moderate	Moderate	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-29-002-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	High
62-029-23-29-004-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-29-005-A	Moderate	Not Applicable	Low	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Exceptional
62-029-23-29-006-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-29-009-A	Moderate	Not Applicable	Not Applicable	Moderate	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-29-010-A	Low	Not Applicable	Low	Low	Not Applicable	Recharge	Not Applicable	Low	Moderate
62-029-23-29-011-A	Low	Not Applicable	Low	Low	Not Applicable	Recharge	Moderate	Low	Moderate
62-029-23-29-012-A	Moderate	Moderate	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate
62-029-23-29-013-A	Low	Moderate	Low	Exceptional	Not Applicable	Recharge	Not Applicable	Moderate	Moderate

FINAL

(Issued 5/1/07)

MnRAM 3.1

FOR EVALUATING WETLAND FUNCTIONS

MnRAM 3.1 is designed to help assess functions and values associated with Minnesota wetlands. The Comprehensive Guidance document (available at www.bwsr.state.mn.us) contains explanations, references, definitions, and a ranking formula for each function. After using this tool, the Management Classification Reference will help to organize the results for managing local wetland resources.

GENERAL INFORMATION:

Project Number or Name:		Wetland Number:	
Location: County;	Section; ,	Township	Range
Major Watershed:	Subwatershed:	City:	
Evaluator(s):		Date of Site Visit:	

SCOPE AND LIMITATIONS:

1. Note unusual climatic conditions experienced during this assessment due to seasonal considerations and/or unusual existing hydrologic and climatologic conditions:
2. Describe the **purpose** of this assessment: inventory/planning/monitoring/regulatory/classification____________________

SUMMARY TABLE

ACTUAL CONDITIONS	FUNCTIONAL INDEX*		
FUNCTIONS (and Related Values)	N/A	Functional Index Score	Comments
Vegetative Diversity/Integrity** Plant Comm. #1			
Plant Comm. #2			
Plant Comm. #3			
Maintenance of Characteristic Hydrologic Regime			
Flood/Stormwater/Attenuation			
Downstream Water Quality			
Maintenance of Wetland Water Quality			
Shoreline Protection			
Maintenance of Characteristic Wildlife Habitat Structure			
Maintenance of Characteristic Fish Habitat			
Maintenance of Characteristic Amphibian Habitat			
Aesthetics/Recreation/Education/Cultural			
Commercial Uses			
Groundwater Interaction			
Additional Information			
Wetland Restoration Potential			
Sensitivity to Stormwater and Urban Development			
Additional Stormwater Treatment Needs			

*The functional index may be calculated manually using formulas in the Comprehensive Guidance.

**If more than 3 plant communities are present, use an additional summary table.

FINAL

(Issued 5/1/07)

FUNCTIONAL ASSESSMENT - Special Features

Is the wetland part of, or directly adjacent to, an area of special natural resource interest?
Check those that apply:

a. ____ Designated trout streams or trout lakes (see MnDNR Commissioners Order 2450 Part 6262.0400 subparts 3 and 5) (*if yes, Fish Habitat Rating is Exceptional*).
b. ____ Calcareous fen (Special Status—see MN Rule Chapter 7050) *(if yes, Vegetative Diversity/Integrity functional rating is Exceptional). Consult DNR for regulatory purposes.*
c. ____ Designated scientific and natural area (*if yes, then Aesthetics/Recreation/Education/ Cultural functional rating is Exceptional).*
d. ____ Rare natural community (refer to MnDNR County Biological Survey/Natural Heritage)*(see Question #5 for guidance; if #5 is also yes, then Wildlife Habitat functional rating is Exceptional).*
e. ____ High priority wetland, environmentally sensitive area or environmental corridor identified in a local water management plan.
f. ____ Public park, forest, trail or recreation area.
g. ____ State or Federal fish and wildlife refuges and fish and wildlife management areas, and water fowl protection areas *(if yes, then Wildlife and/or Fish Habitat functional rating is Exceptional).*
h. ____ Archeological or historic site as designated by the State Historic Preservation Office *(if yes, then Aesthetics/Recreation/Education/Cultural functional rating is Exceptional).*
i. ____ Established and persistent populations of federal or state listed endangered or threatened plant species or species of concern naturally occurring in the wetland: list the species of concern at Q#45. *(If yes, then Vegetative Diversity functional rating is Exceptional.)*
j. ____ Federal or state listed endangered or threatened wildlife species or species of concern in or using the wetland: list the species of concern at Q#45. *(If yes, then question 35 is yes, and Wildlife Habitat functional rating is Exceptional.)*
k. ____ Local Shoreland Management Plan area.
l. ____ State Coastal Zone or Shoreland Management Plan area.
m. ____ Shoreland area identified in a zoning ordinance (generally within 1000 feet from a water basin and 300 feet from a watercourse).
n. ____ Floodplain area identified in a zoning ordinance or map.
o. ____ Wetland restored or preserved under a conservation easement.
p. ____ Wetland restored or created for mitigation purposes.
q. ____ Designated Wellhead or Sourcewater Protection Area *(if yes and Ground Water Interaction is Recharge, then Ground Water functional index is Exceptional).*
r. ____ Sensitive ground-water area *(if yes and Ground Water Interaction is Recharge, then Ground Water functional index is Exceptional).*
s. ____ State or Federal designated wild and scenic river (see MN Rule Chapter 7050).
t. ____ Federally identified special area management plan, special wetland inventory study, or an advanced delineation and identification study.
u. ____ State or Federal designated wilderness area (*if yes, then Aesthetics/Recreation/Education/ Cultural functional rating is Exceptional).*

Vegetative Diversity and Integrity

1. **Go to upper canopy to key out wetland plant community(-ities) within the evaluation area using the following key[1].** Evaluate only each contiguous type that comprises at least 10% of the vegetated wetland area; the exception is a shallow, open water community in which any fringe emergent communities must be evaluated. Be sure to sample shallow, open water areas for submergent vegetation. Enter in page 1 of field data form, MnRAM database second tab, or the manual-use summary table located in the Guidance.

Wetland Community Classification Key

1A. Mature trees (dbh of 6 inches or more) are present and form closed stands (more than 17 trees per acre; more than a 50 percent canopy cover) on wet, lowland soils (usually floodplains and ancient lake basins).

2A. Hardwood trees are dominant (>50% areal coverage or basal area of the tree stratum); usually alluvial, peaty/mucky, or poorly drained mineral soils.

3A. Silver maple, American elm, river birch, green ash, black willow, box elder and/or eastern cottonwood are dominant; growing on alluvial soils associated with riverine systems... **FLOODPLAIN FOREST** (Type 1); (PFO; 1,6; A)

3B. Black ash, green ash, American elm, eastern cottonwood, black willow, box elder, yellow birch, silver maple, quaking aspen and/or red maple are dominant; northern white cedar may be subdominant; growing on poorly-drained mineral or peat/muck soils, often associated with ancient lake basins............................... **HARDWOOD SWAMP** (Type 7); (PFO;1, 6; A, B, C)

2B. Coniferous trees are dominant (>50% areal coverage or basal area of the tree stratum); soils usually peaty.

4A. Tamarack and/or black spruce are dominant; growing on a continuous sphagnum moss mat and acid, peat soils.. **CONIFEROUS BOG** (Type 8); (PFO; 2, 4, 6, 7; B)

4B. Northern white cedar and/or tamarack are dominant; continuous sphagnum moss mat absent; usually growing on neutral to alkaline peat/muck soils........ **CONIFEROUS SWAMP** (Type 7); (PFO;2, 4, 6, 7; B, C)

1B. Mature trees are absent or, if present, form open, sparse stands; other woody plants, if present, are shrubs or saplings and pole-size trees (dbh less than 6 inches) less than 20 feet high and growing on wet, lowland, or poorly-drained soils, or in ground-water seepage areas.

5A. Community dominated (>50% areal coverage) by woody shrubs.

[1] Refer to Pages 19 - 22 of *"Wetland Plants and Plant Communities of MN and WI"*; (USACOE - St. Paul District; Eggers and Reed).

6A. Low, woody shrubs usually less than 3 feet high; sphagnum moss mat layer may or may not be present.

7A. Shrubs are ericaceous and evergreen growing on a sphagnum moss mat layer; peat soils are acidic...**OPEN BOG**
(Type 8); (PSS;2, 3, 4, 7; B)

7B. Shrubs are deciduous, mostly shrubby cinquefoil, often growing on sloping sites with a spring-fed supply of internally flowing, calcareous waters; other calciphiles are also dominant; sphagnum moss mat layer absent; muck/poorly-drained mineral soils are alkaline.........................**CALCAREOUS FEN**
(Type 2/6), (PEM/PSS;1; B)

6B. Tall, woody deciduous shrubs usually greater than 3 feet high; sphagnum moss mat layer absent: SHRUB SWAMPS.

8A. Speckled alder is dominant; usually on acidic soils in and north of the vegetation tension zone (a map of the tension zone is on page 9 of Eggers and Reed [1997]). ....**ALDER THICKET**
(Type 6); (PSS;1, 6; B, C)

8B. Willows, red-osier dogwood, silky dogwood, meadowsweet and/or steeplebush are dominant on neutral to alkaline poorly drained muck/mineral soils; found north and south of the vegetation tension zone. NOTE: Non-native buckthorns (*Rhamnus cathartica* and *R. frangula*) may occur as dominant shrubs or small trees in disturbed shrub-carrs. ....**SHRUB-CARR**
(Type 6); (PSS;1, 6; B, C)

5B. Community dominated (>50% areal coverage) by herbaceous plants.

9A. Essentially closed communities, usually with more than 50 percent cover.

10A. Sphagnum moss mat on acid peat soils; leatherleaf, pitcher plants, certain sedges, and other herbaceous species tolerant of low nutrient conditions may be present. ....**OPEN BOG**
(Type 8); (PSS; 2, 3, 4, 7; B; and PML; 1; B)

10B. Sphagnum moss mat absent; dominant vegetation consists of sedges (Cyperaceae), grasses (Gramineae), cattails, giant bur-reed, arrowheads, forbs and/or calciphiles. Soils are usually neutral to alkaline, poorly-drained mineral soils and mucks.

11A. Over 50 percent of the cover dominance contributed by the sedge family, cattails, giant bur-reed, arrowheads, wild rice, and/or giant reed grass (*Phragmites*).

12A. Herbaceous emergent plants growing on saturated soils to areas covered by standing water up to 6 inches in depth throughout most of the growing season.

13A. Major cover dominance by the sedges (primarily genus *Carex*) typically on saturated soils with, at most, short periods of inundation. Canada blue-joint grass may be a subdominant. Lake sedges (*Carex lacustris*, *C. utriculata*) and slough sedge (*Carex atherodes*) can also be dominants in shallow marshes – see 13B. below.........................**SEDGE MEADOW**
(Type 2), (PEM; 1; B)

13B. Major cover dominance by cattails, bulrushes, water plantain, *Phragmites*, arrowheads, slough sedge and/or lake sedges typically on soils that are inundated by up to 6 inches of water depth for a significant portion of most growing seasons..........
....**SHALLOW MARSH**
(Type 3); (PEM; 1, 2; C)

12B. Herbaceous submergent, floating-leaved, floating and emergent plants growing in areas covered by standing water greater than 6 inches in depth throughout most of the growing season................**DEEP MARSH**
(Type 4); (PEM; 1, 2; F, G, H; and PAB; 2, 4, 5; F, G; and PUB; F, G; and L2EM2; F, G; and L2AB; 2, 4, 5; F, G)

11B. Over 50 percent of the cover dominance contributed by grasses (except wild rice and *Phragmites*), forbs and/or calciphiles.

14A. Spring-fed supply of internally flowing, calcareous waters, often sloping sites; calciphiles such as sterile sedge, wild timothy, Grass-of-Parnassus and lesser fringed gentian are dominant....**CALCAREOUS FEN**
(Type 2); (PEM; 1; B)

14B. Water source(s) variable; calciphiles not dominant.

15A. Dominated by native prairie grasses (e.g., big bluestem, prairie cordgrass, Canada blue-joint grass) usually with characteristic wet prairie forbs (e.g., Riddell's goldenrod, gayfeather, mountain mint)...
....**WET TO WET- MESIC PRAIRIE**
(Type 2); (PEM; 1; A, B)

15B. Dominated by other grass species (e.g., reed canary grass, redtop) and/or generalist forbs (e.g., giant goldenrod, giant sunflower, swamp aster, marsh aster, wild mint)..............
....**FRESH (WET) MEADOW**
(Type 2); (PEM; 1; B)

9B. Essentially open communities, either flats or basins usually with less than 50 percent vegetative cover during the early portion of the growing season, or shallow open water with submergent, floating and/or floating-leaved aquatic vegetation.

16A. Areas of shallow, open water (< 6.6 feet in depth) dominated by submergent, floating and/or floating-leaved aquatic vegetation ....**SHALLOW, OPEN WATER COMMUNITIES** (Type 5); (PAB; 2, 4, 5; G, H; and PUB; G, H; and L2EM; 2; G, H; and L2AB; 2, 4, 5; G, H)

16B. Shallow depressions or flats including vernal pools; standing water may be present for a few weeks each year, but are dry for much of the growing season; often cultivated or dominated by annuals such as smartweeds and wild millet; when not cultivated, perennial vegetation may be present (see Table 4 on page 15)..................................**SEASONALLY FLOODED BASIN** (Type 1); (PEM; A)

2. **Utilizing the "50/20 Rule" identify the dominant species within each plant community and which ones are non-native or invasive and the cover class of each species present.** Use species list found on the MnDNR website[2] that includes non-native status and use the following six cover classes[3]: *Note: Cover Class 1 and 2 are for use with invasive species only.*

Cover Class	Class Range
1	0 – 3%
2	>3 – <10%
3	>10 –25%
4	>25 –50%
5	>50 –75%
6	>75 – 100%

Table 1: Partial List of Invasive Species[4]

Scientific Name	Common Name	Scientific Name	Common Name
Acer negundo	Box elder	*Myriophyllum spicatum*	Eurasian water milfoil
Alliaria petiolata	Garlic mustard	*Pastinaca sativa*	Wild parsnip
Berteroa incana	Hoary alyssum	*Phalaris arundinacea*	Reed canary grass
Bromus inermis	Smooth brome grass	*Phragmites australis*	Common reed grass
Butomus umbellatus	Flowering rush	*Potamogeton crispus*	Curly leaf pondweed
Cirsium arvense	Canada thistle	*Rhamnus cathartica*	Common buckthorn
Cirsium vulgare	Bull thistle	*Rhamnus frangula*	Glossy buckthorn
Euphorbia esula	Leafy spurge	*Sonchus arvensis*	Sow thistle

[2] www.dnr.state.mn.us
[3] Adapted from Kuchler, A.W.
[4] See MnRAM **3.1** database for a list of invasive/non-native plant species referenced from the MnDNR.

Glechoma hederacea	Creeping charlie, ground ivy	*Trapa natans*	Water chestnut
Hydrilla verticillata	Hydrilla	*Typha angustifolia*	Narrow leaved cattail
Hydrocharis morsus-ranae	European frog-bit	*Ulmus pumila*	Siberian elm
Iris pseudacorus	Yellow iris	*Urtica dioica*	Stinging nettle
Lonicera x *bella*	Honeysuckle	*Vicia cracca*	Cow vetch
Lotus corniculatus	Birdsfoot trefoil	*Vicia villosa*	Hairy vetch
**Typha x glauca*	Blue (hybrid) cattail	*Setaria glauca*	Yellow foxtail
Lythrum salicaria	Purple loosestrife	*Echinochloa crusgalli*	Barnyard grass
Salix fragilis	Crack willow	*Elytrigia repens*	Quack grass
Salix alba	White willow	*Sonchus arvensis*	Perennial sowthistle
Salix babylonica	Weeping willow	*Cirsium vulgare*	Bull thistle
Ambrosia artemisiifolia	Common ragweed	*Alliaria petiolata*	Garlic mustard

Cattail Key (Adapted from Smith, 1986)

Two species of cattail (*Typha* sp.) occur in Minnesota and they readily hybridize producing a highly variable hybrid known by the common name of White (or Blue or hybrid) cattail *Typha* x *glauca* (ITIS 2002) as referred to in the 'National List of Plant Species That Occur In Wetlands Region 3 – North Central, second printing 1988. Broad-leaved cattail (*Typha latifolia*) is native throughout Minnesota. Narrow-leaved cattail (*Typha angustifolia*) is believed to be native to the eastern region of the U.S. and made its way to the Upper Midwest where it began to hybridize with *T. latifolia.* Both *Typha angustifolia* and *Typha* x *glauca* are more tolerant to a wide range of human influences including hydrologic changes, nutrient inputs, loading of certain toxic compounds such as chloride and heavy metals such as cadmium, copper and zinc and are therefore more invasive. Older, more extensive stands may have both *Typha* species present; various generations of the hybrid make reliable species cover estimates difficult. The following condensed key may be used to help determine what species of cattail is encountered in the field. See the database for a more detailed key.

Table 2: Diagnostic characteristics of cattails

Characteristic	***Typha latifolia* (Broad-leaved cattail)**	***Typha angustifolia* (Narrow-leaved cattail)**	***Typha x glauca* (White/Blue or hybrid cattail)**
Mature Leaf width	14 – 23 mm	4 – 10 mm	10 – 14 mm
Leaf Cross-section shape	Flat, scarcely concave below mid.	Convex below middle	Flat to convex below middle
Spike width	25 – 34 mm	15 –22 mm	19 – 25 mm
Spike length	≤15 cm	≤15 cm	≥15 cm
Spike separation	Frequently contiguous but not more than 2 cm apart	Separated by at least 2 cm and usually >3 cm	Occasionally contiguous, more commonly up to 4 cm
Spike color	Dark brown to black	Brown	Brown to bright brown
Colony density	Sparse, often large gaps between shoots	Frequently very dense	Density intermediate

3. Characterize the current vegetative quality of each wetland community comprising at least 10% of the wetland using the following key and enter the community proportion of the whole wetland (**3a**), and the vegetative quality rating for each community in the table below. **Compute the index for vegetative diversity and integrity for each plant community by doing the following:** If any of questions **#4-6** are answered yes and/or if any of the Special Features **b, d, or i** have been selected, enter **Exceptional** for the functional index; if not, use the answer in the Vegetative Quality Index from the table for each community (Question 3). The overall vegetative diversity index for the wetland may be calculated one of four ways. The method should be based on the purpose of the assessment:

3b) Maintain Individual Community Scores: preserves data to the highest level by maintaining the quality ratings of each community within the wetland. While it may be cumbersome to maintain this data for a large number of wetlands, this data should always be maintained and reported when the MnRAM is utilized for inventory or regulatory purposes.

3c) Highest Quality Community: This method of presenting the Vegetative Diversity/Integrity can be utilized for determining sensitivity to impacts such as stormwater/hydrologic alterations. Typically, communities with the highest quality are also those that are most sensitive to alteration. *(This method would be preferable in regulatory situations in which a wetland basin may be impacted).*

3d) Non-Weighted Average Quality of all Communities: This method of data presentation results in the greatest dilution of the individual community data. However, it may be the only reasonable method for comparing large numbers of wetlands such as for an inventory and/or planning project. In some instances, it may not be possible, given budget and scope constraints, to collect community dominance data. In that case, one way to get a single measure of overall wetland vegetative diversity/integrity quality is to utilize the non-weighted average. It is important to maintain and report the individual community quality data, even if it cannot be readily used to develop management classifications. *(This method is not recommended for regulatory purposes).*

3e) Weighted Average Quality Based on Percentage of Each Community: This data presentation method provides the best average Vegetative Diversity/Integrity measure for the entire wetland. Here the quality rating is computed by summing the product of each community rating and the proportion of the wetland that community comprises. Whenever possible, the community proportion data should be collected to preserve the highest possible value for a single Vegetative Diversity/Integrity rating. Again, the individual community ratings should be preserved and reported to provide a complete data set. *(This method is not recommended for regulatory purposes).*

Guidance: The plant community rating incorporates two principal components: integrity and diversity. **Diversity** refers to species richness, e.g., number of plant species. Generally, the more floristically diverse a community is, the higher the rating. **Integrity** refers to the condition of the plant community in comparison to the reference standard for that community. The highest rating is given to those communities that represent the characteristic condition of that particular community. The degree (e.g., minor versus substantial) and type of disturbance typically play an important role in the diversity/integrity of plant communities. Some native plant communities are maintained by periodic, natural disturbances (e.g., fire, annual floods). For purposes of this functional assessment, disturbances are more in reference to man-induced alterations (e.g., filling, dredging, drainage) that are typically detrimental to vegetative diversity/integrity.

It is important to note that some native wetland plants naturally form large colonies or clones creating communities that are low in diversity, but high in integrity. Examples are stands of wild rice, arrowhead, lake sedges, river bulrush, hardstem bulrush, American lotus, wild celery, pickerelweed, wire-grass sedge and tussock sedge. Plant communities with low diversity but high integrity can have a high vegetative diversity/integrity ranking if they represent the characteristic condition of that plant community (i.e., compared to the reference standard community).

Size of the area sampled for the rating can also be a factor. If the area sampled is small, the evaluator must be aware that it may not naturally support the diversity of species a larger area of the same plant community supports.

User Notes: Each community is outlined below with descriptions for high, medium, and low quality. Many sites have more than one community; consult the descriptions individually to decide the appropriate rating for each community, *except* the following description of "exceptional" quality is applicable to all communities:

Exceptional Quality: Plant community is undisturbed, or sufficiently recovered from past disturbances, such that it represents pre-European settlement conditions. Non-native plant species are absent or, if present, constitute a minor percent cover of the community. Unique features (e.g., old growth forest, never-plowed wet prairie, T/E species) may also be present.

NOTE: For purposes here, "dominant" or "dominated by" refers to the dominant species determined by the "50/20 Rule" or other appropriate method for determining which species are dominants. "Subdominant" refers to species that may not meet the "50/20 Rule" for dominance, but have at least 10 percent areal cover (or other dominance measure)[5].

16A. SHALLOW, OPEN WATER COMMUNITIES[6]

High Quality: Aquatic bed communities with greater than 10 percent coverage of the open water area and dominated by 3 or more species of native aquatic plants such as pondweeds, water lilies, bladderworts, wild celery, duckweed, water crowfoots, native milfoils, etc.; or communities with low diversity but high integrity as given in additional guidance (e.g., beds of wild celery). Eurasian water milfoil and/or curly leaf pondweed, if present, cumulatively comprise less than 20 percent cover of the aquatic bed community.

Medium Quality: Aquatic bed communities with greater than 10 percent coverage of the open water area and dominated by 1 or 2 species of native aquatic plants; and/or Eurasian water milfoil and/or curly leaf pondweed cumulatively comprise 20 to 50 percent cover of the aquatic bed community.

Low Quality: Aquatic vegetation absent or coverage is less than 10 percent of the open water area; or, Eurasian water milfoil and/or curly leaf pondweed cumulatively comprise greater than 50 percent cover of the aquatic bed community.

13B. SHALLOW MARSHES[7]

High Quality: Three or more native aquatic plants (e.g., bur-reeds, bulrushes, arrowheads, duckweeds, cattails, sweet flag, pondweeds) are dominants; or, communities with low diversity but high integrity as described in guidance (e.g., stands of arrowhead, lake sedges). Cattails, if present,

[5] The "50/20 Rule" is explained in the *Corps of Engineers Wetlands Delineation Manual* (1987).
[6] I., page 28, Eggers and Reed.
[7] II.B., pages 51-53, Eggers and Reed.

comprise less than 40 percent cover. Purple loosestrife absent or comprises less than 20 percent cover.

Medium Quality: At least 2 species of native aquatic plants are dominants; and/or purple loosestrife comprises 20 to 50 percent cover; and/or cattails comprise 40 to 85 percent cover.

Low Quality: Dominated by 1 native aquatic species; and/or purple loosestrife comprise more than 50 percent cover; and/or cattail comprises more than 85 percent cover.

12B. DEEP MARSHES[8]

High Quality: Three or more species of native aquatic plants (e.g., bur-reeds, bulrushes, arrowheads, duckweeds, cattails, sweet flag, pondweeds) are dominants; or communities with low diversity but high integrity as described in guidance (e.g., stands of bulrushes, wild rice, lotus, arrowheads). Cattails, if present, comprise less than 40 percent cover. Purple loosestrife and/or Eurasian water milfoil absent or cumulatively comprise less than 20 percent cover.

Medium Quality: Dominated by 2 species of native aquatic plants; and/or purple loosestrife and/or Eurasian water milfoil, cumulatively comprise 20 to 50 percent cover; and/or cattail comprises 40 to 85 percent cover.

Low Quality: Dominated by 1 native aquatic species; and/or purple loosestrife and/or Eurasian water milfoil cumulatively comprise more than 50 percent cover; and/or cattail comprises more than 85 percent cover.

13A. SEDGE MEADOWS[9]

High Quality: Stands dominated solely by sedges (e.g., wiregrass sedge, hummock sedge, lake sedge, woolgrass [*Carex lasiocarpa, C. stricta, C. lacustris, Scirpus cyperinus*, respectively]) including nearly monotypic stands; or stands with a mixture of sedge dominants and dominant or subdominant native forbs/ferns/grasses/rushes (e.g., Canada blue-joint grass, joe-pye weed, giant sunflower). Reed canary grass, purple loosestrife, stinging nettle and/or other invasive species (Table 1) are absent or cumulatively comprise less than 20 percent cover in the herbaceous stratum. Non-native buckthorns, if present, comprise less than 10 percent cover within the sedge meadow community.

Medium Quality: Stands of sedges where the invasive species listed above cumulatively comprise 20 to 40 percent cover in the herbaceous stratum; and/or non-native buckthorns comprise 10 to 30 percent cover within the sedge meadow community.

Low Quality: Invasive herbaceous species listed above cumulatively comprise 40 to 50 percent cover; and/or non-native buckthorns comprise 30 to 50 percent cover within the sedge meadow community.

[Note: Stands with less than 50 percent cover by sedges key out to wet meadows, 15B. Stands with greater than 50 percent cover by buckthorn shrubs key out to shrub-carrs, 8B.]

[8] II.A., pages 51-53, Eggers and Reed.

[9] III.A., page 86, Eggers and Reed.

15B. WET MEADOWS[10]

High Quality: Composed of 10 or more species of native/non-invasive grasses, sedges, ferns, rushes and/or forbs. Reed canary grass, purple loosestrife, stinging nettle and/or other invasive species (Table 1), if present, cumulatively comprise less than 20 percent cover. Non-native buckthorns absent or comprise less than 10 percent cover within the wet meadow community.

Medium Quality: Community composed of 5 to 9 species of native grasses, sedges, rushes, ferns and/or forbs; and/or invasive herbaceous species listed above cumulatively comprise 20 to 50 percent cover; and/or non-native buckthorns, comprise 10 to 30 percent cover within the wet meadow community.

Low Quality: Composed of 4 or fewer species of native grasses, sedges, rushes, ferns and/or forbs; and/or invasive herbaceous species listed above cumulatively comprise more than 50 percent cover; and/or non-native buckthorns comprise 30 to 50 percent cover within the wet meadow community. For example, this rating includes the nearly monotypic stands of reed canary grass that are commonly encountered.

[Note: Greater than 50 percent cover by buckthorn shrubs key out to shrub-carrs, 8B.]

15A. WET to WET-MESIC PRAIRIES[11]

High Quality: Community composed of native grasses (e.g., prairie cord-grass, switchgrass, Canada blue-joint grass), sedges, and forbs characteristic of wet to wet-mesic prairies. Reed canary grass, purple loosestrife, quack grass, Canada thistle and/or other invasive species (Table 1) are absent or cumulatively comprise less than 20 percent cover. Non-native buckthorns absent or comprise less than 10 percent cover within in the prairie community.

Medium Quality: Invasive species listed above cumulatively comprise 20 to 50 percent cover in the herbaceous stratum; and/or non-native buckthorns comprise 10 to 30 percent cover within the prairie community.

Low Quality: Invasive species listed above cumulatively comprise more than 50 percent cover in the herbaceous stratum; and/or non-native buckthorns comprise 30 to 50 percent cover within the prairie community.

7B. & 14A. CALCAREOUS FENS[12]

Due to their uniqueness, rarity, and disproportionate number of threatened and special concern plant species, calcareous fen communities are rated as "exceptional" for vegetative diversity/integrity (see Special Features, item b.).

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[10] III.B., page 105, Eggers and Reed.
[11] III.C., page 125, Eggers and Reed.
[12] III.D., page 141, Eggers and Reed.

7A. & 10A. OPEN BOGS[13]

High Quality: Composed of the characteristic assemblage of sphagnum mosses, sedges and heath family shrubs, often with carnivorous plants and various orchid species. Cattails, quaking aspen, non-native buckthorns, reed canary grass, stinging nettle and/or other invasive species (Table 1) are absent or comprise less than 20 percent cover in each stratum (e.g., bryophyte, herbaceous, shrub).

Medium Quality: Invasive species listed above comprise 20 to 50 percent cover in one or more strata.

Low Quality: Invasive species listed above comprise greater than 50 percent cover in one or more strata. Dieback of sphagnum mosses due to flooding, nutrient loading, salt spray, sediment input, etc., can be an indicator.

4A. CONIFEROUS BOGS[14]

High Quality: Stands of tamarack and/or black spruce with the characteristic assemblage of sphagnum mosses, sedges and heath family shrubs. Cattails, quaking aspen, non-native buckthorns, stinging nettle, reed canary grass, and/or other invasive species (Table1) comprise less than 20 percent cover in any stratum (e.g., bryophyte, herbaceous, shrub, tree).

Medium Quality: Stands of tamarack and/or black spruce invaded by cattail, quaking aspen, non-native buckthorns, stinging nettle and other invasive species (Table 1) that comprise 20 to 50 percent cover in one or more strata.

Low Quality: Non-native buckthorns, quaking aspen, stinging nettle, cattail and/or other invasive species (Table 1) cumulatively comprise more than 50 percent cover in one or more strata. Also includes stands where greater than 50 percent of the black spruce and tamarack are dead (due to impoundment, drainage, salt spray, etc.).

8B. SHRUB-CARRS[15]

High Quality: Dominated by native shrubs (e.g., dogwoods, willows) with a herbaceous stratum composed of five or more species of native grasses, sedges, rushes, ferns and/or forbs. Non-native buckthorns, non-native honeysuckles, box elder and/or other invasive woody species (Table 1), cumulatively comprise less than 20 percent cover of the shrub stratum. Reed canary grass and other invasive herbaceous species comprise less than 20 percent cover of the herbaceous stratum.

Medium Quality: Invasive species listed above comprise 20 to 50 percent cover in any one stratum (shrub or herbaceous or both); and/or the herbaceous stratum has 4 or fewer species of native grasses, sedges, rushes, ferns or forbs.

Low Quality: Invasive species listed above comprise more than 50 percent cover in any one stratum (shrub or herbaceous or both).

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[13] IV.A., page 161, Eggers and Reed.
[14] IV.B., page 175, Eggers and Reed.
[15] V.A., page 180, Eggers and Reed.

8A. ALDER THICKETS[16]

High Quality: Stands of speckled alder with less than 20 percent cumulative cover by non-native buckthorns, non-native honeysuckles, box elder and/or other invasive woody species (Table 1). Herbaceous stratum composed of 5 or more species of native grasses, sedges, rushes, ferns and forbs. Reed canary grass, if present, comprises less than 20 percent cover.

Medium Quality: Invasive species listed above cumulatively comprise 20 to 40 percent cover of the shrub stratum; and/or the herbaceous stratum has 4 or fewer native herbaceous species; and/or herbaceous stratum has 20 to 50 percent cover of reed canary grass or other invasive species.

Low Quality: Forty to 50 percent cover of the shrub stratum consists of invasive woody species listed above (Table 1); and/or reed canary grass comprises more than 50 percent cover of the herbaceous stratum.

[Note: Stands with more than 50 percent cover by buckthorns, key out to shrub-carrs, 8B.]

3B. HARDWOOD SWAMPS and 4B. CONIFEROUS SWAMPS[17]

High Quality: Tree/sapling/shrub strata each have less than 20 percent cover of box elder, non-native buckthorns, non-native honeysuckles, eastern cottonwood, quaking aspen (see note below regarding aspen) and/or other invasive species (Table1). Herbaceous stratum composed of 5 or more species of native grasses, sedges, rushes, ferns and/or forbs, and reed canary grass comprises less than 20 percent cover. Another factor is the common presence of seedlings/saplings of the characteristic tree species, which indicates regeneration of the stand, as opposed to observing abundant seedlings/saplings of invasive woody species. NOTE: aspen parkland in northern Minnesota is a special case. Stands of quaking aspen with a ground layer of native prairie species should be rated by a separate method specific to aspen parklands.

Medium Quality: Invasive species listed above comprise 20 to 50 percent cover in one or more strata, and/or the herbaceous stratum has 4 or fewer species of native grasses, sedges, rushes, ferns and forbs. This rating also includes early successional forests of quaking aspen with an under story of characteristic tree species of swamps (e.g., green ash, black ash, red maple, balsam poplar, northern white cedar.).

Low Quality: Invasive species listed above comprise more than 50 percent cover in one or more strata (e.g., tree, sapling, shrub, herbaceous). Typically, few to no indications of regeneration of the characteristic tree species are present.

3A. FLOODPLAIN FORESTS[18]

High Quality: Tree stratum with less than 20 percent cumulative cover by box elder, crack willow, weeping willow or white willow. Herbaceous stratum, if present, composed of native forbs, ferns,

[16] V.B., page 192, Eggers and Reed.
[17] VI.A and VI.B., pages 197 to 213, Eggers and Reed.
[18] VII., page 214, Eggers and Reed

sedges and grasses characteristic of floodplain forests (e.g., wood nettle, jewelweed, Virginia rye, cut-leaf coneflower) with less than 20 percent cover by reed canary grass.

Medium Quality: Invasive species listed above comprise 20 to 50 percent cover in one or more strata.

Low Quality: Invasive species listed above comprise greater than 50 percent cover in one or more strata. Also include stands where greater than 50 percent of the trees are dead.

16B. SEASONALLY FLOODED BASINS[19]

High Quality: Dominated by native/non-invasive species (examples in Table 4) with less than 20 percent cover in any one stratum by non-native and/or invasive species (e.g., common buckthorn, reed canary grass, Canada thistle, yellow foxtail, barnyard grass, common ragweed, stinging nettle, quack grass – see Table 1). Typically located within an area of permanent vegetative cover (e.g., forest, prairie, non-agricultural settings) undisturbed or minimally disturbed by artificial drainage, haying, grazing, plowing, stormwater input, or other disturbances.

Medium Quality: Invasive species listed above comprise 20-50 percent cover in one or more strata. Typically located in areas that are partially drained, infrequently cropped, lightly grazed, subject to some stormwater input, etc.

Low Quality: Invasive species listed above comprise greater than 50 percent cover in one or more strata. Typically located in frequently cropped agricultural fields, heavily grazed, or subjected to substantial inputs of stormwater, or other adverse disturbances.

Table 4: Examples of Native/Non-Invasive Species of Seasonally Flooded Basins Including Vernal Pools

Scientific Name	Common Name	Scientific Name	Common Name
Onoclea sensibilis	Sensitive fern	*Geum canadense*	White avens
Athyrium filix-femina	Lady fern	*Impatiens capensis*	Jewelweed
Ribes americanum	Wild black currant	*Juncus canadensis*	Canada rush
Sambucus canadensis	Common elderberry	*Juncus tenuis*	Slender rush
Vitis riparia	Riverbank grape	*Juncus torreyi*	Torrey's rush
Boehmeria cylindrica	False nettle	*Leersia virginica*	Whitegrass
Carex grayi	Gray's sedge	*Leersia oryzoides*	Rice cut-grass
Carex lupulina	Hop sedge	*Rudbeckia laciniata*	Cut-leaf coneflower
Carex muskingumensis	Muskingum sedge	*Sium suave*	Water parsnip
Carex stipata	Stalk-grain sedge	*Polygonum pensylvanicum*	Penn. smartweed
Carex typhina	Cattail sedge	*Polygonum lapathifolium*	Nodding smartweed
Cyperus strigosus	Straw-color flatsedge	*Ranunculus septentrionalis*	Buttercup
Eleocharis obtusa	Blunt spikerush	*Elymus virginicus*	Virginia wild-rye
Aster lateriflorus	Calico aster	*Bidens cernua*	Nodding beggartick

[19] VIII., page 227, Eggers and Reed.

4. Y N **Are state or federally listed plant species, rare, threatened or of special concern, found or known to be found in the wetland recently?** If Special Features questions d or i [rare natural community, rare plant species] are answered yes, then this question is yes and Vegetative Diversity function is Exceptional.

5. Y N **Is the wetland or a portion of the wetland a rare natural community or habitat based on the Minnesota Natural Heritage Database or the County Biological Survey[20]?** If yes, wildlife habitat functional level rating = exceptional. (If Special Features question d is answered yes, this question will also be affirmative.)

Guidance: Rare Natural Communities. The Minnesota Department of Natural Resources Natural Heritage and Nongame Research Program and the County Biological Survey collects, manages, and interprets information about nongame animals, native plants, and plant communities to promote the wise stewardship of these resources. A ranking system is intended to reflect the extent and condition of natural communities and species in Minnesota. These 'state ranks' have no legal ramifications; they are used by the Natural Heritage Program to set priorities for research and for conservation planning. They are grouped as follows:

State Element Rank:

S1: Critically imperiled in the state because of extreme rarity.
S2: Imperiled in state because of rarity.
S3: Rare or uncommon in state.
S4: Apparently secure in state.
S5: Demonstrably secure in state.

For this question, a rare natural community is defined as a wetland native plant community having a state element rank of S1, S2, or S3 that is mapped or *determined to be eligible for mapping* in the Natural Heritage Information System OR a wetland native plant community contained within an area mapped or determined to be eligible for mapping in the NHIS as a Site of Outstanding or High Biological Diversity. If a special case is suspected, consider using a specific assessment tool in addition to MnRAM.

6. Y N **Does the wetland represent pre-European-settlement conditions? (e.g., MnDNR Native Plant Communities publication)** If yes, then Vegetation function is Exceptional (continue to answer subsequent questions). Created wetlands would not qualify, regardless of quality.

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[20] These references are available at local Soil & Water Conservation District offices; some counties are online at the Minnesota Department of Natural Resources/Ecological Services website.

General information about the wetland site:

7. **Describe** the hydrogeomorphology of the wetland and associated topography (check those that apply):

___ Depressional/Isolated (no discernable inlets or outlets)
___ Depressional/Flow-through (apparent inlet and outlet)
___ Depressional/Tributary (outlet but no perennial inlet or drainage entering from upstream subwatershed)
___ Riverine (within the river/stream banks)
___ Lacustrine Fringe (edge of deepwater areas)/Shoreland
___ Extensive Peatland/Organic Flat
___ Slope
___ Floodplain (outside waterbody banks)
___ Other ______________________________

8. Approximate maximum depth of standing water in the wetland (inches): ______

Percent of wetland area inundated: ______%

~ **9. What is the estimated area of the wetland's immediate drainage area in acres?_____**

~ **10. Estimated size of existing wetland in acres:_________**

10. Guidance: Determining wetland size. The estimated size of existing wetlands can be calculated off aerial photos, preferably infrared, and/or in some cases calculating the size of the depressional hydric soil polygon. If available on a GIS system, these polygon areas can automatically be calculated.

~ **11. General description of soil(s)** from Soil Survey and on site:

	Adjacent UPLAND Area (within 500 feet)	**WETLAND Area**
Soil Survey Classification(s):		
Soil texture and drainage		

12. For depressional wetlands, describe the wetland surface and subsurface outlet characteristics as it relates to the wetland's ability to detain runoff and/or store floodwater.

A = No surface or subsurface outlet, or a restricted outlet at or greater than 2 feet higher than the wetland boundary

B = Swale, channel, weir, or other large, surface outlet (>18 inch pipe) with outflow elevation 0-2 feet above the wetland boundary, subsurface tile with no surface inlet.

C = Wetland outflow elevation below the wetland boundary with either a high capacity surface outlet (swale, channel, weir, pipe >18 inch diameter, etc...) or a subsurface outlet (drain tile) with a surface inlet.

N/A = Not applicable for floodplain, slope, lacustrine, riverine, and extensive peatland/flat wetlands.

13. Describe the wetland surface and subsurface outlet characteristics as it relates to the wetland hydrologic regime[21]:

A = No outlet, natural outlet condition, or a constructed outlet at the historic outflow elevation; no evidence of subsurface drainage (drain tile).

B = Constructed, reduced capacity outlet below the top of the temporary wet meadow zone; moderate indications of subsurface drainage; outlet raised but managed to mimic natural conditions; watercourse has been recently ditched/channelized.

C = Excavated or enlarged outlet constructed below the bottom of the wet meadow zone; strong indications of subsurface drainage; outlet removes most/all long-term and temporary storage; or outlet changes hydrologic regime drastically.

12/13. Guidance: Outlet Characteristics. The ability of a wetland to maintain a hydrologic regime characteristic of the wetland type is somewhat dependent upon whether a natural outlet is present, or whether an outlet has been constructed or modified by humans. Constructed outlets can significantly diminish the ability of a wetland to provide temporary and long-term water retention, and thus its ability to maintain its characteristic hydrologic regime. Wetlands with natural outlets are functioning at the highest level possible for the type within the wetland comparison domain, and should be rated A [high]. Constructed outlets above the temporary wetland (wet meadow) zone are rated B [medium] if managed to mimic natural conditions. Constructed outlets, either surface or subsurface, below the top of the temporary wet meadow zone reduce the ability of the wetland to provide temporary and long-term water retention; if a constructed outlet is present below the top of the temporary wetland zone, but is such that the wetland is able to provide some temporary and long-term water retention (i.e. the wetland is only partially drained), the rating should be B [medium]. Constructed outlets, either surface or subsurface, which remove most or all temporary and long-term retention capabilities, significantly reduce the ability of the wetland to maintain its characteristic hydrologic regime; the rating should be C [low]. Constructed outlets that keep open water wetlands open water or keep saturated wetlands saturated are rated B [medium]. If the constructed outlet changes the wetland to non-wetland or to deepwater habitat or from saturated conditions to open water or from open water to saturated then it is rated C [low].

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[21] Lee et al., 1997.

~ **14. Describe the dominant land use and condition of the immediate upland drainage area of wetland.[22] If the immediate upland drainage is not evident, then within 500 feet.**

A = Watershed conditions essentially unaltered; < 10% impervious (i.e. low density residential, >1 acre lots); land use development minimal, idle lands, lands in hay or forests or low intensity grazing.

B = Watershed conditions somewhat modified; e.g., 10–30 % impervious (i.e. medium density residential, 1/3 to 1 acre lots); moderate intensity grazing or haying with some bare ground; conventional till with residue management on moderate slopes, no-till on steep slopes.

C = Watershed conditions highly modified; e.g., >30 % impervious surfaces (i.e. high density residential, lots smaller than 1/3 acre, industrial, commercial, high impervious institutional) maximizing overland flow to the wetland; intensive agriculture or grazing with a high amount of bare ground, no residue management on moderate or steep slopes, intensive mining activities.

14. Guidance: Dominant upland land use[23]. Overland flow affects wetland flood storage capabilities and overland flow is affected by changes in upstream vegetative communities. Upland land use within the watershed contributing to the wetland (as defined in Question #9) and the watershed size have a significant influence on the flow of runoff and sediments to the wetland, and thus the ability of the wetland to desynchronize flood flows and maintain its characteristic hydrologic regime. The more developed and intensively the watershed is used, the greater the delivery of runoff and sediments to the wetland is likely to be and the more likely the wetland will have the opportunity to minimize flooding downstream. With increased runoff and sediment delivery, the wetland will be less likely to maintain its characteristic hydrologic regime. As the proportion of the impervious watershed area increases, runoff volume and rate increases along with sediment concentrations.

15. Describe the conditions of the wetland soils:

A = There are no signs or only minor evidence of recent disturbance or alteration to the wetland soils; temporary wetland wet meadow zone intact; idle land, hayed or lightly to moderately grazed or logged. Minimal compaction, rutting, trampling, or excavation damage to wetland.

B = Moderate evidence of disturbance or alteration to the wetland soils. Temporary wet meadow zone tilled or heavily grazed most years. Zones wetter than temporary receive tillage occasionally. Some compaction, rutting, trampling, or excavation in wetland is evident.

C = Evidence of significant disturbance or alteration to the wetland soils. Wetland receives conventional tillage most (>75%) years; or otherwise significantly impacted (e.g., fill, sediment deposits, cleared, excavated). Severe compaction, rutting, trampling, or excavation damage to wetland.

15. Guidance: Condition of Wetland Soils. The condition of the soils in the wetland affects the vegetation within the wetland, and thus the relationships affecting ground-water discharge, recharge, and evapotranspiration. The more developed and intensively the wetland is used (i.e. tillage, excavation, vehicle traffic, pedestrian or livestock usage), the more likely these relationships are to be impacted, and the more likely the ability of the wetland to maintain its characteristic hydrologic regime will be reduced.

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[22] Lee et al., 1997.

[23] The range of impervious proportions for various land uses is borrowed from Chow, Maidment, and Mays (1988)

16. Enter the proportion of the wetland that is vegetated with woody, emergent, submergent, or floating-leaved vegetation.

______%

16. Guidance: Wetland Vegetation is assessed here for two related properties:

1) Water/Vegetation Proportions and Interspersion. Rooted vegetation in flow-through wetlands slows floodwaters by creating frictional drag in proportion to stem density, more or less according to vegetation cover type and interspersion. Flow-through wetlands with relatively low proportions of open water to rooted vegetation and low interspersion of water and rooted vegetation are more capable of altering flood flows. Dense stands of rooted vegetation, including trees, shrubs, and herbaceous emergent are more capable of slowing floodwater than open water alone. Ratings follow these categories: High (dense vegetative cover) >75%; Medium (combination some unvegetated open water and vegetative cover) = 25 - 75%; Low (primarily unvegetated open water) = <25%. Isolated wetlands, which are perfect containers of floodwaters, should be rated 100%.

2) Nutrient Uptake/Cycling. A wetland's ability to uptake, metabolize, sequester and/or remove nutrients and imported elements from the water is primarily dependent on wetland vegetative conditions. Microbial processing and bioaccumulation are associated with plant cover including floating, emergent or submergent vegetation.[24] Vegetative density can serve as an index of primary production, which is an indicator of nutrient assimilation. Forested wetlands retain ammonia during seasonal flooding and wetland environments are effective at denitrification. Wetlands take up metals both by adsorption in the soils and by plant uptake via the roots. They allow metabolism of oxygen-demanding materials and can reduce fecal coliform populations. These pollutants are often buried by deposition of newer plant material, isolating them in the sediments.

17. Describe the roughness coefficient of the potential surface floodwater flowpath in relation to wetland vegetation biomass, numeric density and plant morphology[25]:

A = Dense bushy willow, heavy stand of timber with or without downed trees, or mature field crops with flow at half or less of crop height.

B = Dense grass with rigid stems, weeds, tree seedlings, or brushy vegetation where flows can be two to three times the height of the vegetation.

C = Primarily flexible turf grass or other supple vegetative cover or unvegetated.

N/A = Not applicable if wetland is isolated.

17. Guidance: Floodwater resistance. Forest cover and other woody stems increase surface roughness resulting in an increased detention of high flows. The cumulative effect is reduced peak flows downstream. A forest (i.e. ash, boxelder, red maple, conifers) with a dense understory is best for detaining high flows. Without a forest present, woody shrubs (i.e. alder, willow, red osier dogwood) can be extremely effective but lose effectiveness once high flows approach and exceed the woody shrub height. Dense, non-woody vegetation (i.e. cattails, reed canarygrass) are effective at detaining minor flood flows but lay down to higher flows and the surface roughness greatly diminishes. Turf grass and other supple vegetation has minimal effects on flood flows. Open water wetlands with submergent and scattered emergent vegetation are part of the channel characteristics and have minimal effect on detaining flood flows. The Manning's roughness coefficient decreases as water depth increases above

[24] Magee and Hollands, 1998; Lee et al., 1997.
[25] Adamus et al., 1991.

the macrophytes and other surface roughness characteristics. Dense, robust, tall vegetation is best for floodplains.

18. Describe the extent of observable/historical sediment delivery to the wetland from anthropogenic sources including agriculture:

A = No evidence of sediment delivery to wetland.

B = Minor evidence of accelerated sediment delivery in the form of stabilized deltas, sediment fans.

C = Major sediment delivery evidenced by buried detritus and/or vegetation along outer edge of temporary wetland (wet meadow) zone. Recent deltas, sediment plumes, etc. in areas of concentrated flow or sedimentation raising bottom elevation of wetland.

18. Guidance: Sediment Delivery. Wetlands filled by sediment from anthropogenic sources will have reduced capacity to store stormwater. Land use, ground slope, and erodibility characteristics of the soils affect the potential for sediment delivery to the wetland.

~ **19. Describe the predominant upland soils within the wetland's immediate drainage area that affect the overland flow characteristics to the wetland[26]:**

A = Sands (Hydrologic soil group A)

B = Silts or loams (Hydrologic soil group B)

C = Clays or shallow to bedrock (Hydrologic soil groups C, D, A/D, B/D, C/D)

19. Guidance: Watershed Soils. Use hydrologic grouping if available, otherwise, use soil texture from the soil survey [see chart in Guidance for Question #60]. Greater runoff and higher flood peaks occur in watersheds having primarily impermeable soils. These types of soils impede water infiltration and so produce increased runoff. Wetlands located downslope of more impermeable soils are more likely to provide flood attenuation.

20. Describe the characteristics of stormwater, wastewater, or concentrated agricultural runoff detention/water quality treatment prior to discharging into the wetland:

A = Receives significant volumes of untreated/undetained stormwater runoff, wastewater, or concentrated agricultural runoff directly, in relation to the wetland size.

B = Receives moderate volumes of directed stormwater runoff, wastewater, or concentrated agricultural runoff in relation to wetland size, which has received some treatment (sediment removal) and runoff detention.

C = Does not receive directed stormwater runoff, wastewater, or concentrated agricultural runoff; receives small volumes of one or more of these sources in relation to wetland size; or stormwater is treated to approximately the standards of the National Urban Runoff Program (NURP); and runoff rates controlled to nearly predevelopment conditions.

20. Guidance: Stormwater Runoff Pretreatment and Detention. These ratings apply to both Flood/Stormwater Storage and Attenuation *and* Downstream and Wetland Water Quality Protection.

[26] See the Soil Data Mart on the NRCS/USDA website for help with soil characterization.

When used for determining water quality characteristics, the ratings are reversed (i.e. A=High shown above will be counted as C=Low). Wetlands receiving undetained, directed stormwater from developed areas generally provide a higher functional level for flood/stormwater storage than do similar wetlands receiving stormwater at rates of, and with water quality equivalent to, that prior to development.

A NURP pond is most easily identified by having a 10-foot wide, nearly flat shelf just below the normal water level and will be 4 to 10 feet deep. Typically, these ponds will have a wet surface area (at the normal level) approximately equal to 1% of the watershed area (when the impervious percentage is less than 50), or 2% of the watershed impervious area (when the impervious percentage is >50). For example, a 0.5 acre pond will serve 50 acres of drainage area with 15% impervious surfaces or a 35 acre watershed containing 25 acres of impervious surfaces). Ponds that remove sediment only are typically smaller with a depth of 4 feet or less. The high rating equates with direct pipe discharge into the wetland and runoff rates, which will likely increase the water level in the wetland significantly (i.e. a pipe discharge from a short length of road or from several residential back yards to a 100 acre wetland complex does not constitute a significant impact).

~**21. Describe the proportion of wetlands within the DNR minor watershed** (the 5,600 DNR minor watersheds as defined in Minnesota Rules 8420.0110, Subp. 31) **and the opportunity for contributing to floodwater detention[27]:**

A = Wetlands make up less than 10% of the minor watershed area.
B = Wetlands make up 10-20% of the minor watershed.
C = Wetlands make up more than 20% of the minor watershed.

21. Guidance: Subwatershed Wetland Density. The density of wetlands in the minor watershed will determine the benefit each provides downstream. Wetlands reduce flood peaks up to 75 percent compared to rolling topography when they occupy only 20 percent of the total basin.[23] When wetland densities in the minor watershed exceed 20% total cover, the flood storage benefits of additional wetlands rapidly decrease.

22. Describe the functional level of the wetland in retarding or altering flows based on the surface flow characteristics through the wetland:

A = No channels present.
B = Channels present, but not connected, or meandering channels.
C = Channels connecting inlet to outlet.

22. Guidance: Channels/Sheet Flow. Channels are formed in the underlying substrate, not just as paths through emergent vegetation. Sheet flow, rather than channel flow, offers greater frictional resistance. The potential for floodflow desynchronization is greater when water flows through the wetland as sheet flow. Connecting channels will carry water directly from the inlet to the outlet preferentially in the channel. Channels not connected indicate that some channelized flow may occur within the wetland but not all the way through the wetland via a single channel; some sheet flow will occur. No channels present represents wetlands in which water from the inlet will spread out over the wetland to the outlet (e.g., unchannelized meadows, shallow marshes, deep marshes, ponds, typical floodplains without meander channels, etc…).

[27] Verry, 1988; Wells et al., 1988; Flores et al., 1981; and Ogawa and Male 1983/MA:P.

23. Adjacent Buffer width: Average width of the naturalized buffer:_____feet [Within 500']

23. Guidance: Upland Buffer. Vegetated buffers around wetlands provide multiple benefits including wildlife habitat, erosion protection, and a reduction in surface water runoff. A buffer is an unmanicured area immediately adjacent to the wetland boundary. For this question, do not include lawn areas. If the buffer varies from one side to another, take the average width over the entire perimeter.

Widths for Water Quality
High = >50 feet
Medium = 25 – 50 feet
Low = <25 feet

Widths for Wildlife Habitat
High = >300 feet
Medium = 50 – 300 feet
Low = <50 feet

To score the next three questions, consider a 50-foot ring around the wetland or assessment area. Describe the condition (minimum 10%) of each category. Total should equal 100%.

24. Adjacent Area Management: average condition of vegetative cover for water quality.

____% Full vegetative cover

____% Manicured, primarily vegetated (i.e. short-grass lawn, clippings left in place)

____% Lacking vegetation: bare soil or cropped, unfenced pasture, rip-rap, impervious/pavement.

24. Guidance: Adjacent Area Management. This question refers to the 50 feet surrounding the wetland assessment area (unlike the shoreland wetland vegetation question, which refers to the vegetation within the wetland itself). Maintenance may include mowing, haying, spraying or burning.

25. Adjacent Area Diversity & Structure (composition of characteristics for habitat)

____% Full coverage of native non-invasive vegetation

____% Mixed native/non-native vegetation, moderate density coverage, OR dense non-native cover.

____% Sparse vegetation and/or impervious surfaces.

25. Guidance: Adjacent Area Diversity and Structure. Many wetland-associated wildlife utilize upland areas for breeding, nesting, and foraging activities. Quality of the upland will affect the diversity and stability of the wetland wildlife community. This question combines estimates of both diversity and density—most wetlands will fall in the middle.

26. Adjacent Upland Slope

____% gentle slopes, 0-6%

____% moderate slopes, >6-12%

____% steep slopes, >12%

26. Guidance: Adjacent Upland Slope. Gentle slopes are associated with greater use by wildlife and also are less likely to erode. This measurement is best estimated on site.

27. Describe the proximity of the first recreational lake, recreational watercourse, spawning area or significant fishery, or water supply source down-gradient of the wetland[28]:

A = Isolated wetlands *or* wetland with one or more resource within 0.5 mile downstream via any form of channel, pipe.
B = One or more resource within 0.5 to 2 miles downstream.
C = No significant resources are located within 2 miles downstream.

27. Guidance: Downstream Sensitivity. The water quality function wetlands provide help disperse the physical, chemical and biological impacts of pollution in downstream waters. Sensitive water resources located within 0.5 miles downstream of the wetland will realize the greatest benefit to water quality from the wetland. As discharges from the wetland move farther downstream, the benefits to water quality provided by the wetland will continue to diminish.

28. Does the wetland water quality and/or plant community exhibit signs of excess nutrient loading:

A = No evidence of excess nutrient loading or nutrient sources (e.g., evidence of diverse, native vegetative community, no pipes, etc.).

B = Some evidence of excess nutrient loading source and evidence in the plant communities such as dense stands of reed canary grass or narrowleaf, and/or blue (hybrid) cattail.

C = Strong evidence of excess nutrient loading by evident nutrient sources or evidence in the plant community such as algal mats present or evidence of excessive emergent, submergent and/or floating macrophyte growth.

28. Guidance: Nutrient Loading. Excessive nutrient loading to a wetland can cause nuisance algal blooms and the production of monotypic stands of invasive or weed species. Observed point source or nonpoint source of nutrients may include but is not limited to: fertilized lawns, agricultural runoff, manure storage or spreading, concentrated stormwater runoff, or pet waste inputs.

29. Y N Is the wetland fringing deepwater habitat, a lake, or within a watercourse? If NO, enter "not applicable" for this function in the Summary Table and skip to Question 35 [remove from computation of Shoreline Protection function.] If YES, answer the following questions.

29. Guidance: Shoreline Wetlands. The Shoreline Protection function only applies to wetlands that lie at the fringe of lakes, deepwater habitats, and within creeks, streams, rivers, and other watercourses. Typically, these include lacustrine wetlands i.e. fringing lakes which are defined as being situated in a topographic depression; lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent areal coverage; and greater than 20 acres in size or fringing deepwater habitats which are defined as less than 20 acres in size, but either greater than 6.6 feet deep at the deepest, or has a wave-formed shoreline[29]. The wetland portion is typically the area that is less than 6.6 feet deep. Also included as shoreline wetlands are floodplain/riverine systems (i.e. wetlands present between the active river channel and river banks that may experience frequent water level fluctuations and/or erosive forces).

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[28] Wells et al., 1988.
[29] Cowardin, 1979

30. Enter the percent cover of rooted shoreline wetland vegetation[30].

______% (High = Macrophyte cover in the wetland >50%;
Medium = Macrophyte cover in the wetland is 10% - 50%;
Low = Macrophyte cover in the wetland <10%.)

30. Guidance: Rooted Shoreline Vegetation. The erosive strength of waves and currents can be greatly dissipated by a dense vegetation cover including submerged macrophytes. The greater the vegetation density, the greater the shoreline protection.

31. Enter the average wetland width in feet between the shoreline/streambank and deep water/stream[31]:

_____ feet; (High = Wetland width >30 feet;
Medium = Wetland width 10-30 feet;
Low = Wetland width <10 feet)

31. Guidance: Wetland Width. Wetlands with wide stands of vegetation are more likely to stabilize sediments than those with narrow stands. Knutson et al. (1981) found that wetlands wider than 30 feet reduced wave energy by 88% while emergent wetlands less than 6 feet wide were relatively ineffective in wave buffering. Measure width starting from the deepwater edge up to the normal water's edge, not to include the shore area up out of the water itself (the shore-area wetland is considered in Question #34).

32. Describe the emergent vegetation type and resistance within the shoreline wetland[32]:

A = Dominance of emergent species with strong stems present all year and/or dense root mats in the wash zone (e.g., cattails, shrubs) that are resistant to erosive forces.

B = Presence of some emergent species with strong stems or dominance of weak-stemmed emergent species persisting most of the year and/or moderately dense root mats in the wash zone (e.g., bulrushes, grasses) that are resistant to erosive forces.

C = Presence of some weak-stemmed emergent species and/or no dense root mats in the wash zone (e.g., rushes).

32. Guidance: Emergent Vegetation. The erosive strength of waves and currents can be greatly dissipated by a dense, emergent vegetation cover. In addition, species with stronger stems will provide greater protection than weak-stemmed species. The greater the vegetation density, the greater the shoreline protection. Some of the more common species with potentially high value for shoreline anchoring include: sweetflag (*Acorus calamus*), speckled alder (*Alnus incana* ssp. *rugosa*), blue joint grass (*Calamagrostis canadensis*), sedges (*Carex* spp.), red-osier dogwood (*Cornus stolonifera*), spike rush (*Eleocharis palustris*), scouring rush (*Equisetum fluviatile*), rice cutgrass (*Leersia oryzoides*), switchgrass (*Panicum virgatum*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), smartweeds (*Polygonum* spp.), pickerelweed (*Pontederia cordata*), cottonwood (*Populus deltoides*), arrowhead (*Sagittaria* spp.), willows (*Salix* spp.), bulrushes (*Scirpus* spp.), cordgrass (*Spartina pectinata*), and cattails (*Typha* spp.).

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[30] Wells et al., 1988.
[31] Adamus et al., 1991.
[32] Wells, et al., 1988.

33. Describe the shoreline erosion potential at the site[33]:

A = Strong wave action or water current (greatest wind fetch on a lake or outside river bend); frequent boat traffic and restrictions that funnel boats into narrow passages; sandy soils or evidence of erosion or slope failure.

B = Moderate wave action or water current (small lakes or large ponds); moderate boat traffic with some evidence or potential for erosion or slope failure.

C = Negligible erosive forces (little open water or wave action or slow-moving, straight river); minimal to no boat traffic or no-wake zone; no evidence of past erosion or slope failure.

33. Guidance: Shoreline Erosion Potential. Wetlands located in areas with strong currents and wave action have the greatest potential for protecting shoreline. Shorelines composed of sandy or erodible soils will benefit the most from shoreline wetland protection.

34. Describe the shoreline/streambank vegetation conditions up slope from the water level in relation to the ability to protect the bank from erosion or slope failure:

~~High~~A = Lack of vegetation; regularly manicured, short-grass lawn.

~~Medium~~B = Full vegetative cover composed of shrubs receiving only moderate maintenance or grasses/understory vegetation that is not manicured.

~~Low~~C = Deep-rooted vegetation not actively manicured (e.g., trees, native shrubs and grasses), or rip-rap.

34. Guidance: Bank Protection Ability. The potential for erosion and/or slope failure of shoreline or streambank areas is also dependent on the land use and condition on the slope above the water level and on top of the bank. Bare soils or those with shallow rooted grasses that are manicured on a regular basis provide less protection than deep-rooted native grasses allowed to grow naturally. For this question, consider that part of the wetland starting at the water's edge up to the upland edge, to encompass the shore area up out of the water itself (the water-level wetland is considered in Question #31).

~ **35. Y N Is the wetland known to be used recently by rare wildlife species or wildlife species that are state or federally listed?** If yes, wildlife habitat functional level rating = exceptional. (If Special Features, question J is answered yes, the functional level will also be exceptional)

35. Guidance: Rare Wildlife. Rare wildlife species include any of those listed in the Minnesota Natural Heritage Database or County Biological Survey or are federally listed.

~ **36. Y N Is the wetland plant community scarce or rare within the watershed?** If the wetland community has a High quality rating from Question #2 and this question is yes, then Vegetation function is Exceptional.

36. Guidance: Rare Community. This question is meant to address local conditions rather than statewide priorities. Although consulting the Natural Heritage Database and County Biological Survey (see Question #5) will be helpful to guide the assessment, local considerations of scarcity or abundance

[33] Wells et al., 1988.

must be applied here.

37. For deep and shallow marshes or shallow open water wetland types (types 3, 4, and 5) select the cover category that best illustrates the interspersion of open water and emergent, submergent, or floating-leaved vegetation within the wetland (See Interspersion Diagram Figure 1[34], Appendix Fig. 1 or the database *image*).

Enter the cover category based on the diagram: _____~~type type types~~

N/A = Not applicable for wetland types 1, 2, 6, 7, 8.

37. Guidance: Vegetation Interspersion[35]. Wetlands that contain vegetation interspersed with open water are more likely to support notably greater on site diversity and/or abundance of fish and wildlife species. Those with very dense vegetation and no channels or open water areas are less likely to support this function. Vegetation interspersion is a measure of the amount of edge between vegetation and open water, which is valuable to wildlife. Cover categories 5 and 7 rate High; 3, 4, and 6 rate Medium; 1, 2, and 8 rate Low.

38. For wetlands having more than one vegetative community (see Question 1), indicate the interspersion category that best fits the wetland (see Appendix Fig. 2 or database version *Image*).

Category =____. (Category 3=High, 2=Medium, 1=Low)

N/A = Only one vegetative community is present.

38. Guidance: Vegetative Interspersion. For wetlands that are characterized by multiple vegetative communities, the increased structural diversity and amount of edge associated with greater interspersion is generally positively correlated with wildlife habitat quality. Interspersion is a modification based on the Wells et al., 1988, Page 67, Interspersion Diagram, Golet et al., 1976. The figures shown in the appendix are examples of complexity, not meant to be exact representations of any individual site. Choose the one that most closely approximates the degree of interspersion at your site, regardless of structural differences. "Site," in some instances, may mean a portion of a larger basin, if that is how the assessment area has been defined from the start.

39. A healthy wetland will have detritus (vegetative litter) in several stages of decomposition. Describe the wetland condition[36]:

A = The presence of litter layer in various stages of decomposition.

B = Some litter with apparent bare spots, or dense litter mat (e.g., reed canary grass mat).

C = No litter layer.

N/A = Deep marshes, shallow open water and bog communities.

39. Guidance: Wetland Detritus. Detritus or vegetative litter in various stages of decomposition is a sign of a healthy wetland. Detrital biomass impacts nutrient cycling processes and disturbance regime and thereby influences plant assemblages. Detritus maintains thermal regulation of rhizomes and propagules, and is essential to nutrient cycling. The integrity of the system's vegetation components supplies the bulk

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[34] Wells et al., 1988; Adamus et al., 1991.

[35] Interspersion is based on Wells et al., 1988, Page 180 Interspersion Diagram

[36] Lee et al., 1997

of the faunal habitat requirements. When assessing a site, consider that the amount of detritus will vary with the time of year; floodplain forests may show no litter after spring flood events, for example.

~ **40. Describe the relative interspersion of various wetlands in the vicinity of the assessment wetland[37]:**

A = The wetland occurs in a complex of wetlands of various types (general guideline: at least 3 wetlands within 0.5 miles of assessment wetland, at least one of which has a different dominant plant community than the assessment wetland); or the assessment wetland is the only wetland within a 2 mile radius.

B = Other wetlands of the same plant community as the assessment wetland are present within 0.5 miles.

C = No other wetlands are present within 0.5 miles of the assessment wetland but are present within 2 miles.

40. Guidance: Wetland Interspersion. This question is best determined using GIS (except in forested areas where wetlands smaller than one to three acres may not appear). This question uses a 0.5-mile radius and rates wetlands higher for having more wetland neighbors. However, research indicates that the critical radius varies by species[38]. Wetlands that are isolated in the landscape may provide the last refuge for wetland dependent plant and animal species in an otherwise upland or developed area.

41. Habitat value diminishes when fragmented by barriers, which restrict wildlife migration and movement. Describe barriers present between the wetland and other habitats[39]:

A = No barriers or minimal barriers present; i.e. low traffic; uncurbed roads, low density housing (> 1 acre lots), golf courses, utility easements, or railroads.

B = Moderate barriers present; i.e. moderately traveled; curbed roads, moderate density housing (1/3 to 1 acre lots), residential golf courses, low dikes, row crops.

C = Large barriers present; i.e. 4-lane or wider, paved roads, parking lots, high-density residential (<1/3 acres), industrial and commercial development.

41. Guidance: Wildlife Barriers. This variable is defined as a measure of habitat fragmentation of the wetland relative to other wetlands and native plant communities to indicate the ecosystem connectivity. It identifies barriers to wildlife migration ranging from very small barriers such as unpaved roads and low-density housing to large hydrologic barriers such as regional canals and levied roads. Reference area will affect this rating: "other habitats" includes upland areas usable as wildlife resting or reproductive habitat. Because agricultural use can vary in intensity, use Best Professional Judgment to determine if cropland could be considered "habitat."

42. Amphibian breeding potential – hydroperiod (check one)

___ Adequate—the wetland is inundated long enough in most years to allow amphibians to successfully breed (Cowardin et al. water regimes A, C, F, H, G) (Score = 1.0)

___ Inadequate—the wetland is not inundated long enough in most years to allow amphibians to

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[37] Wells et al., 1988; Adamus et al., 1991

[38] Whited et al., 2000

[39] Rheinhardt et al., 1997

successfully breed (Cowardin et al. water regimes B, D, E, J) (Score = 0)

42. Guidance: Frogs, toads and salamanders reproduce at different times from late March to June, depending on the species[40]. Early breeders (such as spring peepers, wood frogs, chorus frogs, salamanders) typically reproduce in shallow, seasonal wetlands. Green frogs and mink frogs reproduce in larger more permanent wetlands. For breeding to be successful, the wetland must remain inundated long enough for the larval stages to metamorphose into adults. This period varies depending on the species, but a rough guide is that the wetland should remain inundated at least through June 1 for the portion of the state south of I-94 and at least through June 15 north of I-94. This period of inundation will not accommodate all species, but is reasonably likely to ensure that the wetland is suitable for breeding by some amphibians.

The Cowardin et al. water regimes listed above are approximate indicators—more direct evidence of hydroperiod should be used when possible. Direct evidence of amphibian breeding **may** be an indication of a sufficient hydroperiod. Such evidence would include observations of frogs calling, egg masses in the water, presence of tadpoles or presence of young, newly metamorphosed frogs, toads or salamanders at the wetland. Note however, that some species are opportunistic and will lay eggs in temporary pools that will not remain inundated long enough for successful reproduction. Exercise caution when using this indicator.

43. Amphibian breeding potential – fish presence

A = The wetland is isolated so that predatory fish (e.g., bass, northern pike, walleye, bluegill, perch, etc…) are never present.

B = The wetland may occasionally be connected to other waters so that predatory fish may be present in some years.

C = The wetland is connected with a lake or river so that predatory fish are always present or the wetland is used for rearing of game fish.

43. Guidance: Optimal amphibian breeding habitat is characterized by a lack of predatory fish[41]. These habitats are wetlands that winterkill, dry periodically, are periodically anoxic, and are not connected to waters bearing predatory fish. The wetland should not be used to rear bait or game fish. This question utilizes observable characteristics of the wetland to infer about the status of fish. Direct observation or knowledge about fish presence should be substituted where possible.

44. Amphibian and reptile overwintering habitat

A = The wetland is normally more than 1.5 meters deep (never or rarely winterkills).

B = The wetland is normally around 1 meter deep (may occasionally winterkill).

C = The wetland is normally less than 1 meter deep and often freezes to the bottom.

N/A = The wetland never or rarely contains standing water or is nearly always dry in winter.

44. Guidance: Wetlands that are deep and well oxygenated provide over-wintering habitat for leopard, green and mink frogs, as well as turtles[42]. Evidence of over-wintering would be observations of migrations of frogs to the wetland in fall and away from the wetland in spring and basking turtles in the spring. Recent evidence of Blandings turtles overwintering in Type 6 wetlands may alter this assessment.

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[40] Oldfield and Moriarty, 1994
[41] Lannoo, 1998
[42] Oldfield and Moriarty, 1994

45. List any noteworthy wildlife species observed or in evidence (e.g., tracks, scat, nest/burrow, calls, viewer reports), including birds, mammals, reptiles, and amphibians. *(Note: This list is for documentation only and is not necessarily an indication of habitat quality.)*

46. Is the wetland contiguous or intermittently contiguous with a permanent waterbody or watercourse such that it may provide spawning/nursery habitat for native fish species? Choose the condition from the following list that best describes the wetland in relation to fish habitat:

Exceptional = The wetland is a known spawning habitat for native fish of high importance/interest or the wetland is part of or adjacent to a trout fishery as identified by the DNR.

A = The wetland is lacustrine/riverine or is contiguous with a permanent water body or watercourse and may provide spawning/nursery habitat, refuge for native fish species in adjacent lakes, rivers or streams, or provides shade to maintain water temperature in adjacent lakes, rivers or streams.

B = The wetland is intermittently connected to a permanent water body or watercourse that may support native fish populations as a result of colonization during flood events, or the wetland is isolated and supports native, non-game fish species.

C = The wetland is isolated from a permanent water body or watercourse or has exclusive, high carp populations which cause degradation to the wetland.

N/A = None of the above. The wetland does not have standing water during most of the growing season. The site is not capable of supporting fish.

46. Guidance: Fish Habitat Quality. Generally, the value of a wetland for fish habitat is related to its connection with deepwater habitats. In the north central region, spawning habitat for warm water species can be an important function of a wetland, and northern pike are among the most valuable warm water species spawning in wetlands[43]. Cold-water species are relatively rare and wetlands (according to traditional definition) do not provide habitat for spawning trout, but have an indirect effect through improving water quality[44].

Northern pike wetland spawning habitat will have several characteristics including: 1) A semi-permanent or permanent connection to a lake or stream that has a population of northern pike; 2) The wetland is vegetated primarily with reeds, grasses, or sedges; or secondarily with cattails, rushes, arrowhead, water lilies, submerged plants, and shrubs or lowland hardwoods with grass and low emergents; 3) The wetland is flooded during the early spring at least once every 3 years for at least 20 days and remains connected to the lake or stream during that time; 4) Lacustrine areas should have 4 to 8 acres of actual spawning area for each 100 littoral acres of lake[45]; and 5) Shallow or deep marsh wetland spawning areas are typically located on the upstream side of the lake or stream[46].

A wetland should be rated as having high value for fish if it provides spawning/nursery habitat, or refuge for *native* fish species in adjacent lakes, rivers or streams. Some isolated deep marshes may intermittently support populations of sunfish and northern pike as a result of colonization during flood events. Permanently flooded isolated wetlands that support native populations of minnows provide

[43] Adamus et al., 1991.
[44] Adamus et al., 1991.
[45] MIDNR, 1981; Adamus et al., 1991.
[46] Personal communication, D. Ellison, MnDNR.

moderate value. Wetlands with exclusive, high carp populations provide low value for fish habitat because carp cause extreme degradation of the wetland. Isolated wetlands that are not permanently flooded do not generally support fish populations.

47. List any fish species observed or evidenced. *Note: This list is for documentation only and is not necessarily an indication of habitat quality* (database drop-down list: northern pike, perch, sunfish, bass, minnows, carp).

48. Y N Does the wetland provide a unique or rare educational, cultural, or recreational opportunity (e.g., located in an outdoor learning park focused on wetland study)?[47] (If yes this function rates exceptional)

48. Guidance: Unique Opportunity.
The wetland must provide a rare or unique opportunity within the ecoregion, wetland comparison domain, or study area, such as a wetland associated with a school environmental program or public education institution (University of Minnesota's Cedar Creek, Landscape Arboretum's Spring Peeper Wetland), cultural experience (wild rice areas), or a pristine-reference site for another assessment tool[48].

49. Is the wetland visible from vantage points such as: roads, waterways, trails, houses, and/or businesses?

A = The wetland is highly visible and can be seen from several public vantage points.
B = The wetland is somewhat visible and can be seen from a few vantage points.
C = Very limited visibility.

49. Guidance: Visibility. While dependent on accessibility, a wetland's functional level could be evaluated by the view it provides observers. Distinct contrast between the wetland and surrounding upland may increase its perceived importance. Multiple vantage points increase the likelihood and number of people that may view the wetland.

50. Y N Is the wetland in/near a city, town, or village so as to generate aesthetic/recreation/ educational/cultural use?

50. Guidance: Population Centers. Accessibility of the wetland is key to its aesthetic or educational appreciation. Thus, proximity to population centers may increase its perceived importance. However, proximity to population centers and locations in public areas may have associated noise and/or pollution factors that could degrade the aesthetic and educational functional level.

~ **51. Is any part of the wetland in public or conservation ownership?**

A = Completely contained within publicly owned land or entirely within a conservation easement.

B = Partially within publicly owned land or partially within a conservation easement.

C = Privately owned or not within a conservation easement.

51. Guidance: Public Ownership. Wetlands located on lands in public ownership inherently will provide open accessibility. Wetlands being on lands within a conservation easement provides some certainty that the wetlands will not be subject to impact pressures.

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[47] If yes, Aesthetics/Recreation/ Education/Cultural/Science Index is Exceptional.
[48] Minnesota's Index of Biologic Integrity uses several wetlands as reference-standard sites for both high- and low-functioning sites.

52. Does the public have access to the wetland from public roads or waterways?

A = Direct access through a public facility with an established parking area or boat access.

B = Cumbersome access from a public facility (i.e. no established trails to or near wetland) or no public parking or boat access available.

C = No public access available.

52. Guidance: Public Access. Accessibility of the wetland is key to its aesthetic or educational appreciation. Wetlands located on private lands are not likely to provide aesthetic or educational opportunities to the general public.

53. What are the obvious human influences on the wetland itself, such as:

A = No structures, pollution, trash, or other alteration present in the wetland.

B = Wetland only moderately disturbed by structures, pollution, trash, or alteration.

C = Wetland has signs of extensive pollution/trash, severe vegetative alteration, or multiple structures.

53. Guidance: Human Disturbances in Wetland. Wetlands subject to direct human disturbances/impacts are not likely to provide aesthetically pleasing natural environments.

54. What are the obvious human influences on the viewshed of the wetland, such as:

A = No or minimal buildings, roads, or altered land uses surrounding the wetland.

B = Surrounding area composed of mostly open space with a few buildings or roads, low intensity agriculture.

C = Wetland surrounded by residential, other intensively developed land uses, or intensive agriculture.

54. Guidance: Wetland Viewshed. This question requires a judgment as to the dominant land use visible at the primary viewing locations within the wetland. This method assumes that the most appealing views of wetlands are from other areas of natural beauty such as an upland forest[49]. Wetlands occurring in densely developed urban areas equate with lower ratings. Excessive noise from nearby highway or factories could be considered an intrusive human influence.

55. Does the wetland and buffer area provide a spatial buffer between developed areas?

A = Spatial buffer more than 500 feet wide.
B = Spatial buffer between developed areas less than 500 feet wide.
C = Does not provide a spatial buffer—no developed land near the wetland.

55. Guidance: Spatial Buffer. Views of open water and open space in general are considered to be aesthetically appealing[50]. Distinct contrast between the wetland and surrounding upland may increase its

[49] Ammann and Stone, 1991.
[50] Ammann and Stone, 1991.

perceived importance. Expansive wetlands and associated buffer areas provide open space and a feeling of a natural environment while reducing the visibility of adjacent human development. If the wetland is surrounded by undeveloped land within its immediate viewshed, the wetland has little value as a spatial buffer. Developed lands across any portion of the wetland will benefit from the spatial buffering of the wetland. Spatial buffer is measured from the edge of the developed area, across the wetland, to the edge of the next developed area. The edge may be considered the end of manicured lawn or golf course, sidewalk or paved area, or up to a wall or fence.

56. Is the wetland and immediately adjacent area assumed to be currently used for (or does it have the potential to be used for) recreational activities such as the following: education, cultural, scientific study, hiking, biking, skiing, hunting, fishing, trapping, boating, canoeing, wildlife observation, exploration, play, photography, or food harvest.

A = Evidence or a high probability for multiple recreational uses.
B = Evidence of or a high probability for a few recreational uses.
C = Low probability or potential for recreational use

56. Guidance: Activities. Wetlands can provide recreational and educational opportunities that enhance their value. Use Best Professional Judgment to decide the likelihood and value of multiple uses from the list above, or of others not noted.

57. Is the vegetation or hydrology currently controlled or modified to sustain a commercial product?

A = Highly Sustainable Use: commercial use of the wetland does not permanently alter the wetland characteristics.

B = Somewhat Sustainable Use: wetland characteristics have been altered but vegetation is still hydrophytic.

C = Hydrology dramatically altered to produce a commercial product such as row crops or peat.

N/A = This wetland is not used for commercial products.

57. Guidance: Commercial Quality. Is the wetland being used for a commercial product that does not sustain the wetland? If so, consider the nature of the use. Sustainable uses of the wetland would not require modifying a natural wetland. Products in this category would include collection of botanical products, wet native grass seed, floral decorations, wild rice, black spruce, white cedar, and tamarack. Other sustainable uses may require modification of the natural hydrology, such as for wetland-dependent crops that rely on the wetland hydrology for part of their life cycle (rice, cranberries). Haying and grazing are less intrusive agricultural activities utilized more or less casually when hydrologic conditions permit; light pasture and occasional haying might be considered highly sustainable [A], whereas heavier use would result in a rating of [B]. Row crops such as corn and soybeans can be planted in some wetlands after spring flooding has ceased and still have adequate time to grow to maturity. Like peat-mining, cropping is an unsustainable use of the wetland as it is results in severe alterations of wetland characteristics (soil, vegetation, hydrology).

The following questions (#58-63) relate to the movement of groundwater into and out of the wetland. Base your answers on the best available information. Classification of a given site as a primarily recharge or discharge wetland will be based on how a majority of the questions are answered and does not offer a definitive result as to the actual movement of groundwater in the assessment area. When the primary hydrology comes from ground-water, wetlands are labeled discharge, whereas recharge wetlands are those whose hydrology is primarily supported by surface-water that then seeps into a ground-water system.

~ 58. Describe the soils within the wetland[51]:

Recharge = Mineral soils with a high organic content (all soils not included in discharge system).

Discharge = Organic/peat soils, formed due to more continuous wetness associated with a ground water discharge system

58. Guidance: Wetland Soils. Wetlands with mineral hydric soils typically represent drier hydrologic regimes where groundwater recharge is more likely (i.e. saturated, seasonally flooded, and temporarily flooded) where the wetness does not significantly limit oxidation of organic materials. Groundwater discharge wetlands represent more stable and permanent hydrologic regimes where excessive wetness limits the oxidation of organic matter resulting in the accumulation of peat and/or muck. In addition, coarser-grained mineral hydric soils may have higher permeabilities allowing groundwater recharge, while histosols generally have low permeabilities, reducing groundwater discharge. Disturbed soils in excavated wetlands or stormwater ponds are subject to best professional judgement for this question.

~ 59. Describe the land use/runoff characteristics in the local subwatershed upstream of the wetland[52]:

Recharge = Land is primarily developed to high-density residential, commercial, industrial and road land uses (equivalent to lots 1/4 acre or smaller) indicating impervious surfaces (>38%), which result in more runoff to wetlands and lowered water tables creating a gradient for recharge under wetlands.

Discharge = Upland watershed primarily undeveloped or with low to moderate density residential development (i.e. lots larger than ¼ acre) with low percentage of impervious surfaces (<38%) so upland recharge (to groundwater) and higher water table will be more likely to contribute discharge to wetlands.

59. Guidance: Land Use/Runoff. The local subwatershed boundary, smaller still than the DNR minor watershed, is available from the local Soil and Water Conservation District office. Watersheds with extensive paved surfaces, topographic disruptions, and the presence of wells are associated with human development that lowers the potentiometric contours. Lowered or diversified potentiometric

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[51] R.P. Novitzki, 1998 personal communication in MnRAM 2.0; Magee and Garrett, 1998.

[52] Adamus et al., 1991.

contours enhance the likelihood of recharge, not discharge[53]. Wetlands with unpaved watersheds are more likely to allow groundwater discharge to occur.

60. Indicate conditions that best fit the wetland based on wetland size and the hydrologic properties of the upland soils within 500 feet of the wetland[54].

Recharge = Wetland is <200 acres and surrounding soils (within 500 feet) are primarily in the C or D hydrologic groups.

Discharge =Wetland is >200 acres in size or wetland is <200 acres and the surrounding soils (within 500 feet) are primarily in the A or B hydrologic groups.

60. Guidance: Wetland Size and Surrounding Soils. The size or area of the wetland and the soil texture in the surrounding upland are two factors controlling the wetland's water budget. A large wetland with a proportionately small watershed may indicate subsidization of its water budget by groundwater discharge. The probability of groundwater discharge occurring may, thus increase as the wetland/watershed ratio increases. The wetland size also controls the amount of recharge potential. The more fine-grained the soil texture in the surrounding uplands, the more water will flow to the wetland via overland flow and less likely water is to flow to the wetland via groundwater discharge. Williams (1968) observed that a small wetland situated in a large watershed favored groundwater recharge, because surface water inflow from a large watershed was sufficient to create a water mound conducive to recharge. Sandy and loamy upland soils allow more infiltration of precipitation than clayey soils. The infiltrated water will percolate downward vertically and/or flow laterally becoming groundwater discharge where wetlands intersect the water table.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The four hydrologic soil groups are as follows[55]:

↓ higher) Runoff Potential (lower ↑

Soil Group	Infiltration rate	Depth and drainage characteristics	Water Transmission Rate
A	High	Deep, very well drained to excessively drained sands or gravelly sands.	high
B	Moderate	Moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.	moderate
C	Slow	Soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.	slow
D	Very slow	Clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.	very slow
A/D B/D C/D	The first letter (for drained areas) should be used for the determination of recharge/discharge; if unsure, the second letter (D) would be used for undrained areas and therefore put it into the recharge category.		

[53] Fetter, 1980.
[54] Adamus et al., 1991; Magee and Garrett, 1998.
[55] USDA Natural Resources Conservation Service Hennepin County Soil Survey – Issued 2004.

61. Indicate the hydroperiod of the wetland[56]:

Recharge = Cowardin et al. water regimes: A, C, D, E, and J (i.e. temporarily flooded, seasonally flooded, seasonally flooded/well drained, seasonally saturated, and intermittently flooded as well as wetlands with the B regime (saturated) that: (1) are on flats; and/or (2) are acid bogs (indicates precipitation-driven systems).

Discharge = Cowardin et al. water regimes: F, G, H, (i.e. semi-permanently flooded, intermittently exposed, and permanently flooded), as well as wetlands with the B water regime (saturated) that: (1) consist of sloping organic soils; (2) are on a river valley terrace or at the toe of a bluff or beach ridge, etc.; or (3) have any observed springs or seepages.

61. Guidance: Hydroperiod. Permanently flooded, semi-permanently flooded, and saturated water regimes, especially in regions having high evaporation rates, often indicate groundwater discharge to a wetland. Exceptions are saturated wetlands on flats and/or bogs that are precipitation-driven systems. Wetlands that are seasonally- or temporarily-flooded are more likely to recharge groundwater.

62. Describe the inlet/outlet configuration that best fits the wetland[57]:

Recharge = No outlet or restricted outlet in natural wetlands and lacustrine wetlands.

Discharge = Perennial outlet but no perennial or intermittent stream inlet; perennial stream riverine or floodplain wetland.

62. Guidance: Inlet/Outlet for Groundwater. A wetland with a permanent stream inlet but no permanent outlet is more likely to recharge groundwater than one with an outlet. Several factors support this ranking. First, a higher hydraulic gradient will likely be present in an area with no outlet, especially if an inlet is present. Second, the longer water is retained in an area, the greater the opportunity for it to percolate through the substrate. Third, wetlands without outlets generally experience more water-level fluctuations, resulting in inundation of unsaturated soils. Finally, lack of an outlet suggests that water is being lost either through recharge or evapotranspiration, especially if an inlet is present. A wetland with a permanent outlet and no inlet is more likely to discharge groundwater than one with other combinations of inlets and outlets. Continuous discharge of water (i.e. permanent outlet) without surface water feeding the wetland through an inlet suggests an internal source of groundwater (e.g., springs or seeps). Flow-through wetlands would be considered discharge wetlands for the purposes of this question.

~ **63. Characterize the topographic relief surrounding the wetland[58]:**

Recharge = Land slopes away from (below) the wetland (wetland is elevated in the subwatershed).

Discharge = Topography characterized by a downslope toward the wetland around the majority of the wetland (wetland is found lower in the subwatershed).

63. Guidance: Topographic Relief. This question refers to landscape-level topography at a large, subwatershed scale. Groundwater discharge is more likely to occur in areas where the topographic relief is characterized by a sharp downslope toward the wetland (i.e. wetland is located at the toe of a slope). Groundwater recharge is more likely in wetlands where the topographic relief is characterized

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[56] Adamus et al., 1991; Lee et al., 1997.
[57] Adamus et al., 1991; Lee et al., 1997.
[58] Adamus et al., 1991.

by a sharp downslope away from most of the wetland. The slope of the water table with respect to the wetland influences the hydraulic gradient for groundwater movement. The water table usually slopes roughly parallel to the land surface topography. Thus, when local topography slopes sharply toward the wetland, the result is typically a hydraulic gradient favorable for groundwater discharge.

END OF PRIMARY QUESTION SET FOR MNRAM 3.1

Optional Evaluation Information

64. Y N Does the wetland have the potential for hydrologic restoration without flooding: roads, houses, septic systems, golf courses or other permanent infrastructure (active agricultural fields are acceptable uses within potential restoration areas) within the restoration area? If yes, answer the following questions. If no, skip to question 71.

64. Guidance: Hydrologic Restoration Potential. The purpose of this question is to identify opportunities for restoration of drained or partially drained wetlands. Generally, this question applies to wetlands that have been ditched or tiled for agricultural or other purposes. Some drained or partially drained wetlands will not have the potential for restoration because of altered land uses that rely on continued drainage of surface and/or subsurface water. It is important to look at land uses upstream of the drained wetland to determine if any of the features mentioned could be flooded by plugging a ditch, breaking drain tiles or creating an impoundment.

65. Indicate the number of landowners that would be affected by the wetland restoration project:

- ❑ Completely within public ownership
- ❑ 1
- ❑ 2
- ❑ 3 or more

65. Guidance: Landowners. The number of landowners of the drained or partially drained wetland and any obvious upstream areas that would be flooded by hydrologic restoration of the wetland directly affects the feasibility of a restoration project. Typically, as the number of private owners of a potential restoration site goes up the project becomes more complex and the probability of success is reduced due to conflicting desires among the landowners. All public=Exceptional, 1=High, 2=Medium, 3 or more=Low.

66. Enter the existing wetland area and estimated size of the total wetland if effectively drained or filled areas were restored (not including any buffer area). Two characteristics will be computed from the following information: 1) total restored wetland size, and 2) percentage of historic wetland effectively drained.

Programming the overall restoration potential will assign the rank based on size.

A. Size of existing wetland (acres) ________ (should be the same as Question #10)

B. Total wetland including restorable and existing wetland (acres) _______

C. Calculated potential new wetland area (acres) _________

66. Guidance: Wetland Restoration Area. The size of the potential wetland restoration will be determined partially by the extent of historic hydric soils mapped on the site, but must also take into consideration upstream land uses, current land uses on the site, methods of hydrologic alteration that have occurred, and the current topography of the site. Restoring the natural hydrology to partially drained wetlands will restore the historic wetland type. Restoration of existing wetlands that had some ditching or tiling that did not effectively drain the entire wetland may result in some new wetland and some hydrologically restored wetland. Some wetland laws may allow for wetland replacement credit for hydrologically restored wetlands as well as restoration of drained wetlands. Two ratings will be determined for this question;

1) **Total restored wetland size (acres)**: (High >10 acres, Medium = 2 to 10 ac, or Low = less than 2 ac.)

2) **Percent of historic wetland effectively drained:** (High = >60%, Medium = 20 - 60%, or Low = < 20%)

67. Enter the average width of naturalized upland buffer that could potentially be established around the restored wetland:

______ feet (High = more than >50' around the potential wetland restoration area;
Medium = between 25' and 50' around the potential wetland restoration area;
Low = less than <25' around the potential wetland restoration area)

67. Guidance: Upland buffer protects wetland function.

68. Rate the potential ease of wetland restoration:

A = Break tile line and/or plug ditch, discontinue pumping.
B = Break multiple tile lines and/or ditch plugs.
C = Diking, berming, excavation or grading.

68. Guidance: Restoration Ease. The easiest wetlands to restore are those that were drained by a single ditch or drain tile. Restoration of those wetlands will typically involve simply plugging the ditch or breaking the tile line. The most difficult situation for creating wetlands is by impoundment or excavation in uplands. This involves much more uncertainty and greater cost.

69. Indicate the type of hydrologic alteration:

____Ditching
____Drain Tiles
____Ground Water Pumping
____Lowered Outlet Elevation
____Watershed Diversion
____Filling

69. Guidance: Hydrologic Alteration. Alterations may include ditching or tiling which is typical in agricultural settings. Also important are ground water pumping activities that can lower local ground water levels and drain wetlands (i.e. dewatering for quarries, underground construction, or utility construction; ground water pumping for residential, commercial or municipal water use). In metro areas, the natural wetland outlet elevation may be lowered by the construction of an outlet structure (i.e. weir, culvert, lowered overland outflow elevation). Development activities occasionally result in the diversion of drainage away from a wetland, which can change the natural hydrology. This information is not used in calculations.

70. Indicate the potential restoration wetland classification according to Circular 39 (USFWS, 1956): Type 1, 2, 3, 4, 5, 6, 7, or 8. (Informational purposes only.)

When using the database, these last two questions <u>will be calculated for you</u> based on answers to previous questions.

71. The susceptibility of the wetland to degradation from stormwater input: wetland type classification (Question #1, Community Type and Question #3, Vegetative Diversity/Integrity) will be utilized to determine the best fit to the following categories based on the most sensitive, dominant wetland community:

Exceptional = Sedge meadows, open and coniferous bogs, calcareous fens, low prairies, wet to wet mesic prairies, coniferous swamps, lowland hardwood swamps, or seasonally flooded basins.

A = Shrub-carrs, alder thickets, diverse fresh wet meadows dominated by native species, diverse shallow and deep marshes and diverse shallow, open water communities.

B = Floodplain forests, fresh wet meadows dominated by reed canary grass, shallow and deep marshes dominated by cattail, reed canary grass, giant reed or purple loosestrife, and shallow, open water communities with moderate to low diversity.

C = Gravel pits, cultivated hydric soils, or dredge/fill disposal sites.

71. Guidance: Stormwater Sensitivity. Guidelines are taken from State of Minnesota, 1997, Section IV, Wetland Susceptibility.

72. The sustainability of the wetland with regard to stormwater treatment prior to discharge into the wetland. (This rating uses the calculated outcome from the Wetland Water Quality Protection Function (H, M, or L) and applies it as follows):

A = No additional stormwater treatment needed.

B = Additional stormwater nutrient removal needed.

C = Additional sedimentation and nutrient removal needed.

72. Guidance: Nutrient Loading. Wetlands that receive untreated, directed stormwater containing sediment and nutrients will not be as sustainable as in a native landscape. Typically, wetlands receiving stormwater treated to approximately NURP standards will have a higher likelihood of sustainability. Wetlands receiving stormwater with just sediment removal will be subject to nutrient loading and excessive plant growth.

Comprehensive General Guidance

for
Minnesota Routine Assessment Method (MnRAM)
Evaluating Wetland Function, Version 3.1

5/1/07

Table of Contents

1.0 Introduction to MnRAM

1.1 History

The Minnesota Routine Assessment Method (MnRAM) for Evaluating Wetland Functions originally was devised soon after the passage of the Wetland Conservation Act (WCA) in 1991. An interagency wetland workgroup sought to fill the need for a practical assessment tool that would help local authorities make sound wetland management decisions as they assumed responsibility for regulating wetland impacts.

Although the original version was soon updated to MnRAM Version 2.0 (1998), the fundamental approach of applying descriptive rather than numeric ratings was maintained. In subsequent years, development of heavily quantitative methods on the national level and demand for a more refined procedure on the local level led to the formation of another workgroup in January 2002. Starting with both the MnRAM Version 2.0 and a database version sponsored by an EPA grant, the workgroup examined every function, question by question, with the goal of developing a numeric model.

1.2 Functions and Values

Because land use decisions involving wetlands typically consider both functions and values, MnRAM has always included some value-related questions. Although a primary focus in this version of MnRAM is on the functional aspect of wetlands, some strictly value-related aspects are included, such as "Aesthetics" and "Commercial Uses." Value-related considerations are incorporated into some of other evaluated functions, as well.

1.3 User Advisories

Current scientific understanding of wetlands and indicators limits our ability to predict which wetlands are ecologically sound; other limiting factors include time, expertise, and training of the people performing the evaluation. For more difficult or controversial sites, it is recommended that a diverse team of professionals conduct the evaluation together or that other more detailed assessment methods be considered.

MnRAM 3.1 provides an organized, consistent procedure to document observations and conclusions about wetland processes. It would be considered a Tier 2 assessment methodology, a rapid assessment method. MnRAM is intended for routine planning and inventory applications as well as for project-specific evaluations. Using it requires experience and training in wetland science, since professional judgment is incorporated in several questions.

A preliminary review of reference material such as soil data, topography, watersheds, inlets, outlets, land uses, aerial photographs, and other information is recommended prior to assessing a wetland. Establishing the history and setting of the wetland under evaluation will speed the field assessment. Questions that can potentially be answered utilizing other information sources, maps in the office, or digital data in a Geographic Information System (GIS) are marked with a "~" in the margin (in the printed version) or in red text (in the digital format). With training, practice, and experience, the fieldwork for an evaluation of a small wetland (< 1 acre), under normal circumstances (assuming background information regarding topography, watersheds, inlets and outlets, land use, etc. has been previously gathered) in an area familiar to the evaluator(s) can be completed in less than one hour.

Wetland assessments using this methodology cannot be conducted without a site visit. Even with photos, maps, and written notes, questions will arise that should only be answered at the site. Bringing the database into the field on a laptop will prove to be the most efficient way to document wetland conditions; however, paper score sheets are available which correspond to a Microsoft Excel™ spreadsheet containing the formulas for computing the functional indices. The field assessment data need only be entered into the spreadsheet and the functional indices will be computed. Immediate field data-entry reduces the potential for interpretation and data-entry errors compared to gathering data in the field and trying to translate that into an assessment later.

1.4 Assessment Sites

This assessment method is intended to be applied to existing wetlands or potential restoration sites. If evaluating a wetland to determine the functions based on projected conditions, it is necessary to assess the current status of the wetland/basin, as well. See Section 1.11 for more about using MnRAM for regulatory purposes.

1.5 MnRAM Database

The full MnRAM 3.1 methodology has been programmed into a Microsoft Access™ database within which all data can be entered and stored. The database computes the functional indices using the formulas outlined in this methodology. One of the fundamental benefits of a database program and this methodology in particular is that information is tabulated and stored for each of the 72 wetland parameters evaluated as well as the wetland location, other general information, and computed functional indices. The database can store records for a nearly infinite number of wetlands. Any wetland data evaluated using this methodology can then easily be compiled into a single, central database. In addition, the database allows for the ability to analyze individual pieces of data for selected groups of wetlands or all wetlands within the database or to evaluate groups of parameters on groups of wetlands. The flexibility for conducting analyses is one of the most powerful aspects of this methodology.

1.6 Wetland Ranking

MnRAM Version 3.1 includes numeric ranking; great care should be taken to use the results in light of local conditions and based on a landscape-level management plan. People, not the assessment, will decide what combination of functions are the most important. Each wetland is part of an integrated ecological system that should not be thought of as a group of distinct packages, but really an assemblage of interactive elements.

1.7 Wetland Management Classification

Determining the relative value of each function is an activity that must take place after the assessment is complete, in a management and planning context. A basic framework for applying wetland functions and values information to management is supplied in an associated document entitled "Management Classification." This is one basic method of applying the results of a complete assessment of wetlands within a defined management area (e.g. watershed, city, county, etc.) where the wetland functions are the basis for various management strategies.

Standards are suggested that could be applied to meet the general goals of each classification level.

The management classification includes an approach for dealing with watersheds that have few high-quality wetlands remaining. In short, if the best wetlands in an area rate "Medium" using MnRAM, an adjustment of the scale for ranking wetlands is imperative. These policy-based decisions are discussed in the management classification document.

1.8 Reference Standard Wetlands

Reference standard wetlands were defined in MnRAM 2.0 as those judged to have the highest level of overall sustainable functional capacity for that type in the Wetland Comparison Domain. In that method, the wetland under investigation was to have been compared to the reference wetland before the evaluation took place.

In Version 3.1, it is not necessary to have pre-established physical reference standard wetlands. As an assessment tool, MnRAM 3.1 may be part of an initial effort to inventory local wetlands and establish such reference sites. A subject wetland will fall into place on a watershed-based ranking after many wetlands have been evaluated. Only in comparison with these compiled results will planning watershed priorities be possible.

1.9 Functional Ratings

MnRAM Version 3.1 was developed using the concept of ideal theoretical, pre-European-settlement wetland conditions as the baseline. In highly urban or agricultural watersheds, few basins may fall into the High category. Local authorities will need to take this into account when establishing a scale for management decisions (see "Wetland Management Classification," above).

Each wetland function will be rated with a numeric index according to the formulas or decision trees accompanying this methodology. The scoring system is from 0.001 to 1.0 signifying low to high[1], respectively; in the instances where an exceptional rating applies, a score of 2 accentuates the rarity. For yes-no questions, yes will receive a score of 1 and no will receive a score of zero*. Each wetland function then receives an index score with ratings as follows:

Functional Ratings	Question Score	Functional Index Score
• **Exceptional:**	**2.0**	**1.01 - 2.00**
• **High:**	**1.0**	**0.66 - 1.00**
• **Medium:**	**0.5**	**0.33 - 0.65**
• **Low:**	**0.1**	**0.001 - 0.32**
• **Not Applicable:**	**N/A**	**0.0**

MnRAM includes numeric as well as general ratings. The numeric ratings are based on standardized formulas to achieve consistency among users and are, in effect, placeholders for the general rating categories of exceptional, high, medium and low. Great care should be taken when interpreting the results. In particular, <u>the general and numeric ratings should not be summed or</u>

[1] Ammann and Stone, 1991

* Some questions worded yes-no are actually yes-not applicable; use caution when scoring by hand.

averaged across different functions (or for different wetlands). Mixing the ratings of disparate functions (or different wetlands) can be misleading if not meaningless. The primary intent of MnRAM 3.1 is to provide a function-by-function rating for individual wetlands (or plant communities). See discussion below regarding comparison of different wetlands.

1.10 Comparison of Two or More Wetlands

The optimum method of comparison using MnRAM 3.1 ratings is that between wetland plant communities of the same type ("apples to apples") where a reference standard wetland is used. "Wetland type" refers to the wetland plant communities described in MnRAM 3.1.[2] A reference standard wetland includes the highest functioning example(s) of a specific plant community within a watershed or ecoregion. It serves as the baseline for comparing the MnRAM 3.1 ratings among examples of the same plant community. For example, the reference standard hardwood swamp may have four high, two medium, and two low ratings while the hardwood swamp within a particular project site may have two medium and six low ratings. Or, if a particular function(s) is of most concern, the MnRAM 3.1 rating for that specific function can be compared between examples of the same plant community within the study area.

Comparisons between examples of the same plant community type can be valid without a reference standard wetland. Because there is no baseline for the highest functioning example of a particular wetland plant community type, care must be taken to place the subject wetland in the proper context. For example, all the sedge meadows within an agricultural site may be lower functioning due to agricultural impacts, while all the sedge meadows within a northern Minnesota site may be high functioning because of the lack of disturbances.

Comparisons of function-by-function MnRAM 3.1 ratings between different wetland plant community types ("apples to oranges") are problematic because different wetland plant community types function differently. Not all wetlands are flow-through wetlands, or shoreland wetlands, or provide fish habitat, or support amphibians, or have a woody canopy. While some functions are provided by nearly all wetlands, the process and intensity of those functions can be different among different plant community types. Great care is advised when drawing conclusions from "apples to oranges" comparisons. The greater the disparity between wetland plant community types, the less valid the comparison becomes. Comparing the functional levels of, for example, a precipitation-driven bog versus a floodplain forest is of little utility.

For planning purposes, the wetland function(s) of greatest concern in a particular study area could be identified. MnRAM analyses could then identify those wetlands ranked exceptional or high for that function(s).

1.11 Uses of MnRAM 3.1 for Regulatory Purposes

MnRAM 3.1 is a qualitative approach to identifying wetland functions. Because the input is qualitative the output is qualitative. Therefore, MnRAM 3.1 ratings should not be used to quantify impacts or compensatory mitigation.

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[2] Further refinement of this approach is to define "wetland type" as the wetland plant community + HGM classification (e.g., depressional, slope, lacustrine fringe, organic flat). For example, sedge meadow communities on slopes may have a different water source and hydroperiod than those in depressions.

Evaluating the pre- and post-project condition of a particular wetland is often part of the regulatory process. Be advised that MnRAM 3.1 is typically not sensitive enough to show changes in the functional ratings that are commensurate with the differences between pre- and post-project conditions.

Determining general compensatory mitigation needs based on a MnRAM 3.1 analysis of a wetland that is proposed to be impacted is appropriate for regulatory purposes. For example, if the wetland to be impacted has four high ratings and four medium ratings, the focus of the compensation would be to design and establish compensation that replaces those specific high and medium functional ratings. This is a qualitative measure, not a quantitative one.

MnRAM 3.1 has four options for the vegetative diversity/integrity function ranging from individual ratings for each plant community to averaging the ratings of two or more plant communities. For regulatory purposes, the individual rating for vegetative diversity/ integrity should be used (unless all of the plant communities have the same rating for this function). Averaging high and low ratings, for example, yields a medium rating that obscures the presence of the high-rated plant community. Averaging is not appropriate because the high-rated plant community may prompt important regulatory considerations such as avoidance or special consideration for compensatory mitigation. A second option for the vegetative diversity/integrity function—highest-rated plant community—is also appropriate for regulatory purposes.

1.12 Wetland functions/value characteristics evaluated:

1. Maintenance of Characteristic Vegetative Diversity/Integrity
2. Maintenance of Hydrologic Regime
3. Flood/Stormwater Attenuation
4. Downstream Water Quality
5. Maintenance of Wetland Water Quality
6. Shoreline Protection
7. Maintenance of Characteristic Wildlife Habitat Structure
8. Maintenance of Characteristic Fish Habitat
9. Maintenance of Characteristic Amphibian Habitat
10. Aesthetics/Recreation/Education/Cultural
11. Commercial Uses
12. Ground Water Interaction

Additional Evaluation Information

1. Restoration Potential
2. Sensitivity to Stormwater & Urban Development
3. Additional Stormwater Treatment Needs

Each characteristic is described in more detail in the Formulas section.

2.0 Wetland Classification Systems

This section summarizes methods that can be utilized to classify wetland resources. The last part of this section describes critical wetland resource designations.

2.1 Dominant Vegetation

Identify and record the dominant plant species within each plant community using the 50/20 Rule[3], along with rare, endangered, or threatened species. For each plant species, record the scientific name, common name, typical stratum, and regional indicator status[4] for each wetland; preferably these should be stored in the project Microsoft® Access database. The definitions of hydrologic indicator status are:

OBL: Obligate Wetland Plants occur almost always (estimated probability >99%) in wetlands under natural conditions, but may also occur rarely (estimated probability <1%) in nonwetlands.

FACW: Facultative Wetland Plants occur usually (estimated probability 67% to 99%) in wetlands, but also occur (estimated probability 1% to 33%) in nonwetlands.

FAC: Facultative Plants have a similar likelihood (estimated probability 33% to 67%) of occurring in both wetlands and nonwetlands.

FACU: Facultative Upland Plants occur sometimes (estimated probability 1% to 33%) in wetlands, but occur more often (estimated probability >67% to 99%) in nonwetlands.

UPL: Obligate Upland Plants occur rarely (estimated <1%) in wetlands, but occur almost always (estimated probability >99%) in nonwetlands under natural conditions.

Note: Categories were originally developed and defined by the USFWS National Wetlands Inventory. Regional panels assigned the indicator status for individual plant species. The three facultative categories are subdivided by (+) and (-) modifiers.

2.2 Topographic Setting

Classify each inventoried wetland by its topographic setting[5] based on a field evaluation and review of available stormwater infrastructure data:

Floodplain: (8420.0110, subp. 19) A floodplain wetland is a wetland located in the floodplain of a watercourse, with no well defined inlets or outlets, including tile systems, ditches, or natural watercourses. This may include the floodplain itself when it exhibits wetland characteristics.

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[3] The 50/20 Rule, detailed in the 1987 Corps of Engineers Wetland Delineation Manual, describes a method of considering dominance within each stratum. All dominants are treated equally in characterizing the plant community to determine whether hydrophytic vegetation is present. The most abundant plant species (when ranked in descending order of abundance and cumulatively totaled) that immediately exceed 50 percent of the total dominance measure for a given stratum, plus any additional species comprising 20 percent or more of the total dominance measure for that stratum are considered dominant species for the stratum. Dominance measures include percent areal coverage and basal area, for example.

[4] in accordance with *The National List of Plant Species that Occur in Wetlands* (Reed, 1988).

[5] as defined in Minnesota Rules Chapter 8420.0110 (Wetland Conservation Act).

Flow-through: (8420.0110, subp. 20) A flow-through wetland has a well-defined outlet and one or more well defined inlets.

Isolated: (8420.0110, subp. 28) An isolated wetland is without a well-defined inlet or outlet.

Riverine: (8420.0110, subp. 43) A riverine wetland is a wetland contained in the banks of a channel that may contain moving water or that forms a connecting link between two bodies of standing water.

Shoreland: (8420.0110, subp. 44a) A shoreland wetland is a wetland located along the shoreline of a lake or edge of a deepwater habitat.

Tributary: (8420.0110, subp. 48) A tributary wetland has a well-defined outlet but is lacking a defined inlet.

Other: A wetland that does not fit into one of the three previously mentioned groups.

2.3 Circular 39

The *Wetlands of the United States* was published in 1959 by the U.S. Fish and Wildlife Service and is commonly referred to as "Circular 39"[6]. The Circular 39 Classification System was the first method that the U.S. Fish and Wildlife Service used to classify wetland basins in the U.S. It is composed of 20 wetland types of which eight are found in Minnesota. Wetland plant community types and some common vegetation found in each wetland type are provided in Table 2.1. A general description of each wetland type is provided below.

2.3.1 TYPE 1: SEASONALLY FLOODED BASIN, FLOODPLAIN FOREST

Soil is covered with water or is waterlogged during variable seasonal periods, but usually is well-drained during much of the growing season. This wetland type is found both in upland depressions and in overflow bottomlands. In uplands, basins or flats may be filled with water during periods of heavy rain or melting snow.
Vegetation varies greatly according to season and duration of flooding: from bottomland hardwoods to herbaceous plants. Where the water has receded early in the growing season, smartweeds, wild millet, fall panicum, chufa, various amaranths and other plants (i.e. marsh elder, ragweed, and cockleburs) are likely to occur. Shallow basins that are submerged only very temporarily usually develop little or no wetland vegetation.

2.3.2 TYPE 2: WET MEADOW, FRESH WET MEADOW, WET TO WET-MESIC PRAIRIE, SEDGE MEADOW, AND CALCAREOUS FEN

Soil is usually without standing water during most of the growing season, but is waterlogged within at least a few inches of the surface. Meadows may fill shallow basins, sloughs, or farmland sags, or these meadows may border shallow marshes on the landward side. Vegetation includes grasses, sedges, rushes and various broad-leaved plants. Common representative plants are *Carex* sp. (sedges), *Juncus* sp. (rushes), redtop, reed grasses, manna grasses, prairie cordgrass, and mints. Other wetland plant community types include low prairies, sedge meadows, and calcareous fens.

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[6] Shaw and Fredine, 1959

2.3.3 Type 3: Shallow Marsh

Soil is usually waterlogged early during the growing season and may often be covered with as much as 6 inches or more of water. These marshes may nearly fill shallow lake basins or sloughs, or may border deep marshes on the landward side. These are common as seep areas on irrigated lands. Vegetation includes grasses, bulrushes, spikerushes, and various other marsh plants such as cattails, arrowhead, pickerelweed, and smartweeds. Common representatives are reed, whitetop, rice cutgrass, *Carex*, and giant burreed.

2.3.4 Type 4: Deep Marsh

Soil is usually covered with 6 inches to 3 feet or more of water during the growing season. These deep marshes may completely fill shallow lake basins, potholes, limestone sinks and sloughs, or they may border open water in such depressions. Vegetation includes cattails, reeds, bulrushes, spikerushes and wild rice. In open areas, pondweeds, naiads, coontail, watermilfoils, waterweeds, duckweed, water lilies, or spatterdocks may occur.

2.3.5 Type 5: Shallow Open Water

Shallow ponds and reservoirs are included in this type. Water is usually less than 10 feet deep and is fringed by a border of emergent vegetation similar to open areas of Type 4. Vegetation (mainly at water depths less than 6 feet), includes pondweeds, naiads, wild celery, coontail, watermilfoils, muskgrass, waterlilies, and spatterdocks.

2.3.6 Type 6: Shrub Swamp; Shrub Carr, Alder Thicket

The soil is usually waterlogged during the growing season and is often covered with as much as 6 inches of water. Shrub swamps occur mostly along sluggish streams and occasionally on flood plains. Vegetation includes alders, willows, buttonbush, and dogwoods.

Table 2.1
Wetland Communities, Classification Systems, And Common Vegetation

Wetland Plant Community Types	Classification of Wetlands and Deep Water Habitats of the United States (Cowardin et al. 1979)	Fish and Wildlife Service Circular 39 (Shaw and Fredine 1971)	Examples of Common Vegetation
Shallow, Open Water	Palustrine or lacustrine, littoral; aquatic bed; submergent, floating, and floating-leaved	Type 5: Inland open fresh water	White water lily, Yellow water lily, Northern milfoil, Largeleaf pondweed
Deep Marsh	Palustrine or lacustrine, littoral; aquatic bed; submergent, floating-leaved; and emergent; persistent and nonpersistent	Type 4: Inland deep fresh marsh	Bullrushes, Cattail, Duckweed, Water shield
Shallow Marsh	Palustrine; emergent; persistent and nonpersistent	Type 3: Inland shallow fresh marsh	Cattails, Reed canary grass, Common reed
Sedge Meadow	Palustrine; emergent; narrow leaved persistent	Type 2: Inland fresh meadow	Sedges, Canada bluejoint, Fowl bluegrass
Fresh (Wet) Meadow	Palustrine; emergent; broad and narrow-leaved persistent	Type 1: Seasonally flooded basin of flat; Type 2: Inland fresh meadow	Reed canary grass, Sawtooth sunflower, Joe-pye-weed, Giant goldenrod
Wet to Wet-Mesic Prairie	Palustrine; emergent; broad- and narrow leaved persistent	Type 1: Seasonally flooded basin of flat; Type 2: Inland fresh meadow	Cattail, gayfeather, Prairie cordgrass, Slender rush, Black bentgrass
Calcareous Fen	Palustrine; emergent; narrow-leaved persistent; and scrub	Type 2: Inland fresh meadow	Dioecious sedge, Beaked spikerush, Needle beakrush, Shrubby cinquefoil
Open Bog	Palustrine; moss/lichen; and scrub/shrub; broad-leaved evergreen	Type 8: Bog	Bog moss, Leatherleaf, Bog rosemary, Cranberry
Coniferous Bog	Palustrine; forested: needle-leaved evergreen and deciduous	Type 8: Bog	Tamarack, Black spruce, Cotton grass, Leatherleaf
Shrub-Carr	Palustrine; scrub/shrub; broad leaved deciduous	Type 6: Shrub swamp	Meadow willow, Pussy willow, Uptight Sedge, Canada blue-joint grass
Alder Thicket	Palustrine; scrub/shrub; broad-leaved deciduous	Type 6: Shrub swamp	Speckled Alder, American elder, Narrowleaf meadowsweet, Cinnamon fern
Hardwood Swamp	Palustrine; forested; broad-leaved deciduous	Type 7: Wooded swamp	Black ash, Lake sedge, Ostrich fern, Marsh marigold
Coniferous Swamp	Palustrine; forested; needle-leaved deciduous and evergreen	Type 7: Wooded swamp	Northern white cedar, Cinnamon fern, Yellow birch
Floodplain Forest	Palustrine; forested; broad-leaved deciduous	Type 1: Seasonally flooded basin or flat	Silver maple, Canada wood-nettle, Canada hornwort, Green ash
Seasonally Flooded Basin	Palustrine; flat; emergent; persistent and non-persistent	Type 1: Seasonally flooded basin or flat	Willow-weed, Pennsylvania smartweed, Barnyard grass, White goosefoot

2.3.7 TYPE 7: WOODED SWAMPS; HARDWOOD SWAMP, CONIFEROUS SWAMP

The soil is waterlogged at least to within a few inches of the surface during the growing season and is often covered with as much as 1 foot of water. Wooded swamps occur mostly along sluggish streams, on old riverine oxbows, on floodplains, on flat uplands, and in very shallow lake basins. Forest vegetation includes tamarack, white cedar, black spruce, balsam fir, red maple, and black ash. Northern evergreen swamps usually have a thick ground covering of mosses. Deciduous swamps frequently support beds of duckweeds, smartweeds, and other herbs.

2.3.8 TYPE 8: BOGS; CONIFEROUS BOGS, OPEN BOGS

The soil is usually waterlogged and supports a spongy covering of mosses. Bogs occur mostly in shallow lake basins, on flat uplands and along sluggish streams. Vegetation is woody or herbaceous or both. Typical plants are heath shrubs, sphagnum moss, and sedges. In the North, leatherleaf, Labrador-tea, cranberries, *Carex*, and cottongrass are often present. Scattered, often stunted, black spruce, and tamarack may occur in northern bogs.

2.4 Cowardin[7]

This methodology was used to classify wetlands for the National Wetlands Inventory maps beginning in the late 1970's and early 1980's. The hierarchical structure progresses from Systems and Subsystems at the most general levels to Classes, Subclasses, and Dominance Types at the most specific levels. A comparison of Circular 39 and Cowardin wetland classifications along with the typical Cowardin classification symbols are provided in Table 2.2.

2.4.1 SYSTEM

The term System refers to a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors. The primary systems found in the Minnesota are Palustrine, Lacustrine, and Riverine.

L: **Lacustrine** (lakes and deep ponds) - Lacustrine Systems include wetlands and deepwater habitats with all of the following three characteristics:

1. Situated in a topographic depression or a dammed river channel;
2. Lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent areal coverage;
3. Total area exceeds 8 hectares (20 acres).

Basins or catchments less than 8 hectares in size are included if they have at least one of the following characteristics:

1. A wave-formed or bedrock feature forms all or part of the shoreline boundary; or
2. The catchment has, at low water, a depth greater than two meters (6.6 feet) in the deepest part of the basin.

[7] Cowardin et al,. 1979.

P: Palustrine (shallow ponds, marshes, swamps and sloughs) - Palustrine Systems include all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens.

R: Riverine (rivers, creeks and streams) - Riverine Systems are contained in natural or artificial channels periodically or continuously containing flowing water. Upland islands or Palustrine wetlands may occur in the channel, but they are not part of the Riverine System.

2.4.2 SUBSYSTEM

The term Subsystem refers to a further subdivision of Systems into more specific categories. The Palustrine System has no subsystems associated with it while Lacustrine Systems have two Subsystems and Riverine Systems have four). Each Subsystem is unique for the System to which it applies.

L1: Limnetic - Extends outward from Littoral boundary and includes deepwater habitats within the Lacustrine System.

L2: Littoral - Extends from shoreward boundary to 2 meters (6 feet) below annual low water or to the maximum extent of non-persistent emergents, if these grow at greater than 2 meters.

R2: Lower Perennial

R3: Upper Perennial

R4: Intermittent

2.4.3 CLASS, SUBCLASS

The wetland Class is the highest taxonomic unit below the Subsystem level. The Class code describes the general appearance of the habitat in terms of either the dominant life form of the vegetation or the physiography and composition of the substrate. Life forms (e.g. trees, shrubs, emergents) are used to define classes because they are easily recognizable, do not change distribution rapidly, and have traditionally been used to classify wetlands. Finer differences in life forms are recognized at the Subclass level.

Mixed classes are used as sparingly as possible, under two main conditions: (1) The wetland contains two or more distinct cover types each encompassing at least 30 percent areal coverage of the highest life form, but is too small in size to allow separate delineation of each cover type; and (2) The wetland contains 2 or more classes or subclasses each comprising at least 30 percent areal coverage so evenly interspersed that separate delineation is not possible at the scale used for classification. Mixed subclasses are also allowed and follow the same rules for mixed classes[8].

AB: Aquatic Bed - Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.
Subclasses include: AB1 = Algal, AB2 = Aquatic Moss, AB3 = Rooted Vascular, AB4 = Floating Vascular, AB5 = Unknown Submergent, and AB6 = Unknown Surface.

EM: Emergent - Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years.

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[8] Cowardin et al., 1979

Subclasses include: EM1 = Persistent (plants that normally remain standing at least until the beginning of the next growing season), and EM2 = Nonpersistent (plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season).

FO: Forested - Woody vegetation greater than 6 meters (20 feet) tall.
Subclass determination is based on which type represents more than 50 percent of the areal canopy coverage during the leaf-on period and Subclasses include: FO1 = Broad-leaved Deciduous, FO2 = Needle-leaved Deciduous, FO3 = Broad-leaved Evergreen, FO4 = Needle-leaved Evergreen, FO5 = Dead, FO6 = Deciduous, and FO7 = Evergreen.

SS: Scrub/Shrub - Woody vegetation less than 6 meters (20 feet) tall. The species include true shrubs, young trees (saplings) or trees that are small or stunted because of environmental conditions.
Subclass determination is based on which type represents more than 50 percent of the areal canopy coverage during the leaf-on period and include: SS1 = Broad-leaved Deciduous, SS2 = Needle-leaved Deciduous, SS3 = Broad-leaved Evergreen, SS4 = Needle-leaved Evergreen, SS5 = Dead, SS6 = Deciduous (used if deciduous woody vegetation cannot be identified on aerial photography as either Broad-leaved or Needle-leaved), and SS7 = Evergreen (used if evergreen woody vegetation cannot be identified on aerial photography as either Broad-leaved or Needle-leaved).

UB: Unconsolidated Bottom - Includes all wetlands and deepwater habitats with at least 25 percent cover of particles smaller than stones (less than 6-7 cm.), and a vegetative cover less than 30 percent.

2.4.4 Water Regime

Precise description of hydrologic characteristics requires detailed knowledge of the duration and timing of surface inundation, both yearly and long-term, as well as an understanding of groundwater fluctuations. Because such information is seldom available, the water regimes that, in part, determine characteristic wetland and deepwater plant and animal communities are described here in only general terms[9]. Water regimes are grouped under two major categories, Tidal and Nontidal. The Tidal Water Regime does not occur in Minnesota so is not described here.

A: Temporarily Flooded - Surface water present for brief periods during the growing season, but the water table usually lies well below the soil surface. Plants that grow both in uplands and wetlands are characteristic of this water regime. The temporarily flooded regime also includes wetlands where water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this regime may change as soil moisture conditions change.

B: Saturated - The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.

C: Seasonally Flooded - Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. When surface water is absent, the water table is often near the land surface. The water table after

[9] Cowardin, et al., 1979

flooding ceases is highly variable, extending from saturated to a water table well below the ground surface.

F: Semipermanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

G: Intermittently Exposed - Surface water is present throughout the year except in years of extreme drought.

H: Permanently Flooded - Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes.

2.4.5 SPECIAL MODIFIERS

Many wetlands and deepwater habitats are human-made and natural ones have been modified to some degree by the activities of humans or beavers. Since the nature of these modifications often greatly influences the character of such habitats, special modifying terms have been included here to emphasize their importance[10].

b: Beaver – Created or modified by a beaver dam.

d: Partly Drained – The water level has been artificially lowered, but he area is still classified as wetland because soil moisture is sufficient to support hydrophytes. Drained areas are not considered wetland if they can no longer support hydrophytes.

f: Farmed – The soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become reestablished if farming is discontinued.

h: Diked/Impounded – Created or modified by a barrier or dam which purposefully or unintentionally obstructs the outflow of water. Both humans-made and beaver dams are included.

r: Artificial – Refers to substrates classified as Rock Bottom, Unconsolidated Bottom, Rocky Shore, and Unconsolidated Shore that were emplaced by humans, using either natural materials such as dredge spoil or synthetic materials such as discarded automobiles, tires, or concrete.

s: Spoil – Refers to the placement of spoil materials which have resulted in the establishment of wetland.

x: Excavated – Lies within a basin or channel excavated by humans.

[10] Cowardin, et al., 1979

Table 2.2
Circular 39 and Cowardin Wetland Classification Systems
Minnesota Routine Assessment Method for Evaluating Wetland Functions, Version 3.1

Circular 39 Type	**SYSTEM SUBSYSTEM CLASS SUBCLASS**	**Common Water Regimes**	**Typical NWI Symbols (Cowardin System)**
Type 1	PALUSTRINE (P) Emergent (EM) Persistent (1) Forested (FO) Broad-Leaf Deciduous (1)	Temporarily Flooded (A) Intermittently Flooded (J)	PEM1A PEM1J PFO1A PFO1J
Type 2	PALUSTRINE (P) Emergent (EM) Persistent (1)	Saturated (B)	PEM1B
Type 3	PALUSTRINE (P) Emergent (EM) Persistent (1)	Seasonally Flooded (C) Semipermanently Flooded (F)	PEM1C PEM1F
Type 4	PALUSTRINE (P) OR LACUSTRINE (L) Littoral (2) Emergent (EM) Aquatic Bed (AB) Unconsolidated Bottom (UB)	Semipermanently Flooded (F) Intermittently Exposed (G) Permanently Flooded (H)	PEMF L2EM2F PEMG L2EM2G PABF L2EM2H PABG L2ABF PUBF L2ABG PUBG L2ABH
Type 5	PALUSTRINE (P) OR LACUSTRINE (L) Limnetic (1) Littoral (2) Aquatic Bed (AB) Unconsolidated Bottom (UB)	Intermittently Exposed (G) Permanently Flooded (H)	PABG L2ABG PABH L2ABH PUBG L2UBG PUBH L2UBH L1UBH
Type 6	PALUSTRINE (P) Scrub-Shrub (SS) Broad/Needleleaf Deciduous (1,2) Broad/Needleleaf Evergreen (3,4) Dead (5)	All nontidal regimes except Permanently Flooded (A,B,C,F,J,G)	PSS1,2,3,4, or 5A PSS1,2,3,4, or 5B PSS1,2,3,4, or 5C PSS1,2,3,4, or 5F PSS1,2,3,4, or 5J PSS1,2,3,4, or 5G
Type 7	PALUSTRINE (P) Forested (FO)	All nontidal regimes except Intermittently Flooded and Permanently Flooded (A,B,C,F,J)	PFO1,2,4, or 5A PFO1,2,4, or 5B PFO1,2,4, or 5C PFO1,2,4, or 5F PFO1,2,4, or 5J
Type 8	PALUSTRINE (P) Scrub-Shrub (SS) Broad + Needleleaf Deciduous (1,2) Broad + Needleleaf Evergreen (3,4) Dead (5) Forested (FO) Broad + Needleleaf Deciduous (1,2) Broad + Needleleaf Evergreen (3,4) Dead (5) Moss-Lichen (ML) Emergent (EM)	Saturated (B)	PSS1,2,3,4, or 5B PFO1,2,3,4, or 5B PMLB PEMB
	RIVERINE (R) Lower Perennial (LP) Upper Perennial (UP) Intermittent (IN) Unconsolidated Bottom (UB)	Intermittently Exposed (G) Permanently Flooded (H)	RUBG RUGH

2.5 Critical Wetland Resource Designations

Wetlands in the assessment area should be evaluated for designation as critical resources based on several features defined in Minnesota Statutes. These critical wetland resources should be classified into the Preserve management class due to their special functions. Criteria for designating wetlands as critical resources are as follows:

- Outstanding Resource Value Waters (Minn. Rules 7050.0180)
- Designated Scientific and Natural Areas (Minn. Rules 86A.05)
- Wetlands with known occurrences of Threatened or Endangered Species (Minn. Stat. 84.0895)
- State Wildlife Management Areas (Minn. Stat. 86A.05, subpart 8)
- State Aquatic Management Areas (Minn. Stat. 86A.05, subpart 14).
- Wellhead Protection Areas (Minn. Stat. 103I.101, MN Rules Chapter 4720).
- Sensitive Ground Water Areas (MN Rules 8420.0548, Subp. 6).
- Designated trout streams or trout lakes (MN Rules 6264.0050).
- Calcareous fens (MN Rules 8420.1010 through 8420.1060).
- High priority areas for wetland preservation, enhancement, restoration and establishment (MN Rules 8420.0350, subpart 2).
- Designated Historic or Archaeological Sites
- State or federal designated wild and scenic rivers (MN Rule Chapter 7050)
- Mn Pollution Control Agency “special waters search” mapping utility: www.pca.state.mn.us/water/stormwater/specialwaters

2.6.1 OUTSTANDING RESOURCE VALUE WATERS

"Outstanding resource value waters" are defined in MN Rules 7050.0180 as waters within the Boundary Waters Canoe Area Wilderness; Voyageur's National Park; and Department of Natural Resources designated scientific and natural areas; wild, scenic, and recreational river segments; Lake Superior; those portions of the Mississippi River from Lake Itasca to the southerly boundary of Morrison County that are included in the Mississippi Headwaters Board comprehensive plan dated February 12, 1981; and other waters of the state with high water quality, wilderness characteristics, unique scientific or ecological significance, exceptional recreational value, or other special qualities which warrant stringent protection from pollution.

2.6.2 CALCAREOUS FENS

Calcareous fens are defined in MN Rules 8420.1020 as peat-accumulating wetlands dominated by distinct groundwater inflows having specific chemical characteristics. The water is characterized as circumneutral to alkaline, with high concentrations of calcium and low dissolved oxygen content. The chemistry provides an environment for specific and often rare hydrophytic plants[11]. Minnesota Rules 8420.1010-1070 sets out minimum standards and criteria for the identification, protection, and management of calcareous fens as authorized by Minnesota Statutes, section 103G.223. The MnDNR is charged with identifying and maintaining a list of calcareous fens in the state and maintains a database of them. Calcareous fens are also listed in the Classifications for Waters in Major Surface Water Drainage Basins[12]. Finally, the rules for

[11] MN Rules 8420.1020

[12] MN Rules 7050.0470

Nondegradation of Outstanding Resource Value Waters[13] also lists identified calcareous fens in the state.

2.6.3 SCIENTIFIC AND NATURAL AREAS

State scientific and natural areas (SNA) are established to protect and perpetuate, in an undisturbed natural state, those natural features which possess exceptional scientific or educational value (MN Statutes 86A.05). This may include but is not limited to any of the following features: geological processes; significant fossil evidence, an undisturbed plant community, an ecological community significantly illustrating the process of succession and restoration to natural condition following disruptive change; a habitat supporting a vanishing, rare, endangered, or restricted species of plant or animal; a relict flora or fauna persisting from an earlier period; or a seasonal haven for concentrations of birds and animals, or a vantage point for observing concentrated populations, such as a constricted migration route. The area should embrace an area large enough to permit effective research or educational functions and to preserve the inherent natural values of the area.

2.6.4 HABITAT FOR DESIGNATED ENDANGERED, THREATENED, OR SPECIAL CONCERN SPECIES

Endangered and threatened plant and animal species are protected in Minnesota as specified in MN Statutes 84.0895. In MN Statutes, Subp. 3, species of wild animal or plant are designated as:

1. **Endangered**, if the species is threatened with extinction throughout all or a significant portion of its range; or
2. **Threatened**, if the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range; or
3. **Species of special concern**, if although the species is not endangered or threatened, it is extremely uncommon in this state, or has unique or highly specific habitat requirements and deserves careful monitoring of its status.

In 1987, the Minnesota County Biological Survey (MCBS) began a systematic survey of rare biological features. The goal of the MCBS is to identify significant natural areas and to collect and interpret data on the distribution and ecology of rare plants, rare animals, and native plant communities. The MCBS data for the assessment area (if available) should be examined for sites with moderate, high and outstanding biologic diversity significance.

The MnDNR Natural Heritage and Nongame Research Program (Natural Heritage Program) collects, manages, and interprets information about nongame animals, native plants, and plant communities to promote the wise stewardship of these resources. The Natural Heritage Program has developed a ranking system that is intended to reflect the extent and condition of natural communities and species in Minnesota.[14] These 'state ranks' have no legal ramifications, they are used by the Natural Heritage Program to set priorities for research and for conservation planning. They are grouped as follows:

[13] MN Rules 7050.0180, Subp. 6

[14] Aaseng et al., 1993.

State Element Rank:

S1: Critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation from the state.

S2: Imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.

S3: Rare or uncommon in state (on the order of 21 to 100 occurrences).
S4: Apparently secure in state with many occurrences.
S5: Demonstrably secure in state and essentially ineradicable under present conditions.
SH: Of historical occurrence in the state, perhaps having not been verified in the past 20 years, and suspected to be still extant.

SN: Regularly occurring, usually migratory and typically nonbreeding species for which no significant or effective habitat conservation measures can be taken in the state.

SR: Reported from the state, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.

SRF: Reported falsely.

SU: Undetermined. Possibly in peril in the state but status uncertain; need more information.

SX: Extirpated within the state.

The Natural Heritage Program information database should be searched to determine if any endangered, threatened, or special concern species have been sighted within 500 feet of the assessment area. The list of species, the subwatershed location, legal protection status, state element rank and county should be compiled.

2.6.5 STATE WILDLIFE MANAGEMENT AREAS

State wildlife management areas are established to protect those lands and waters which have a high potential for wildlife production and to develop and manage these lands and waters for the production of wildlife, for public hunting, fishing, and trapping, and for other compatible outdoor recreational uses[15]. State wildlife management areas satisfy the following criteria:
1. Includes appropriate wildlife lands and habitat, including but not limited to marsh or wetlands and the margins thereof, ponds, lakes, stream bottomlands, and uplands, which permit the propagation and management of a substantial population of the desired wildlife species; and
2. Includes an area large enough to ensure adequate wildlife management and regulation of the permitted recreational uses.

A map of all MnDNR Wildlife Management Areas can be found at: www.dnr.state.mn.us/maps/compass.html.

2.6.6 DESIGNATED TROUT STREAMS AND LAKES

Designated trout streams and lakes in the state of Minnesota are inhabited by trout other than lake trout. Fishing and other restrictions have been placed on these waterbodies to protect and

[15] MN Statute 86A.05, subpart 8

foster the propagation of trout. Wetlands associated with these lakes are an integral part of the whole ecosystem that functions to maintain the characteristics necessary to support the fishery.[16]

2.6.7 AQUATIC MANAGEMENT AREAS

Minnesota Statutes 86A.05, Subpart 14, allows for the establishment of aquatic management areas to protect, develop, and manage lakes, rivers, streams, and adjacent wetlands and lands that are critical for fish and other aquatic life, for water quality, and for their intrinsic biological value, public fishing, or other compatible outdoor recreational uses. Aquatic management areas may be established to protect wetland areas under ten acres that are donated to the department of natural resources. Aquatic management areas must meet one or more of the following criteria:

1. Provides angler or management access;
2. Protects fish spawning, rearing, or other unique habitat;
3. Protects aquatic wildlife feeding and nesting areas;
4. Protects critical shoreline habitat; or
5. Provides a site for research on natural history.

2.6.8 WELLHEAD PROTECTION AREAS

Wellhead protection is defined as a method of preventing well contamination by effectively managing potential contaminant sources in all or a portion of the well's recharge area. The statutory authority for wellhead protection comes from Minnesota Statutes 103I.101. The rules for establishment of Wellhead Protection Plans are found in Minnesota Rules Chapter 4720, which are administered by the Minnesota Department of Health. Wetlands present within wellhead protection areas are likely to be predominantly recharge wetlands. Since wetlands typically collect surface water runoff from a larger upland area, recharge wetlands within wellhead protection areas have a greater probability of transmitting pollutants to a public groundwater supply than other wetlands. Wellhead protection plans are developed and implemented by the public water supplier, which is typically a city or the Minnesota Department of Health. The state rules governing wellhead protection can be accessed on the web at: www.revisor.leg.state.mn.us/arule/4720/.

2.6.9 SENSITIVE GROUNDWATER AREAS

The Wetland Conservation Act requires that projects proposing to impact wetlands must evaluate whether the impacts would have an adverse impact on groundwater quality[17]. If it is determined that a proposed replacement plan would have a significant adverse impact on groundwater quality, the replacement plan must be denied. Wetlands determined to be primarily recharge wetlands as a result of a functional assessment using *MNRAM Version 3.1* should be evaluated for the potential to affect groundwater resources[18].

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[16] A list of all state trout streams and lakes can be found at: www.revisor.leg.state.mn.us/arule/6264/

[17] Minnesota Rules 8420.0548, Subpart 6

[18] Evaluate according to the guidelines in: *Criteria and Guidelines for Assessing Geologic Sensitivity of Ground Water Resources in Minnesota*, Minnesota Department of Natural Resources, 1991.

2.6.10 HIGH-PRIORITY AREAS FOR WETLAND PRESERVATION, ENHANCEMENT, & RESTORATION

Water management plans prepared by water management organizations in the metropolitan areas under Minnesota Statutes, section 103B.231 must identify those areas that qualify as high priority areas for wetland preservation, enhancement, restoration, and establishment[19]. These priority areas shall be included in the next scheduled water management plan update. Plans should give strong consideration to identifying as high priority areas, minor watersheds having less than 50 percent of their original wetland acreages, and intact wetlands, diminished wetlands, and the areas once occupied by wetlands that have been diminished or eliminated and could feasibly be restored taking into account the present hydrology and use of the area. Plans should give strong consideration to identifying as high priority areas all type 1 or 2 wetlands, and other wetlands at risk of being lost by permanent conversion to other uses. When individual wetlands are identified as high priority for preservation and restoration, the high priority area shall include the wetland and an adjacent buffer strip not less than 16.5 feet wide around the perimeter of the wetland and may include up to four acres of upland for each wetland acre.

Plans may identify additional high priority areas where preservation, enhancement, restoration, and establishment of wetlands would have high public value by providing benefits for water quality, flood water retention, public recreation, commercial use, and other public uses. High priority areas should be delineated by minor or major watershed.

2.6.11 STATE AND FEDERAL DESIGNATED SCENIC AND WILD RIVERS

The rules for the protection of state designated scenic and wild rivers is set forth in Minnesota Rules Chapter 6105[20] as administered by the MnDNR. Wild rivers are defined as those that exist in a free-flowing state with excellent water quality and with adjacent lands that are essentially primitive and scenic rivers are defined as those that exist in a free-flowing state with adjacent lands that are essentially primitive. Management plans must be developed before a river can be included in the wild and scenic river system. The plans must give emphasis to the preservation and protection of the area's scenic, recreational, natural, historic, and similar values while placing no unreasonable restrictions upon compatible, preexisting, economic uses of particular tracts of land.

[19] Minnesota Rules 8420.0350, Subp. 2

[20] The state rules can be accessed at: www.revisor.leg.state.mn.us/arule/6105/.

3.0 Field Assessment and Data Analysis Procedures (sample)

In any inventory project, the data collected should include: wetland location and extent, digital photographs of each wetland, wetland classification, dominant vegetation, wetland functions, hydrologic regime, and identification of potential restoration sites within larger assessment areas.

In general, begin by specifically defining the assessment area. Create baseline wetland inventory and assessment maps utilizing available information including: Minnesota Department of Natural Resources Public Waters Inventory maps, National Wetlands Inventory maps, soil survey data, parcel data, topography, and digital orthoquad aerial photographs to help identify wetland areas. The presence of each wetland should be verified in the field and the wetland functions assessed using the latest version of *MnRAM*. Dominant wetland types may be classified using any one of the classification systems described in Section 2.0[21], in addition to, at the very least, the U.S. Fish and Wildlife Service Cowardin System[22].

The following sample procedure is excerpted from documentation of a Minnehaha Creek wetland inventory project.

3.1 Field Assessment Maps/Data

The total watershed area within which the Functional Assessment of Wetlands (FAW) was conducted covers about 181 square miles. Maps were created for use in the field to locate wetland sites, to assist in completing the wetland assessments, and to act as a field notebook for recording necessary data. Each field map covered one full section of land (one square mile).

3.2 Wetland Base Data: Hennepin Conservation District Wetland Inventory

The Hennepin Conservation District (HCD) had conducted a remote sensing wetland inventory (HCWI) within the District prior to the beginning of this project. The wetlands that had been identified in the HCWI were used as a base layer for the FAW field maps to comprehensively show where existing and potential wetlands are located. In conducting the wetland inventory, HCD followed a stepped procedure, described below.

First, potentially drained wetlands were identified based on depressional areas with hydric soils or transitional soils, or poorly drained depressions identified on the soil survey without clear evidence of wetland hydrology. Areas identified on the NWI were included. Areas appearing on the Metropolitan Mosquito Control maps were also highlighted which are known to pond water periodically.

Next, areas that appeared to have wetland hydrology on infrared (IR) stereo photos, as identified by tone, texture, and presence of a depression, were identified. Then, aerial photography from the past 15 years was evaluated in combination with data of yearly precipitation (wet, normal, dry) to evaluate wetlands that were identified during the IR and soil/topography review. During the aerial photography review each high lighted site was defined

[21] Classify wetlands using the U.S. Fish and Wildlife Service Circular 39 System, Shaw and Fredine, 1959.
[22] Cowardin et al., 1979.

as either: (1) dry cropped, (2) dry and no crop, (3) wet and crop stress, (4) wet and no crop, (5) wet and drowned out, or (6) ponded.

Areas that appear to have wetland hydrology every year and do not appear to be drained were classified as wetlands with unaltered hydrology (EWET and shown as green polygons on the base maps) in the GIS. The areas showing evidence of wetland hydrology in one-third or more 'normal' precipitation years were classified as wetlands with altered hydrology (AWET and shown as blue polygons on the base maps). Estimated restorable areas that did not appear to have wetland hydrology during at least one-third of the normal precipitation years, or could not be observed due to tree cover, were identified as potential wetlands (RWET yellow polygons on the base maps) in the GIS. The extent of these potential wetlands was determined using either: 1) the size during the wettest year, 2) the boundary of the depressional soil unit on the soil survey, and/or 3) the boundary of the NWI or Mosquito Control District mapping.

3.3 Field Assessment Base Data

Each wetland polygon or wetland complex identified in the HCWI was given a unique Wetland ID number. The ID number consists of the township number, followed by the range number, followed by the section number and finally a unique three-digit number for each wetland within the section. A letter designation (D or E) is placed at the beginning of the wetland ID. A "D" indicates that the wetland is completely or partially drained and an "E" indicates that there was not clear evidence that the wetland has been hydrologically altered. Other data on the base maps included; soil type and inclusions and the approximate acreage of each wetland. Color aerial photographs from 2000 were used as a base layer on the field maps for the FAW under the wetland polygons and soil data. In addition, section numbers, parcel lines, road names, and subwatershed boundaries were added to the field maps that were plotted at a scale or 1 inch equals 200 feet.

Separate topography maps were created for use in the field. The topography maps were created in ArcView 8 using 5-ft contours with a subtle hill shading and the ~160 subwatershed boundaries at a scale of approximately 1 inch equals 800 feet. The topography maps were made at a larger scale, to include complete subwatershed areas for assessing wetland location within a subwatershed and proximity to recreational water bodies.

3.4 Field Assessment Procedures

The section maps, topographic maps, digital camera and a letter explaining the project to property owners were used each day during fieldwork. All existing wetlands and all potential wetlands greater than 0.25 acre were evaluated in the field for wetland function and for restoration potential. If potential wetlands under 0.25 acres in size were found to contain rare and/or unique features they were assessed.

Property owners were informed of the project by publishing public notices in each local newspaper and/or newsletter. To begin an assessment the property owner was identified using the parcel lines on the maps, and an attempt was made to contact the owner. If the property owner was available, the field evaluator briefly described the project and asked the owner for permission to access the wetland(s) on their property. If the property owner refused access, a note was made on the section map.

The objective of the field assessment was to answer all questions in the Access database MCRAM, excluding those highlighted in red that were evaluated using existing digital data analyzed using GIS. This included an evaluation of the presence and abundance of hydrophytic and invasive vegetation to identify and appraise the plant community, seeking out surface drain tile inlets, ditches or any other drainage feature to identify hydrogeomorphology, litter and buffer of the wetland, land-use within the subwatershed, and apparent public use of the wetland. The soil and topography maps were used in the field to determine the presence of hydric soils, and the topographic position of each wetland within the subwatershed. Both the Cowardin and Circular 39 classifications were assigned to each wetland during the field assessments (Section 4.0). A comparison of the Cowardin and Circular 39 classification systems is also provided in Tables C.1 and C.2.

3.5 Field Map Notation

Field notes were written on the maps using a permanent marker, preferably in red. Each evaluated wetland or potential wetland was marked on the map using the following mapping symbols:

- **NW** = **Not Wetland**: Identified as a wetland or potential wetland on the HCWI, but observed to be dominated by upland vegetation in the field; these would typically be accompanied by an **X** through the wetland polygon.
- **A** = **Assessed Wetland:** wetlands that were assessed in the field.
- **NA** = **Not assessed**: typically wetlands below the threshold size of 0.25 acres and identified as potential wetlands in the HCWI or wetlands present on inaccessible private property
- **NAW** = **Not Assessed Wetland:** wetlands that were not assessed, but were verified as a wetland, typically classified as potential wetlands and less than 0.25 acres in size with no unique or notable characteristics.
- **SW** = **Stormwater Pond:** clearly excavated out of upland and created to manage stormwater.
- **R** = **Restorable Wetland:** drained wetlands that were only assessed for restoration potential.

Wetland boundaries were revised on field maps when field evaluations indicated a significant difference in the edge of dominant hydrophytic vegetation from the HCWI mapping. If a wetland boundary was changed, an “X” was written through the old boundary to indicate the creation of a new boundary.

3.6 Guidelines for Field Map Notation

New wetland IDs were assigned to new wetlands found in the field but not identified on the HCWI or portions of large wetland complexes that needed to be split. The Access database was reviewed to find the next sequential “D” or “E” designation ID number for the section in which the majority of the wetland resides. The new Wetland ID was entered into the Access database, and the new ID was written within or next to the wetland polygon on the map.

Wetlands separated by roads or railroads (i.e. those with only a restricted hydrologic connection and no ecological connection) were evaluated as unique wetlands. Partially drained wetlands that were determined to be restorable were evaluated as wetlands and for restoration potential. In this case, the existing wetland areas were labeled with an **A** and the drained portions were labeled separately with an **R**, but all parts of the wetland basin were identified with the same Wetland ID.

At completion of each day, or the completion of a section, the dates and persons conducting field evaluations were indicated in the upper right corner of each map, and

‘COMPLETE’ was written in the upper left corner when the entire section was completed. If there were wetlands crossing the section line that have not been fully assessed or mapped they were indicated in the upper left corner of the map.

3.7 Photographs

A digital photograph was taken of each evaluated wetland and drained wetland that was assessed for restoration potential. An arrow was drawn on the map with the point of the arrow at the point where the photograph was taken from, indicating the approximate direction of the photo. Photographs were tracked by writing the photo number next to the location arrow. The photo point locations were digitized in GIS within the corresponding wetland polygon, and UTM coordinates for each point were generated. A list could also be made in a field book indicating the wetland ID and the photograph number. Each photograph was subsequently renamed using the unique Wetland ID (i.e. D1172401001).

3.8 Identifying Potential Wetland Mitigation Sites

All drained wetlands identified in the HCWI and other drained wetlands identified in the field were evaluated for the potential to restore those wetlands. Wetlands with restoration potential typically met one or more of the following conditions:

- Mapped hydric soils or hydric soil inclusions
- Wetland hydrology signatures on past aerial photos (see HCWI database)
- The area was a depression in the landscape
- Wetland hydrology was currently absent within part or all of the depression
- Evidence of ditching, tiling, or other feature that has removed the hydrology should be present
- Drained wetlands within permanently altered land uses (i.e. golf courses) were determined to not be restorable in most cases.

The approximate restorable area was delineated on the map, even if it was adjacent to an existing wetland. The currently non-wetland area which has potential to be restored was marked with an **R** to indicate which Wetland ID the restored area was associated with. A photograph was taken and the photo point was indicated on the map.

3.9 MnRAM Access Database Procedures for Field Work

The functions of each wetland were evaluated by completing the Microsoft Access® database version of the MnRAM using laptop computers which were carried in the field. The database contained a "Complete Box" which, when checked, indicated that the wetland assessment had been completed. This Complete Box was then used to combine the wetland records from all field crews into one master database. All data entered into the MnRAM database was automatically saved and became part of the permanent record as soon as entered.

The photo ID number generated by the digital camera for each wetland photo was entered into the database which also corresponded to the photo number indicated on the field maps to allow easier tracking. For each assessed wetland, the field evaluator recorded their initials and the date of the assessment within the MnRAM database for future reference. The MnRAM database contains *The National List of Plant Species that Occur in Wetlands*[23], which includes

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[23] Resource Management Group, 1999.

common and scientific names and the indicator status for each species. This list was used for entering the dominant plant species (typically those dominants according to the 50/20 rule) within each wetland along with the cover class for each species.

When there were numerous species of one type (i.e. willow, sandbar), the appropriate species was used when known, otherwise the general name was used. When wetlands with uncommon vegetation (e.g. sedges, tamarack, sphagnum moss, bog species) were evaluated, those species were also recorded, even if they weren't dominant for the entire wetland. Species were usually selected from the drop down list to avoid misspellings and improper names. If a species was not present in the plant list, it was added to the species list.

Upon return to the office, each assessed wetland was checked to verify that there was one complete Access database record, one digital photograph, and one wetland polygon marked with an A or an R on the field maps. Also, maps were checked for initials of the field evaluator, and the dates of the fieldwork.

4.0 GIS Procedures (sample)

The following sample procedure is excerpted from documentation of a Minnehaha Creek wetland inventory project.

4.1 GIS Wetland Shapefile

The field evaluation notation for each wetland was entered into the ArcView wetland shapefile table and the wetland boundaries were revised to note any significant changes to the HCWI. This included: adding new wetland boundaries, deleting incorrect boundaries, merging wetland polygons, and splitting wetland polygons. Field assessment notations were added in GIS according to those listed in the Field Evaluation Notation section above. Following are some of the general guidelines followed in updating the HCWI wetland shapefile:

- Upon completion of the FAW, each Wetland ID should only have ONE wetland polygon with an **A** in the *Assessment* field.
- Wetland polygons from the HCWI were generally not deleted; if an area was determined to not be wetland, an **NW** was entered in the *Assessment* field.
- Multiple polygons identified with the same Wetland ID in the HCWI were either combined, split up and given different Wetland ID numbers, or given different designations in the *Assessment* field when indicated as necessary by the field assessment notes.
- The area of each assessed wetland was computed in ArcView after all boundary revisions were made and prior to completing the GIS data analyses.
- Where only minor alterations in the boundary of a wetland were indicated on the field maps, the boundaries were not revised in GIS. If only a portion of the wetland polygon is indicated as changing significantly, just that portion of the wetland was revised. The minor wetland boundary changes indicated on the field maps could be used to refine the digital wetland boundaries in the future.
- A photo location point was digitized in ArcView within each assessed wetland polygon.

4.2 GIS Data Analyses

Seven wetland functional parameter questions were evaluated using analyses of existing digital data in GIS. The resulting evaluation data were then imported into the MnRAM database where all of the functional evaluation data are managed. The following values are given for classifications that were assigned for each of the questions answered using GIS (which are the same values used throughout MnRAM):

Exceptional = 2.0	Discharge = 0.1
High = 1.0	Recharge = 0.0
Medium = 0.5	Yes = 1.0
Low = 0.1	No = 0.1

Following is a brief description of the wetland functional parameter questions analyzed using GIS and a brief description of the criteria and analyses performed in GIS.

Question #2: Are rare plant species or state or federally listed species known to be in/near wetland?

A 200-foot buffer was established around each wetland in ArcView. The wetland and buffer area were then checked for the presence of any state or federally listed species within that area. The wetland polygon with buffer area was used to intersect rare species GIS data provided by the MnDNR Natural Heritage Inventory Database. Values for responses of yes or no were returned based on the outcome of the analysis.

Question #12: Describe the predominant upland soils within the subwatershed that affect the overland flow characteristics.

A 500-foot buffer was established around each wetland polygon. The Soil Conservation Service hydrologic soil group data (i.e. A = sand, B = sandy loam, C = clays loams, and D = plastic and swelling soils) within the 500-foot buffer was evaluated to determine which soil group represents the majority of the area. These resulting values were based on the following rules:

High: Majority of soils C, D, or combinations with C or D
Medium: Majority of soils hydrologic soil group B
Low: Majority of soils hydrologic soil group A

Question #14: Describe the density of wetlands within the subwatershed.

First, an analysis was conducted to determine the proportion of each subwatershed area comprised of wetlands, lakes, or ponds. Then it was determined within which subwatershed each wetland was located. Based on the subwatershed wetland/waterbody density, a value of high, medium, or low was attributed to each wetland based on the following rules:
Classification Rules:

High: Wetlands/water making up < 10% of subwatershed area
Medium: Wetlands/water making up 10-20% of subwatershed area
Low: Wetlands/water making up > 20% of subwatershed area

Question #28: Describe the soils within the wetland.

The digital soil survey data for Hennepin and Carver Counties was evaluated to identify all "organic" wetland soils. The soil mapping underlying each assessed wetland was evaluated for the presence or absence of organic soils. A value for each wetland was determined based on whether the majority of soils were organic or mineral according to the following criteria:
Classification Rules:

Recharge: Majority of soils in the wetland are mineral.
Discharge: Majority of soils in the wetland are organic

Question #30. Indicate conditions that best fit the wetland based on wetland size and the hydrologic properties of the soils within 500 feet of the wetland.

Again, the 500-foot buffer around each wetland was used for this analysis along with the area of each wetland (previously computed in GIS). If the total wetland area is greater than or equal to 200 acres, the wetland is discharge. If the wetland is less than 200 acres in size and the surrounding upland soils within 500-feet are in the A or B hydrologic soil group, then the wetland is discharge. Otherwise the wetland was determined to be recharge for this question.

Question #34. Is the wetland known to be used recently by rare wildlife species (or state or federally listed wildlife)?

Similar to Question 12, a 500-foot buffer around each assessed wetland was checked for known rare wildlife species using GIS data provided by the MnDNR Natural Heritage Inventory database. Based on the analysis results, the field for Question 34 was populated with the numeric values:

Yes = 1.0
No = 0.1

Question #35. Is the wetland or a portion of the wetland a rare natural habitat or community as identified by the MnDNR Natural Heritage Inventory database or the County Biological Survey.

Is the wetland plant community scarce or rare within the watershed, imperiled, or critically imperiled (state rankings S1 and S2)? If this applies, then Special Features question b is answered yes and the wetland wildlife habitat function level rating is exceptional.
Each wetland was compared to the rare habitat features from the County Biological Survey (CBS). An attribute was added to the CBS table data indicating the state rank so that those communities rated S1 and S2 that intersected the wetland were answered yes and the others were answered no. Based on the analysis results, Question 35 was populated with the numeric following values:

Yes = 1.0
No = 0.1

Question #48. Is any part of the wetland in public or conservation ownership?

The property ownership of each evaluated wetland was analyzed using the Hennepin and Carver County Parcel data. The "Find Majority Area" was used with the *ExemptCode* field being the field and Watershed ID being the value summarized. If the area of "E" = 0, then there is no public ownership (Value = "LOW"). If the area of "N" = 0, then there the entire wetland is under public ownership (Value = "High"), if not, then some of wetland is under public ownership, (Value = "Medium"). If there is no summary for wetland, the wetland must fall outside of parcels in shapefile, usually this would be road ROW. If so, assume the value = "high."

4.2.1 Creating GIS Analyses Summary Table and Importing into McRAM Database

A summary table was then created for importing the results of the GIS analyses into the McRAM database. The summary table must be formatted as shown below for proper import to the McRAM database. Each Wetland ID presented in the summary table must have a valid answer for each of the questions analyzed using GIS (i.e. Questions 2, 12, 14, 28, 30, 34, 35, and 48). Running the database import routine operates such that the data for the questions described above will be overwritten for each Wetland ID presented in the summary table. Each time this data was imported the existing data in Access will be overwritten. Missing data for any question will result in that particular question being populated with a value of 0 (zero) for that Wetland ID. In most cases, a 0 (zero) is not valid. The table must be in comma-delimited format in the EXACT question order shown below:

```
"Wetland_ID","Q12_val","Q14_val","Q28_val","Q30_val","Q48_val","Q02_val","Q34_val","Q35_val"
E-117-24-14-008,0.5,0.1,0.1,0.0,0.1,0.1,0.1,0.1
```

This summary table was then imported into the McRAM database using the "Import GIS Data" button on the *General Information* tab of the data entry form. Within the *Import Dialog* box within the "Import GIS Data" button, the *Update GIS Fields* option is chosen and the file name and extension was entered in the *Select a File to Import* box.

4.2.2 CREATING SUMMARY TABLE AND IMPORTING GENERAL INFORMATION EVALUATED UTILIZING GIS

Several other pieces of information were generated using GIS to the improve accuracy and eliminate the possibility of data entry errors. The data generated included:

1. **Municipality/Township** (both primary and secondary) within which the wetland lies.
   A GIS polygon dataset developed by the Metropolitan Council (i.e. County_CTU.shp) containing boundaries of cities, township and unorganized territory (CTU) in the Twin Cities 7-county metropolitan area was used to determine the municipal location of each assessed wetland. The linework for this dataset comes from individual counties and is assembled by the Metropolitan Council for the MetroGIS community. The data was current as of April, 2000. Up to two pieces of data were generated from this analysis indicating the city(ies) or township(s) within which the wetland is located (i.e. "InfoCityName" and "InfoCityName2" fields). The first parameter, InfoCityName is the city within which the majority of the wetland lies, and the second, InfoCityName2 is for wetlands that cross municipal boundaries and indicates the city within which the smaller portion of the wetland lies. Each assessed wetland polygon was evaluated in GIS to determine within which city the majority of the wetland lies.
2. **Subwatershed** within which the majority of the wetland lies.
   The GIS polygon dataset provided by the Minnehaha Creek Watershed District containing the boundaries of the 16 subwatersheds in the District (Figure 1.1) was used to determine within which subwatershed the majority of each wetland lies (i.e. "InfoSubwatershed" field).
3. **Wetland Area** in acres of each assessed wetland and potential wetland restoration areas.
   The area of each wetland and potential wetland restoration area was computed in GIS using the approximate, field-verified wetland boundaries that had been digitized in GIS.

4.2.2.1 City/Subwatershed Data Import

The city and subwatershed location information was then tabulated into a summary table for importing into the McRAM database. Again, a comma delimited file format was used as shown below:

```
"Wetland_id","InfoCityName","InfoCityName2","InfoSubwatershed"
D-028-24-26-001,Richfield,,Richfield/South Minneapolis
D-117-22-12-035,Hopkins,Minnetonka,Upper Minnehaha Creek
```

This summary table was then imported into the McRAM database using the "Import GIS Data" button on the *General Information* tab on the data entry form. Within the *Import Dialog* box within the "Import GIS Data" button, the *Update Gen'l Information* option is chosen and the file name and extension was entered in the *Select a File to Import* box.

4.2.2.2 Wetland Area Data Import

The wetland area information was then tabulated into a summary table for importing into the McRAM database. Again, a comma delimited file format was used as shown below:

"WETLAND_ID","INFOCURRENTSIZE"
D-118-23-16-007,0.47
D-118-23-13-026,2.28

This summary table was then imported into the McRAM database using the "Import GIS Data" button on the *General Information* tab of the data entry form. Within the *Import Dialog* box within the "Import GIS Data" button, the *Update Wetland Areas* option is chosen and the file name and extension was entered in the *Select a File to Import* box.

4.3 Data Management and Data Use in GIS

All wetland functional data and general information is maintained in the MnRAM Microsoft Access® database. Only the wetland polygons and *Assessment* status for each Wetland ID are maintained in GIS. The wetland functional data and general information stored in the MnRAM database can be temporarily referenced in GIS for preparing maps and conducting spatial analyses.

4.3.1 Accessing and Utilizing Data from the McRAM Database

1. Create ODBC connection to Minnehaha Creek Access Database as follows (these directions are for Windows2000):
    a. Go to the control panel and select administrative tools.
    b. Select the “Data Sources (ODBC)” icon
    c. Select the System DSN tab
    d. Push the “Add” button
    e. It will ask for a “driver”, select the Microsoft Access driver (*.mdb).
    f. Type in “Minnehaha Creek Master Database” for Data Source Name. Type in a description (not required).
    g. Specify the MnRAM database location by pushing the “select” button.
    h. When done, say OK and leave the setup program.

2. If the Access table has not been loaded into the ArcView project, do the following:
    a. From the projects menu in ArcView, select “SQL Connect”, a dialog box will appear.
    b. Select “Minnehaha Creek Master Database” from the dropdown list, then press “Connect”.
    c. A list of “Tables” appears. Select **tblSummaryGISDataFinalNums** (contains the computed numeric scores for all functions except groundwater and storm water sensitivity) from the list.
    d. Double click on <all columns> in the columns list
    e. Name the output table **tblSummaryGISDataFinalNums**
    f. Push the query button. This should load the Access table into ArcView as an ArcView table.

Repeat steps a through f for the following tables:

tblSummaryGISDataFinal (contains the Assessment status [*fldStatus*]along with the text ratings for each function)

tblSummaryGISDataTwoFinal (contains the Assessment Status, Circular 39 types, Hydrologic Setting, Geomorphic setting, City1, City 2, Subwatershed, Wetland Size, Cowardin type, and Community description)

Each of these tables can be joined to the Wetland shapefile in GIS using the Wetland_ID as the common field. To map wetland types in GIS based on the dominant Circular 39 wetland type, a wetland classification lookup table must also be joined to the Wetland shapefile. From the ArcView project window, add Table *wet_lkup_sens_121602b.txt*, join to the Wetland shapefile using the *Circular 39* field as the common field and the *Dom_Type* field contains the dominant wetland type for each assessed wetland. The Circular 39 wetland types shown on the Wetland Classification figures for each municipality (i.e. Figures 6.27-6.56) are either the dominant wetland type within the assessed wetland or a known subdominant Exceptionally sensitive wetland type, if present (i.e. Types 7 and 8 wetlands). This data is contained in the field *Design* in the Table *wet_lkup_sens_121602b.txt*. Virtually any of the data tables contained in the McRAM database can be joined to the GIS Wetland shapefile as described above, however, just those tables containing the most commonly utilized data are described above.

4.4 Quality Assurance and Quality Control

Several procedures were implemented to ensure the accuracy and completeness of the data generated during the course of the project. Five primary data products were generated as a result of the project:

1. **Field Assessment Maps**
2. **Wetland GIS Shapefile**
3. **McRAM Database Records**
4. **Wetland Photographs**
5. **Wetland Photo Points**

Each data product contains valuable information that is either explicitly presented in this report or is part of the project record that will be integral for future use. It was important to ensure that each of these five products contained data corresponding to each unique Wetland ID.

The **Field Assessment Maps** are part of the project record and contain all of the direct field notations including approximate wetland boundary mapping, wetland assessment status, Wetland IDs, field evaluator identification, field evaluation dates, wetland photo numbers, and wetland photo location. Many of the wetland boundaries that were revised from the HCWI were not incorporated into the final GIS Wetland shapefile, so the field assessment maps provide valuable wetland boundary information not included in this report. The wetland assessment status data was incorporated into the GIS Wetland shapefile and should correspond precisely. The Wetland ID represents the unique identifier for each wetland and is the most important piece of information that must be connected to all data collected for each wetland. The identification of field evaluators, dates of each wetland assessment, and photo numbers are valuable for tracking down any data entry errors that may be present.

The **Wetland GIS Shapefile** contains the unique spatial wetland location and extent data, which was used as the baseline data on field assessment maps from the HCWI. The original HCWI shapefile was updated and revised based on the field assessments conducted throughout the project. Each assessed wetland must have a unique Wetland ID to which all other data generated during the project is tied.

The **MnRAM Database Records** contain all of the wetland functional data collected in the field and analyzed using GIS which must correspond directly to the Wetland ID noted on the field maps and contained in the Wetland GIS shapefile. The MnRAM database is the primary data storage program for all data generated during the project except the spatial wetland location and extent data. It is imperative that each Wetland ID in the MnRAM database corresponds to the proper wetland in the Wetland shapefile.

The **Wetland Photographs** were taken at the time each wetland was assessed in the field and provides a visual record of each wetland from that point in time. Each digital photograph was automatically assigned a number by the camera when the photo was taken. That wetland photo number then was manually tracked and renamed using the unique Wetland ID number.
The **Wetland Photo Points** represent the approximate location from which the photograph was taken. This location data was designated on the field maps and digitized into a photo point shapefile in GIS at the approximate location from which the photo was taken and within the wetland polygon.

4.5 Automated ArcView and McRAM Database QA/QC

The first quality assurance/quality control analysis was conducted in GIS to ensure that each unique Wetland ID contained only one wetland polygon indicated with an **A** (assessed) in the *Assessment Status* field. The second QA/QC analysis was developed to initially check for a one-to-one correspondence between wetland assessment records in the MnRAM database and "assessed" wetland polygons in ArcView following the completion of the field wetland assessments. From that analysis, a table is produced containing four data columns with the possible values as follows:

1. **GIS Status:** The shapefile indicates whether or not the wetland was indicated as assessed in the wetland shapefile.

    Assessed – Assessment field contains an "A", shown as assessed on map
    Not Assessed – Assessment field contains "NA", shown as not assessed
    N/A – indicated as no record in ArcView

2. **GIS Message:** If the Wetland ID exists in the shapefile, but not the Access database

    OK – there is a polygon in the shapefile and the database
    No Shapefile Record – There is no Wetland ID in the shapefile.
    More than One Shapefile – more than one polygon with the same Wetland ID and both shown as "Assessed"

3. **Access Status:** Indication in Access database table whether or not the wetland has a completed assessment record or restoration potential evaluation.

   Assessed – Wetland has a completed wetland database record.
   Not Assessed – The "Complete Box" in the database has not been checked
   N/A – indicated as no record/ID in Access database

4. **Access Message:** If the Wetland ID exists in the Access database but not in the shapefile.

   Assessed – Database record for this Wetland ID has the Complete Box checked.
   No Table Record – No data in the database for this ID.

A new table summarizing the results will be created. Those with "Assessed" in column 1 and 3, have corresponding records in GIS and Access. Those with different values in columns 1 and 3 must be analyzed in further detail as do those without an "OK" in column 1 or 3 some aspect of the database or shape file is missing. Based on these results inconsistencies were amended. The final, automated QA/QC procedure conducted involved an analysis of wetland photo points to ensure that each "assessed" wetland polygon contain one, and only one, wetland photo point digitized within the wetland polygon.

4.5.1 MANUAL ARCVIEW AND MNRAM DATABASE QA/QC

All spatial wetland assessment data was mapped in ArcView for each municipality within the District. These maps are provided in Figures 6.27 through 6.56, in Section 6.0. The wetland functional data is presented in three sets of tables for each municipality in Section 6.0 also. A manual QA/QC procedure was conducted to ensure that the spatial wetland assessment data and MnRAM database wetland functional data were consistent. The municipal Wetland Classification maps and municipal Wetland Data Tables were manually checked to ensure that each unique, assessed Wetland ID contained one wetland polygon and one database record. The QA/QC procedure for ensuring that one digital photograph was present for each assessed wetland was conducted on approximately a weekly basis throughout the length of the project. Each field evaluator created a log of wetlands assessed and original photo numbers which was then double-checked after the wetland photos were renamed.

4.6 GIS Information:

Data Standards and Practices in Metro/Minnesota

County and Minor Civil Division Coding Exchange Standards (Statewide)
The three-digit FIPS and state standard county code as adopted as a standard for state agencies has been adopted as a MetroGIS standard for data exchange.
http://www.metrogis.org/data/standards/index.shtml

Minnesota Land Cover Classification System
Developed minimum mapping units and can let you know how to cost out a project of this magnitude. They used the MetroGIS community to aid in their development of a standard

product, gain statewide buy-in and then approve/adopt the standard and use for a regional dataset.

Contact Information:
Bart Richardson, DNR Metro Region, Phone: 651-772-6150

MetroGIS Contact Information:
Randy Johnson, Metropolitan Council, MetroGIS Project: 651-602-1638

More information about GIS data is available at the following websites:

National Wetlands Inventory (NWI) Polygons:
http://deli.dnr.state.mn.us/metadata/index_th.html

County Soil Surveys:
(metro Counties) www.datafinder.org/metadata/orthos2000.htm
(statewide): http://lucy.lmic.state.mn.us/metadata/doq.html
check area LGU for updated photography or other resources

Watershed Basins (minor watershed):
(statewide) http://deli.knr.state.mn.us/metadata/full/bas95ne3.html

Parcel (land ownership):
(metro only) http://www.datafinder.org/catalog.asp
statewisde contact information only): http://www.lmic.state.mn.us/cty_contacts.html

MCBS Native Plant Communities:
http://deli.dnr.state.mn.us/metadata/full/mnnpcpy2.html

Mn Scientific and Natural Areas:
http://deli.dnr.state.mn.us/metadata/full/snaxxpy3.html

MCBS Sites of Biodiversity Significance:
http://deli.dnr.state.mn.us/metadata/full/mnsbspy2.html

Color Infrared (CIR):
http://www.dnr.state.mn.us/airphotos/ordering.html

5.0 Quick Reference—how to install the program, enter data, and get reports

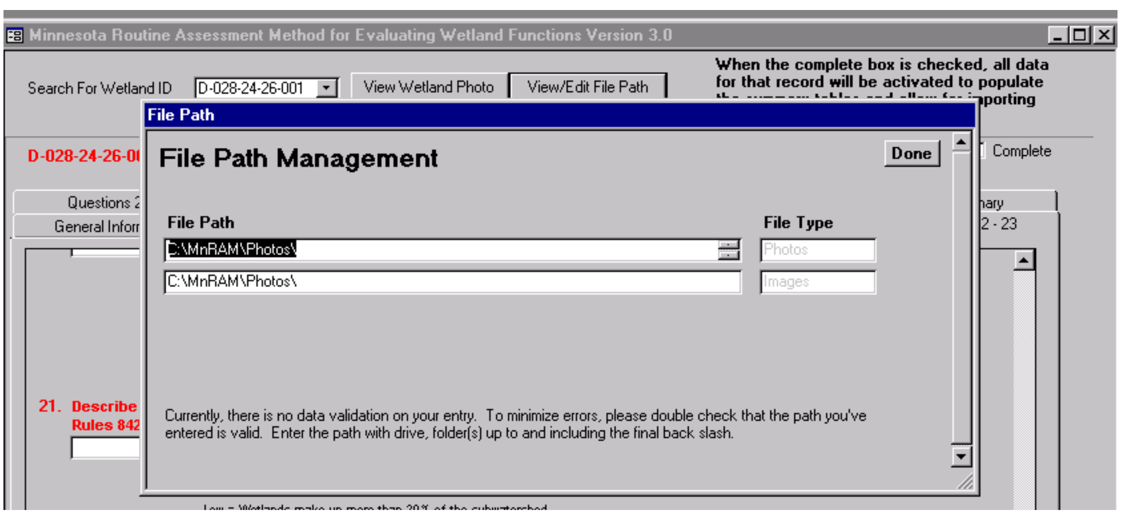
Using the MnRAM 3.1 Access 2000™ (or later) database

This section is meant to supplement, not replace, user training on the wetland assessment method. Training will explain the method and rational behind the questions; this section will explain how to use the program itself. It assumes a level of familiarity with data entry and computers in general and will not attempt to explain common terms or actions.

A Visual User Manual is also available. It is available over the Internet as a PowerPoint™ presentation giving a virtual tour of the database as well as descriptions and explanations of the questions: www.bwsr.state.mn.us/wetlands/mnram/index.html

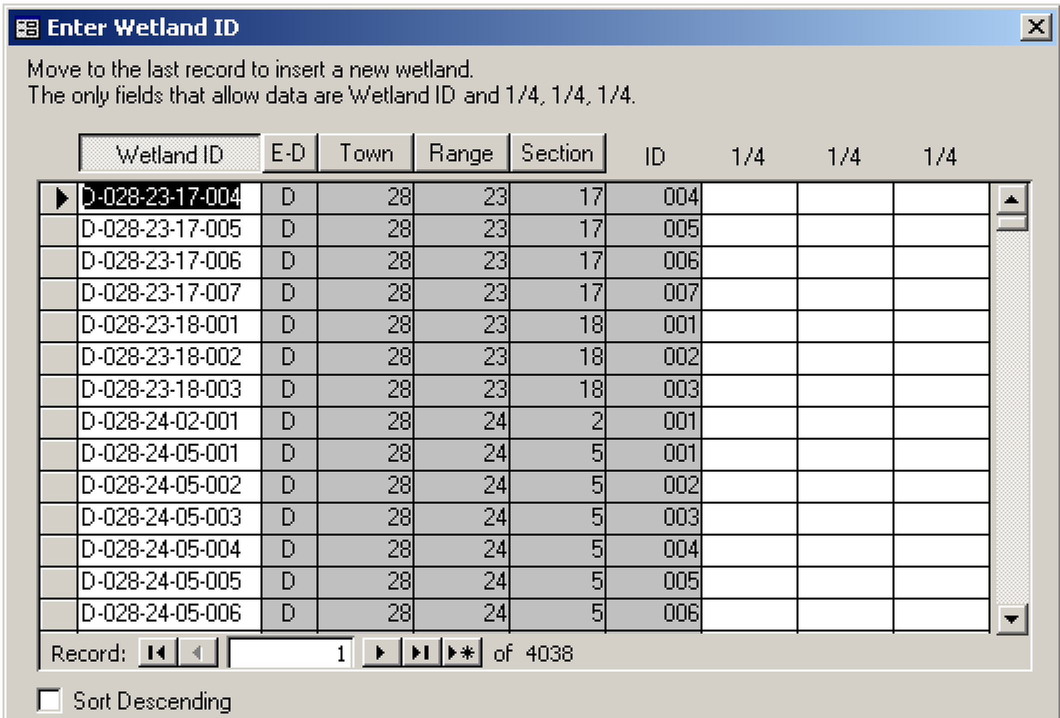
5.1 Installing the Program

Whether you obtain the program via the Internet or a cd, download the program to your hard drive. Place the *interspersion.jpg* and *cover-category.jpg* image files on the same computer or network drive and specify the file path in "**Images**" File Type line within File Path Management screen using the "View/Edit File Path" button at the top of the main page as shown below. The text version (Microsoft Word™), field sheets (Excel™), and other material are also available.



5.2 Opening the Database/Naming Wetland Conventions

When you open the database for the first time, there will be no records except the first blank one. Use your mouse to click the top box in the main window: "Add a New Wetland ID." This brings up a pop-up window as shown. Click on the arrow with an asterisk at the bottom ▶* to bring up a blank record where you may enter (without typing hyphens) the two-digit County code (see Appendix), the three-digit Township number, the two-digit Range number, the two-digit Section number, a unique three-digit wetland number, and a letter indicating whether this is the first, second, third or other assessment of the wetland. This code makes up the unique Wetland ID. To better identify the location of the wetland within the section, then up to three ¼ section locations can be added as in the following example: SW ¼ of the SW ¼ of the SW ¼.


Enter Wetland ID

Move to the last record to insert a new wetland.
The only fields that allow data are Wetland ID and 1/4, 1/4, 1/4.

Wetland ID	E-D	Town	Range	Section	ID	1/4	1/4	1/4
D-028-23-17-004	D	28	23	17	004			
D-028-23-17-005	D	28	23	17	005			
D-028-23-17-006	D	28	23	17	006			
D-028-23-17-007	D	28	23	17	007			
D-028-23-18-001	D	28	23	18	001			
D-028-23-18-002	D	28	23	18	002			
D-028-23-18-003	D	28	23	18	003			
D-028-24-02-001	D	28	24	2	001			
D-028-24-05-001	D	28	24	5	001			
D-028-24-05-002	D	28	24	5	002			
D-028-24-05-003	D	28	24	5	003			
D-028-24-05-004	D	28	24	5	004			
D-028-24-05-005	D	28	24	5	005			
D-028-24-05-006	D	28	24	5	006			

Record: 1 of 4038

Sort Descending

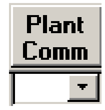
For differentiating wetlands with each section in an inventory, start at the upper right with number "001" and number them sequentially in a counterclockwise direction around the center point.

After you have added the Wetland ID to the list, you will need to search for it from the "Search for Wetland ID" field in the upper left by entering the number (including hyphens) then either click on the number in the drop-down list or press "Enter". The red Wetland ID above the upper left portion of the tabs shows the active record. After this, from the cursor can be advanced from field to field, by using the "Tab" key or "Enter" key after inserting data in a field and the cursor will automatically advance to the next field. Use your mouse to switch tabs to a new set of questions.

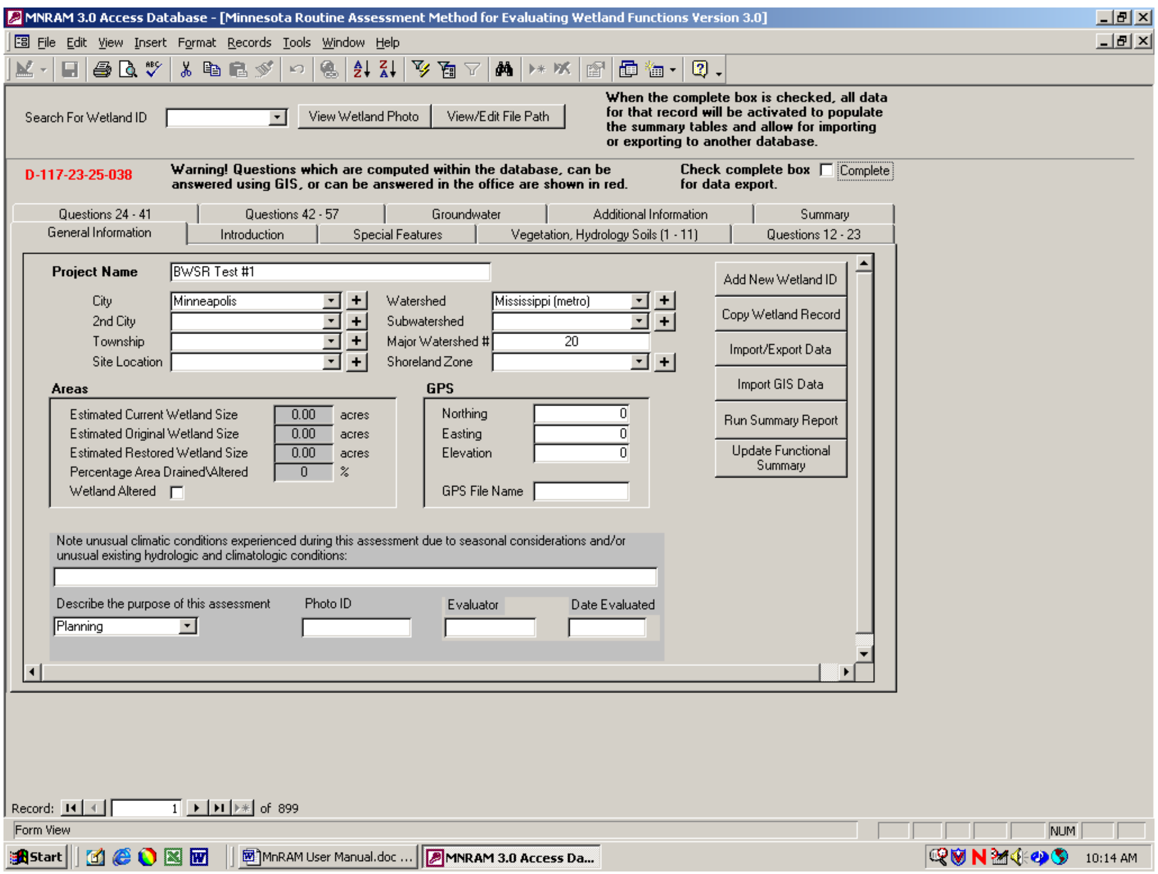
5.3 Entering Data

For a Wetland record to become activated for inclusion into reports or for export to another database, **the "Complete Box" must be checked**. There are several data quality checks built into the database to capture potential errors, but there could be more that have not been discovered, yet. Please take care to answer all of the questions (Except for Questions 30-35 when Shoreline Protection does not apply and Questions 65, 67-70 when

Wetland Restoration potential does not apply. **Questions 66a and 66b MUST BE ANSWERED** for the functional index calculations to perform.

Fields that have a drop-down list available look like this: 

If the choice you want is not listed, you may be able to add it to the list by pressing the + button and entering the data. In some cases (such as the list of vegetative communities), however, you will not be able to modify the list. Please call the BWSR contact for more information about missing choices.

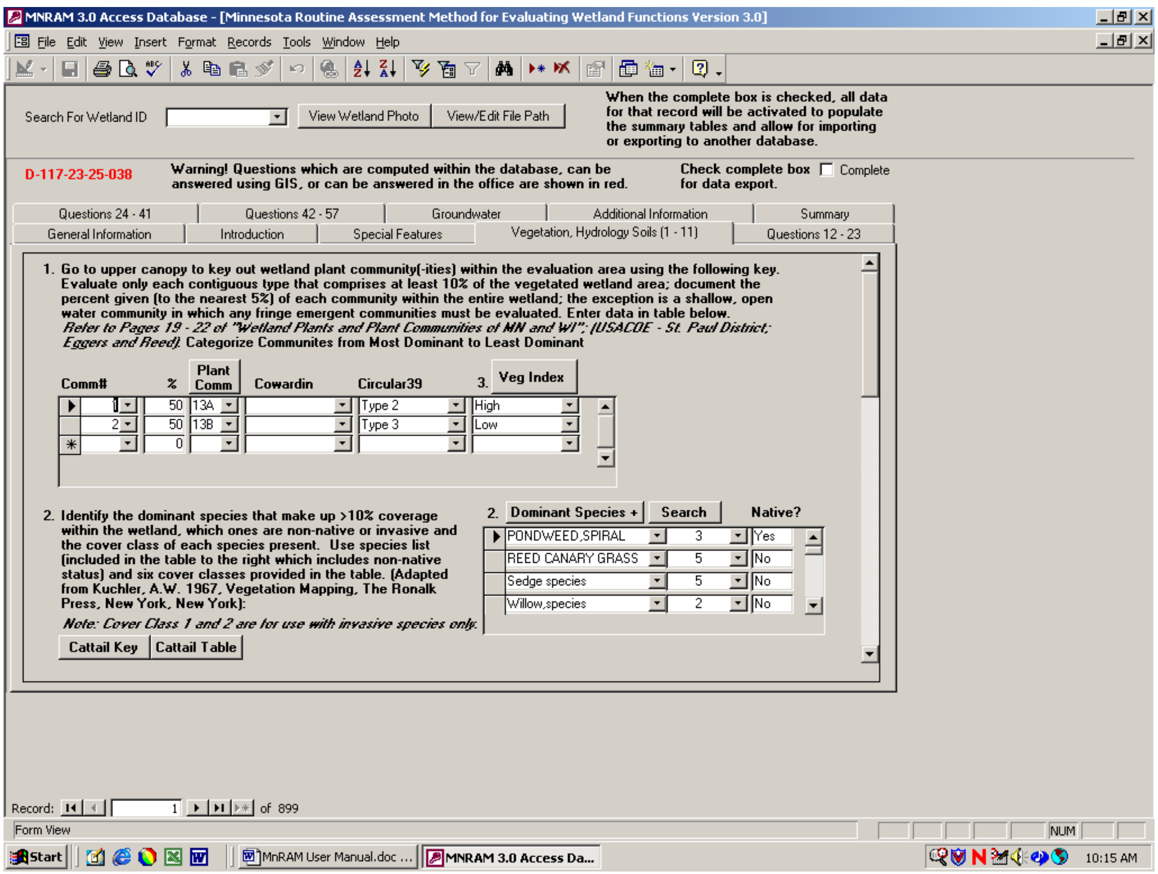


The next tab, "Introduction," includes the history and overall purpose of the wetland assessment method, as well as the ranking structure.

The "Special Features" tab gives a list of checkboxes, "A" through "U", which should only be checked if they apply to the wetland. To check a box, either click on the box with the mouse, or if the box is highlighted (with a dotted line around it by tabbing or entering through) then type "Shift +" to check the box. As on all the screens, use the scroll bar to the right with the mouse to see the lower portion of this page without having to tab all the way through it.

The main questions begin on the next tab, with “Vegetation, Hydrology, Soils (Questions # 1-11).” Up to five communities may be listed under Question #1.

Question #2 refers to vegetation species making up 10 percent or more within the entire wetland and all non-native or invasive species, so there may be many species listed. First set the drop-down list to search by common name or scientific name using the “Search” button. Then, start typing the plant name. If you open the drop-down list (click on the small down-arrow) the list will jump to the entry closest to that you are entering and you can pick the appropriate choice. Common names are listed by **second name, first name** with no spaces. If your species is not on the list, add it by clicking on the box labeled “Dominant Species +.”

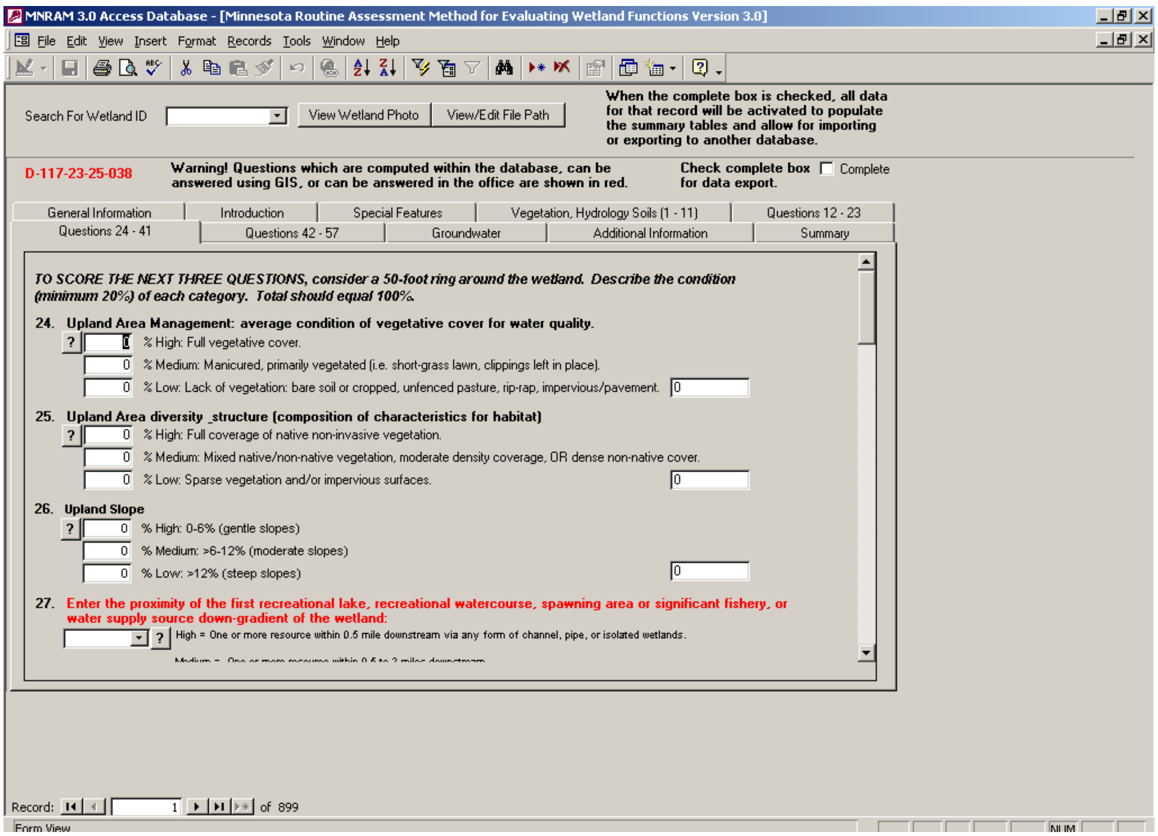


Starting with the next tab, “Questions 12-23”, guidance for each question is available by clicking the question mark next to each field: . Questions shown in red need additional resources to answer and may be answered in the office, or are computed or answered internally by the database within the data reports. All other questions should be answered in the field.

The next set of tabs, Questions #24-41 is “in back” of the first row. When you click on any of these “back” tabs, the entire second row of tabs moves forward and the front row moves back.

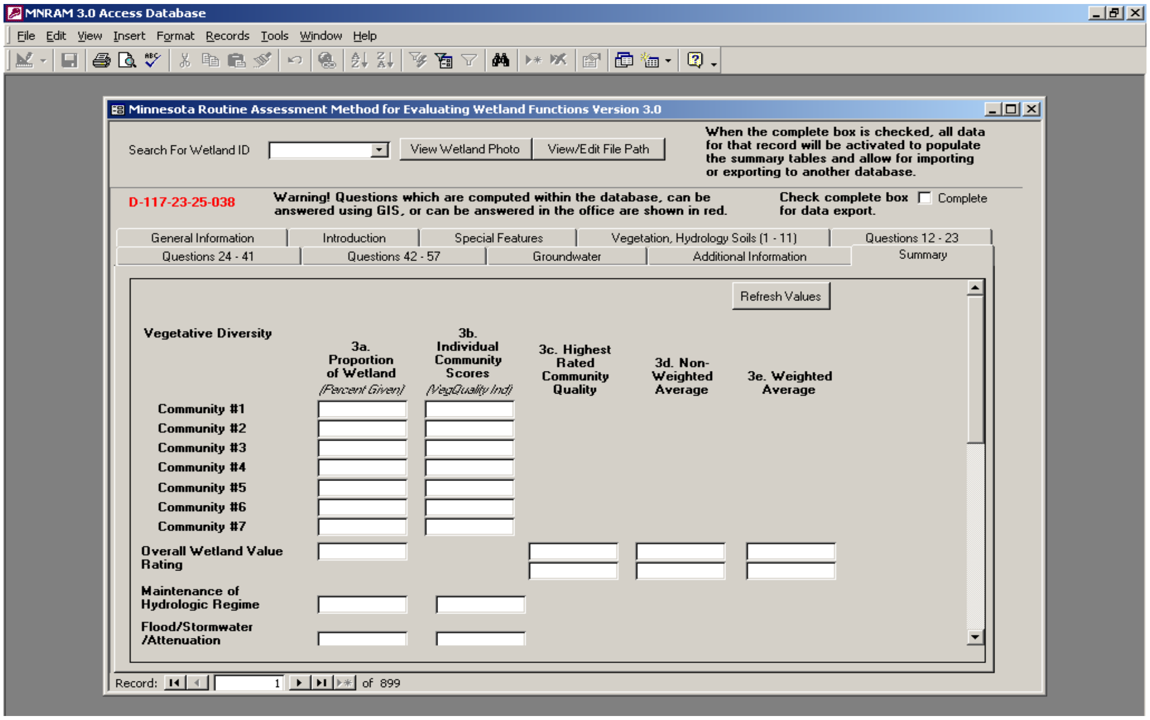
Questions #24-26: remember that these refer to *all* the land surrounding the wetland out to 50 feet, whether or not it would be considered “buffer” by the definition provided in Question 23 guidance. The total of the three boxes for each question must add up to 100 or you will not be able to move off of that tab.

Questions #37 and #38: click on the box labeled “image” to see the choices (these images must be loaded on a self-specified drive for them to be activated, see “Installing the Program.” If an error message results from the first click on the Image button, please try again.



5.4 SUMMARY AND REPORTS

The last tab summarizes the functional ratings using preset formulas to calculate final scores for each function. Because there are four ways to calculate and report vegetative diversity and integrity, these results are all listed separately.



5.5 Extra Features

5.5.1 View Wetland Photo

First, digital wetland photos must be loaded into a specified drive and folder. Place wetland photos on a computer or network drive and specify the file path in "**Photos**" File Type line within File Path Management screen using the "View/Edit File Path" button at the top of the main page as shown below. **The wetland photos must be named using the full Wetland ID without the hyphens:** "County, Township, Range, Section, Wetland Number, Letter" e.g. 271172424001A.jpg. If an alternative naming convention is desired, click on the "Add/Edit Photos" button, enter the Wetland ID and the desired photo name and then close the window. Now click on the "View Wetland Photo" button and the photograph will appear.

5.5.2 Import-export data

The "Import/Export Data" button on the General Information tab is used to export assessment data from one database and import that data into another copy of the database. This feature is useful when it is desirable to compile data from multiple users into a single location. Only records that have had the "Complete" box checked (on the "General Information" tab) will be included in the export. Click on the import data box, type in the specific file path (including a \ at the end of the first line and type in the folder name in the user box) where the data the data is located, select import or export and click "Import Record."

5.5.3 Import GIS data

Three types of data that can be generated using GIS can be imported using this feature. The import data must be set up in a comma-delimited file format and must include the data in the exact order shown below. The dialog box allows one to choose from the three options, which are described below along with the data that is included in each import routine:

1. Update Wetland Areas: "WETLAND_ID","INFOCURRENTSIZE"
   Wetland ID, wetland size (in acres);
2. Update Gen'l Information:
   "Wetland_id","InfoCityName","InfoCityName2","InfoSubwatershed"
   Wetland ID, first city, second city (leave blank if only in one city), subwatershed; and
3. Update GIS Fields:
   "Wetland_ID","Q19_val","Q21_val","Q58_val","Q60_val","Q51_val","Q04_val","Q35_val","6_val"
   Wetland ID, Question 19, Question 21, Question 58, Question 60, Question 51, Question 4, Question 35, Question 36.

For each Wetland ID included in an import file, the data included in each import routine will be overwritten over any existing data in the database. If a blank is provided for any of the data, a null value will be entered for that question within that Wetland ID record.

5.5.4 Copy wetland record

This is a time-saver feature that allows all the ratings of one wetland assessment record to be copied into the record of another. This feature is most useful during inventory situations for wetlands with similar morphological characteristics, location, land uses, and hydrologic features. The receiving record must be reviewed with care to ensure that important, but subtle differences are not overlooked. It is recommended that you use this only with wetlands that are in close proximity to each other on the landscape.

5.5.5 Update functional summary

This feature is used to update added data to the report tables during a working session. Wetland subsets can be chosen here similar to the feature present in the reporting feature and Update Functional Summary **must be run** during a working session **prior to running reports**, otherwise, data entered during the working session will not appear in the reports.

5.5.6 Run summary report

There are three different reports that can be generated: two Functional Assessment Summary reports (shown on two pages), one which reports the numerical functional ratings and the other which reports the text rating (i.e. high, medium, low), and the Wetland Community Summary. Subsets of wetland assessment records can be chosen based on three categories (that are located on the General Information page):

1. Subwatershed
2. City
3. Project

The report will return data for those wetlands within the specified category.

5.6 Using the Data—Management Classification

Once wetlands have been assessed, the data stored in the MnRAM 3.1 database may be used for local planning, regulatory determinations, or other general use. Wetland Management Classification is intended to give local resource managers a framework for using the wetland data to make land use and wetland management decisions. The Wetland Management Classification system provides a scientifically based approach to ranking wetland functions. There are two prepared options for sorting wetlands, Basic and Increased Protection. Sorting must be done manually for each wetland at this time.

6.0 Functional Rating Formulas

GENERAL NOTE: Some questions are not applicable to particular wetlands and will be scored N/A. In these cases, rather than count N/A as zero, an alternate equation is provided that eliminates the question from the formula altogether. Because not every question has N/A as an option, formulas that do not include N/A-option questions have only one configuration.

Formulas with a "reverse rating" (marked as "R") take the actual response and "flip" its value for the calculation, so that a question response of "A" high (value of 1.0) will be calculated as low (value of 0.1). In such a formula, medium ratings stay medium.

6.1 VEGETATIVE DIVERSITY/INTEGRITY

Table 3: Vegetative Diversity/Integrity Summary

The functional rating is based primarily on the diversity of vegetation within the wetland in comparison to an undisturbed condition for that wetland type. An exceptional rating results from one of the following conditions: 1) highly diverse wetlands with virtually no non-native species, 2) rare or critically impaired wetland communities in the watershed, or 3) the presence or previous siting of rare, threatened, or endangered plant species. A high rating indicates the presence of diverse, native wetland species and a lack of non-native or invasive species. Wetlands that rate low are primarily dominated by non-native and/or invasive species.

This table may be used when calculating Vegetative Diversity/Integrity Functional Index manually. It shows four options for calculating and presenting floristic data. If you are entering data directly into the MnRAM 3.1 database, this table does not apply.

	3A Proportion of Wetland	**3B Individual Community Scores**	**3C Highest Quality**	**3D Non-Weighted Average**	**3E Weighted Average**
Community #1	**T**	**A**		**A**	**A**
Community #2	**U**	**B**		**B**	**B**
Community #3	**V**	**C**		**C**	**C**
Community #4	**W**	**D**		**D**	**D**
Community #5	**X**	**E**		**E**	**E**
Community #6	**Y**	**F**		**F**	**F**
Community #7	**Z**	**G**		**G**	**G**
Wetland Rating Value	**1.0**		**Highest Value**	**(A+B+C+D+E +F+G)/7 = Ave.**	**(A*T)+(B*U)+(C*V)+(D *W)+(E*X)+ (F*Y)+(G*Z) = Wt. Ave.**

If any questions #4-6 are answered yes and/or if any of the Special Features b, d, or i have been selected, enter Exceptional for the functional index. If not, compute the contribution to vegetative diversity and integrity by each plant community by doing the following: multiply the ranking for each community (Question #3b) by its total proportion in Question 3a (percent of total). Then, the functional index for the entire wetland can be calculated four ways (as follows) and should be utilized according to the scope of the project:

3b) Individual Community Scores: maintain raw data as recorded.

3c) Highest Quality Community: report the highest-functioning community.

3d) Non-Weighted Average Quality of all Communities: straight average

3e) Weighted Average Quality Based on Percentage of Each Community: multiply each community rating by its percentage, then add all together.

<table>
<tr><th colspan="3">Vegetative Diversity/ Integrity</th><th></th><th></th><th></th></tr>
<tr><th></th><th>3a. Proportion of Wetland</th><th>3b. Individual Community Scores</th><th>3c. Highest Rated Community Quality</th><th>3d. Non-Weighted Average</th><th>3e. Weighted Average</th></tr>
<tr><td>Community #1</td><td>T</td><td>A</td><td colspan="3" rowspan="7">If Spec. Features b, d or i are checked then rate Exceptional (2);
if either question 4, 5, or 6 are Yes, then rate Exceptional (2); else:</td></tr>
<tr><td>Community #2</td><td>U</td><td>B</td></tr>
<tr><td>Community #3</td><td>V</td><td>C</td></tr>
<tr><td>Community #4</td><td>W</td><td>D</td></tr>
<tr><td>Community #5</td><td>X</td><td>E</td></tr>
<tr><td>Community #6</td><td>Y</td><td>F</td></tr>
<tr><td>Community #7</td><td>Z</td><td>G</td></tr>
<tr><td>Overall Wetland Value Rating</td><td>1.0</td><td></td><td>: Highest Value of A-G</td><td>: (A+B+C+ D+E+F+G)/7 = Ave.</td><td>:(A*T)+(B* U)+(C*V)+ (D*W)+(E* X)+(F*Y)+(G*Z) = Wt. Ave.</td></tr>
</table>

6.2 MAINTENANCE OF CHARACTERISTIC HYDROLOGIC REGIME

A wetland's hydrologic regime or hydroperiod is the seasonal pattern of the wetland water level that is like a hydrologic signature of each wetland type. It defines the rise and fall of a wetland's surface and subsurface water. The constancy of the seasonal patterns from year to year ensures a reasonable stability for the wetland[24]. The ability of the wetland to maintain a hydrologic regime characteristic of the wetland type is evaluated based upon wetland soil and vegetation characteristics, land use within the wetland, land use within the upland watershed contributing to the wetland, and wetland outlet configuration. Maintenance of the hydrologic regime is important for maintaining a characteristic vegetative community, and is closely associated with other functions including flood attenuation, water quality and groundwater interaction.

Measures the degree of human alteration of the wetland hydrology, either by outlet control or by altering immediate watershed conditions. Each parameter is weighted equally.

MnRAM #	Excel #	Variable Description	Type of Interaction
13	E17	Outlet—natural hydrologic regime	Controlling
14	E18	Dominant upland land use	Compensatory
15	E19	Soil condition/wetland	Compensatory
20 R	F24	Stormwater runoff/pretreatment-Reversed	Compensatory

Hydrologic Regime Index = $(13+14+15+20_{reverse})/4$

6.3 FLOOD AND STORMWATER STORAGE/ATTENUATION

A wetland's ability to provide flood storage and/or flood wave attenuation is dependent on many characteristics of the wetland and contributing watershed. Characteristics of the subwatershed that affect the wetlands ability to provide flood storage and attenuation include: soil types, land use and resulting stormwater runoff volume, sediment delivery from the subwatershed, and the abundance of wetlands and waterbodies in the subwatershed. Wetland characteristics which affect the wetland's ability to store and or attenuate stormwater include: condition of wetland soils; presence, extent, and type of wetland vegetation; presence and connectivity of channels; and most importantly outlet configuration. Higher rated wetlands will have an unaltered or restricted outlet, undisturbed wetland soils, dense emergent vegetation without channels, a high proportion of impervious surfaces in the subwatershed, large runoff volumes, clayey upland soils, and few wetlands present within the subwatershed.

This formula is based on the Surface Water Storage Functional Capacity Index scoring concept and equation[25]. The formula was altered with the addition of three surface flow characteristics and two stormwater runoff parameters (Stormwater Runoff Quality/Quantity and Subwatershed Wetland Density) along with the removal of two parameters (Soil Porosity and Subsurface Outlet,

[24] Mitsch and Gosselink, 2000
[25] Lee et al., 1997

which is already characterized in another parameter). This index is comprised of 5 primary processes, which are weighted equally; included in each major process are one to three characteristics that equally contribute to that process.

1. **Outlet Characteristics**: Outlet characteristics
2. **Upland Watershed**: Upland land use, Upland soils,
3. **Wetland Condition/Land Use**: Wetland land use, sediment delivery
4. **Runoff Characteristics:** Stormwater runoff quality/quantity, subwatershed wetland density
5. **Surface Flow Characteristics**: Flow-through emergent vegetation density, surface flow characteristics

Flood and Stormwater Storage Index Computation:

Entire Formula: Outlet for flood retention{12} + (Dominant upland use{$14_{reversed}$}+ Upland soils{19})/2 + (Soil condition{15} + Sediment delivery{18})/2 + Stormwater runoff pretreat&det{20} + Subwatershed wetland density{21})/2 + (Percent emergent vegetative cover{16} + Flow-through emergent vegetative roughness{17} + Channels/sheet flow{22})/3)/5.

1. If 12=0, then: (($14_{reversed}$ +19)/2+(15+18)/2+(20+21)/2+(16+17+22)/3)/4

2. If 12>0, then: (12+($14_{reversed}$ +19)/2+(15+18)/2+(20+21)/2+(16+17+22)/3)/5

No changes to the formula are necessary if 16=0.

Flood and Stormwater Storage/Attenuation Variables

MnRAM #	Excel #	Variable Description	Type of Interaction
12	E16	Outlet—flood attenuation	Controlling—optional
14-R	F18	Dominant upland land use—reversed	Compensatory
19	E23	Upland soils	Compensatory
15	E19	Soil condition	Compensatory
18	E22	Sediment delivery	Compensatory
20	E24	Stormwater pretreatment &detention	Compensatory
21	E25	Subwatershed wetland density	Compensatory
16	F20	Emergent vegetation % cover	Comp.—optional
17	E21	Emergent vegetation flood resistance	Comp.—optional
22	E26	Channels/sheet flow	Compensatory

6.4 DOWNSTREAM WATER QUALITY PROTECTION

This rates the wetland's ability and opportunity to protect valuable downstream resources. Valuable downstream resources include recreational waters (i.e. lakes, streams, rivers, creeks, etc) and potable water supplies. The level of functioning is determined based on runoff characteristics, sedimentation processes, nutrient cycling, and the presence and location of significant downstream water resources. Runoff characteristics that are evaluated include: land use and soils in the upstream watershed, the stormwater delivery system to the wetland, and sediment delivery characteristics. The ability of the wetland to remove sediment from stormwater is determined by emergent vegetation and overland flow characteristics. A high nutrient removal rating indicates dense vegetation and sheet flow to maximize nutrient uptake and residence time within the wetland. The opportunity for a wetland to protect a valuable water resource diminishes with distance from the wetland so wetlands with valuable waters within 0.5 miles downstream have the greatest opportunity to provide protection, as do those that receive more (and less-treated) runoff.

Compute Functional Index for Downstream Water Quality Protection

This functional index computation was derived from a combination of Nutrient Cycling and Retention of Particulates functions in the HGM Prairie Pothole draft guidebook[54] with the downstream sensitivity concept from *The Minnesota Wetland Evaluation Methodology.* Three major processes make up equal portions of the Downstream Water Quality Protection function[26] with a measure of opportunity to protect downstream resources; each process is comprised of two to four observable parameters.

1. **Rate, Quantity, and Quality of Runoff to the Wetland**: this is characterized by the conditions in the upstream watershed; both land use and soils, that affect the sediment and nutrient loads to the wetland, and by the existing storm water delivery system to the wetland (Upland watershed conditions, storm water runoff, evidence of sediment delivery, and upland buffer each comprise 1/16 of the entire downstream water quality functional index based on their contribution to sediment removal).
2. **Sedimentation**: this is characterized by the presence of flow-through emergent vegetation density and by the overland flow characteristics within the wetland. A wetland with primarily sheet flow through the wetland and dense emergent vegetation density will allow sediment to drop out more effectively than a wetland with channel flow and no vegetation (When all parameters are applicable; emergent vegetative density and overland flow characteristics each make up 1/8 of the total downstream water quality functional index based on their contribution to sediment removal).
3. **Nutrient Uptake**: this is characterized by the outlet configuration and vegetative characteristics. A wetland with long water retention times has more capacity to remove nutrients from the water column via physical and biological processes. Vegetation slows floodwaters by creating frictional drag in proportion to stem density which allows sediment particles to settle out, thereby improving the water quality for downstream uses (Outlet characteristics and vegetative density each make up 1/8 of the total downstream water quality functional index based on their contribution to nutrient uptake).

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[26] Derived from a combination of Nutrient Cycling and Retention of Particulates functions in the HGM Prairie Pothole draft guidebook (Lee et al., 1997) with the downstream sensitivity concept from *The Minnesota Wetland Evaluation Methodology.*

4. **Downstream Sensitivity**: if the wetland contributes to the maintenance of water quality within one-half mile of a recreational water body or potable water supply source downstream, it operates at a higher functioning level than a similar wetland farther from or without significant downstream water resources (This factor accounts for ¼ of the total downstream water quality functional index).

Downstream Water Quality Functional Index Computations:

1. If 12=0, then: (14+20+18+(**23+24+26**)/3+(**16**+17)/2+27)/6

2. If 12>0, then: (14+20+18+(**23+24+26**)/3+(**16**+17)/2+27+12)/7

No changes to the formula are necessary if 16=0.

Entire Formula:
(Dominant upland land use{14} + Stormwater runoff pretreatment & detention{20} + Sediment delivery {18} + (Upland buffer width{23_{WQ}} + Upland buffer vegetative cover{24} + Upland buffer slope {26})/3 + (Flow-through %emergent vegetative cover{16} + Flow-through emergent vegetative roughness{17})/2 + Downstream sensitivity{27}+ Outlet for flood{12})/7

Downstream Water Quality Variables

MnRAM #	Excel #	Variable Description	Type of Interaction
14	E18	Dominant upland land use	Controlling
20	E24	Stormwater runoff pretreatment & detention	Controlling
18	E22	Sediment delivery	Controlling
23	G27	Upland buffer width—water quality valuation	Comp.
24	G28	Upland area management	Comp.
26	G34	Upland area slope	Comp.
16	F20	Emergent vegetation (% cover)	Comp.—optional
17	E21	Emergent vegetation (roughness coefficient)	Comp.—optional
27	E39	Downstream sensitivity	Comp.
12	E16	Outlet for flood	Controlling--optional

6.5 MAINTENANCE OF WETLAND WATER QUALITY

The sustainability of a wetland is partially driven by the quality and quantity of stormwater runoff entering the wetland. The ability of the wetland to sustain its characteristics is evaluated based on characteristics of the contributing subwatershed and indicators within the wetland. Subwatershed conditions which affect the wetland's sustainability in relation to water quality impacts include: upland land use; sediment delivery characteristics to the wetland; stormwater runoff volumes and rates; and the extent, condition, and width of upland buffer. Indicators of nutrient loading to the wetland indicate that a diverse wetland may not be sustainable. Indicators that a wetland has been affected by nutrient loading include the presence of monotypic vegetation and/or algal blooms.

This functional index was derived from a combination of sources including MNRAM, HGM, WEM, WET, and experiences of the project team. The sustainability of a wetland is partially driven by the quality and quantity of stormwater runoff entering the wetland. The ability of the wetland to sustain its characteristics is evaluated based on characteristics of the contributing subwatershed and indicators within the wetland. Subwatershed conditions which affect the wetland's sustainability in relation to water quality impacts include: upland land use; sediment delivery characteristics to the wetland; stormwater runoff volumes and rates; and the extent, condition, and width of upland buffer. Indicators of nutrient loading to the wetland indicate that a diverse wetland may not be sustainable. Indicators that a wetland has been affected by nutrient loading include the presence of monotypic vegetation and/or algal blooms.

Wetland Water Quality Functional Index Computation:

(3e*2+14+$20_{reversed}$ +(**23**+**24**+**26)**/3+18+28)/7

Entire Formula:
(Vegetative Diversity/Integrity{3e*2} + Dominant upland land use{14} + Stormwater runoff pretreatment & detention{$20_{reversed}$} + (Upland buffer width{23_{WQ}} + Upland buffer vegetative cover {24} + Upland buffer slope {26})/3 + Sediment delivery {18})/2 + Nutrient loading {28})/7

Wetland Water Quality Variables

MnRAM #	Excel #	Variable Description	Type of Interaction
3e	D6*2	Vegetative Diversity/Integrity	Contributing
14	E18	Dominant upland land use	Contributing
20 R	F24	Stormwater runoff pretreatment and detention—RR	Contributing
23	G27	Upland buffer width—water quality valuation	Contributing
24	G28	Upland area management	Contributing
26	G34	Upland area slope	Contributing
18	E22	Sediment delivery	Contributing
28	E40	Nutrient loading	Contributing

This functional index was derived from a combination of sources including MNRAM, HGM, WEM, WET, and experiences of the project team. The sustainability of a wetland is partially driven by the quality and quantity of stormwater runoff entering the wetland. The ability of the wetland to sustain its characteristics is evaluated based on characteristics of the contributing subwatershed and indicators within the wetland. Subwatershed conditions which affect the wetland's sustainability in relation to water quality impacts include: upland land use; sediment delivery characteristics to the wetland; stormwater runoff volumes and rates; and the extent, condition, and width of upland buffer. Indicators of nutrient loading to the wetland indicate that a diverse wetland may not be sustainable. Indicators that a wetland has been affected by nutrient loading include the presence of monotypic vegetation and/or algal blooms.

6.6 SHORELINE PROTECTION

Shoreline protection is evaluated only for those wetlands adjacent to lakes, streams, or deepwater habitats. The function is rated based on the wetlands opportunity to protect the shoreline; i.e. wetlands located in areas frequently experiencing large waves and high currents have the best opportunity to protect the shore. In addition, shore areas composed of sands and loams with little vegetation or shallow-rooted vegetation will benefit the most from shoreline wetlands. The wetland width, vegetative cover, and resistance of the vegetation to erosive forces determine the wetland's ability to protect the shoreline.

Each of the five parameters contributes equally[27]: based primarily on the characteristics presented in WEM with a simple, straightforward computation of the index assuming all characteristics contribute equally.

MnRAM #	Excel #	Variable Description	Type of Interaction
29	E41	Shoreline?	Controlling
30	E42	Rooted shoreline vegetation (% cover)	Contributing
31	E43	Wetland width (average)	Contributing
32	E44	Emergent vegetation erosion resistance	Contributing
33	E45	Shoreline erosion potential	Contributing
34	E46	Bank protection ability	Contributing

Shoreline Protection Functional Index Computation:

If 29=1, then:
Shoreline Protection Index = (30+31+32+33+34)/5

Entire Formula:
(Rooted shoreline vegetation {30} + Average shoreline wetland width {31} + Emergent vegetation erosion resistance {32} + (Shoreline erosion potential {33} + Bank protection ability {34})/5

6.7 MAINTENANCE OF CHARACTERISTIC WILDLIFE HABITAT STRUCTURE

The ability of a wetland to support various wildlife species is difficult to determine due to the specific requirements of the many wildlife species that utilize wetlands. This function determines the value of a wetland for wildlife in a more general sense, and not based on any specific species. The characteristics evaluated to determine the wildlife habitat function include: vegetative quality, outlet characteristics (which control hydrologic regime), upland land use, wetland soil type and conditions, water quality of storm water runoff entering the wetland, upland buffer extent, condition, and diversity; the interspersion of wetlands in the area; barriers to wildlife movement; wetland size; vegetative and community interspersion within the wetland; and amphibian breeding potential and overwintering habitat.

Thirteen parameters are weighed equally as described below; vegetative quality is weighted double the other factors. The questions are borrowed or modified from MNRAM, WET, WEM, and HGM methodologies, combined to provide a measure of wildlife habitat in general, not focusing on any particular species.

If Rare Wildlife (35) or Rare Natural Community (36) are true, then this Index is Exceptional.

[27] Based primarily on the characteristics presented in WEM.

If Special Features d, g, or j are checked, then this Index is Exceptional, otherwise, follow conditions below:

If 37=0 and 38=0 and 39=0 [Vegetation (37) and Community interpersion (38) and Wetland Detritus (39) are all n/a], then:
(3e*2+40+41+(**23**+**24**+**25)**/3+13+ 20)/7

If 38=0 and 39=0 [Community interpersion (38) and Wetland Detritus (39) are n/a], then:
(3e*2+37+40+41+(**23**+**24**+**25)**/3+ 13+20)/8

If 37=0 and 39=0 [Vegetation (37) and Wetland Detritus (39) are n/a], then:
(3e*2+38+40+41+(**23**+**24**+**25)**/3+ 13+20)/8

If 37=0 and 38=0 [Vegetation (37) and Community interpersion (38) are n/a], then:
(3e*2+39+40+41+(**23**+**24**+**25)**/3+ 13+20)/8

If 39=0 [Wetland Detritus (39) is n/a], then:
(3e*2+37+38+40+41+(**23**+**24**+**25)**/3+13+20)/9

If 38=0 [Community interpersion (38) is n/a], then:
(3e*2+39+37+40+41+(**23**+**24**+**25)**/3+13+20)/9

If 37=0 [Vegetation interspersion (37) is n/a], then:
(3e*2+39+38+40+41+(**23**+**24**+**25)**/3+13+20)/9

If 37>0 and 38>0 and 39>0, then:
(3e*2+39+37+38+40+41+(**23+24+25**)/3+13+20)/10

Entire Equation:
(Vegetative Diversity/Integrity{3e*2} + Wetland Detritus {39} + Vegetation Interspersion {37} + Community Interspersion {38} + Wetland Interspersion {40} + Wildlife Barriers {41} + (Upland buffer width $\{23_{\text{wildlife value}}\}$ + Upland Area Management{24} + Upland area diversity {25})/3 + Outlet natural hydrologic regime {13}+ Stormwater runoff pretreatment and detention 20_{reversed})/10

MnRAM #	Excel #	Variable Description	Type of Interaction
41	E53	Wildlife barriers	Controlling
3e	D6	Vegetative Ranking (communities' weighted average)	Compensatory
39	E51	Wetland detritus (n/a)	Contributing
23	I27	Upland buffer average width—wildlife valuation	Contributing
24	G28	Upland area management	Contributing
25	G31	Upland area diversity	Contributing
13	E17	Outlet natural hydrologic regime	Contributing
20 R	F24	Stormwater runoff pretreatment & detention—reversed	Contributing
37	F49	Vegetation interspersion (n/a)	Contributing
38	F50	Community interspersion (n/a)	Contributing
40	E52	Wetland interspersion	Contributing

6.8 *MAINTENANCE OF CHARACTERISTIC FISH HABITAT*

The ability of the wetland to support native fish populations is determined by structural factors within the wetland as well as water quality contributions from upland factors. Wetlands rated High are lacustrine or riverine and provide spawning/nursery habitat, or refuge for native species (included but not limited to game fish). Wetlands rated Low for fish habitat do not have a direct hydrologic connection to a waterbody with a native fishery or have poor water quality.

MnRAM #	Excel #	Variable Description	Type of Interaction
46	E58*2	Fish habitat quality	Controlling
29	D41	Fringe wetland?	Contributing
24	G28	Adjacent area management	Compensatory
18	E22	Sediment delivery	Compensatory
20 R	F24	Storm water runoff—reversed	Compensatory
28	E40	Nutrient load	Compensatory
30	E42	Percent cover	Compensatory
31	E43	Wetland shoreline width	Compensatory
33 (R)	F45	Shoreline erosion potential	Compensatory

Fish Habitat Functional Index Computation:

If Special Features a or g are checked, then Fishery Habitat Index = Exceptional.

If 46=0, then Fishery Habitat = N/A

If 29=0, Fishery Habitat Index = $[(46*2)+24+18+20_{\text{reversed}}+28]/6$

If 29>0, Fishery Habitat Index = $[(46*2)+24+18+20_{\text{reversed}}+28+\mathbf{30}+\mathbf{31}+\mathbf{33(R)}]/9$

6.9 *MAINTENANCE OF CHARACT. AMPHIBIAN HABITAT FOR BREEDING/OVERWINTERING*

The characteristic ability of a wetland to support various amphibian species is difficult to determine due to the specific requirements of the many amphibian species that depend on wetlands. This function determines the value of a wetland for amphibians in general, not based on specific species. An adequate wetland hydroperiod and the presence or absence of predatory fish are considered to be limiting variables for this function. In general, wetlands must remain inundated until early to mid-June to allow the larval stages to metamorphose into adults. Because many amphibians are partly terrestrial, the characteristics evaluated to determine the amphibian habitat function include numerous hydrology and terrestrial measures. The characteristics evaluated include: upland land use, upland buffer width, water quality of storm water runoff entering the wetland, barriers to wildlife movement, and amphibian breeding potential and overwintering habitat.

An adequate wetland hydroperiod (Question 42) is considered to be the primary limiting variable for this functional index. If the hydroperiod is insufficient for breeding, the wetland rating for amphibian use will be Not Sufficient. The status of predatory fish in the wetland (Q.43) is a secondary limiting factor to the final rating; the lowest rating for this variable, however, is 0.1 (Low), rather than zero (Not Sufficient).

Amphibians' ability to use a particular wetland for over wintering is a contributing factor in rating the wetland's functional index (Q.44). Because most amphibians are partly terrestrial, the extent of upland buffer habitat surrounding the wetland (Q.23) is an important habitat component[28] and is weighted by a factor of two. Question 14 (Upland Land Use) is also included as an indicator of the quality of the surrounding upland habitat[56]. Unnatural fluctuations in water depth in wetlands from conducted storm water runoff can impair reproductive success in amphibians, which often attach their eggs to stems of wetland vegetation, e.g., salamanders, tree frogs, green frogs, and wood frogs[29]. Extreme water level fluctuations during winter may also cause mortality in overwintering reptiles and amphibians[30]. Thus, Question 20 is included in the formula, with a reverse rating. Question 41 (Barriers) is included because access to and from the wetland by amphibians is an important factor in habitat quality[31].

Amphibian Habitat Functional Index Computation:

If 42=0, then N/A

Otherwise: Amphibian Habitat Index = (43) * [(44 + 2*23_{wildlife} + 14 + 41 + 20_{reversed})/6]

Entire Formula:

If Amphibian Breeding Potential-Hydroperiod {42} is applicable, then: (Amphibian Breeding Potential-Predator Fish {43}) * {[(Amphibian Overwintering Habitat {44}+ 2*Upland Buffer Width $(23)_{\text{Wildlife}}$ + Dominant Upland Land Use {14} + Barriers {41} + Stormwater Input {20_{reverse}}]/6}

Amphibian Habitat Variables

MnRAM #	**Excel #**	Variable Description	Type of Interaction
42	D54	Amphibian breeding potential—hydroperiod	Controlling
43	D55	Amphibian breeding potential—fish presence	Controlling
44	E56	Amphibian overwintering habitat	Compensatory
23	I27	Upland buffer width	Compensatory
41	E53	Wildlife barriers	Compensatory
14	E18	Dominant upland land use	Compensatory
20	F24	Stormwater runoff pretreatment & detention—RR	Compensatory

28 Knutson et al., 2000
29 Richter and Azous, 1995
30 Hall and Cuthbert, 2000
31 Knutson, et al., 1999; Findlay and Bourdages, 2000; Semlitsch, 2000.

6.10 *AESTHETICS/RECREATION/EDUCATION/CULTURAL/SCIENCE*

The aesthetics/recreation/education/cultural and science function and value of each wetland is evaluated based on the wetland's visibility, accessibility, evidence of recreational uses, evidence of human influences (e.g. noise and air pollution) and any known educational or cultural purposes. Accessibility of the wetland is key to its aesthetic or educational appreciation. While dependent on accessibility, a wetland's functional level could be evaluated by the view it provides observers. Distinct contrast between the wetland and surrounding upland may increase its perceived importance. Also, diversity of wetland types or vegetation communities may increase its functional level as compared to monotypic open water or vegetation. Excess negative human influence on the wetland is counted double in the formula.

All questions contribute equally to the overall index.

MnRAM #	Excel #	Variable Description	Type of Interaction
48	E60	Rare educational opportunity	Controlling
49	E61	Wetland visibility	Compensatory
50	E62	Proximity to population	Compensatory
51	E63	Public ownership	Compensatory
52	E64	Public access	Compensatory
53	E65	Human influence—wetland	Compensatory
54	E66	Human influence—viewshed	Compensatory
55	E67	Spatial buffer	Compensatory
56	E68	Recreational activities in wetland	Compensatory

Aesthetics/Recreation/Education/Cultural/Science Functional Index Computations:

If Special Features c, h, or u is checked[32], or

If 48=1, then Index = Exceptional;

If 53=0.1 (Low), then = (50+51+52+2*53+54+55+56)/8

If 53>0.1, then = (49+50+51+52+53+54+55+56)/8

Entire Formula

(Wetland Visibility {49} + Proximity to Population {50} + Public Ownership {51} + Public Access {52} + Human Influence - Wetland {53} + Human Influence - Viewshed {54} + Spatial Buffer {55} + Recreational Activities in Wetland {56})/8

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[32] c = Designated scientific and natural area; h = Archeologic or historic site designated by the State Historic Preservation Office; u = State or Federal designated wilderness area.

6.11 COMMERCIAL USES

This question considers the nature of any commercially-valuable use of the wetland and requires the assessor to consider how such use may be a detriment to the sustainability of the wetland. Some row crops can be planted in Type 1 wetlands after spring flooding has ceased and still have adequate time to grow to maturity. This non-wetland-dependent agricultural use of wetlands may include hay, pasture/grazing, or row crops such as soybeans or corn. Wetland-dependent crops include wild rice and cranberries, which rely on the wetland hydrology for part of their life cycle.

Sustainable uses of the wetland would not require modifying a natural wetland. Products in this category would include collection of botanical products, wet native grass seed, floral decorations, wild rice, black spruce, white cedar, and tamarack. Sustainable uses may require modification of the natural hydrology, such as for wetland-dependent crops (rice, cranberries). Haying and grazing can be less intrusive agricultural activities utilized more or less casually when hydrologic conditions permit; light pasture and occasional haying would be considered more or less sustainable. Like peat-mining, cropping is an unsustainable use of the wetland as it is results in severe alterations of wetland characteristics (soil, vegetation, hydrology).

MnRAM #	**Excel #**	Variable Description	Type of Interaction
57	**E69**	Commercial crop—hydrologic impact	Controlling

Commercial Uses Functional Index = 57

6.12 GROUND-WATER INTERACTION

The ground water interaction function is the most difficult to assess. Here the most likely type of ground water interaction is determined, i.e. recharge or discharge, or a combination. In many cases, a wetland will exhibit both recharge and discharge characteristics, however one is usually more dominant. Several wetland and watershed characteristics are evaluated to determine the likely interaction including: wetland soil type, upland land use, upland soil types and wetland size, wetland hydroperiod, wetland outlet characteristics, and topographic relief.

The purpose of this function is strictly to determine the likelihood of the appropriate ground-water interaction based on observable characteristics of the wetland and watershed. The significance of ground water as a component of the wetland water budget is the most difficult functional characteristic to determine without large quantities of detailed hydrologic and geologic information. The following methodology takes the most easily observable and distinct measures of recharge/discharge relationships from the *Wetland Evaluation Technique*[33] and the *Hydrogeomorphic Assessment Methodology*[34]. In

[33] Adamus, et al., 1987

many wetlands, surface water and ground water both make significant contributions to the water budget, but occasionally recharge or discharge is dominant. The goal here is to identify the dominant ground-water interaction (if there is one) to help guide future management and provide an indication when additional information may be warranted.

- If 5 or 6 of questions 58-63 are answered the same, this indicates a strong likelihood that the most frequently stated interaction exerts the primary influence on the wetland.
- If 3-4 questions are answered the same, then the wetland is likely influenced by a combination of both recharge and discharge interactions (i.e. both types of ground water interaction are likely to be present at some point during most years).

58. Wetland Soils – from HGM system functional assessments and Novitzki
59. Subwatershed Land Use/Imperviousness – taken from WET Volume I
60. Wetland Size and Upland Soils – taken from WET Volume I and HGM
61. Wetland Hydrologic Regime– taken from WET Volume I and HGM
62. Inlet/Outlet Configuration – taken from WET Volume I and HGM
63. Upland Topographic Relief – taken from WET Volume I

Special Concerns for Recharge Wetlands

Wherever ground water recharge is indicated as the **primary** interaction and the wetland lies within a sensitive ground water area (**Special Feature Question q**), a contribution area to a public water supply, or a wellhead protection area (**Special Feature Question r**), it should be recorded as Exceptional for the ground water/wetland function.

6.13 WETLAND RESTORATION POTENTIAL

The potential for wetland restoration is determined based on the ease with which the wetland could be restored, the number of landowners within the historic wetland basin, the size of the potential restoration area, the potential for establishing buffer areas or water quality ponding, and the extent and type of hydrologic alteration. Each variable uses the High, Medium, Low rating rather than raw numbers—see MnRAM for individual ranges.

MnRAM #	Excel #	Variable Description	Type of Interaction
64	**D79**	Wetland Restoration Potential	Controlling
65	F80	Number of Landowners Affected	Contributing
21	E25	Subwatershed Wetland Density	Contributing
66b	F82	Total Wetland Restored Size (Potential)	Contributing
66c	F83	Calculated potential new wetland area	Contributing
67	F84	Potential Buffer Width	Contributing
68	F85	Likelihood of Restoration Success	Contributing

[34] Magee and Hollands, 1998

If 64="Yes", then Wetland Restoration Potential = (65+21+66b+66c+67+68)/6,

Otherwise, if 64="No" then "N/A"

Entire Formula
(Landowners Affected by Restoration (65)+Subwatershed Wetland Density (21)+ Wetland Restoration Size (66b)+Proportion of Wetland Drained (66c)+Potential Buffer Width (67)+Likelihood of Restoration Success (68))/6

6.14 WETLAND SENSITIVITY TO STORMWATER INPUT AND URBAN DEVELOPMENT

The sensitivity of the wetland to stormwater and urban development is determined based on guidance within the *Storm-Water and Wetlands: Planning and Evaluation Guidelines for Addressing Potential Impacts of Urban Storm-Water and Snow-Melt Runoff on Wetlands*, State of Minnesota Storm-Water Advisory Group, June, 1997.

Use habitat proportions from Vegetative Integrity section and enter into a formula to compute answer according to the following criteria[35].

Exceptional = Sedge meadows, open and coniferous bogs, calcareous fens, low prairies, wet to wet-mesic prairies, coniferous swamps, lowland hardwood swamps, or seasonally flooded basins.

A = Shrub-carrs, alder thickets, diverse fresh wet meadows dominated by native species, diverse shallow and deep marshes, and diverse shallow, open water communities.

B = Floodplain forests, fresh wet meadows dominated by reed canary grass, shallow and deep marshes dominated by cattail, reed canary grass, giant reed or purple loosestrife, and shallow, open water communities with low to moderate vegetative diversity.

C = Gravel pits, cultivated hydric soils, or dredge/fill disposal sites.

6.15 ADDITIONAL STORMWATER TREATMENT NEEDS

This rates the sustainability of the wetland with regard to stormwater discharges to the wetland. The need for additional stormwater treatment prior to discharge to the wetland is rated based on the overall rating for Maintenance of Wetland Water Quality. If a wetland is severely degraded by stormwater inputs, the rating will be low, since a diverse, high quality wetland will not be sustainable.

Use functional rating for Maintenance of Wetland Water Quality (MWWQ) as follows (this index is rated strictly from the measure of the water quality in the wetland and the sustainability, i.e. if the water quality in the wetland is low, additional stormwater treatment is needed to protect the wetland and the rating is low):

Use Value for Maintenance of Wetland Water Quality Index (D76, Excel spreadsheet) and apply to criteria below.

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[35] Taken directly from State of Minnesota Storm-Water Advisory Group, 1997.

A = Maintenance of Wetland Water Quality Index >0.66 (no additional treatment needed)

B = 0.33 < Maintenance of Wetland Water Quality Index # < 0.66 (sediment removal needed)

C = Maintenance of Wetland Water Quality Index < 0.33 (sediment and nutrient removal needed)

7.0 References

Most reference material will be available at the Board of Water & Soil Resources library. Please report errors or omissions to natasha.devoe@bwsr.state.mn.us.

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8.0 Appendices

Appendix 1. County Code List

Two-digit	FIPS	COUNTY NAME	Two-digit	FIPS	COUNTY NAME
Two-digit/FIPS CROSS REFERENCE COUNTY CODE LIST					
01	001	AITKIN	**45**	089	MARSHALL
02	003	ANOKA	**46**	091	MARTIN
03	005	BECKER	**47**	093	MEEKER
04	007	BELTRAMI	**48**	095	MILLE LACS
05	009	BENTON	**49**	097	MORRISON
06	011	BIG STONE	**50**	099	MOWER
07	013	BLUE EARTH	**51**	101	MURRAY
08	015	BROWN	**52**	103	NICOLLET
09	017	CARLTON	**53**	105	NOBLES
10	019	CARVER	**54**	107	NORMAN
11	021	CASS	**55**	109	OLMSTED
12	023	CHIPPEWA	**56**	111	OTTER TAIL
13	025	CHISAGO	**57**	113	PENNINGTON
14	027	CLAY	**58**	115	PINE
15	029	CLEARWATER	**59**	117	PIPESTONE
16	031	COOK	**60**	119	POLK
17	033	COTTONWOOD	**61**	121	POPE
18	035	CROW WING	**62**	123	RAMSEY
19	037	DAKOTA	**63**	125	RED LAKE
20	039	DODGE	**64**	127	REDWOOD
21	041	DOUGLAS	**65**	129	RENVILLE
22	043	FARIBAULT	**66**	131	RICE
23	045	FILLMORE	**67**	133	ROCK
24	047	FREEBORN	**68**	135	ROSEAU
25	049	GOODHUE	**69**	137	ST LOUIS
26	051	GRANT	**70**	139	SCOTT
27	053	HENNEPIN	**71**	141	SHERBURNE
28	055	HOUSTON	**72**	143	SIBLEY
29	057	HUBBARD	**73**	145	STEARNS
30	059	ISANTI	**74**	147	STEELE
31	061	ITASCA	**75**	149	STEVENS
32	063	JACKSON	**76**	151	SWIFT
33	065	KANABEC	**77**	153	TODD
34	067	KANDIYOHI	**78**	155	TRAVERSE
35	069	KITTSON	**79**	157	WABASHA
36	071	KOOCHICHING	**80**	159	WADENA
37	073	LAC QUI PARLE	**81**	161	WASECA
38	075	LAKE	**82**	163	WASHINGTON
39	077	LAKE OF THE WOODS	**83**	165	WATONWAN
40	079	LE SUEUR	**84**	167	WILKIN
41	081	LINCOLN	**85**	169	WINONA
42	083	LYON	**86**	171	WRIGHT
43	085	MCLEOD	**87**	173	YELLOW MEDICINE
44	087	MAHNOMEN			

NOTE: MnRAM currently accepts the two-digit county code.

The three-digit FIPS – Federal Information Processing Standard – number often is used for other county reporting.

To be sure that data reporting is consistent within the state, please use the two-digit code for MnRAM.

Appendix 2: Possible Best Management Practices, Detailed Listing

Type of Practice	Area of Benefit	Storm Protection Benefit	Pollutants Controlled	Construction Requirements
Institutional Source Controls				
Public Education (Billing inserts, news releases, radio public service announcements, school programs, and pamphlets)	Not applicable.	Reduced pollutant load to storm drain system.	Can reduce improper disposal of paints, varnishes, thinners, pesticides, fertilizers, and household cleansers, and chemicals, etc.	None.
Litter Control	Site dependent.	Reduced potential for clogging and discharge.	Household and restaurant paper, plastics, and glass.	Increase number of trash receptacles and regulary service.
Recycling Programs	Site dependent.	Reduction in potential for clogging and harmful discharge.	Household paper, glass, aluminum, and plastics. Oil and grease from auto maintenance.	Collection and sorting stations.
"No Littering" Ordinance	Storm drain system and receiving water.	Prohibits littering and prevents litter from entering storm drains.	Paper, plastics, glass, food wrappers, and containers.	None.
"Pooper Scooper" Ordinance	Storm drain system and receiving water.	Requires animal owners to clean up and properly dispose of animal wastes.	Coliform bacteria and nitrogen/urea.	None.
Develop and Enact Spill Response Plan	Site dependent.	Prevent pollutants from entering storm drain.	Hazardous chemical, harmful chemicals, oil, and grease.	None.
Clean Up Vacant Lots	Site dependent.	Prevent debris from accumulating on lot. Prevent site from appearing as a "dump" for others to use for disposal. Eliminate sources of hazardous waste.	Hazardous and/or harmful chemicals, wind blown for water borne debris.	None.
Prohibit Illegal and Illicit Connections and Dumping into Storm Drain System	Storm drain system and receiving water.	Reduces pollutant load entering storm drains.	Coliform bacteria, nitrogen, contaminants, and toxic or harmful chemicals.	None.

Type of Practice	Area of Benefit	Storm Protection Benefit	Pollutants Controlled	Construction Requirements
Identify, Locate, and Prohibit Illegal or Illicit Discharge to Storm Drain System	Area-wide.	Halt hazardous and harmful discharges, whether intentional or negligent.	Sewage from cross connections, oil, grease, direct disposal of pesticides and fertilizers, contaminated water, paint, varnish, solvents, water from site dewatering, swimming pool and spa water, flushing water from radiators and cooling systems, and hazardous or harmful chemicals.	Monitor storm drain system for flows and water quality.
Require Proper Storage, use, and Disposal of Fertilizers, Pesticides, Solvents, Paints and Varnishes, and Other Household Chemicals (oil, grease, and antifreeze, etc.)	Site dependent (City, State, or County-wide).	Reduce pollutant load to storm system.	Household hazardous materials.	None.
Restrict Paving and Use of Nonporous Cover Materials in Recharge Areas	Recharge area site.	Promotes infiltration to groundwater and reduces runoff volume and velocity. Filters pollutants.		Establishment of vegetation or use of recharge/infiltration materials.
Nonstructural Source Controls				
Street Sweeping	Street right-of-way.	Reduction in potential for clogging storm drains with debris. Some oil and grease control possible.	Paper and plastics, leaves and twigs, dust, and oil and grease.	Acquire street sweeping equipment.
Sidewalk Cleaning	Sidewalk right-of-way in areas of heavy foot traffic.	Reduction in pollutants entering storm drain.	Oil and dirt.	None.
Clean and Maintain Storm Drain Channels Annually	Channel capacity and receiving water. Upstream flood control benefits. Includes benefits to channel wildlife habitat and vegetation.	Prevent erosion in channel. Improve capacity by removing silt and sedimentation. Remove debris that is habitat destroying or toxic to wildlife.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed in channel.	None.
Clean and Inspect Storm Inlets and Catch Basins Annually	Site dependent flood control benefits.	Allows proper drainage to prevent flooding and continued proper operation of facilities.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed into facilities.	None.
Clean and Inspect Debris Basins Annually	Site dependent flood control benefits.	Allows proper drainage to prevent flooding and continued proper operation of facilities.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed into facilities.	None.

Type of Practice	Area of Benefit	Storm Protection Benefit	Pollutants Controlled	Construction Requirements
Storm Drains Cleaned and Maintained Every 3 to 6 Years	Flood control and water quality benefits.	Allows proper drainage to prevent flooding and continued proper operation of facilities.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed into facilities.	None.
Storm System Pump Stations Cleaned and Maintained Annually	Site dependent flood control and water quality benefits.	Prevents flooding and allows continued proper operation of facilities.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed into facilities.	None.
Inspect and Maintain Sewer System	Storm drain system and receiving water.	Prevents and eliminates sewer system surcharges.	Contaminants, toxics, and coliform bacteria.	None.
Minor Structural Source Controls				
Storm Drain Inlet Protection	Storm drain drainage area.	Prevent debris from entering storm drain.	Dirt, leaves, twigs, paper, plastic, and other incidentals.	Not available.
Outlet Protection	Storm drain receiving water.	Prevent erosion at the outlet of pipes or paved channels and protect downstream water quality.	Turbidity and sediment.	Structural apron lining at the outlet location. Made of riprap, grouted riprap, concrete, or other structural materials.
Slope Stabilization and Erosion Control Measures	Site and topography dependent.	Reduce silt and sediment load to storm drains.	Silt and sediment and the contaminants therein.	None.
Interceptor Swale	Dependent on flow velocity. Max. velocity for earth channel is 6 fps. Max. velocity for vegetated or riprap channel is 8 fps.	Shorten length of exposed slopes and intercept and divert storm runoff from erodible areas.	Sediment and silt and the contaminants contained therein.	Excavation drainageway across disturbed areas or rights-of-way.
Improve and Maintain Natural Channels	Channel capacity and receiving water. Upstream flood control benefits. Includes benefits to channel wildlife habitat and vegetation.	Prevent erosion in channel. Improve capacity by removing silt and sedimentation. Remove debris that is habitat destroying or toxic to wildlife.	Silt and sediment and the contaminants contained therein. Plastic, glass, paper, and metal thrown or washed in channel.	None.
Diversion Channel	Dependent of flow velocity. Maximum velocities: 5 fps for vegetated channel and 8 fps for riprap channel. Not for use on slopes greater than 15%. Drainage area should be 5 acres or less.	Intercept and convey runoff to outlets at nonerosive velocity.	Sediment and erosion controls.	Lined drainageway of trapezoidal cross section.
Grass-Lined Channel	Site dependent but of larger capacity than interceptor or perimeter swales.	Intercept runoff and convey runoff from site.	Sediment and silt and the contaminants contained therein.	Excavation of channel or improvements to natural channel. Stabilization with vegetation.

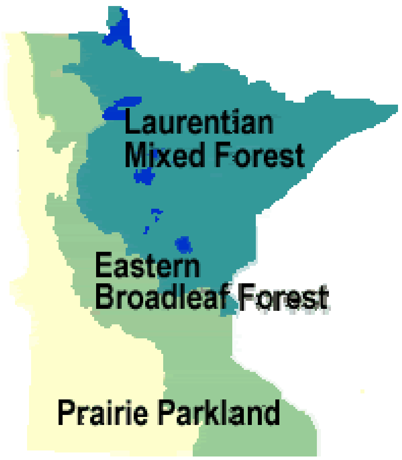
Type of Practice	Area of Benefit	Storm Protection Benefit	Pollutants Controlled	Construction Requirements
Storm Drain Drop Inlet Protection	Areas less than 1 to 2 acres.	Filters sediment from runoff before it enters inlet. Provides relatively good protection.	Sediment and the contaminants contained therein.	Barrier around storm drain inlet. Useful for areas where storm drain is operational before area runoff area is stabilized.
Riprap	Site dependent	Provides stabilization and erosion control for stream banks and channels, outlet, and slopes.	Erosion and sediment.	Placement of rock on area to be stabilized. May also require use of filter fabric liner.
Gabions	Site dependent	Provides stabilization and erosion control for stream banks, outlet, and slopes.	Erosion and sediment.	Placement of wire cage will with rocks over area to be stabilized. May also require use of filter fabric liner.
Vegetative Control	Applicable and effective for most sites.	Provides stabilization and erosion control for streambanks, swales, channels, outlets, slopes, open disturbed areas. Can be up to 99% effective with established cover. Temporary seeding can be up to 90% effective.	Erosion and sediment.	Site preparation (can include land leveling and installation of irrigation system), seeding or planting, and netting or mulching to establish seed. Can also include other sodding, ground cover, shrubs, trees, and native plants.
Filter Strips	Site dependent.	Receives overland flow slowing runoff and trapping particulates. Can be 30 to 50% effective for sediment control.	Silt, sediment, trash, organic matter, and to an extent, soluble pollutants through infiltration.	Grading and vegetative establishment. Should have a minimum width of 15 to 20 feet. Good performance is achieved with a 50 to 75 foot width.
Fence Open Channels	Site dependent.	Prevent windblown trash from entering channel. Prevents illegal dumping in channel.	Trash and pollutants.	Construction of fences.
Discharge Elimination Methods				
French Drains and Subsurface Drains	Dependent on site topography and soil permeability.	Provides drainage of “wet” soils to allow establishment of vegetation. Can reduce runoff.	Sediment.	Underground perforated pipe leading to a surface water outlet. Pipe size, bedding and depth is dependent on site conditions.
Infiltration Trench and Dry Well	Small drainage areas. Runoff from rooftops, parking lots, residential, etc.	Provides temporary storage of runoff and infiltration to soil. Not for use in areas where groundwater could become contaminated.	Prevents 100% of pollutants from entering surface water. Oil, grease, floating organic matter, and settleable solids should be removed before water enters trench.	Excavation of a shallow trench 2’ to 10’ deep. Backfilled with coarse stone aggregate.

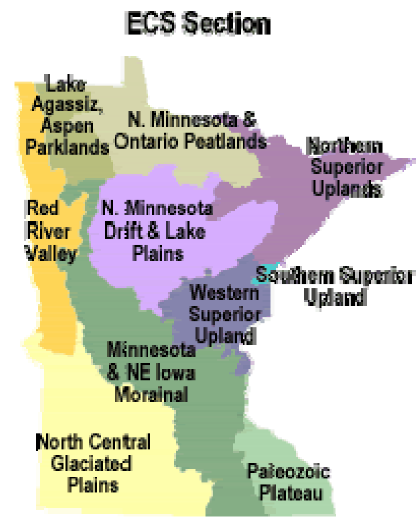
Type of Practice	Area of Benefit	Storm Protection Benefit	Pollutants Controlled	Construction Requirements
Exfiltration Trench	Site dependent.	Prevent silting on underlying filter gravel or rock bed. Retain first flush, reduce runoff volume and peak discharge rate and promote water quality improvement.	Prevents pollutants from entering surface water. Oil, grease, floating organic matter, and settleable solids should be removed before water enters trench.	Uses perforated pipe with suitable membrane filter material. Installed before receiving water outlet or in groundwater recharge area.
Porous Pavement	Site dependent. Requires relatively flat surface.	Allow infiltration of surface runoff. Reduce runoff volume and pollutant loadings from low volume traffic areas.	Oil and grease.	Install porous pavement. May require twice as much paving material as standard asphalt to achieve same strength.
Retention Basin	Best for sites of 5 to 50 acres.	Promotes infiltration to groundwater and reduces runoff volume and velocity. Filters pollutants.	Sediment, trace metals, nutrients, and oxygen-demanding substances.	Excavation of a basin over permeable soils. Size is site dependent. Depth is 3 to 12 feet.
Floatables and Oil Removal				
Clarifiers and Oil and Water Separators on Parking Structures	Parking lot structure and receiving water.	Collect debris before it can enter storm drain.	Oil, grease, and antifreeze from vehicles and foods and food wrappers.	Install grit and separators.
Oil and Grit Separators	Site dependent. For heavy traffic areas or areas with high potential for oil spills.	Remove pollutants.	Sediments and hydrocarbons.	Install oil and grit separators on storm drains.
Sediment/Grease Trap	Installed on storm drain inlets.	Intercept and trap sediment and grease from runoff.	Sediment, oil, and grease.	Install sediment and grease traps.
Solids Removal				
Detention Basin	Four acres of drainage area for each acre/foot of storage provided to retain a permanent pool of water.	Temporary storage of storm runoff until release. Can also improve water quality.	Sediment, trace metals, hydrocarbons, nutrients, and pesticides.	Excavation of a basin over soils which will cause excessive seepage. May require a liner. Can be used aesthetically as a small pond in landscaping.
Extended Detention Basin	Size for a minimum detention time of 24 hours.	Temporary storage of runoff for an extended period of time. Can improve water quality.	Sediment, trace metals, hydrocarbons, nutrients, and pesticides.	Excavation of a basin over soils which will cause excessive seepage. May require a liner. Can be used aesthetically as a small pond in landscaping.
Bar Screens	Site dependent.	Restrict passage of objects which may obstruct pump station suction bays.	Large debris.	Install bar screens before pump station suction bays.

Appendix 3: Ecological Classification System

The Ecological Classification System (ECS) is part of a nationwide mapping initiative developed to improve our ability to manage all natural resources on a sustainable basis. This is done by integrating climatic, geologic, hydrologic and topographic, soil and vegetation data.

Three of North America's ecological regions, or biomes, representing the major climate zones converge in Minnesota: prairie parkland, deciduous (Eastern broadleaf) forest and coniferous (Laurentian mixed) forest. The presence of three biomes in one non-mountainous state is unusual, and accounts for the diversity of ecological communities in Minnesota.





Appendix 4: Glossary

Aquatic Bed (AB) – A class within the Cowardin Wetland Classification system. Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Best Management Practices: Land management actions that can be implemented to protect wetlands from various nonpoint source pollutants. In general, they must be designed and often implemented to meet site-specific needs. Typically, BMPs are chosen and implemented for their ability to treat or reduce sediment, nutrient removal and to reduce excess surface water from entering the wetland.

Buffer: A buffer is an unmanicured upland area dominated by permanent native and noninvasive vegetation immediately adjacent to the wetland boundary.

Discharge: Wetland systems in which water preferentially discharges from groundwater into the wetland.

Emergent shoreline vegetation: These plants grow along edges of lakes and ponds, or on wet ground away from open water. Examples of such vegetation include: cattail, bulrush, loosestrife, and reed canary grass.

Exotic Plant: A plant not originally from this area or location.

Facultative Plants: Plants with a similar likelihood of occurring in both wetlands and nonwetlands (estimated probability 33% to 67%).

Facultative Upland Plants: Plants that sometimes occur in wetlands (estimated probability 1% to 33%), but occur more often in nonwetlands (estimated probability >67% to 99%).

Facultative Wetland Plants: Plants that usually occur in wetlands (estimated probability 67% to 99%), but also occur in nonwetlands (estimated probability 1% to 33%).

Flood Attenuation: The slowing of a flood wave by spreading water flow laterally over the ground surface or by the increased resistance of water flow through emergent vegetation.

Genera: Genera or genus is a level of taxonomy and is typically the first part of a scientific name that is utilized to identify a plant or animal. The scientific name for purple loosestrife is *Lythrum salicaria* (*Lythrum* is the genus name, while *salicaria* is the specices name).

Geographic Information System (GIS): A system designed to work with data referenced by spatial or geographic coordinates.

Hydric Soils: Soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part.

Hydrologic Regime (Hydroperiod): The seasonal pattern of wetland water level that is like a hydrologic signature of each wetland type. It defines the rise and fall of a wetland's surface and subsurface water. Constancy of seasonal patterns from year to year ensures a reasonable stability for the wetland.

Hydrophytic Vegetation: Macrophytic plant life growing in water, soil, or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

Inundation: Covering or flooding of the land surface with water.

Invasive Plant: A non-native plant that escapes from where it was planted and invades native plant communities.

Macrophyte: A plant that is physiologically adapted to live in sediment, which is saturated or inundated for an extended duration or permanently.

Monotypic Vegetation: Vegetative communities dominated by a single plant species.

National Wetland Inventory (NWI): An inventory of the Nation's wetland resources and deepwater habitats conducted by the U.S. Fish and Wildlife Service containing information on the extent and characteristics of wetlands identified primarily from aerial photographs.

Native Vegetation: Plant species that are indigenous to Minnesota, or that expand their range into Minnesota without being intentionally or unintentionally introduced by human activity and are classified as native in the Minnesota Plant Database.

Non-invasive Vegetation: Plant species that do not typically invade or rapidly colonize existing, stable plant communities.

Non-native Plant: A plant introduced by human activities to areas where they do not naturally occur.

Nutrient Loading: The import of nutrients (phosphorus and nitrogen) carried in runoff water.

Obligate Upland Plants: Plants that rarely occur in wetlands (estimated <1%), but almost always occur in nonwetlands (estimated probability >99%) under natural conditions.

Obligate Wetland Plants: Plants that occur almost always (estimated probability >99%) in wetlands under natural conditions, but which may also occur rarely (estimated probability <1%) in nonwetlands.

Pretreatment: Removal of nutrients or sediment from stormwater runoff prior to discharging into a wetland.

Recharge: Wetland systems in which water preferentially seeps into groundwater.

Reference Standard Wetland: Reference Standard Wetlands are the least disturbed/altered wetlands within the Wetland Comparison Domain.

Submergent Aquatic Vegetation: The entire plant is usually underwater, but the flowers and fruits may rise above the water surface. Submergent species are rooted in the sediment and have underwater leaves. They can grow from shallow water to depths greater than 20 feet.

Subwatershed: Major watersheds are split up into subwatersheds, each of which defines the land area in which all water drains to a defined point.

Terrestrial Exotic Plant: A plant not originally from this area that is best adapted to life on ground that is not saturated or inundated for extended periods of time.

Watershed: The land area in which all water drains to a defined point.

Wetland: Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must:

(1) have a predominance of hydric soils;
(2) be inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and
(3) under normal circumstances, support a prevalence of hydrophytic vegetation.

Wetland Community: A characteristic assemblage of various vegetation species typically found in specific wetland conditions.

Wetland Comparison Domain: A Wetland Comparison Domain is defined in the MnRAM 2.0as the geographic area, generally of a size so as to include some relatively undisturbed Reference Standard Wetlands (e.g., the political boundary, major or local watershed boundary or ecoregion subsection), used for functional comparison.

Wetland Conservation Act (WCA): The Wetland Conservation Act became effective on January 1, 1992. WCA rules are administered by Local Government Units (LGU) with oversight provided by the Board of Water and Soil Resources and technical assistance from the Soil and Water Conservation Districts. The Department of Natural Resources conservation officers and other peace officers provide enforcement of the WCA. The primary goals of the WCA are to:

1. Achieve no net loss in the quantity, quality, and biological diversity of Minnesota's existing wetlands.
2. Increase the quanitity, quality, and biological diversity of Minnesota's wetlands by restoring or enhancing diminished or drained wetlands.
3. Avoid direct and indirect impacts to wetlands from activities that destroy or diminish the quantity, quality, and biological diversity of wetlands.
4. Replace wetland values where avoidance of activity is not feasible or prudent.

Wetland Functions: Physical, chemical, or biological processes or attributes of a wetland -- simply something a wetland does. For example, the process of retaining surface water is a commonly cited wetland function.

Wetland Creation: The conversion of a persistent upland into a wetland by human activity.

Wetland Restoration: Reestablishment of a historical wetland in an area in which wetland hydrology has been removed.

Wetland Value: A wetland value is the extent to which a wetland function is perceived as beneficial to an individual or society. Reduced flood damage to downstream properties is a value generally associated with the function of surface water retention.

Figure 6
Wetland Management Classification Process Flowchart

Each wetland will be ranked into a Wetland Management group by the highest rated function for the wetland. Follow the arrows to progress through the tables and classify wetlands into the first group that applies.

Example 1.1: Basic Protection Standard

Wetland Field Assessment → **GIS Analyses** → **Functional Index Calculations** → **Is the Wetland a Special Resource?**

- No → **Wetland Management Classification System**
- Yes → Special Resource Criteria → **Preserve**

Special Resource Criteria
1. Outstanding Value Resource Waters
2. Designated Scientific & Natural Areas
3. Threatened or Endangered Species
4. State Wildlife Management Areas
5. State Aquatic Management Areas
6. Calcareous Fens
7. Designated trout streams and lakes
8. Rare natural communities
9. Designated Historic or Archaeological Sites
10. Element of Wildlife Corridor

	Vegetative Diversity/ Integrity	Habitat Structure (Wildlife)	Amphibian Habitat	Fish Habitat	Shoreline Protection	Stormwater/ urban sensitivity & Veg. Diversity	Wetland H_2O Quality & Vegetative Div.	Characteristic Hydrology & Veg. Diversity	Flood/ Stormwater Attenuation	Commercial Use	Downstream Water Qual. Sensitivity
PRESERVE	Except'l	Except'l	High	Except'l	High	Exceptional[1] & Medium	High & High	High & High	*	*	*
MANAGE 1	High	High	Medium	High	Medium	High & Medium	High & Medium	High & Medium	*	High	*
MANAGE 2	Medium	Medium	Low	Medium[2]	Low				*	*	*
MANAGE 3	Low	Low	N/A	Low	N/A	* & *	Low & Low	Low & Low	High	*	High

[1] For types as shown in Table 1-2. * This rating does not apply here.

Summary of Management Classification Amendments

The drop from P to M3 for wetland numbers 4 and 5 is due to the existing storm water treatment functions these two wetlands have. The original P classification was generated from the wetlands having high storm water sensitivity (because they area temporarily flooded basins) and moderate vegetative diversity, however, these ponds currently function in storm water retention. The drop from P to M3 for wetland #28 occurred because this wetland is a constructed pond.

Table 3. Changes to MnRAM Management Classification

Wetland ID Number	Original Management Class	Modified Management Class
1	M2	M3
4	P	M3
5	P	M3
7	M2	M3
13	M2	M3
28	P	M3
60	M2	M3
62	M2	M3
63	M2	M3
64	M2	M3
65	M2	M3
135	M2	M3
136	M2	M3
137	M2	M3
138	M2	M3
139	M1	M2