RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

2017-2026 WATERSHED MANAGEMENT PLAN

Quality Water for Quality Life

April 2017

Watershed Management Plan

2017-2026
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Acronyms

Acronym	Description
AIS	Aquatic Invasive Species
BFE	Base Flood Elevation
BMP	Best Management Practices
BOD	Biological Oxygen Demand
BWSR	(Minnesota) Board of Water and Soil Resources
CAC	Citizen Advisory Committee
CAMP	Citizen-Assisted Monitoring Program
CFS	Cubic Feet per Second
CIP	Capital Improvement Program
CLMP	Citizen Lake Monitoring Program
CLP	Curlyleaf Pondweed
CSAH	County State Aid Highway
CWA	Clean Water Act
CWP	Clean Water Partnership
DWSMA	Drinking Water Supply Management Area
EAW	Environmental Assessment Worksheet
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EQB	(Minnesota) Environmental Quality Board
EWM	Eurasian Watermilfoil
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
GWMA	Groundwater Management Area
IDDE	Illicit Discharge Detection and Elimination
LGU	Local Governmental Unit
LiDAR	Light Detection and Ranging
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
MBS	Minnesota Biological Survey
MCM	Minimum Control Measure
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MDNR	Minnesota Department of Natural Resources
MGS	Minnesota Geological Survey
MLCCS	Minnesota Land Cover Classification System
MnDOT	Minnesota Department of Transportation

MnRAM	Minnesota Rapid Assessment Method for Evaluating Wetland Functions
MPCA	Minnesota Pollution Control Agency
MRCC	Midwestern Regional Climate Center
MS4	Municipal Separate Storm Sewer System
MSP	Minneapolis-St. Paul International Airport
MUSA	Municipal Urban Services Area
NCDC	National Climatic Data Center
NFIP	National Flood Insurance Program
NHIS	Natural Heritage Information System
NHNRP	Natural Heritage and Non-game Research Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NWI	National Wetland Inventory
NWS	National Weather Service
OHWL	Ordinary High Water Level
ORVW	Outstanding Resource Value Water
PAH	Polycyclic Aromatic Hydrocarbon
PWI	Public Waters Inventory
RCD	Ramsey Conservation District
RWMWD	Ramsey-Washington Metro Watershed District
SCS	Soil Conservation Service
SLMP	Strategic Lake Management Plan
SNA	Scientific and Natural Area
SSTS	Subsurface Sewage Treatment System
SSURGO	Soil Survey Geographic Dataset
SWBCA	Special Well and Boring Construction Area
SWCD	Soil and Water Conservation District
SWCS	Soil and Water Conservation Society
SWPPP	Storm Water Pollution Prevention Program
TAC	Technical Advisory Committee
TCMA	Twin Cities Metropolitan Area
TEP	Technical Evaluation Panel
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VIC	Voluntary Investigation and Cleanup

WCA	Wetland Conservation Act
WCD	Washington Conservation District
WHPP	Wellhead Protection Plan
WLA	Waste Load Allocation
WMO	Watershed Management Organization
WOMP	Watershed Outlet Monitoring Program
WRAPS	Watershed Restoration and Protection Strategies
WSE	Water Surface Elevation

Executive Summary

The mission of the Ramsey-Washington Metro Watershed District (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.*

In its pursuit of the above mission, the District will adhere to the following core set of principles to guide its actions:

The District will be:

- A leader and innovator in watershed management that integrates natural and built environments.
- An organization focused on high levels of performance and results.
- An organization that uses adaptive management, accurate information, and sound science to guide decision making.
- A trusted and accountable steward of public resources and moneys.
- An active collaborator with a wide variety of public and private organizations.
- An important and reliable source of information, services, and projects.
- An effective advocate of watershed management principles and values.
- An organization that educates and inspires current and future stewards of the watershed.

This RWMWD Watershed Management Plan (Plan) establishes the guidelines for managing the water resources within the boundaries of the RWMWD to achieve the District's mission. This Plan and its strategic overview provide data and other background information for the District and its 25 major subwatersheds, assess watershed-wide and resource-specific issues, establish goals and action items, and summarize District projects and programs, including a 10-year implementation plan. The major sections of the Plan, in addition to general background information about the District, are described in this executive summary.

Background and Purpose

The RWMWD is a local unit of government (LGU) that manages water resources within portions of Ramsey and Washington counties per authorities given in Minnesota Statutes 103B, Minnesota Statutes 103D, and Minnesota Rules 8410. The Metropolitan Surface Water Management Act (Minnesota Statutes 103B.201–103B.255) states the purposes of watershed management organizations such as the RWMWD:

1. Protect, preserve, and use natural surface and groundwater storage and retention systems.
2. Minimize public capital expenditures needed to correct flooding and water quality problems.
3. Identify and plan for means to effectively protect and improve surface and groundwater quality.

4. Establish more uniform local policies and official controls for surface and groundwater management.
5. Prevent erosion of soil into surface water systems.
6. Promote groundwater recharge.
7. Protect and enhance fish and wildlife habitat and water recreational facilities.
8. Secure the other benefits associated with the proper management of surface and groundwater.

The statutory authority and purposes of Minnesota watershed management organizations are described in greater detail in Section 3.1.2.

The District was established on February 24, 1975, by the Minnesota Water Resources Board (now the Minnesota Board of Water and Soil Resources, or BWSR) pursuant to the Minnesota Watershed Act, to affect the protection and provident use of water resources. The RWMWD is located in eastern Ramsey County and western Washington County. It covers approximately 65 square miles that ultimately drain into the Mississippi River (see Figure ES-1). Approximately 53.4 square miles of the area lie within Ramsey County; the remaining 11.6 square miles are within Washington County. The RWMWD includes all or part of 12 communities:

- Gem Lake
- Landfall
- Little Canada
- Maplewood
- North St. Paul
- Oakdale
- Roseville
- St. Paul
- Shoreview
- Vadnais Heights
- White Bear Lake
- Woodbury

The RWMWD is governed by a five-member Board of Managers. Four managers are appointed by the Ramsey County Board and one manager is appointed by the Washington County Board. Managers are appointed for staggered three-year terms. The RWMWD Board of Managers hold regular meetings on the first Wednesday of each month, which are open to the public and held at the District office in Little Canada, located at 2665 Noel Drive. Meeting information is posted on the District website: www.rwmwd.org.

Additional information about the formation, history, and governance of the District is provided in Section 3.1.

Strategic Overview

A strategic overview of the RWMWD is included as a chapter in this Plan. It identifies the District's mission, goals, and signs of success, summarizes the primary issues facing the District, and lists action items to address those issues.

Goals

The District has identified six goals in pursuit of its mission:

1. **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.
2. **Achieve healthy ecosystems—**Manage water and related natural resources to create and preserve healthy ecosystems.
3. **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.
4. **Support sustainable groundwater—**Consider groundwater sustainability management and connections to surface waters in decisions and collaborate with others responsible for groundwater management and protection.
5. **Inform and empower communities—**Inform and empower communities to become partners in improving and protecting the watershed through their own efforts.
6. **Manage organization effectively—**Operate in a manner that achieves the District's mission while adhering to its core principles.

The strategic overview also includes several signs of success that the District will review as indicators of progress towards each goal.

Issues and Focus Areas

The strategic overview discusses significant issues facing the District. These issues were identified as part of an extensive stakeholder engagement process soliciting input from cities, counties, state agencies, community groups, residents, and District staff. Issues were prioritized at a "community confluence" public meeting. The public engagement and issue identification process is described in Section 4.5.1. Areas of focus to address issues identified are organized according to District goals, as follows:

- **Achieve quality surface water:**
    - Researching and implementing innovative water quality practices
    - Monitoring and maintaining District water quality improvement projects
    - Promoting and supporting residential and other private best management practices
    - Reversing the impact of development
- **Achieve healthy ecosystems**
    - Partnering with agencies, cities, organizations, and residents on ecological restoration
    - Monitoring and managing aquatic invasive plant and animal species
    - Controling shoreline erosion
    - Recognizing natural resource elements in all District projects
- **Manage risk of flooding**
    - Reducing and managing stormwater runoff volume
    - Identifying, assessing, and mitigating of potential flooding problems
    - Making infrastructure improvements to increase stormwater management capacity

- **Support sustainable groundwater**
    - Supporting research to better define relationships between surface water and groundwater quality
    - Identifying sensitive areas where infiltration should be limited
    - Implementing programs to control or limit potential groundwater contamination
    - Collaborating other entities to ensure the sustainability of groundwater resources
- **Inform and empower communities**
    - Supporting residents, institutions, and businesses to create shared watershed stewardship efforts
    - Educating city staff, advisory commissions, and public works departments
    - Expanding awareness of District programs
    - Developing education efforts targeted and tailored to specific audiences
- **Manage organization effectively**
    - Promoting leadership in innovation through research, projects, and collaboration
    - Using adaptive management strategies
    - Implementing cost-effective projects

Action Items

The District identified 86 action items to address the issues and goals described in the strategic overview. Action items are organized according to goal and are presented in the strategic overview. Many of the action items included in this iteration of the Plan are a continuation of existing District practices to address ongoing District responsibilities (e.g., continued administration of the Wetland Conservation Act (WCA)). Other action items are new, reflecting emerging issues and changing priorities within the RWMWD. New or expanded action items of note in this Plan update include the following:

- **WQ11—**Expand the use of innovative water quality improvement designs, products, equipment, and methods as necessary to address sites with limited land area for conventional treatment techniques.
- **WQ19—**Consider long-term changes to precipitation and hydrology when planning water quality projects or infrastructure modifications.
- **EC5—**Collaboratively manage invasive species that threaten water resources and associated upland habitats.
- **FL9—**Incorporate anticipated precipitation and hydrology changes when planning flood control projects or infrastructure modifications.
- **GW3—**Collaborate with local and state agencies to:
    - Gain a better understanding of groundwater-surface water interaction and develop management strategies that address the protection of both resources.
    - Identify data gaps and work to fill those gaps through collection of groundwater-level data, surface water data, research, or other methods.
    - Identify areas of potential vulnerability.

    - Develop and utilize tools to assess the impacts of groundwater use on surface water and groundwater (e.g., refinement of the Metro groundwater model, better synchronization of surface water and groundwater models, etc.).
    - Identify sensitive groundwater areas where infiltration should be limited.
- **GW4—**Use available information and guidance to evaluate potential impacts of stormwater infiltration best management practices on groundwater and make changes to the District's infiltration standards and programming, as appropriate.
- **IE3—**Develop and support educational programs and resources that will inform residents and other stakeholders about how individuals can be responsible stewards of the watershed through their own actions.
- **IE16—**Develop a program to incorporate public art into District programs and projects.
- **MO11—**Develop and implement methods/programs for measuring, tracking, and reporting progress towards achieving District goals.
- **MO12—**Practice adaptive management: implement, monitor, track progress, learn from experience, adjust (and repeat).

A complete list of action items is included within the Strategic Overview. Table 4-1 cross-references these action items with the District's 10-year implementation Plan, allowing the District to track efforts made toward each goal in conjunction with implemented projects and programs.

Section 1—District-Wide Inventory and Assessment

Section 1.0 of this Plan contains information on topography and soils, land use, climate and precipitation, topography, geology, groundwater resources, major subwatersheds and waterbodies, water quality, wetlands, water quantity and flooding, natural communities and rare species, and pollutant sources in the RWMWD. This important information describes the condition of the watershed and affects decisions about infrastructure, development, and ecological preservation. By way of summary, some of the most notable information in Section 1.0 includes:

Topography and soils: 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. Hydrologic soil groups are identified for only 44 percent of the watershed, with the remaining 56 percent unknown, not rated, or unavailable. The areas where hydrologic soil groups are defined are concentrated in the extreme north and southeast portions of the District. Within these areas, the soils exhibit a wide range of infiltration potential.

Land use: Almost all of the land in the RWMWD is now fully developed. Undeveloped areas expected to develop in the future are limited to small areas (e.g., individual parcels) located in the eastern portion of the District and other scattered infill locations. Single-family residential is the major land use found in the District (38 percent), followed by park, recreational, or preserve (17 percent). Vacant or undeveloped land, including non-developable lands (e.g., wetlands) occupy 9 percent of the watershed, and open water occupies another 8 percent of the watershed.

Climate and precipitation: The climate of the Minneapolis-St. Paul area is a humid continental climate characterized by moderate precipitation, wide daily temperature variations, large seasonal variations in temperature, warm humid summers, and cold winters with moderate snowfall. Average weather imposes little strain on the typical drainage system; however, extremes of precipitation and snowmelt are important for design of flood control systems. The National Oceanic and Atmospheric Administration (NOAA) published data, now called Atlas 14, on extreme precipitation events that can be used to aid in the design of flood control systems. This data indicates increased precipitation depths for more extreme storm events relative to previously published values.

Geology and groundwater: Surficial geology in the RWMWD is primarily in the form of outwash, till, and stream and lake sediments, which are composed of varying percentages of sand, silt, clay, and gravel. The overall thickness of glacial deposits above bedrock ranges from 10 to 400 feet. Groundwater is a vital natural resource for the residents, cities, and industries within the RWMWD. There are 45 municipal supply wells and approximately 1,400 private wells located within the RWMWD. Most high-capacity wells draw water from bedrock aquifers, while the majority of private wells are located in the surficial aquifer.

Major subwatersheds and waterbodies: 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 to the south or Vadnais Lake to the north. For management purposes, the RWMWD has been broken down geographically into 25 subwatersheds. Many of the 25 District subwatersheds are part of the Phalen Chain of Lakes or Grass Lake Chain of Lakes. The Phalen Chain of Lakes is a group of lakes and streams that are interconnected and all drain to Lake Phalen. The Grass Lake Chain of Lakes is a group of lakes that are interconnected and all drain to the Grass Lake wetland and to West Vadnais Lake (outside the RWMWD).

Within the District's 25 major subwatersheds are numerous waterbodies, including several classified as public waters or public waters wetlands by the Minnesota Department of Natural Resources (MDNR). The District has identified 20 lakes and five streams as "District-managed waterbodies," including:

- Battle Creek Lake
- Beaver Lake
- Bennett Lake
- Carver Lake
- Eagle Lake
- Emily Lake
- Gervais Lake
- Keller Lake
- Kohlman Lake
- Lake Owasso
- Lake Phalen
- Round Lake (Maplewood)
- Round Lake (Little Canada)
- Shoreview Lake
- Snail Lake
- Tanners Lake
- Twin Lake
- Wabasso Lake
- Wakefield Lake
- Willow Lake
- Fish Creek
- Battle Creek
- Gervais Creek
- Willow Creek
- Kohlman Creek

While the District focuses its efforts on the District-managed waterbodies identified above, it may pursue activities in waterbodies (or its watersheds) not included in the above list on a case-by-case basis as necessary to achieve District goals.

Water quality: The District has adopted the Minnesota Pollution Control Agency's (MPCA) eutrophication water quality standards applicable to lakes and streams within the District. To assist in prioritizing management efforts, the District has classified District-managed waterbodies as "stable," "at-risk," or "impaired" relative to eutrophication standards. The District monitors many waterbodies for chemical, physical, and biological parameters and cooperates with many other entities that are also monitoring water resources in the watershed. Several waterbodies within the District are included on the MPCA's Impaired Waters 303(d) List because they do not meet MPCA water quality standards for eutrophication (nutrients), chloride, mercury, *Escherichia coli*, polychlorinated biphenyls (PCBs), or various bioassessments. The District has identified several actions to address water quality in its implementation program.

Wetlands: The wetlands in the RWMWD are an important community and ecological asset. To protect these valuable resources, the District continues to manage wetlands to achieve no net loss of acreage, functions, and value. The District serves as the LGU responsible for administration of the WCA rules for all cities in the District except the City of Saint Paul, and except for on Minnesota Department of Transportation projects (see Section 4.1.2 for more information). The RWMWD completed a District-wide wetland assessment from 2003-2005 and has classified for management purposes, based on the observations and conclusions of the 2003-2005 wetland inventory and assessment.

Water quantity and flooding: Since its creation in 1975, the District has addressed water level and flooding issues through its capital improvement program (CIP) projects, District actions, and programs (e.g., its permitting program). The District has cooperated with developers and local municipalities to construct many projects to address flooding issues. Many of these projects incorporate secondary benefits for water quality, habitat improvement, or other uses. The District maintains a District-wide hydrologic and hydraulic model. The model was used to estimate flood elevations based on the 100-year storm event and establish regulatory standards (e.g., minimum building elevations) based on the Atlas 14 100-year event. Flood levels within each major subwatershed are included in Section 2.0.

Natural communities and rare species: Prior to settlement, the RWMWD was covered predominantly by oak forest interrupted by tall grass prairie and marsh and a dense deciduous forest known as the "Big Woods." Elm, sugar maple, and basswood are representative Big Woods tree species. Concentrated areas of Big Woods remaining within the RWMWD are in Battle Creek Regional Park and the Fish Creek Open Space. Other natural communities present in the RWMWD prior to settlement include wet prairie (concentrated around lakes) and conifer bogs and swamps. Sites of biological importance within the RWMWD include the Pig's Eye Island Heron Rookery and Tamarack Swamp, a wetland found in the southeast portion the Battle Creek Lake subwatershed.

Pollutant sources: The sources of pollution impacting water resources in the RWMWD are many and varied. While there are point sources of pollution that are regulated under state permits, the vast majority of pollution reaching waterbodies in the RWMWD comes from non-point source—those which cannot be

traced back to a single source or pipe. Instead, pollutants are carried from land to water in stormwater or snowmelt runoff, in seepage through the soil, and in atmospheric transport. These pollutants include nutrients, bacteria, sediment, chlorides, pesticides, solvents, and chemicals.

Section 2—Major Subwatersheds

Section 2.0 presents detailed information for each of the 25 major subwatersheds within the RWMWD. Each subwatershed Section includes watershed summary information, past studies, land use, drainage patterns, and available water quality data. The sections also detail the District's past management activities related to four District goals: (1) achieve quality surface water; (2) manage risk of flooding; (3) support sustainable groundwater; and (4) achieve healthy ecosystems. Each subwatershed Section includes a watershed-specific subset of the District's overall implementation program. The major subwatersheds included in Section 2.0 include:

Section	Subwatershed Name
2.1	Willow Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.2	Kohlman Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.3	Kohlman Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.4	Twin Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.5	Gervais Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.6	Gervais Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.7	Keller Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.8	Lake Phalen Subwatershed (Phalen Chain of Lakes Watershed)
2.9	Wakefield Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.10	Beaver Lake Subwatershed
2.11	St. Paul Beltline Storm Sewer Subwatershed
2.12	Mississippi River Bottomlands Subwatershed
2.13	Tanners Lake Subwatershed
2.14	Battle Creek Lake Subwatershed
2.15	Battle Creek Subwatershed
2.16	Blufflands Subwatershed
2.17	Carver Lake Subwatershed
2.18	Fish Creek Subwatershed
2.19	Grass Lake (Grass Lake Area)
2.20	Bennett Lake (Grass Lake Area)
2.21	Shoreview Lake (Grass Lake Area)
2.22	Snail Lake (Grass Lake Area)
2.23	Lake Owasso (Grass Lake Area)
2.24	Lake Emily (Grass Lake Area)
2.25	Lake Wabasso (Grass Lake Area)

Section 3—Purpose, Roles, and Responsibilities

This Section summarizes the roles and responsibilities of the District, the cities and counties within its borders, and state agencies. Major roles and responsibilities of the District described in Section 3.0 include:

- Implementation of the District's rules, regulations, and permitting program
- Wetland and natural resource management
- Projects and studies
- Maintenance of District facilities and MS4 permit responsibilities
- Monitoring
- Reporting and evaluation
- Assistance to Local Governmental Units
- Collaboration with other agencies and organizations
- Watershed Restoration and Protection Strategies (WRAPS) and Total Maximum Daily Load (TMDL) implementation

The actions, projects, and programs the District performs in addressing the above roles are detailed within the strategic overview (i.e., action items) and Section 4.0—District Operations and Implementation. Generally, the District roles and responsibilities described in this Plan similar to those described in the 2007 Watershed Management Plan. With this Plan, the District has added several new action items targeting water and natural resource management issues identified and prioritized by stakeholders during Plan development (see Section 4.5.1). Emerging areas of focus receiving greater emphasis in this Plan relative to past District plans include:

- Monitoring and management of aquatic invasive plans and animals
- Planning for anticipated changes in precipitation and hydrology
- Increasing knowledge of groundwater resources and addressing groundwater resource sustainability

The action items included in the Strategic Overview and the implementation items included in Table 4-1 reflect the increased emphasis on emerging issues, as well as the District's commitment to core water resource management issues (e.g., water quality, flood risk).

Coordination of District and City responsibilities is necessary for the District to remain an effective and successful organization. The District's primary expectations of cities are summarized below and are described in greater detail in Section 3.2.2:

1. **Local water management plan:** Cities shall prepare a local water management plan that conforms to the requirements of Minnesota Rules 8410 and this Plan. The District shall review and approve each local plan. Section 4.4.1 contains more information about local plan requirements.
2. **Public works group:** The District formed this group to provide regular opportunities for important communication between the cities, District, and other units of government. The forum provides opportunities to organize staff training and discuss public works issues and National Pollutant Discharge Elimination System (NPDES MS4 implementation. All cities and counties should participate in this group to provide consistent communication and coordination.
3. **Project review and permitting**: Cities are responsible for informing developers and other project applicants regarding District rules and the potential need to obtain a District permit. Cities are also responsible for developing and implementing permit programs for projects that fall below the threshold for a District permit (e.g., projects less than 1 acre). If cities assume permitting responsibility from the District, those cities are responsible for implementing a permit program consistent with the District. Section 4.1.2.1 includes more information about the process for transferring District permitting authority to the cities.
4. **Maintenance of city stormwater management systems:** Cities are responsible for the inspection, maintenance, cleaning, repair, and reconstruction of their stormwater management systems (storm sewers, ponding areas, ditches, water level control structures, etc.) to keep them in good working order and prevent flooding and water quality problems. Such maintenance requirements are addressed in each city's NPDES MS4 stormwater permit (see Section 3.2.4.3) and the city's local water management plan.
5. **City official controls:** The cities' official controls shall be revised to include District standards for flood control, erosion and sediment control, and stormwater management. The District encourages the cities to revise their ordinances to be consistent with low-impact development principles.
6. **Wetlands management:** The District is the LGU responsible for administering the WCA for all the cities in the District except the City of Saint Paul. Other cities shall promptly refer permit applicants whose projects contain possible wetlands to the District to identify wetland management issues, review WCA requirements, and identify District wetland buffer requirements.
7. **Groundwater:** Member cities are responsible for developing, adopting, and implementing wellhead protection programs. Cities shall submit their wellhead protection plans to the District during the review process. Cities should coordinate with the District and consider potential for groundwater recharge when planning stormwater management projects.

Section 4—District Operations and Implementation

Section 4.0 of this Plan describes the District operations and implementation program. District operations described in Section 4.0 include:

- Administrative programs
- RWMWD permit program
- Best management practice (BMP) incentive program
- Public education and involvement (PIE)
- Information gathering, research, and studies
- Natural resources program
- Monitoring programs
- Groundwater management
- District facility maintenance

The District's ongoing operations, programs, and capital improvements are summarized in a 10-year implementation table (Table 4-1) are also described in this section. Generally, the District prioritizes projects using a three tier priority framework:

> **Tier 1** – Tier 1 projects and programs are considered the most relevant to the District goals and have the highest priority of implementation. In general, the RWMWD will assume 100% funding responsibility for Tier 1 projects and programs.
>
> **Tier 2** – Tier 2 projects and programs are placed at a priority lower than those in Tier 1, but remain critical to accomplishing the goals of the District. In general, the RWMWD will assume 100% funding responsibility for Tier 2 projects and programs.
>
> **Tier 3** – Tier 3 projects and programs generally contribute towards accomplishing District goals in a less direct manner than Tier 1 and Tier 2 projects, and are considered lower priority. Typically, the District will pursue Tier 3 projects only when funded in collaboration with other funding sources.

The three tier priority framework is a guideline that can be adjusted by the board as necessitated by specific circumstances. Factors that may impact the priority of a project may include availability of partners, outside funding support, coordination with other activities (e.g., redevelopment), and others.

White Bear Township
Dellwood
North Oaks
Grant
Shoreview
Snail Lake
Arden Hills
Mahtomedi
Vadnais Heights
Gem Lake
White Bear Lake
Birchwood Village
Willernie
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Pine Springs
Little Canada
Round Lake
Kohlman Lake
Gervais Lake
Casey Lake
Bennett Lake
Roseville
North Saint Paul
Lake Elmo
Maplewood
Keller Lake
Falcon Heights
Round Lake
Wakefield Lake
Oakdale
Lake Phalen
Beaver Lake
Saint Paul
Tanners Lake
Landfall
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Lilydale
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake
Woodbury
West Saint Paul
South Saint Paul
Mendota
Mendota Heights
Sunfish Lake
Inver Grove Heights
Eagan
Newport

Figure ES-1

GENERAL DISTRICT MAP
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 07:06 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure ES-1 - General District Map.mxd User: jrv









STRATEGIC OVERVIEW

2017-2026 WATERSHED MANAGEMENT PLAN

APPROVED BY
The Minnesota Board of
Water and Soil Resources
March 22, 2017

ADOPTED BY
The Ramsey-Washington
Metro Watershed District
Board of Managers
April 5, 2017

RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT









Strategic Overview

Ramsey-Washington Metro Watershed District 2017–2026 Watershed Management Plan

This plan was prepared for the Ramsey-Washington Metro Watershed District with assistance from:

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Introduction

The Ramsey-Washington Metro Watershed District (RWMWD or District) is a special-purpose unit of local government that manages water resources on a watershed basis. The 2017–2026 RWMWD Watershed Management Plan (Plan) is a 10-year plan that includes goals, actions, and measures in six primary areas—surface water quality, ecosystems, flood management, groundwater, citizen education and involvement, and organizational management. The Plan was prepared in accordance with Minnesota Statutes 103D and 103B.231 and Minnesota Rules 8410.

The Plan is composed of two main parts: a strategic overview and a resource and organizational assessment. This document, the strategic overview, is designed to reach a broad audience and provide them with an understanding of the District's past, present, and future approach to effective watershed management. The resource and organizational assessment provides more specific details of the District's resources (district-wide and watershed-based) and organizational management (e.g., District operations such as regulatory programs, local water management plans, and the District standards).



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RWMWD VISION

QUALITY WATER FOR QUALITY LIFE

Mission

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.

Core Principles

The Ramsey-Washington Metro Watershed District (RWMWD or District) will adhere to the following core set of principles that will guide their efforts to achieve the mission stated above.

The District will be:

- A leader and innovator in watershed management that integrates natural and built environments.
- An organization focused on high levels of performance and results.
- An organization that uses adaptive management, accurate information, and sound science to guide decision-making.
- A trusted and accountable steward of public resources and moneys.
- An active collaborator with a wide variety of public and private organizations.
- An important and reliable source of information, services, and projects.
- An effective advocate of watershed management principles and values.
- An organization that educates and inspires current and future stewards of the watershed.

Goals

Accomplishing the vision and mission of the District requires a focus on measurable goals. The District will pursue the following goals to ensure progress towards achieving its vision and mission:



1. **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.



2. **Achieve healthy ecosystems—**Manage water and related natural resources to create and preserve healthy ecosystems.



3. **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.



4. **Support sustainable groundwater—**Consider groundwater sustainability management and connections to surface waters in decisions and collaborate with others responsible for groundwater management and protection.

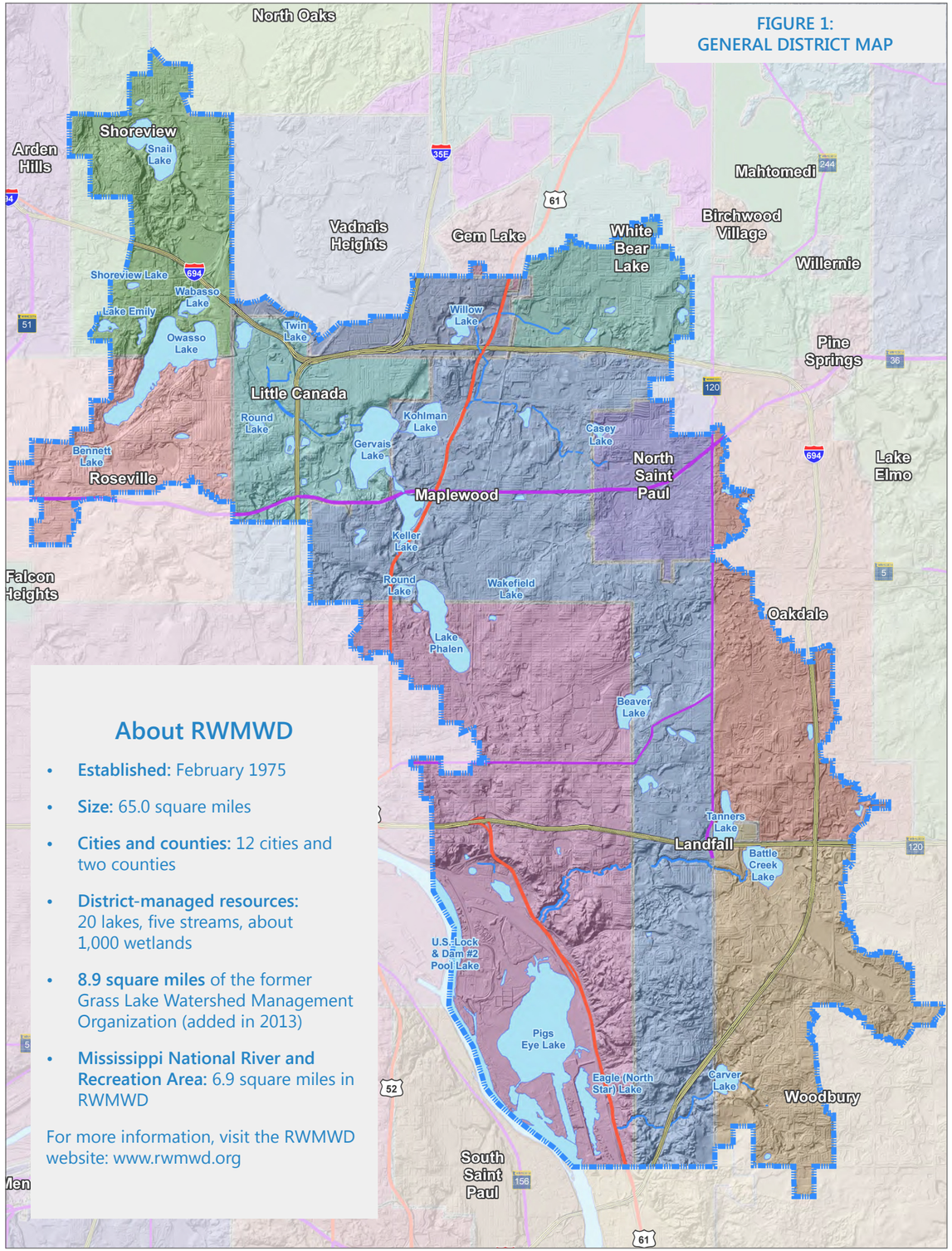


5. **Inform and empower communities—**Inform and empower communities to become partners in improving and protecting the watershed through their own efforts.



6. **Manage organization effectively—**Operate in a manner that achieves the District's mission while adhering to its core principles.

FIGURE 1:
GENERAL DISTRICT MAP



About RWMWD

- **Established:** February 1975
- **Size:** 65.0 square miles
- **Cities and counties:** 12 cities and two counties
- **District-managed resources:** 20 lakes, five streams, about 1,000 wetlands
- **8.9 square miles** of the former Grass Lake Watershed Management Organization (added in 2013)
- **Mississippi National River and Recreation Area:** 6.9 square miles in RWMWD

For more information, visit the RWMWD website: www.rwmwd.org

The District will maintain or improve surface water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits.

Accomplishments

Surface water quality has been the primary emphasis of the District, with many relevant studies, projects, and programs implemented over the past decade.

The District tracks water quality in lakes and streams through its Water Quality Monitoring Program. As of 2016, the annual program included the monitoring of 15 major lakes. The District has also been monitoring outlet flows from Battle Creek, Fish Creek, and the Beltline Interceptor since 1995. The District uses this water quality data to assess progress towards its goals and adjust its programs, as needed, to make the best use of available resources.

The District has also completed numerous lake studies to:

1. Characterize the stormwater runoff and pollutant loading to District lakes.
2. Identify the effects of land-use changes on the water resources.
3. Assist in determining realistic water quality targets for individual lakes.
4. Develop strategies to protect and improve water quality.

A more comprehensive list of the lake studies completed by the District is included in Section 1 of the Plan and includes several strategic lake management plans and other lake and watershed studies. Based on recommendations from these studies and other water quality analyses, the District has implemented numerous projects to maintain or improve the quality of its water resources.

Most recently, the District cooperated with the Minnesota Pollution Control Agency on a watershed restoration and protection strategy study. Completed in 2016, this study identifies strategies to restore water quality in impaired waters and protect waterbodies that are not impaired. At the same time, the District worked with the Minnesota Pollution Control Agency to complete total maximum daily load studies for Bennett Lake, Wakefield Lake, Battle Creek, and Fish Creek. The District also worked with the Minnesota Pollution Control Agency to complete a total maximum daily load study for Kohlman Lake in 2010. The actions identified in the watershed restoration and protection strategy and total maximum daily load studies are included among the implementation items in this Plan.

The District also protects water quality through its permitting program. The program regulates activities at construction sites to minimize erosion and sediment loss and requires a stormwater management plan that adheres to District standards and criteria for treating stormwater runoff. Through this program, the District has facilitated implementation of a number of best management practices which minimize the impacts of development on water quality.

The District also implements a cost-share program that provides technical resources and funding to cities, counties, businesses, and residents who install stormwater best management practices (BMPs).

The location of all permit, cost-share, and District capital improvement projects implemented since the District's inception is shown on Figure 2.

Challenges

Water quality is commonly defined by its physical, chemical, biological, and aesthetic (appearance and smell) characteristics, but it is more than a collection of metrics. Water quality may be used to describe a water's suitability for specific and diverse purposes (drinking water, recreation, aquatic life). Good water quality results in a waterbody fulfilling its intended uses in a sustainable manner.

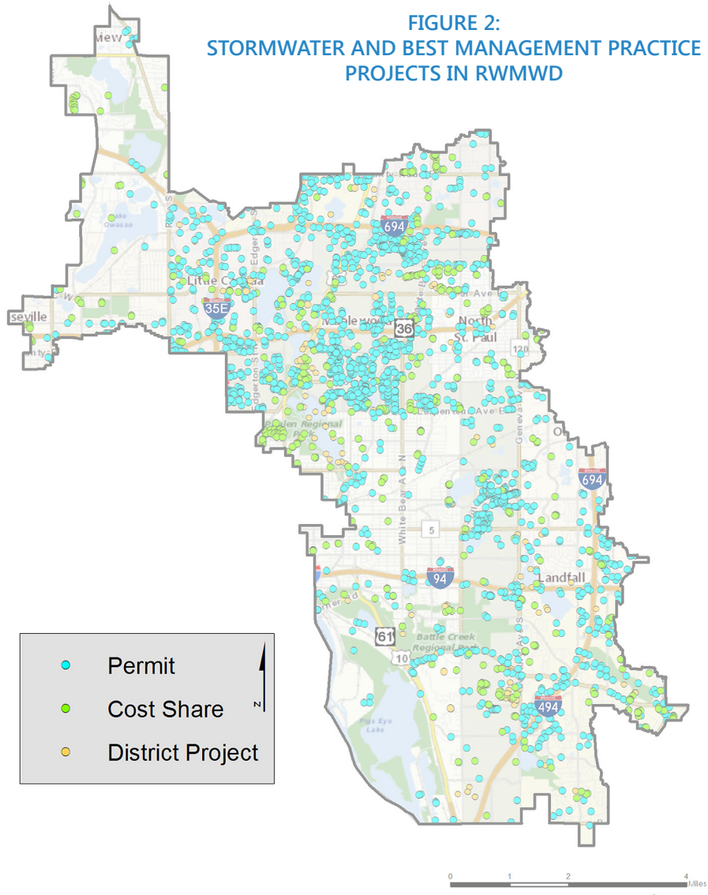
The lakes, ponds, streams, and wetlands in the RWMWD are important community assets, supplying recreational and aesthetic benefits, wildlife habitat, and fishery resources. The urban nature of the District makes it challenging to maintain high water quality, due to the extent of impervious surfaces, limited space for treatment, and sometimes long histories of pollutant loading. If water quality becomes degraded, a waterbody's intended uses may be impaired. If water quality is not maintained, the ecological function as well as the commercial and recreational value of our water resources will diminish and public health may be compromised. Several District waterbodies are classified as "impaired" by the Minnesota Pollution Control Agency because their intended uses are limited by excessive nutrients or other pollutants.

To address the water quality challenges facing the District, the board has prioritized the following as key areas to be addressed over the life of this Plan:

Research and implementation of innovative water quality practices— Due to the difficulty of removing phosphorus from stormwater runoff and surface waters, it will be necessary to explore innovative best management practices and treatment techniques. The District is giving special consideration to stormwater infiltration practices and alternative treatment options as they become known.

Monitoring and maintenance of District water quality improvement projects—To ensure lasting benefit from the many water quality improvement projects implemented by the District, periodic inspection and maintenance is necessary. Ongoing monitoring programs allow the District to assess the benefits of specific projects and programs and measure progress toward overall water quality goals.

FIGURE 2:
STORMWATER AND BEST MANAGEMENT PRACTICE PROJECTS IN RWMWD



Promotion of and support for residential and other private best management practices—Due to the developed nature of the RWMWD and the fact that stormwater runoff is discharged over a wide area, small-scale best management practices throughout the watershed provide an opportunity to have a significant cumulative benefit on water quality. Future water quality improvements will require the involvement and action of property owners. The District can encourage cities, counties, businesses, and residents to implement best management practices by providing education, technical resources, and funding. This emphasizes the need for a comprehensive watershed education program that reaches multiple target audiences with relevant educational messages.

Reversing the impact of development—The quantity of stormwater runoff and mass of pollutants it carries depends on the amount of impervious surface within the watershed. Reducing the amount of impervious surface will reduce the pollutant load to downstream waterbodies while potentially reducing the risk of flooding. Because the District is already fully developed, redevelopment is the primary opportunity to reduce impervious area. The District's permitting program is an opportunity to limit increases and promote reductions of impervious area.

A major deterrent in achieving quality surface water is the cost associated with implementing best management practices and other treatment technologies. In fully developed areas, improvements in water quality often require significant investments to retrofit existing public and private infrastructure and acquire land for best management practice implementation. Focusing on the issues described above, the District plans to accomplish its goals by maximizing the benefit from available resources.

The challenges of achieving water quality in an urban environment

Water quality is closely linked to current and past land use and conditions in the surrounding watershed. The water quality of a lake, pond, wetland, or stream depends on:

- How much runoff reaches the waterbody and the path the runoff takes (hydrology).
- How much groundwater reaches a waterbody (hydrogeology) and the pollutants carried by runoff and groundwater.
- Processes occurring within the waterbody and the soil-water interface.

Stormwater runoff can carry significant amounts of sediment, phosphorus, and other pollutants. As urbanization continues, the resulting land disturbance and additional impervious surfaces (e.g., parking lots, roofs, roads, and driveways) increase the amount of pollutants carried in stormwater runoff.

Water quality ponds and other best management practices that slow/detain the discharge of stormwater are effective in removing particulate phosphorus in runoff. Ponds and other detention practices, however, require significant land resources which may not be readily available. These best management practices are also relatively ineffective in removing soluble phosphorus, which continues to be problematic for several District lakes.

For examples of the innovative approaches the District uses to meet these challenges, read about the Maplewood Mall stormwater retrofit project.

Maplewood Mall stormwater retrofit

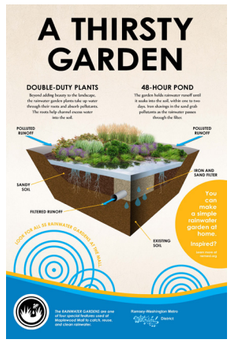
The Maplewood Mall stormwater retrofit project incorporates an array of best management practices to significantly reduce the amount of polluted stormwater runoff leaving the parking lot and entering downstream lakes.

In addition to rainwater gardens, porous paver crosswalks, a sand filter, and a cistern that captures mall roof runoff for irrigation, the system features more than a mile of rock trenches planted with 200 trees. These trees will remove up to 50 pounds of phosphorus annually. In addition, public art and educational components were incorporated to educate mall visitors about the benefits of treating stormwater.

The large-scale system captures and treats an average of 67 percent of the stormwater runoff from the 35-acre lot. By intercepting, filtering, and/or infiltrating the first inch of runoff, it removes an estimated 60 percent or more of the phosphorus that would otherwise flow into impaired Kohlman Lake.







A multi-faceted approach to stormwater management

Top: The cistern outside the Maplewood Mall entrance (top photo) captures runoff from the mall's roof, used for irrigation. The public art, seen behind the cistern, was incorporated to increase the project's aesthetics and facilitate community involvement.

Bottom: Left—Special tree trenches reduce the pollutants that enter Kohlman Lake from rainwater runoff. Right—Public education efforts included signage that explains the best management practices and how they work.

Action items

WQ1	Cooperate with the Minnesota Pollution Control Agency to complete future total maximum daily load studies, as necessary.
WQ2	Implement, or assist in implementing projects and/or programs recommended in total maximum daily load studies, watershed restoration and protection strategy studies, or other District studies.
WQ3	Assist local communities in implementing projects or other management actions resulting from the Minnesota Pollution Control Agency's Twin Cities Metro Chloride Project or future chloride total maximum daily load studies.
WQ4	Monitor lakes, streams, and watershed outlets to assess and evaluate long-term water quality trends.
WQ5	Assist local communities in meeting the water quality components of their National Pollutant Discharge Elimination System municipal separate storm sewer system (MS4) permit requirements.
WQ6	Assist the Minnesota Pollution Control Agency, as appropriate, with issues related to industrial stormwater management permits issued within the District.
WQ7	Implement and maintain water quality monitoring and research to assess performance of District projects and identify ways to further improve water quality.
WQ8	Support and promote research, monitoring, or other efforts to achieve a better understanding of factors influencing the quality of the water resources in the District and seek opportunities to incorporate this information into the implementation of water quality projects.
WQ9	Maintain District water quality improvement projects and consider opportunities to support the maintenance activities of others.
WQ10	Expand District collaboration efforts with cities and counties to assist in the implementation of appropriate technologies and maintenance practices for improving water quality.
WQ11	Expand the use of innovative water quality improvement designs, products, equipment, and methods as necessary to address sites with limited land area for conventional treatment techniques.
WQ12	Implement the District's permitting program.
WQ13	Encourage and provide technical assistance to individuals to implement water quality improvement practices at their homes and businesses and in public places.
WQ14	Continue the District's cost-share program to assist citizens, institutions, and businesses in implementing water quality improvement projects on their properties.
WQ15	Collaborate with local entities to reduce barriers to green infrastructure and alternative stormwater infrastructure design (minimum street widths, allowable pavement materials, etc.).
WQ16	Emphasize and promote pollution prevention throughout the District through education of stakeholders.
WQ17	Reduce stormwater runoff from impervious surfaces where opportunities arise (e.g., infiltration, impervious surface reduction, stormwater capture and use).
WQ18	Implement retrofit water quality improvement projects.
WQ19	Consider long-term changes to precipitation and hydrology when planning water quality projects or infrastructure modifications.

Signs of success

- Current and historical water quality data informs water resource management decisions.
- Projects and programs maintain or improve water resources, as confirmed by water quality trends.
- Water quality improvement projects are functional, properly maintained, and monitored for cost-effectiveness and long-term performance.
- Projects and programs work to remove impaired water bodies from the Minnesota Pollution Control Agency's list of impaired waters.
- Water resources are managed according to their unique characteristics and the goals established for them.
- Permitted projects are implemented following rules and standards, as demonstrated by improved contractor performance and decreased need for inspections and enforcement actions.
- Projects and programs incorporate new methods and innovative technology resulting from watershed management research.
- Landowners implement BMPs to improve water quality.

The District will manage water and related natural resources to create and preserve healthy ecosystems.

Accomplishments

The District has developed and implemented a natural resources program that creates and sustains healthy urban ecosystems. The overall program approach integrates the creation, preservation, and restoration of aquatic, wetland, and associated upland habitats with flood control, water quality protection, and other projects. The District has also completed several large-scale ecological restoration projects and actively manages a variety of urban habitats for fish and wildlife. It is committed to maintaining these areas over the long-term and providing opportunities for residents to learn about and enjoy them, and build personal connections. The locations of many of these ecological restoration projects are shown in Figure 2.

The District protects natural resources through its permitting program. With the exception of the City of Saint Paul, the District is responsible for administering the Wetland Conservation Act within the District boundaries. The Wetland Conservation Act and the District's permitting programs limit alterations to wetlands and require measures to protect these areas and associated ecosystems (e.g., vegetated buffers).

The District has implemented several projects and monitoring programs to characterize the current condition of ecosystems, addressing:

- Wetland inventory, assessment, and classification.
- Shore buffers, natural areas, and lake aquatic plant communities.
- Aquatic invasive species.

Data collected through these projects and programs are used to assess ecosystem health, track changes in environmental conditions, and help identify ongoing management tasks. Wetland data has been used in conjunction with District wetland buffer protection policies and city permitting to protect wetland habitat. Aquatic plant data has been used to develop and implement management plans addressing invasive species such as curlyleaf pondweed and Eurasian watermilfoil.

The District has developed successful partnerships with multiple stakeholders to facilitate healthy ecosystems. Collaborative efforts include:

- Encouraging land stewardship by administering the Landscape Ecology Awards Program (LEAP), which recognizes landowners in the watershed for implementing good land and water management practices (see page 16).
- Involving local school groups in its natural resources projects—from classroom exercises to hands-on, real-life field work (see page 17).
- Collaborating with university researchers on projects related to ecological restoration, biological monitoring, and invasive species management.
- Partnering with the University of Minnesota (since 2009) to study the presence and movement of invasive carp within the watershed and develop and implement practices to mitigate their impact (see page 9).

The District supports natural resource projects through cost-sharing and grant opportunities. Since its inception in 1998, the natural resources program has secured close to one million dollars in grant funds to conduct ecological restoration and research projects.

Challenges

Clean water and healthy wetland, shorelands, and associated upland ecosystems are critical components of the natural environment. These areas support an immense variety of microbe, plant, insect, amphibian, reptile, bird, fish, and mammal species and provide multiple benefits, including recreational and aesthetic benefits, flood risk reduction, increased biodiversity and wildlife habitat, sources for groundwater recharge, and more.

Healthy water, wetland, and associated upland ecosystems are defined by more than water quality; they are also defined by the characteristics of the plants and animals in and near bodies of water. Managing wetland, shoreland, and associated upland areas with consideration for their ecological functions is necessary to prevent degradation of these resources.

High quality natural habitats associated with the District's surface waters are relatively uncommon. There are numerous challenges when it comes to managing and restoring these natural systems in an urban watershed, some of which include:

- Limited land available for restoration and the complicated land ownership issues.
- Partner involvement and a commitment to long-term maintenance.
- The threat of invasive plant and animal species.
- Public perception—communicating the value of natural areas.
- Physical disturbance from human use (loving restoration areas "to death").
- Urban watershed stressors—extreme hydrological fluctuations, disturbed soils, erosion, elevated nutrient inputs, and legacy nutrients in aquatic systems.

To address the challenges facing water, wetland, and associated upland ecosystems in the District, the board has prioritized the following key areas to be addressed over the life of this Plan:

Partnering with agencies, cities, organizations, and residents on ecological restoration—The District does not own large tracts of land for preservation and management. Thus, forming partnerships with cities, counties, state agencies, and residents is critical to the ecological restoration program. A high priority is given to projects that are ecologically connected, visible, and provide recreational and educational value. We have a commitment to share technical knowledge with our local partners. We have a long history of securing state grant funds, and we will continue to pursue outside funding for large restoration efforts. A substantial portion of lake shoreland is in private ownership. We will support restoration of this critical habitat by offering cost-share opportunities and technical services to shoreland owners. We have a commitment to long-term maintenance of restored natural areas, and will communicate the importance of this approach to our partners.

Residents are essential District partners. The District will continue to incorporate public involvement in its restoration and natural resource management efforts. This includes providing opportunities to work in the field—preparing areas, installing native plants, or maintaining and monitoring ecological restoration sites. Through these efforts, the District will build community involvement and communicate the critical importance of natural areas in the watershed on many levels.



Keller Golf Course: An urban nature preserve

Keller Golf Course is a beautiful public course located just to the east of Lake Keller. It has played host to two national PGA championships, nine LPGA tournaments, and 38 Saint Paul Open competitions. The course has been a favorite of thousands of local golfers for nearly a century.

In 1996, Superintendent Paul Diegnau had a vision to minimize the golf course's impact on the environment. He has had an ongoing commitment to preserve the top-flight golf experience while establishing an "urban nature preserve" on the property. The no-play areas on this course are part of the natural corridor of the Phalen Chain of Lakes. This land provides critical habitat and improves water infiltration, which means less stormwater runoff to the lakes. In partnership with the District, Diegnau has received grant funding over the years to restore pond and wetland buffer areas, prairie, and woodlands. Today, the course boasts 26 acres of high quality no-play area, the greatest quantity of any course in the Twin Cities. A multitude of educational signs throughout the course share conservation messages. The golf experience remains exceptional, while innovative management has provided substantial benefits to the region's water and natural resources

Monitor and manage aquatic invasive plant and animal species—The District will actively manage invasive plant and animal species in waters where there is a benefit to water quality, ecosystems, and recreation. We will conduct and support monitoring programs that will detect new infestations, gauge management activities, and be used to develop new control programs. We will look for opportunities to support university research. We will partner with counties and the Department of Natural Resources in supporting a regional aquatic invasive species program which includes lake and boat

ramp monitoring, prevention plans, management, and education.

Control of shoreline erosion— Limiting shoreline erosion in wetlands, lakes, and streams is critical to preserving the ecological functions and environmental benefits of downstream waterbodies. The presence of vegetated buffers or other best management practices reduces the potential for shoreline erosion by obstructing the flow of runoff, reducing runoff velocities, and allowing infiltration. Leaf litter from vegetation has the added benefit of increasing the organic content of the soil and increasing adsorption and infiltration. Vegetation also scatters sunlight and provides shade—reducing water temperature in the summer, limiting nuisance algae growth, and reducing the release of nutrients from the sediment. Finding space for buffers in developed areas is often difficult; however, redevelopment provides a good opportunity to plan for them.

Recognize natural resource elements in all District projects— To achieve healthy ecosystems, the District must consider all opportunities to have a positive impact on natural resources. This includes evaluating the potential impact of all District projects and programs on the natural resources with which they coexist. The District will continue to looks for ways to optimize its actions to achieve natural resource benefits while accomplishing its other goals.

Monitoring and managing invasive species

Invasive aquatic animals, such as carp, zebra mussels, and spiny water fleas, can negatively impact water quality and ecological health. The common carp is an invasive benthivorous (bottom-feeding) fish found in the District and most metro-area lakes. Feeding on the lake's bottom, these fish stir up sediment and uproot beneficial aquatic plants, causing the water to become turbid or cloudy. This behavior also releases phosphorus from the sediment, leading to increased algal blooms and a decline in native aquatic plant communities.

In 2009, the District partnered with the University of Minnesota's Sorensen Lab on an applied research project to investigate carp in the Phalen Chain of Lakes. Through research and management the District has:

- Reduced the adult carp biomass by over 60 percent—from 130 pounds per acre to 48 pounds per acre (average biomass for Kohlman, Gervais, and Keller Lakes). Ninety pounds per acre is the threshold where carp negatively impact water quality.
- Eliminated carp in connected shallow lakes that were key spawning areas.
- Installed a carp barrier in Kohlman Creek to block carp from moving into spawning areas.

The District will continue to monitor and actively manage carp in the Phalen Chain and investigate opportunities for carp reduction in other lake systems.



Through summer box-netting, RWMWD has been able to remove 500 carp from the Phalen Chain of Lakes.

Creating critical pollinator habitat



In addition to cleaning and infiltrating water, high quality natural areas with a variety of native plants provide important pollinator habitat, especially in urban watersheds. Significant declines in the populations of pollinating insects have been widely reported over the last decade. Suspected stressors are disease, use of pesticides, habitat loss, and poor nutrition due to limited quantity and quality of appropriate flowering plants.

Ecological restoration areas in the District provide habitat that supports local animal pollinators throughout the seasons. A diversity of native plants provides food and shelter for bees, butterflies, moths, and hummingbirds. These species, which provide nectar, pollen, and other nutrition though the growing season, need to be considered when planning and managing restored native plant communities. The District must also consider pollinator ecology when developing long-term management plans that include prescribed burns and mowing.

During the summer, flowering plants and busy animal pollinators add enjoyment for visitors to restored areas. During the winter months, dormant standing vegetation offers important opportunities for nesting and hibernation.



Over the last 15 years, the District and numerous public and private partners have succeeded in restoring over 40 acres of critical park land in the Phalen Chain of Lakes corridor—once home to eroding lakeshore, weedy reed canary grass thickets, and noxious buckthorn and smooth brome slopes.

Action items

EC1	Implement the District's wetland permitting program.
EC2	Implement the District's lake aquatic plant monitoring program and assess data for trends.
EC3	Lead ecological restoration projects to improve water resources and associated upland habitat.
EC4	Monitor and maintain District restoration sites and natural areas.
EC5	Collaboratively manage invasive species that threaten water resources and associated upland habitats.
EC6	Coordinate with public and private organizations that are responsible for restoration and management of natural areas.
EC7	Provide technical services to organizations (e.g., cities, counties) that restore and manage natural areas.
EC8	Provide opportunities for schools, civic groups, and the Citizen Advisory Committee to become involved in restoration projects.
EC9	Inform watershed residents and stakeholders about ecological preservation and best management practices.
EC10	Publish and share information on water resources management and ecological restoration.

Signs of success

- The quantity of ecologically diverse aquatic, wetland, and associated upland habitats is increased.
- Priority natural areas are preserved, improved, and maintained.
- Wetlands are preserved and protected, as measured by their net area (no net loss) and the continued viability of their functions and value.
- Invasive species populations are reduced to lessen or eliminate their adverse impacts on water quality and associated habitats.
- Monitoring and research data are used to inform District projects and programs, and District data are shared to contribute to the science of ecological restoration.
- The District collaborates with public and private organizations to promote, implement, and maintain ecological restoration projects.
- Public awareness of accessible natural areas in the watershed is increased through partnerships.

The District will reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

Accomplishments

The District has performed many studies and projects to address identified flooding problems within its boundaries. In addition, the District has collaborated with developers and local municipalities to address flooding issues. Many of these projects have been multipurpose in nature—providing not only flood protection, but water quality treatment, habitat improvement, and erosion control. They have reduced runoff volume (via infiltration), provided storage, and/or controlled stormwater discharge rates. These projects have also resulted in the removal of numerous homes and businesses from the floodplain. Notable flood protection projects and their locations include:

- Battle Creek Project 1—Saint Paul and Maplewood
- Battle Creek Lake Area Flood Protection—Woodbury
- Phalen/Keller Outlet Project—Saint Paul
- Target Pond—North Saint Paul
- Owasso Basin—Little Canada
- Beltline Interceptor Rehabilitation—Saint Paul
- Hoyt/Montana Project—Saint Paul
- Tanners Lake Emergency Response Plan—Oakdale
- Gervais Lake Emergency Response Plan (Little Canada)
- Battle Creek Lake Emergency Response Plan (Woodbury)
- McKnight Basin Emergency Response Plan (Maplewood)



In 1978, Battle Creek Park was closed to the public due to severe erosion and dangerous flash flooding. This ongoing problem became a significant focus for the District for nearly a decade. Successful flood management of Battle Creek required work on nearly 3 miles of creek and included installation of sheet pile drop structures, construction of a major flood detention basin, and installation of pipe to route flood flows underground.

The District continues to manage the risk of flooding through permitting and education programs. Projects that meet specific criteria, including those involving alteration to wetlands or floodplain areas, must be permitted. District rules include requirements for controlling the rate and volume of runoff from development sites; this reduces the strain on existing stormwater infrastructure. The rules also establish minimum building elevation requirements for development and redevelopment sites to protect homes and businesses from flooding. Floodplain areas are protected by ensuring 100-year flood storage volumes are maintained (i.e., no net loss of floodplain).

The District further manages the risk of flooding by promoting stormwater best management practices that limit runoff volume, including infiltration and water reuse. Encouraging these practices through its education program and best management practice cost-share program has the added benefit of reducing the potential pollutant load to downstream waterbodies.

In 2015, the District performed District-wide hydrologic and hydraulic modeling to assess the impact of recently updated precipitation data on 100-year flood elevations (see Section 1 of the Plan). The modeling results suggest increased 100-year flood levels and peak flow rates in many locations. The District will use this information in the design of future projects and programs.

Challenges

Both natural and developed environments are at risk of flooding. However, development can significantly increase flood risk by reducing the infiltration capacity of soils and increasing the amount of impervious area. These changes in the landscape increase the volume and rate of runoff, resulting in higher flows and higher water levels in downstream conveyances and basins. The risk of flooding may be further increased by future climate trends. According to the National Oceanic and Atmospheric Administration (NOAA) 2013 report on regional climate trends, storm amounts and intensities in the Midwest are trending upwards (see Section 1 of the Plan). Higher intensity precipitation events are more likely to overwhelm the capacity of the land to infiltrate and attenuate runoff.

As development and redevelopment continues throughout the RWMWD, routing stormwater runoff to manage the risk of flooding remains a challenge. To address these challenges, the board has prioritized the following key areas to be addressed over the life of this Plan:

Reduction and management of stormwater runoff volume— Developed watersheds produce significantly more runoff than natural, undeveloped areas. This can result in flooding along stormwater conveyances or in downstream waterbodies. Even when feasible, increasing the capacity or storage of existing infrastructure is expensive and may simply shift flooding issues farther downstream. Reducing stormwater runoff volume where it is generated via infiltration, water reuse, or other best management practices is a more practical solution.

Identification, assessment, and mitigation of potential flooding problems—Though it may be a challenge to balance flood control efforts with other priorities, it will be necessary for the District to continue committing resources to the identification and management of flooding issues.

Infrastructure improvements to increase stormwater management capacity—Recent updates in regional precipitation data (see Section 1 of the Plan) project significant increases in the 100-year and other "design storm" events (events used to size infrastructure). The new data suggests that some existing infrastructure may be undersized for current or future estimated conditions. Increasing the capacity of existing stormwater management devices and planning for new infrastructure to accommodate future climate conditions poses a challenge for the District and its cities.

Action items

FL1	Maintain District flood storage facilities and storm sewer systems.
FL2	Implement and enforce the District permitting program, including volume control and flood-risk-management criteria.
FL3	Cooperate with appropriate stakeholders to identify, assess, and address potential flooding problems in the District.
FL4	Monitor lake levels within the RWMWD.
FL5	Implement flood emergency response plans for homes and businesses where a complete structural solution is not feasible or cost-effective.
FL6	Collaborate with cities to enforce minimum building elevations.
FL7	Update the District's 100-year flood levels and other critical hydraulic characteristics to reflect the best available information.
FL8	Reduce stormwater runoff volumes during development, redevelopment, or retrofit opportunities.
FL9	Incorporate anticipated precipitation and hydrology changes when planning flood control projects or infrastructure modifications.
FL10	Manage public ditches in a manner consistent with their current use as primary conveyors.

Signs of success

- Public and private infrastructure susceptible to flooding is identified.
- Collaboration with public and private organizations mitigates flood risk.
- Flood emergency response plans are implemented.
- The number of private and public structures within the established floodplain are reduced (where necessary) to minimize flood damage.
- Flood-control-prevention facilities and related storm sewer systems function as intended.
- Sound science and historical data are used to define flood elevation (100-year) and floodplain extent and to inform flood risk mitigation decisions.

The District will consider groundwater sustainability management and connections to surface waters in decisions and collaborate with others responsible for groundwater management and protection.

Accomplishments

Throughout its existence, the District has collaborated with other entities responsible for the management and protection of groundwater resources. From 1990 through 2002, the District implemented a cost-share program that provided applicants with 50 percent of the funds required to seal unused and abandoned wells. The District also assisted Ramsey County and several cities in sealing large, abandoned deep-aquifer wells.

The District participated in the most recent Ramsey County (2010) and Washington County (2015) groundwater planning and provided technical assistance to its cities during the development of their municipal wellhead protection plans. From 2013 to 2015, the District also cooperated with the Minnesota Department of Natural Resources in developing the North and East Metro Groundwater Management Area Plan. This plan will guide efforts to sustainably manage groundwater appropriations. The District is open to future collaborative efforts to assure the safety of area groundwater resources.

The District has also conducted, funded, and/or participated in numerous groundwater studies. In 2005 the District helped fund the Washington County and Washington Conservation District joint study, *Integrating Groundwater and Surface Water Management: Southern Washington County.* More recently, the District performed a *Groundwater/Surface Water Interaction Study* (Barr 2015), which considered local geology and soils, depth to groundwater, proximity to surface waters, and volume. The study also identified areas for focused groundwater recharge via stormwater infiltration.

Challenges

Many District residents obtain their drinking water from groundwater. This makes it especially important to ensure that these aquifers are protected from contamination and provide adequate supplies. Overuse and contamination of groundwater can impact human health and have negative effects on highly valued resources such as streams, wetlands, groundwater-connected lakes, and fish, wildlife, and plant communities. Well data collected by the Minnesota Department of Natural Resources, the United States Geological Survey, and others have raised concern about the long-term sustainable use of groundwater across the state, including the RWMWD.

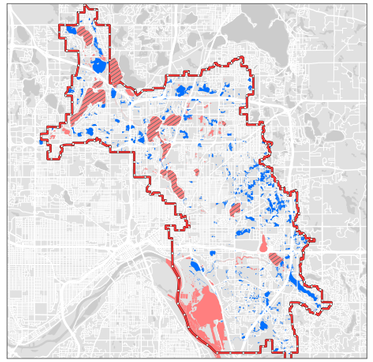
To address the District's groundwater management challenges, the board has prioritized the following key areas to be addressed over the life of this Plan:

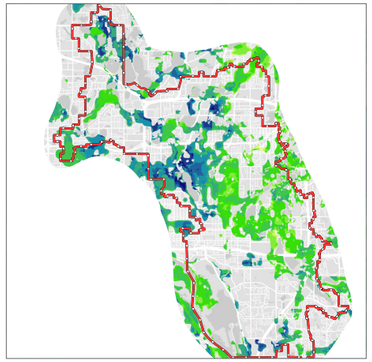
Support of research to better define relationships between surface water and groundwater quality—Groundwater quality and quantity is linked to the above-ground environment. Quality is dependent on the infiltration of surface water/rainfall through the soil. Soil type, land cover, and other factors influence groundwater recharge and, ultimately, groundwater supply. Conversely, the quality of groundwater may impact the quality of water in the waterbodies it feeds. Understanding the types and extents of surface water-groundwater interactions is critical to evaluating the impacts of proposed projects and actions in the RWMWD.

Identification of sensitive areas where infiltration should be limited—As the District increasingly promotes the use of infiltration basins as a best management practice to reduce the volume of stormwater runoff and pollutant load, it is important to evaluate the potential impacts of infiltration on the quality of groundwater. Determining whether proposed infiltration basins could contribute pollutants to the groundwater is a challenge since available information on the migration of pollutants into shallow groundwater and subsequent implications is limited. Several cities in the watershed have identified vulnerable groundwater recharge areas in their wellhead protection plans. The District needs to be aware of these designated areas and consult with cities when making stormwater management decisions that may affect groundwater supplies.

Implementation of programs to control/limit potential groundwater contaminants—Groundwater can be contaminated by commercial and industrial waste disposal, landfills, leaking underground storage tanks, salt and other road chemical applications, non-functioning subsurface sewage treatment systems, and other sources. With adequate knowledge of potential contaminant sources and impacts, the District may develop and prioritize programs or projects to address these contaminants.

Collaboration with other entities to ensure the sustainability of groundwater resources—Cities, counties, and state agencies are assigned various groundwater protection and management roles, including preparation of wellhead protection and groundwater management plans and data collection. The role of watershed management organizations in protecting and managing groundwater resources is not clearly defined by statute. This has made it challenging to manage stakeholder expectations regarding the District's level of involvement in groundwater-related activities. Further definition of the District's role and responsibilities will contribute to more effective management efforts.





In 2015, the RWMWD completed a groundwater-surface water interaction study to identify areas that are well-suited for targeted infiltration projects. These projects would help recharge groundwater aquifers—benefitting surface waters and drinking water supplies. The figure above (left) shows waterbodies that are likely vulnerable to changes in groundwater level (pink areas are particularly vulnerable, blue less so). The figure above (right) shows District areas that are well-suited for targeted infiltration (the "bluer" areas).

Signs of success

- The relationship between priority surface waters and groundwater resources is increasingly understood.
- Collaboration with cities, counties, and other agencies contributes to the effective management and protection of groundwater.
- Programs and projects support sustainable groundwater quantity and quality.

Action items

GW1	Review implementation of the Ramsey County and Washington County groundwater plans and participate in collaborative efforts to promote the quality and quantity of groundwater resources within the RWMWD.
GW2	Study the connection between surface water and groundwater throughout the District.
GW3	Collaborate with local and state agencies to: • Gain a better understanding of groundwater-surface water interaction and develop management strategies that address the protection of both resources. • Identify data gaps and work to fill those gaps through collection of groundwater-level data, surface water data, research, or other methods. • Identify areas of potential vulnerability. • Develop and utilize tools to assess the impacts of groundwater use on surface water and groundwater (e.g., refinement of the Metro groundwater model, better synchronization of surface water and groundwater models, etc.). • Identify sensitive groundwater areas where infiltration should be limited.
GW4	Use available information and guidance to evaluate potential impacts of stormwater infiltration best management practices on groundwater and make changes to the District's infiltration standards and programming, as appropriate.
GW5	Maintain an inventory of infiltration projects that can be shared with agencies that govern groundwater resources.
GW6	Cooperate with Ramsey and Washington Counties to promote sealing of abandoned wells.
GW7	Review updated city wellhead protection plans.
GW8	Participate in local and state agency groundwater permitting and planning programs, as necessary to protect District water resources.
GW9	Research and identify the impact of District infiltration projects on regional aquifer recharge to guide future actions.
GW10	Inform residents, city staff, and other stakeholders about topics key to supporting sustainable groundwater (e.g., groundwater-surface water interaction, impacts of withdrawal, conservation practices).

The District will inform and empower communities to become partners in improving and protecting the watershed through their own efforts.

Accomplishments

Engaged, cooperative stakeholders support a water management organization's ability to achieve its mission. Recognizing this, the RWMWD established a public involvement and education (PIE) program. The mission of the PIE program is to create sustainable networks of watershed stewards to help the District inform and empower communities to engage in their own efforts to improve and protect the watershed. The RWMWD has established PIE program activities, methods, and tracking mechanisms to ensure that appropriate, relevant education messages reach multiple target audiences. The District periodically updates its messages and methods to maximize its effect.

The District advances its PIE mission and goal by:

- Frequently interacting with cities—providing support for permit review and compliance and hosting a monthly meeting with city and county public works staff and engineers and planners regarding best management practices and stormwater infrastructure maintenance.
- Educating and informing various stakeholder communities by publishing information via the District website, blog, newsletter, social media, and hosting workshops.
- Interacting with District communities including residents, schools, faith-based organizations, homeowner associations, and businesses to provide watershed education on rain gardens and other best management practices, sustainable landscaping, winter maintenance, aquatic invasive species, habitat restoration, water conservation and groundwater protection, and a variety of other topics. District staff engage up to 20 schools annually, develop lesson plans, lead tours, organize the annual WaterFest celebration, and support classes with service learning projects.
- Coordinating a robust collaboration among Master Gardener, Master Naturalist, and Master Water Steward volunteers to assist in a variety of watershed initiatives, including BMP education and project implementation and natural resources habitat and shoreline restoration projects.
- Encouraging landowner participation in protecting local water resources by administering the Landscape Ecology Awards Program (see sidebar at right).
- Implementing a best management practice cost-share program. Since 2006 this cost-share program has provided technical resources and funding to watershed residents, faith-based organizations, and businesses to implement over 300 projects using best management practices.



The Landscape Ecology Awards Program (LEAP) team, which includes nine volunteers, identifies landowners who model sound management practices that preserve and improve the District's water quality and natural resources (see sidebar at right).

Through this combination of efforts, the District has leveraged its resources to create an increasingly self-sustaining program. The intent is for individuals, schools, faith–based organizations, and businesses to take what they have learned through District programs and educate others within their own communities. As K–12 schools, community colleges, and neighborhood groups adopt watershed-friendly practices and, subsequently, educate more people, the District gains a sustainable community of watershed stewards. In this spirit, all staff members are educators and ambassadors for the District. The District office itself is an educational tool—designed to function as a best management practice demonstration site and education center.

The District extends its education reach beyond its boundaries by participating in several collaborations including Metro WaterShed Partners and Blue Thumb. These groups develop collaborative watershed education outreach initiatives, exhibits, brochures, communication/media campaigns, advertisement, and websites. The District has also collaborated with other metro watersheds on strategic communication efforts and with the University of Minnesota on a community capacity study to understand and remove obstacles that prevent the realization of District goals.

Challenges

Partners and other stakeholders (e.g., residents) play an important role in the District's pursuit of its vision. For example, informed and involved citizens may choose to take action in their neighborhoods and on their properties to improve the quality of stormwater runoff. Conversely, public opposition to projects or programs can prevent their implementation or limit their effectiveness.

To address the challenges to fostering informed and empowered communities, the board has prioritized the following key areas to be addressed over the life of this Plan:

Support for residents, institutions, and businesses to create shared watershed stewardship efforts— Community support and participation can greatly increase the return on investment from District programs and projects. Implementation of modest stormwater best management practices throughout a community can have a cumulative positive effect on water resources. However, to affect positive change in the watershed, communities must be provided with the knowledge, resources, and inspiration to do so. The District's education program must continue to provide this support (e.g., through the best management practice cost-share program).

Education for city staff, advisory commissions, and public works departments—Cities are responsible for maintaining their storm sewer systems (MS4 permits) and serve various other water resource management roles (e.g., maintaining trails or other recreational facilities). The District is in a position to assist cities in fulfilling these roles. Such collaboration between the cities and the District may reduce redundancies and maximize limited municipal resources.

Expanded awareness of District programs—Increasing the visibility of the District and its accomplishments will help expand its influence on public behavior, increase the number of volunteers and other partners, and foster a community of watershed stewards.

Education efforts targeted and tailored to specific audiences—To develop a shared vision of watershed stewardship, the District must connect with a broad range of audiences. However, stakeholders span a wide range of ages, have different educational and cultural backgrounds, and may have contrasting water resource priorities. It will be a challenge to reach the most relevant audiences in ways that encourage them to learn about and adopt behaviors that positively impact water resources.

LEAP program

The Landscape Ecology Awards Program (LEAP) recognizes owners of private, public, and commercial properties within the RWMWD that use best management practices to preserve and improve water quality and natural resources. These practices include the use of native plants in landscaping, rain gardens, rain barrels, limited use of fertilizers and pesticides, and vegetated buffers around lakes, ponds, and wetlands.

Since the inception of the LEAP program in 2002, 83 sites have been recognized, including 64 private residences, four schools, four businesses, two churches, and nine government entities.



RWMWD in the schools

Each year over 800 students and teachers in the RWMWD get involved in watershed-based programs and projects. Through their participation, students engage in the natural world, gain awareness and understanding of issues in the watershed, and make meaningful contributions toward the improvement of water quality and habitats in their neighborhoods.

Photo (top): Fifth-grade classes at L'Etoile Du Nord French Immersion School participated in a service learning project, using spray paint to stencil the message "Keep 'em Clean/ Drains to River" next to 100 storm drains.

Photos (bottom): Eighth-grade students from Battle Creek Middle School held their science class at the creek, monitoring water quality parameters and collecting macroinvertebrate samples.









WaterFest

The District held its first WaterFest in 2000 to promote connections between residents and the natural community. The free event, which attracts more than 4,500 participants, offers outdoor entertainment and hands-on educational opportunities. It creates awareness of the District, its programs, and the resources it protects.

WaterFest is a collaborative effort, supported by area cities, counties, conservation districts, non-profits, and local businesses.

Action items

IE1	Use the District's best management practice programs and participants to increase public awareness, visibility, and interest in the District and its efforts and positively influence the actions of others.
IE2	Recruit and engage volunteers in District projects and programs (including restoration activities, best management practice implementation, aquatic invasive species management, and others).
IE3	Develop and support educational programs and resources that will inform residents and other stakeholders about how individuals can be responsible stewards of the watershed through their own actions.
IE4	Implement tours, workshops, and other events to increase awareness of watershed issues.
IE5	Collaborate with cities, watershed management organizations, and other stakeholders to develop and implement shared communication and messaging strategies.
IE6	Cooperate with city staff and other MS4 permittees to provide ongoing education regarding stormwater best management practices and other topics relevant to MS4 permit compliance.
IE7	Integrate the District's education efforts into all projects and programs.
IE8	Evaluate the District's education program annually and update the program, as necessary, to address emerging issues and use current science, available resources, and communication methods.
IE9	Tailor information content and delivery methods to appropriate audiences and intended outcomes.
IE10	Implement the District's communication plan, using various media (e.g., press releases, social media, blog) and keeping the District's key messaging items current (e.g., logo, website).
IE11	Implement a K–12 school program that empowers youth and educators to take action to address watershed issues in cooperation with the District and community partners.
IE12	Build partnerships with community involvement groups, college classrooms, and other stakeholder groups to recruit volunteers and increase community participation in watershed activities.
IE13	Hold events (e.g., WaterFest) to celebrate community connections and participation, showcase partner accomplishments, and educate youth, families, and residents about clean water.
IE14	Work with cities, neighborhoods, and other stakeholders to promote understanding and acceptance of green infrastructure and alternative stormwater management practices.
IE15	Support a Citizens Advisory Commission and engage the group in a meaningful watershed management role.
IE16	Develop a program to incorporate public art into District programs and projects.
IE17	Coordinate with cities and other entities to accommodate additional benefits (e.g., recreation access, aesthetic improvements) to District projects as opportunities arise.

Signs of success

- Cities are active partners in water resource management through project collaboration, program support, application of best management practices, and promotion of public education about watershed protection and improvement measures.
- Residents, neighborhoods, and other community stakeholders increasingly participate in District projects and programs.
- The District's school and community education programs contribute to educating young citizens about watershed issues.
- District events continue to expand their audience, public participation, and partner involvement.
- The Citizen Advisory Commission is an active and effective volunteer advisory group.
- Community awareness of the District and its role in water resource management is increased among watershed residents and stakeholders through the expanded use of communication channels.

The District will operate in a manner that achieves its mission while adhering to its core principles.

Accomplishments

The District is governed by a five-member board of managers. Four managers are appointed by the Ramsey County Board and one by the Washington County Board. The long average tenure of its board members (12 years) is an indicator of the overall health of the District as an organization. The current board members have served on the board from one to 30 years. The board continues to provide clear leadership for the District by focusing on the strategic direction of the organization and its responsibility to manage water and related resources.

Since its creation in 1975, the organization has seen significant growth in its staff. After relying solely on consulting staff from 1975 to 1988, the District hired its first administrator in 1989. As of 2016, the District has 12 full-time staff and employs several seasonal interns. The District strives to provide a work environment and professional experience that attracts and retains high-quality natural resource and administrative personnel. The District offers a competitive salary schedule and benefits program. The low turnover rate among the District staff is one indicator of effective organizational management, which increases operational efficiency.

Though it has developed an ambitious implementation program, the District continues to maintain a balanced budget, with approximately $6,500,000 in expenditures in 2015. Most of the District's funds come from taxpayers (either directly through the District's ad valorem levy, or indirectly through government agency grants). The District will continue to demonstrate that it is cost-conscious and responsible with public dollars. This includes annual reporting of expenditures and budgeting and periodic review of program costs and available funding methods.





Photos (left and above): The Ramsey-Washington Metro Watershed District office building incorporates environmental stewardship and serves as an example of low-impact site development. The design includes an infiltration-based stormwater management system using native plants, rainwater gardens, a green roof, and a pervious asphalt parking lot.

To be both effective and efficient, the District coordinates and collaborates with other organizations and agencies on a number of efforts to accomplish its goals. One example of this is the District's Public Works Forum, comprised of city and county public works staff. The forum allows the District to share ideas and information and develop collaborative implementation programs with other local governmental units.

Challenges

While the District is recognized as an effective watershed district, it faces a number of organizational challenges to maintain and its high level of performance. Board members and staff must understand their respective organizational roles. The organization operates most efficiently when the board focuses its attention on larger issues (such as setting organizational goals and defining organizational policies) and staff focuses on the implementation of programs, projects, and other planned actions. Effective communication between the board and staff is necessary to ensure that the District's actions are aligned with goals that support the ultimate vision.

The District includes all or part of 12 cities and two counties. Several state agencies also have jurisdiction over resources within the watershed. Each of these entities has unique interests, political challenges, and land-use and operational issues. A significant challenge for the District is working and collaborating with other entities that are required to balance water resource management interests with other responsibilities (e.g., transportation, police and fire protection, economic development, human services).

To address the challenges of managing the District organization effectively, the board has prioritized the following key areas to be addressed over the life of this Plan:

Leadership in innovation through research, projects, and collaboration—The challenges facing the District in achieving its goals are complex. Solutions are subject to multiple constraints, including cost, technical feasibility, and community support or opposition. Effective solutions to current and emerging water resource management problems will require innovation. The District is committed to leading innovation through its own research efforts and demonstration projects, as well as collaborative efforts with its partners (see example on page 22).

Adaptive management—Water resource management issues continue to evolve due to a number of factors: underlying science becomes better understood, regulatory environments change, and community priorities shift. To accomplish its vision under such conditions requires the District to monitor its actions, track progress towards its goals, learn from experience, and adjust accordingly. To do this, the District must use accurate and relevant assessment tools, allowing the board to evaluate progress toward goals and whether alternative projects, programs, or actions should be implemented.

Implementation of cost-effective projects—The District recognizes its duty to its taxpayers to spend its funds in a manner that considers the relative benefits of its actions. The District evaluates relative costs/benefits using past experiences, best professional judgment, and drawing on resources such as consultants, advisory committees, and other cooperating entities. The District annually reassesses its implementation programs to remain fiscally responsible.



Green roof at the RWMWD office building

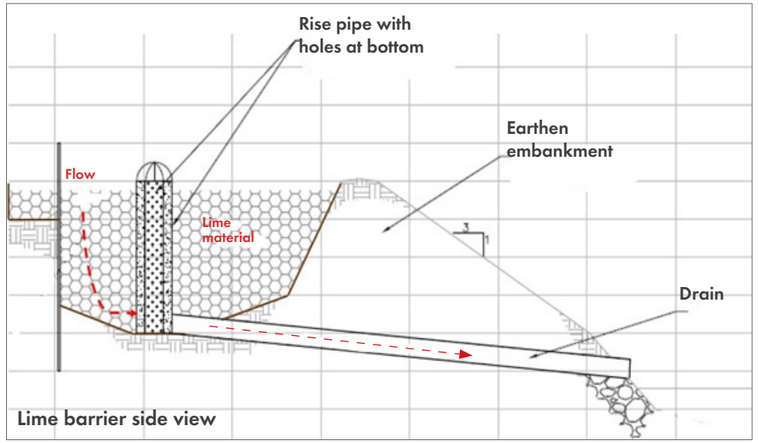
Action items

MO1	Implement effective board leadership through continued board education, succession of positions, and maintenance of the District's charter, bylaws, and mission statement.
MO2	Periodically assess the District's vision and mission to ensure they reflect the intentions of the District and its board.
MO3	Assess projects and programs relative to the District's vision, mission, and ongoing strategic planning.
MO4	Develop an annual plan and budget, including periodic reassessment of District project and program priorities and District capacity.
MO5	Maintain financial solvency and accountability through annual review of the District's accomplishments and spending; the District will document its performance in its annual report.
MO6	Implement cost-effective projects and perform a cost-benefit analysis on projects.
MO7	Follow all legal requirements applicable to watershed districts.
MO8	Pursue opportunities for grant funding for District projects and programs.
MO9	Continually develop staff through education and collaboration, focusing on emerging technology and the latest information.
MO10	Create a positive work environment for staff by offering competitive salaries and benefits as well as opportunities for professional growth.
MO11	Develop and implement methods/programs for measuring, tracking, and reporting progress towards achieving District goals.
MO12	Practice adaptive management: implement, monitor, track progress, learn from experience, adjust (and repeat).
MO13	Promote innovation by sponsoring research projects and collaborating with organizations and agencies to address water resource management challenges.
MO14	Base decisions on sound science; use methods and procedures that are affirmed through existing research, monitoring, and/or accepted practices.
MO15	Implement, track, and update the District's permitting program, including periodic updates to the District's rules, as necessary.
MO16	Coordinate management efforts and collaborate with local and state agencies and governments to promote the efficient use of resources.
MO17	Coordinate with private sector and nonprofit organizations.
MO18	Consistently provide and maintain current technology and equipment to effectively manage information and processes.
MO19	Maintain a service-oriented, fair-minded, and courteous approach in all District business.
MO20	Conduct reviews of permit applications and project proposals in a fair and equitable manner.
MO21	Consider the social, economic, and environmental impact of projects and programs.

District innovation highlighted by spent-lime project

The District is committed to innovation in stormwater management—that's why it was the first to use spent lime to treat stormwater. The spent-lime system (shown below) was designed to reduce phosphorus loading to Wakefield Lake. Spent lime is a by-product of lime-softened drinking water; its primary components are calcium carbonate and magnesium carbonate. The properties of this material enable it to bind or remove dissolved phosphorus (orthophosphate), particulate phosphorus, suspended solids, and metals. Performance monitoring indicates that 74.4 percent of orthophosphate is removed from the stormwater, as well as 66 percent of particulate phosphate.

Spent lime is "green" waste material that can be cheaply obtained from water treatment facilities. In addition to its cost and effectiveness, advantages include a long life span, the ability to treat large volumes of stormwater within a relatively small footprint, and easy maintenance. In addition, treated stormwater is not toxic to aquatic life.



When stormwater enters the cell it begins to infiltrate through the spent-lime material; the average contact time is 5 minutes. The outlet consists of a riser with 1-inch-diameter holes. Peak outflow rates are often seen after the peak of the storm event, as the water level draws down around the riser and a head differential develops between the outlet and inlet of the cell. Below: A treatment cell before (left) and after (right) introduction of spent lime.





Signs of success

- The District is a positive, productive, and efficient place to work.
- Sound fiscal management is demonstrated.
- The board establishes goals, policies, and procedures, and regularly evaluates progress toward goals.
- Input from stakeholders informs the District's projects and programs.
- Progress towards District goals is measured.
- Qualified and highly effective staff are employed and retained.
- District facilities and equipment are maintained to perform as designed or manufactured.
- Other organizations recognize the District as a leader in innovation.



Ten-year implementation program/funding

The Plan includes a comprehensive list of the projects and programs that comprise the District's implementation program. The implementation program includes operational costs, District-wide activities, and anticipated actions targeting specific subwatersheds over the next 10 years. The District's expenses are summarized in the pie chart on page 24. The District will fund its implementation program using three primary sources:

1. Property tax levy
2. Grant funds
3. Local cost-share funding

Approximately 95 percent of the District's funds for implementing capital projects, programs, and other operations are raised through a property tax levy. This tax is an ad valorem tax (a tax on all taxable parcels in the District, based on property value).

Per Minnesota Statutes 103B, watershed districts in the Twin Cities metropolitan area have the authority to levy an ad valorem tax to pay for the costs of implementing their watershed management plan. This includes costs related to the District's operations (facilities and staff), programs, capital improvement projects, and maintenance. The District also has the authority to finance large capital projects by selling bonds or securing loans.

The District's preferred financing approach is to pay for District capital improvements in the year they are constructed. Larger projects (in excess of approximately $1 million) may be financed in multiple years. For example, the Maplewood Mall retrofit project, constructed from 2009–2012, was broken into multiple phases and partially financed by the capital improvement budget over each year of construction. Large projects may also be funded through bonds or loans. The District has issued its own bonds and will continue to do so, if needed. Current and past bond issues and loans and their original amounts are listed in Section 3 of the Plan.

Grants and loans make up a small percentage of the District's funding sources. The District will continue to apply for grants and loans to offset project and program costs whenever possible and cost-effective. However, grant and loan programs are highly competitive and change frequently as available funds and priorities change, new grants/loans become available, and existing programs are terminated. The District will also seek opportunities for partnerships or cost-sharing to reduce its portion of project and program costs.

Since its inception in 1975, the District has determined and justified the amount of its annual levy through its work program and budgeting process. As a guiding principle, the District intends to restrict its annual levy to a property tax rate of approximately 0.025 percent, or about $25 per $100,000 of property value. From 2006 through 2015, the District's annual levy ranged from approximately $3 to $6 million. This tax rate will allow the District's levy to grow at approximately the same rate as the increase in property values. This self-imposed tax limit requires that the District establish spending priorities to assist the board in decision-making when there is a high demand for the District's programs.



The general schedule of the District annual work program, budgeting, and levy process is as follows:

1. **March 1–July 1:** Prepare biennial work program and budget report. Present to board for review
2. **July 1–August 1:** Develop preliminary work program and budget for the next calendar year using the biennial report and current year spending estimates
3. **August 1:** Board review of preliminary work program and budget; board approves distribution of work program and budget for review and comment by District cities, counties, and community groups
4. **September 1:** Public hearing on proposed work program, budget, and preliminary levy
5. **September 15:** File preliminary levy certification with counties
6. **October 1–December 1:** Refine work program, budget, and levy as needed to address community input and public comments
7. **December 1:** Board approval of final work program, budget, and tax levy
8. **December 28:** File final levy certification with counties

The District will follow all applicable Minnesota Statutes and Rules for notification and hearings on budgets and capital improvement projects. The District will cooperate and work with Washington and Ramsey Counties to provide District budget and levy information prior to preliminary and final levy notice deadlines.

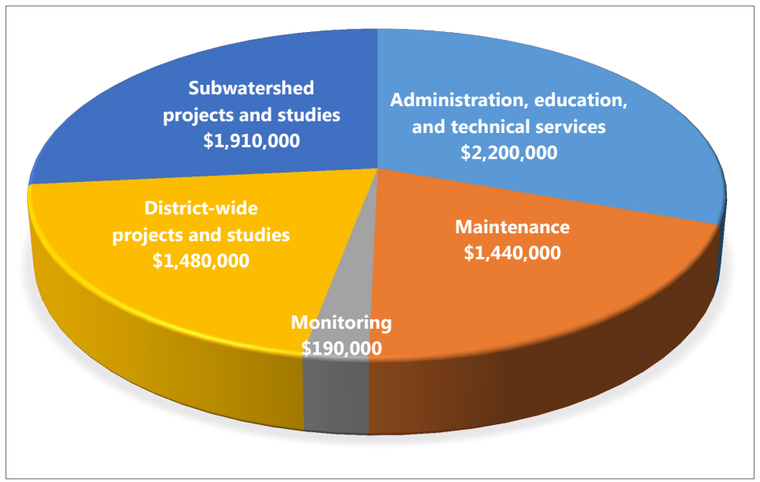
The implementation program costs shown in the pie chart at right are expressed in 2016 dollars and will be adjusted according to inflation.



The Ramsey-Washington Metro District's board is responsible for overseeing the implementation of the District's programs and managing its budget. Pictured from left to right are: Cliff Aichinger, Pam Skinner, Jen Oknich, Marj Ebensteiner, and Robert Johnson.

Estimated annual program costs by category

Total average annual costs = $7,220,000



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1.0 District-Wide Inventory and Assessment

This Section of the Ramsey-Washington Metro Watershed District (RWMWD or District) Watershed Management Plan (Plan) summarizes the land and water resources located within the District. It contains information on land use and public utilities, climate and precipitation, topography, soils, geology, groundwater resources, surface water resource, water quality, water quantity and flooding, natural communities and rare species, fish and wildlife habitat, and pollutant sources. This information is important because it describes the condition of the watershed and how those conditions impact decisions about infrastructure, development, and ecological preservation. This Section is intended as an overview of the entire District. Detailed information for each of the 25 individual subwatersheds in the RWMWD is included in Section 2.0.

1.1 Topography

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 (Soil Conservation Service, 1980).

The highest elevation in the District is 1,100 feet above sea level at four locations: (1) southwest of the intersection of 10th Street North and Hadley Avenue North, in Oakdale; (2) southeast of the intersection of 15th Street North and Helmo Avenue North, in Oakdale; (3) southwest of the intersection of Tower Drive and Afton Road, in Woodbury; and (4) at Interstate-494 and Valley Creek Road, in Woodbury. The lowest elevation in the District is approximately 687 feet above sea level, at the extreme southern tip of the District in the Mississippi River floodplain.

The urbanization of the watershed over time has altered the natural topography of the watershed. With these alterations, drainage patterns have become more defined. Many of the wetland areas that existed prior to urbanization have been eliminated or altered, especially in the older developed areas. The location of steep slopes within the watershed is of interest as these areas limit options for land development and have a higher potential for erosion. The locations of steep slopes, as identified using available LiDAR data, are shown in Figure 1-1.

Snail Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Round Lake
Kohlman Lake
Gervais Lake
Casey Lake
Bennett Lake
Keller Lake
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
Tanners Lake
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake
94
35E
694
61
96
244
36
120
5
51
149
13
952A
52
494
3
156

RWMWD Jurisdictional Boundary
Major Subwatersheds
creeks
Steep Slopes (>12%)

MN DNR LiDAR

(Feet)

High : 1115.27

Low : 681.35

Source: MN DNR; 2011

Figure 1-1

TOPOGRAPHY & STEEP SLOPES
Ramsey-Washington Metro Watershed

Feet
0 6,000 12,000

1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 11:11 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-1 Topography and Steep Slopes.mxd User: jrv

1.2 Climate and Precipitation

The climate of the Minneapolis-St. Paul area is a humid continental climate, characterized by moderate precipitation (normally sufficient for crops), wide daily temperature variations, large seasonal variations in temperature, warm humid summers, and cold winters with moderate snowfall.

The mean annual temperature in the District is 46.2°F, as measured at the Minneapolis/St. Paul (MSP) airport station (1981-2010). Mean monthly temperatures vary from 15.6°F in January to 73.8°F in July (1981-2010). According to the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) (http://www.ncdc.noaa.gov/) extreme temperatures recorded at MSP (or downtown Minneapolis prior to April 1938, when the location of official measurement was changed to MSP) were a high of 108°F on July 14, 1936 and a low of -34°F on January 1, 1936 and January 19, 1970. For the 1981-2010 climate normal period, the average date for latest occurrence of freezing temperatures was April 26, while the average date for the first autumn frost was October 7. The average frost-free period (growing season) is approximately 160 days (Figure 1-2).

Table 1-1 summarizes precipitation data for the MSP airport station. Average total annual precipitation at the MSP airport station is 30.6 inches (1981-2010). Annual precipitation recorded at downtown Minneapolis and MSP has ranged from a low of 11.5 inches in 1910 to a high of 40.2 inches in 1911. The mean monthly precipitation varies from 4.3 inches in August to 0.9 inches in January (1981-2010). From May to September, the growing season months, the average rainfall (1981-2010) is 19.03 inches, or about 62% of the average annual precipitation.

Figure 1-2 shows the average high and low temperatures for the Minneapolis-St. Paul International Airport. The figure also displays average precipitation events for the area.

Snowfall averages 54.4 inches annually at the MSP airport station (1981-2010). Extreme snowfall records range from 98.6 inches during the 1983-1984 season to 14 inches during the 1930-1931 season.

The amount, rate, and type of precipitation are important in determining flood levels and stormwater rates, all of which impact water resources. In urbanized watersheds, shorter duration events tend to play a larger role in predicting high water levels on basins. Shorter duration events are generally used by hydrologists to study local issues (sizing catch basins, storm sewer pipes, etc.). Longer duration events are generally used by hydrologists to study regional issues, such as predicting high water levels for regional basins and basins that have no outlets (landlocked), or have small outlets relative to their watershed size.

Average weather imposes little strain on the typical drainage system. Extremes of precipitation and snowmelt are important for design of stormwater management and flood control systems. Extremes of snowmelt most often affect major rivers, the design of large stormwater storage areas, and landlocked basins, while extremes of precipitation most often affect the design of conveyance facilities. The National Oceanic and Atmospheric Administration has data on extreme precipitation events that can be used to aid in the design of stormwater management and flood control systems.

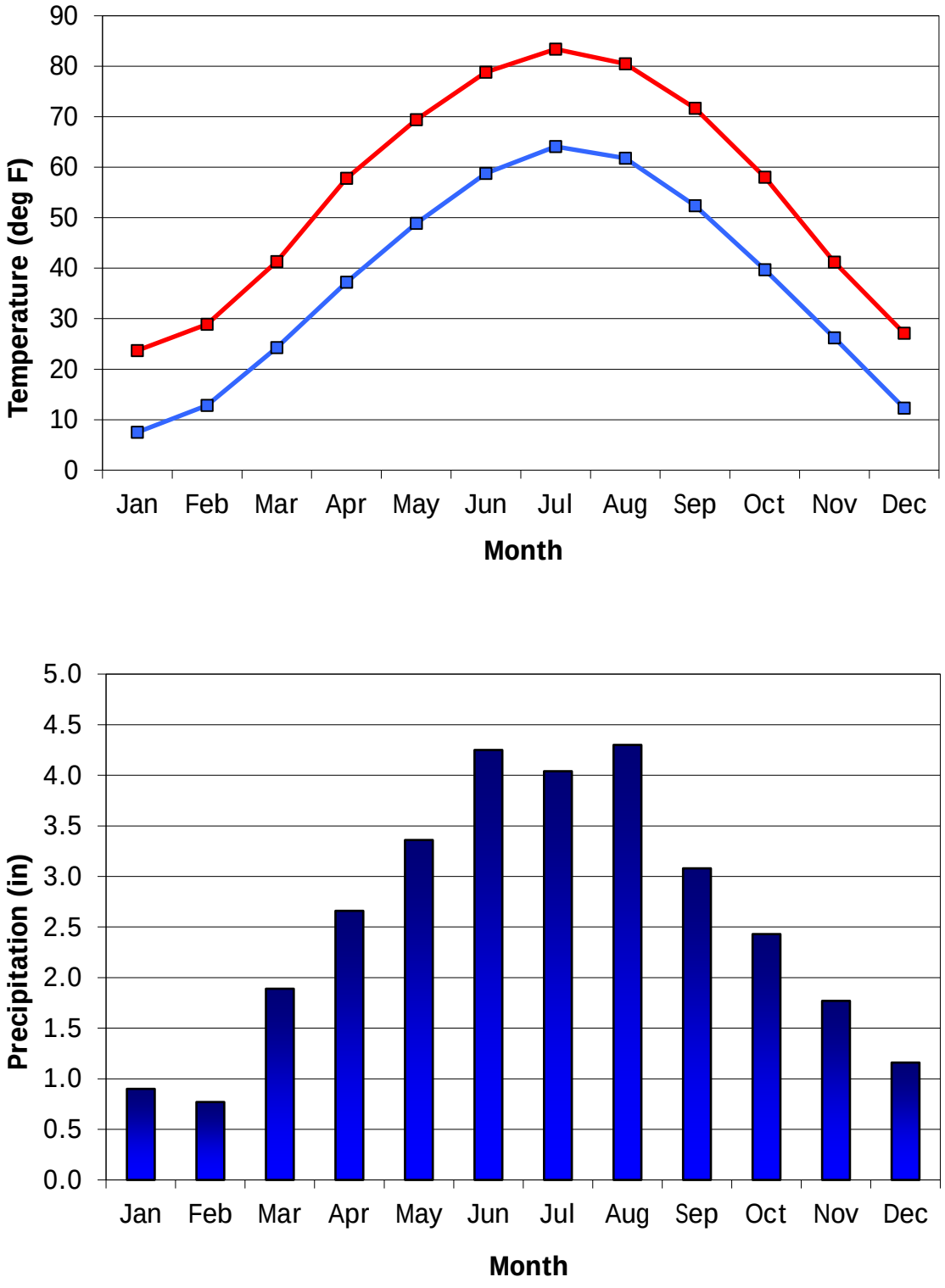


Figure 1-2 MSP Average Monthly Temperature and Precipitation (1981-2010)

Table 1-1 Historical Precipitation Summary for Minneapolis-St. Paul Area

Month	Rainfall							Snowfall		
	Mean (in)	Max (in)	Year of Max	Min (in)	Year of Min	1-day Max (in)	Year of 1-day Max	Mean (in)	Max (in)	Year of Max
January	0.90	3.63	1967	0.05	1892	1.21	1967	12.2	46.4	1982
February	0.77	3.25	1922	0.03	1894	1.90	1930	7.7	26.5	1962
March	1.89	4.75	1965	0.09	1910	1.66	1965	10.3	40.0	1951
April	2.66	7.00	2001	0.16	1987	2.58	2006	2.0	21.8	1983
May	3.36	10.33	1906	0.21	1934	3.39	2012	0.0	3.0	1946
June	4.25	9.82	1990	0.22	1988	3.28	2003	0.0	T	1995
July	4.04	17.90	1987	0.11	1936	10.00	1987	0.0	T	1994
August	4.30	9.32	2007	0.20	1925	7.36	1977	0.0	T	1992
September	3.08	7.77	1903	0.30	2012	4.96	1903	0.0	1.7	1942
October	2.43	6.42	1911	0.01	1952	4.83	2005	0.6	8.2	1991
November	1.77	5.29	1991	0.02	1939	2.91	1940	9.3	46.9	1991
December	1.16	4.27	1982	T	1943	2.47	1982	11.9	33.2	1982
Annual	30.61	40.15	1911	11.54	1910	--	--	54.4	101.5	1983

Mean values based on 1981-2010 period; minimum and maximum values based on downtown Minneapolis (1891-1938) and MSP (1938-2014) records

T = trace amount

Source: Minnesota Climatology Working Group (www.climate.umn.edu)

NOAA published Atlas 14, Volume 8, in 2013. Atlas 14 is the primary source of information regarding rainfall in the region. Atlas 14 supersedes publications TP-40 and TP-49 issued by the National Weather Bureau (now the National Weather Service) in 1961 and 1964. Improvements in Atlas 14 precipitation estimates include denser data networks, longer (and more recent) periods of record, application of regional frequency analysis, and new techniques in spatial interpolation and mapping. Atlas 14 provides estimates of precipitation depth (i.e., total rainfall, in inches) and intensity (i.e., depth of rainfall over a specified period) for durations from 5 minutes up to 60 days.

Snowmelt and rainstorms that occur with snowmelt in early spring are significant in this region. The volumes of runoff generated, although they occur over a long period, can have significant impacts where the contributing drainage area to a lake or pond is large and the outlet is small. Runoff from spring snowmelt is not provided in Atlas 14. The Soil Conservation Service's (now the Natural Resources Conservation Service, or NRCS) National Engineering Handbook, Hydrology, Section 4, presents maps of regional runoff volume. Table 1-2 lists selected precipitation and runoff events used for design purposes.

Table 1-2 Selected Rainfall and Snowmelt Runoff Events

Type	Event Frequency	Duration	Depth (inches)
Rainfall	2-year	24 hour	2.80
	5-year	24 hour	3.49
	10-year	24 hour	4.18
	25-year	24 hour	5.29
	50-year	24 hour	6.29
	100-year	24 hour	7.40
	10-year	10 day	6.62
	100-year	10 day	9.95
	100-year	96-hour	8.32
Snowmelt[1]	10-year	10 day	4.7
	25-year	10 day	5.7
	50-year	10 day	6.4
	100-year	10 day	7.1

Source: NOAA Atlas 14 – Volume 8. Station: St. Paul (21-7377). Hydrology Guide for Minnesota (USDA Soil Conservation Service – NRCS)

[1] Snowmelt depth reported as liquid water.

Even with wide variations in climate conditions, climatologists have found four significant recent climate trends in the Upper Midwest (Minnesota Weather Almanac, Seeley, 2006):

- Warmer winters
- Higher minimum temperatures
- Higher dew points
- Changes in precipitation trends – more rainfall is coming from heavy thunderstorm events and increased snowfall

According to the National Oceanic and Atmospheric Administration (NOAA) 2013 report on regional climate trends, total precipitation amounts in the United States (and in the Great Lakes region) are trending upward, as are storm intensities. Higher intensity precipitation events typically produce more runoff than lower intensity events with similar total precipitation amounts; higher rainfall intensities are more likely to overwhelm the capacity of the land surface to infiltrate and attenuate runoff. Precipitation records in the Twin Cities area show the annual average precipitation has increased, as shown in the following examples:

- **Minneapolis-St. Paul Airport station**—the average annual precipitation increased from 28.32 inches (1961–1990 average) to 30.61 inches (1981–2010 average), an 8.1% increase (data from the Climatology Working Group website: http://climate.umn.edu/).

- **St. Paul station—**the average annual precipitation increased from 30.30 inches (1961–1990 average, from the Minnesota Department of Natural Resources [MDNR] State Climatology Office) to 33.45 inches (1981–2010 average), a 10.4% increase (data from the Climatology Working Group website: http://climate.umn.edu/).

Comparison of precipitation depths between TP-40 and Atlas 14 indicates increased precipitation depths for more extreme events. As noted by the SWCS, increased storm intensities result in increased soil erosion and increased runoff. The Minnesota Pollution Control Agency's (MPCA) global warming website states that increased flooding could also result from more intense precipitation events: http://www.pca.state.mn.us/index.php/topics/climate-change/index.html.

Additional climate information can be obtained from a number of sources, such as the following sources:

- For climate information about the Twin Cities metropolitan area: http://www.dnr.state.mn.us/climate/twin_cities/index.html
- Local data available from the Midwestern Regional Climate Center (MRCC): http://mrcc.isws.illinois.edu/CLIMATE/
- For a wide range of climate information: http://www.nws.noaa.gov/climate/index.php?wfo=mpx
- For other Minnesota climate information: http://www.dnr.state.mn.us/climate/index.html

1.3 Land Use

Nearly all of the land in the RWMWD is now fully developed. Figure 1-3 shows the current land use in the RWMWD (source: Metropolitan Council, 2010). Undeveloped areas expected to develop in the future are limited to small areas (e.g., individual parcels) located in the eastern portion of the District and other scattered infill locations (note that the "undeveloped" land use designation may include undevelopable land such as wetlands). Thus, the majority of the expected overall change in land use will be from redevelopment. Proposed redevelopment areas are scattered throughout the watershed. The comprehensive plans for cities within the RWMWD contain more information about these future redevelopment areas.

Land use data compiled by the Metropolitan Council for 2010 is presented geographically in Figure 1-3. The percentage breakdown of land cover within the District is shown in Figure 1-4. Single family residential is the major land use found in the District (38%), followed by park, recreational, or preserve (17%). Vacant or undeveloped land, including non-developable lands (e.g., wetlands) occupy 9% of the watershed and open water occupies another 8% of the watershed. Additional land uses found in the watershed include: industrial, institutional, major highways, retail/commercial, office space, medium density residential and very limited amounts of agriculture.

Snail Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Round Lake
Kohlman Lake
Gervais Lake
Casey Lake
Bennett Lake
Keller Lake
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
Tanners Lake
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake

35E
94
694
61
96
244
36
120
51
5
149
52
952A
110
156
494
3
20

RWMWD Jurisdictional Boundary
Major Subwatersheds
Creeks

Metropolitan Council 2010 Generalized Landuse

- Agricultural
- Single Family Residential
- Multifamily Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Park, Recreational or Preserve
- Rights-of-Way (i.e., Roads)
- Airport
- Railway (inc. LRT)
- Vacant or Unknown
- Water

Source: Metropolitan Council, 2010

Figure 1-3

CURRENT LAND USE (2010)
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000

1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 11:56 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-3 Current Land Use (2010).mxd User: jrv

Figure 1-5 shows the anticipated future land use based on Metropolitan Council 2030 data. Knowledge of estimated future land use is useful to identify areas where redevelopment might offer opportunities for additional stormwater treatment or retrofits of existing stormwater infrastructure. Land uses for each subwatershed are also presented in the subwatershed sections included in Section 2.0.

Land use can be a significant factor in stormwater management, as increased impervious area results in increased rate and volume of stormwater runoff from precipitation. For the report *Detailed Assessment of Phosphorus Sources to Ramsey-Washington Metro Watershed District* (Barr, September 2005), the RWMWD compiled the amount of impervious surface areas within each subwatershed, based on the University of Minnesota's color-infrared Landsat photography (2002). That analysis found the impervious surface areas of the RWMWD subwatersheds ranged from 21.3% to 43.1%, and the average was 34.0%.

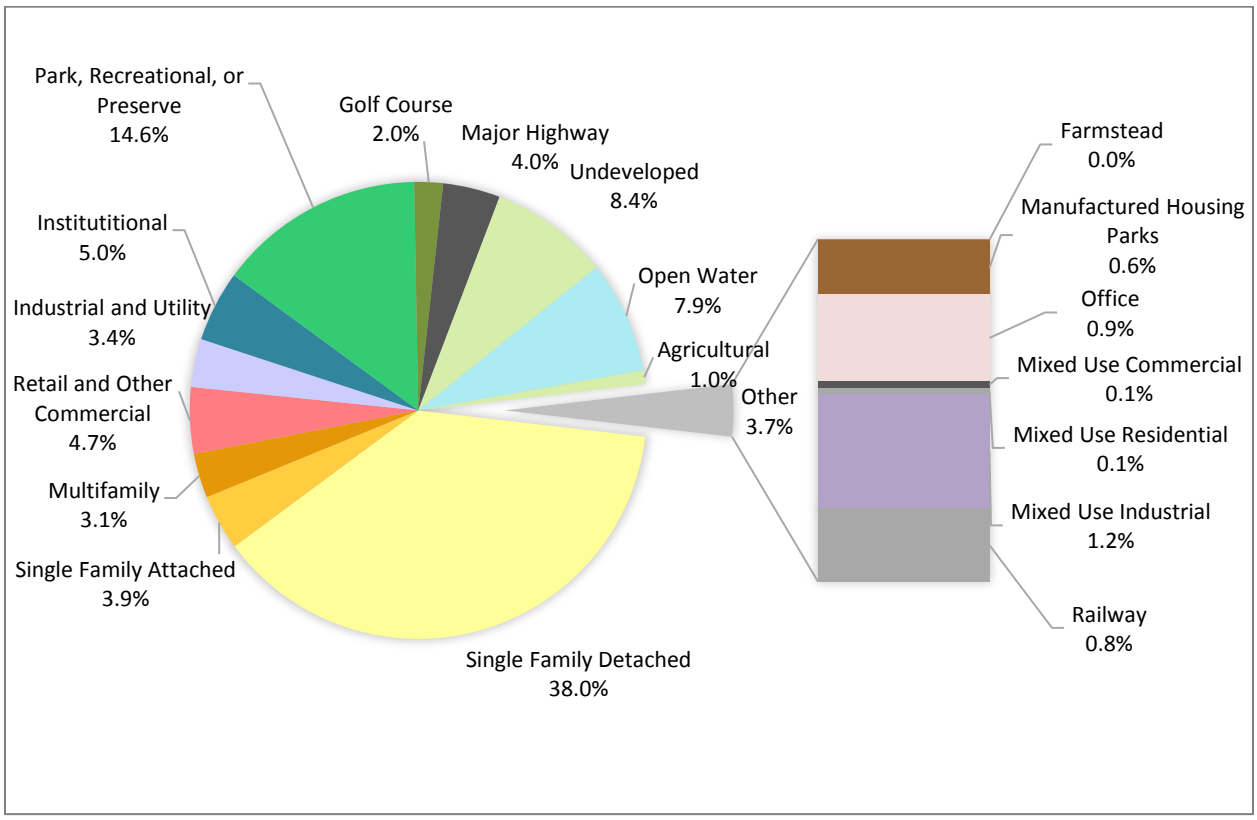


Figure 1-4 Distribution of Metropolitan Council Land Use Data (2010) in RWMWD

Snail Lake
Snail Lake
Grass Lake
Shoreview Lake
Wabasso Lake
Lake Wabasso
Lake Emily
Owasso Lake
Twin Lake
Twin Lake
Willow Lake
Willow Creek
Gervais Creek
Kohlman Lake
Lake Owasso
Round Lake
Kohlman Lake
Casey Lake
Bennett Lake
Gervais Lake
Kohlman Creek
Gervais Lake
Keller Lake
Keller Lake
Lake Phalen
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
St. Paul Beltline
Beaver Lake
Tanners Lake
Tanners Lake
St. Paul Beltline
Battle Creek
Battle Creek Lake
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Mississippi River Bottomlands
Blufflands
Carver Lake
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake
Fish Creek
Blufflands

RWMWD Jurisdictional Boundary
Major Subwatersheds
Creeks

Metropolitan Council - Planned Land Use

- Single Family Residential
- Agricultural
- Urban Residential
- Multifamily Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Park and Recreation
- Rights-of-Way (i.e., Roads)
- Railway (inc. LRT)
- Vacant or Unknown
- Open Water

Source: Metropolitan Council, 2010

Figure 1-5

ESTIMATED FUTURE LAND USE (2030)
Ramsey-Washington Metro Watershed

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:15 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-5 Estimated Future Land Use (2030).mxd User: jrv

1.4 Soils

1.4.1 Hydrologic Soil Groups and Infiltration

Soil composition, slope and land management practices determine the impact of soils on water resource issues. Soil composition and slope are important factors affecting the rate and volume of stormwater runoff. The shape and stability of aggregates of soil particles—expressed as soil structure—influence the permeability, infiltration rate, and erodibility (i.e., potential for erosion) of soils. Slope is important in determining stormwater runoff rates and susceptibility to erosion.

Infiltration capacities of soils affect the amount of direct runoff resulting from rainfall. Higher infiltration rates result in lower potential for runoff from the land, as more precipitation is able to enter the soil. Conversely, soils with low infiltration rates produce high runoff volumes and high peak discharge rates, as most or all of the rainfall moves as overland flow.

The Natural Resources Conservation Service (NRCS – formerly the Soil Conservation Service) has established four general hydrologic soil groups. These groups are:

Hydrologic Soil Group A—(Low runoff potential): Group A soils have a high infiltration rate and are typically composed of more than 90% sand and gravel.

Hydrologic Soil Group B—(Moderately low runoff potential): Group B soils have a moderate infiltration rate and are typically composed of 50-90% sand.

Hydrologic Soil Group C—(Moderately high runoff potential): Group C soils have a slow infiltration rate and are composed of less than 50% sand.

Hydrologic Soil Group D—(High runoff potential): Group D soils have a very slow infiltration rate and are composed of more than 40% clay. These soils have of combination of high swelling potential, a permanently high water table, and a clay layer at or near the surface.

Dual hydrologic groups, A/D, B/D, and C/D, are soils that are considered D soils primarily because of a high water table. However, if the soil were drained it would be classified into a different group. The second group listed for dual hydrologic group soils is for an undrained condition. For the purpose of infiltration all dual hydrologic groups are considered as D soils.

Combined with land use, the hydrologic soil grouping symbols (A-D) may be used to estimate the amount of runoff that will occur over a given area for a particular rainfall amount. The most current soils data for the RWMWD are based on the Soil Survey Geographic dataset (SSURGO) from the NRCS and are presented in Figure 1-6.

Most of the District, including the most heavily developed areas, fall within the Not Rated/Not Available category (56%, see Figure 1-6). This classification is typically assigned to areas where development has altered the existing soil, or data were unavailable prior to development; hydrologic soil groups or infiltration rates are typically not determined after development. The areas where hydrologic soil groups

are defined are concentrated in the extreme north and southeast portions of the District. Within these areas, soils consist mostly of hydrologic soil group A (11%) and group C (11%). Hydrologic soil group B (9%) and B/D (7%) are also prevalent.

Development is another factor that may increase the potential for high volumes of runoff. As land is developed for urban use, much of the soil is covered with impervious surfaces, and soils in the remaining areas are significantly disturbed and altered. Development often results in consolidation of the soil and tends to reduce infiltration capacity of otherwise permeable soils, resulting in significantly greater amounts of runoff. Grading, plantings, and tended lawns tend to dominate the pervious landscape in urbanized areas and may become more important factors in runoff generation than the original soil type.

The hydrologic soil groups map (Figure 1-6) provides general guidance about the infiltration capacity of the soils throughout the watershed. In 2015, the District identified areas suitable for focused infiltration projects as part of a *Groundwater/Surface Water Interaction Study* (Barr, 2015, see Section 1.6.2). That study considered hydrologic soil group as part of the analysis.

Snail Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Round Lake
Kohlman Lake
Gervais Lake
Casey Lake
Bennett Lake
Keller Lake
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
Tanners Lake
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake

94 35E 694 61 96 244 51 36 120 5 149 52 952A 156 494

RWMWD Jurisdictional Boundary
Major Subwatersheds
Creeks

Hydrologic Soils Groups

A	High Permeability
A/D	
B	
B/D	
C	
C/D	
D	Low Permeability
Not rated or not available	

Source: NRCS, 2016

Figure 1-6

SOILS (HYDROLOGIC SOIL GROUPS)
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000

1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:15 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-6 Soils (Hydrologic Soils Groups).mxd User: irv

1.4.2 Surficial Soils

The surficial soils within the RWMWD are described in the Minnesota Geological Survey's (MGS) 1992 publication of the *Geologic Atlas of Ramsey County, Minnesota* and its 2016 update of the *Geologic Atlas of Washington County, Minnesota*. The Soil Surveys classified the soils in the RWMWD into five groups:

1) soils formed dominantly in outwash
2) soils formed dominantly in glacial till
3) soils formed dominantly in lacustrine sediments
4) soils formed dominantly in loamy sediments over bedrock
5) soils formed dominantly in glacial till or outwash

Much of the north and western portions of the District are composed of soils formed dominantly in outwash, including soils of the Zimmerman-Urban Land-Rifle complex and the Chetek-Mahtomedi complex. These soils range from nearly level to steep, are well drained to excessively drained (with some poorly drained areas), and are medium-textured to coarse-textured. The main management concern of these soils is their relatively high ability to infiltrate water and their susceptibility to erosion. There is a hazard of groundwater pollution if sanitary facilities are placed in these soils due to potentially high infiltration rates.

The central and eastern portions of the District consist primarily of soils formed dominantly in glacial till, including soils belonging to the Hayden-Urban Land complex, Kingsley-Urban Land complex, and Santiago-Kingsley complex. These soils are undulating to steep, well drained, and medium and moderately coarse textured. They are well suited to pasture and woodland, but also have good to fair suitability for urban uses. Steep slopes and moderately slow permeability (when fully wetted) are the main limitations to using the soils as building sites or for sanitary facilities.

Soils formed dominantly in glacial till and soils formed dominantly in outwash occur throughout the District. The remaining soil types present in the District are concentrated in a few locations. Localized soil types include soils formed dominantly in lacustrine sediments (Barronett-Grays complex) in north of Gervais Lake in Little Canada; these soils are level to gently sloping, poorly to moderately drained, and medium textured. Soils formed dominantly in recent alluvium (Udorthents-Algansee complex) are concentrated near Pigs Eye Lake in the Mississippi River floodplain; these soils are nearly level to gently sloping, somewhat poorly drained, coarse textured soils.

1.5 Geology

1.5.1 Glacial and Bedrock Geology

The geology of the District can be subdivided into two basic classifications: unconsolidated glacial sediments and consolidated bedrock formations. The *Ramsey County Geologic Atlas* (MGS, 1992) and the *Washington County Geologic Atlas* (MGS, 2016) together contain a complete description of geologic and hydrogeologic features of the District. The draft *Ramsey County Groundwater Protection Plan* (Ramsey Conservation District, 2009) and the *Washington County Groundwater Plan 2014 – 2024* (Washington

County Department of Public Health and Environment, 2014) also include, reference, and describe the geologic information contained in the county geologic atlases. The following resource description is derived largely from Ramsey County information, along with currently available Washington County information.

Unconsolidated glacial sediments are from glacial deposits left from the Quaternary geologic period and modified by post-glacial erosion and soil formation processes. The Superior glacial lobe and Grantsburg glacial sublobe laid down a large portion of the glacial deposits in the District approximately 12,000 to 20,000 years ago. Glacial deposits form a widespread mantle of sediment that overlays bedrock materials.

The glacial (quaternary) deposits found in Ramsey County are primarily in the form of outwash, till, and stream and lake sediments, which are composed of varying percentages of sand, silt, clay and gravel. The overall thickness of glacial deposits ranges from 10 to 400 feet. Deposits are thickest where preglacial and interglacial stream valleys, incised into underlying bedrock, have been filled with glacial sediment. Thinner deposits are found along the bluffs of the Mississippi River. The glacial deposits found in Washington County are primarily in the form of till, averaging 200 feet in thickness.

Consolidated bedrock formations (bedrock deposits) are much older and lie beneath the mantle of glacial sediments. They include a thick overlapping sequence of sandstones, limestones, dolostones and shales. Most bedrock units in the District were deposited during the Paleozoic era marine environments about 450 to 530 million years ago. Some older undifferentiated Proterozoic-era rocks have been identified in the deep bedrock substrate.

The bedrock deposits in the District are part of a regional geologic setting called the Hollandale embayment. The embayment sequence of sandstone, carbonate and shale bedrock layers underlies portions of Wisconsin, Minnesota and Iowa and acts as a huge groundwater basin. The deposits which the embayment comprises have varying water-holding capacities and include, from top to bottom, the Decorah Shale, the Platteville Limestone, the Glenwood Formation (a shale unit), the St. Peter Sandstone, the Prairie du Chien Group (dolostone), the Jordan Sandstone, the St. Lawrence Formation, the Franconia Formation, the Ironton Sandstone, the Galesville Sandstone, the Eau Claire Formation (another shale unit) and Mt. Simon Sandstone.

1.5.2 Glacial and Bedrock Hydrogeology

The glacial and bedrock deposits discussed above form a layered sequence of aquifers and confining units that make up the hydrogeologic setting of the District. An aquifer is a geologic formation capable of supplying sufficient quantities of water to a well. A confining unit is a geologic deposit that impedes the flow of water between aquifers. More information on the sequence of Quaternary and bedrock aquifers within the RWMWD can be found in the *Ramsey County Geologic Atlas* (MGS, 1992) and the *Washington County Geologic Atlas* (MGS, 2016). The draft *Ramsey County Groundwater Protection Plan* (Ramsey Conservation District, 2009) and the *Washington County Groundwater Plan 2014 – 2024* (Washington County Department of Public Health and Environment, 2014) also include, reference, and describe the hydrogeologic information contained in the county geologic atlases.

The uppermost aquifers in the District are glacial deposits. Glacial aquifers include the water table and buried glacial aquifers, which are primarily used for domestic purposes. The general flow of groundwater in the water table aquifer is toward local discharge zones (wetlands, lakes and streams) and the Mississippi River.

Most high-capacity wells draw water from bedrock aquifers. The bedrock aquifers of the District are the Platteville Formation, the St. Peter Sandstone, the Prairie du Chien-Jordan, the Tunnel City-Wonewoc and the Mt. Simon aquifers. These aquifers are not evenly distributed throughout the District; nor do they all have similar attributes. The main aquifers are briefly described below. For additional information on these aquifers, see the *Ramsey County Geologic Atlas* and the *Washington County Geologic Atlas*.

The Platteville Formation is a carbonate aquifer composed of limestone and dolostone. Groundwater flows through the aquifer towards the Mississippi River in cracks, joints and solution cavities present within the unit. The total thickness of the Platteville is between 25 and 30 feet. In some areas, the aquifer is fully confined and saturated; in others, the Platteville is either part of the water-table system or is unsaturated and incapable of providing water to wells. The Platteville is still used sparingly for domestic supply, but is prohibited for use in many areas where it is too close to the land surface and not sufficiently protected by confining materials

The 150- to 160-foot-thick St. Peter Sandstone is composed mainly of poorly cemented, uniform sand grains that form a porous and permeable aquifer medium. The basal portion of the St. Peter contains layers of mudstone, siltstone and shale that form a confining layer. The St. Peter is used primarily for domestic and other low-volume uses.

The Prairie du Chien Group (a series of dolomite deposits) and the Jordan Sandstone combine hydrologically, due to the absence of a confining unit between them, to form the most important and heavily used aquifer in the District. Many large-diameter and high-capacity wells penetrate this aquifer for industrial, commercial and municipal water supplies. Most of the Prairie du Chien-Jordan aquifer is more than 200-feet thick. Groundwater flows through it from the northeast toward the discharge zone of the Mississippi River. Recharge to the aquifer occurs from overlying materials (especially where nonconfining units overlie the aquifer), lateral groundwater flow and buried bedrock valleys.

The Tunnel City-Wonewoc and the Mt. Simon aquifers lie beneath the Prairie du Chien-Jordan aquifer. The Tunnel City-Wonewoc is not utilized within the District. The Mt. Simon is used minimally for municipal and commercial water supply. Both aquifers are probably recharged outside of the District boundary.

1.6 Groundwater Resources

Groundwater is a vital natural resource for the residents, cities, and industries within the RWMWD. The 1997 RWMWD Watershed Management Plan (1997 RWMWD Plan) estimated that 4.5 to 5 billion gallons of groundwater are extracted each year in the District. The Metropolitan Council estimates the total water use within the District will reach 26 billion gallons per year by 2020, increasing to 27 billion gallons per year by 2040 (Metropolitan Council, 2015). Of this, a significant portion will be groundwater. The cities of Landfall, North Oaks, North St. Paul, Oakdale, Shoreview, Vadnais Heights, White Bear Lake, and

Woodbury utilize municipal wells to supply many of their residents with potable water. The cities of Little Canada, Roseville, Maplewood, and St. Paul are serviced by St. Paul Regional Water Services (SPRWS). Although the vast majority of the SPRWS water supply comes from surface water, the SPRWS may use groundwater as an alternate water supply when there are taste and odor problems, during drought conditions, or in other special situations (e.g., security reasons). Approximately 10% of the SPRWS water supply consists of groundwater annually (Ramsey Conservation District, 2009). As of 2015, the SPRWS maintains 10 groundwater wells located in the Prairie du Chien-Jordan aquifer (SPRWS, 2015).

There are 45 municipal supply wells located within the District. There are approximately 1,400 private wells located within the District, including approximately 900 residential water supply wells (concentrated in the north part of the District) and more than 100 commercial, industrial, and irrigation wells

In 2012, the Minnesota legislature created groundwater management areas (GWMAs) as a tool for the MDNR to address difficult groundwater-related resource challenges (Minnesota Statutes 103G.287). In 2013, the MDNR began developing three pilot groundwater management areas, one of which is the North and East Metro GWMA, which includes the RWMWD. Groundwater management areas provide a means for the MDNR to address the long-term sustainability of groundwater resources. The purpose of the three pilot planning projects is to learn how to effectively create and establish GWMAs in locations facing groundwater management challenges.

Establishment of the GWMA does not replace existing data collection, study, or evaluation efforts performed by local and state agencies. Rather the GWMA will provide a vehicle for focusing resources to improve resource management (e.g., developing a better understanding of surface water-groundwater interaction, integration of available data, etc.). As part of the GWMA program, the MDNR aims to develop a process for assessing appropriations permits and applications for new permits that is applicable statewide, but also considers the possible need for different appropriation limits within different GWMAs. Water appropriations are regulated under MN Rule 6115.0620.

The MDNR has established a project advisory team for the North and East Metro GWMA. The project advisory team includes members from Washington County, Ramsey County, the Metropolitan Council, MDNR, MDA, MDH, US Geological Survey, city staff, and private companies. The MDNR held meetings in early 2014 to obtain input from the project advisory team, with the initial discussions focusing on the GWMA boundary and appropriations permits. With cooperation from the project advisory team, the MDNR seeks to develop a GWMA plan that includes a comprehensive approach to working across the jurisdictional lines of cities and counties, keeping groundwater use management at the local level with agency oversight when needed.

1.6.1 Groundwater/Surface Water Interaction

Many of the lakes, streams and wetlands throughout the District are also interconnected with and depend on groundwater for replenishment. Understanding how changes in the groundwater system may affect water levels, stream flow, and water quality is an important component in the long-term planning and protection of water resources in the District. The connection between surface water and groundwater

affects how surface waters may respond to seasonal changes (e.g., drought), long-term climate change, or groundwater pumping.

In 2015, the District performed a study to assess groundwater/surface water interaction throughout the district to:

1. identify surface waters that may be susceptible to changes in groundwater levels
2. identify areas for focused groundwater recharge to achieve the goals of replenishing stressed aquifers, achieving stormwater runoff volume reductions, and water quality improvements

In the first part of the study, the District reviewed publicly available data sets to determine whether a connection between surface water and groundwater is likely or not, characterize the type of connection, and evaluate the degree of influence that groundwater has on the respective surface water feature.

A surface water is considered to be in connection with the regional groundwater system if the regional water table (excluding localized perched groundwater) intersects or nearly intersects (i.e., is within 5 feet) the bottom elevation of the surface water feature. Surface water features greater than 25 feet above the regional water table are considered to be perched, and are unaffected by groundwater levels below. The groundwater/surface water connection is indeterminate for surface waters located between 5 and 25 feet above the regional water table. For those surface waters where a connection exists, the type of connection depends (e.g., discharging to groundwater, recharging from groundwater, flow through) depends on the relative elevation of the regional water table.

The presence of a hydraulic connection does not necessarily indicate the surface water is vulnerable to changes in groundwater levels. The nature of the geologic units beneath and/or intersecting the surface water feature affect the way the surface water feature responds to changes in the groundwater system. Lakes within low permeability glacial till are likely to be influenced very little by changes in groundwater levels, while lakes that sit in higher permeability sand and gravel glacial outwash are likely to be more sensitive to changes in groundwater levels. Additionally, the bathymetry of the surface water feature influences the impact from groundwater pumping; lakes with wide littoral zones have a greater potential to be negatively impacted by changes in groundwater levels.

District waterbodies most vulnerable to changes in groundwater levels are identified in Figure 3 of the District's *Groundwater/Surface Water Interaction Study* (Barr, 2015).

1.6.2 Groundwater Recharge

In general, recharge to the groundwater system occurs throughout the District. However, the hydrologic characteristics of geologic deposits at the land surface significantly affect the rate, volume, and distribution of recharge. Water infiltrates most rapidly into sandy deposits and flows easily through sandy materials; clay deposits tend to slow and impede infiltration and subsurface flows. Urban development and the widespread construction of impervious surfaces (buildings, streets, parking lots) has reduced the amount of open space and wetlands and has decreased the amount of land available to infiltrate runoff and recharge groundwater.

Groundwater recharge reaches the water table at a fast rate through sandy geologic deposits. Water level data from wells indicate that surficial aquifers usually have higher static water levels than deeper aquifers, indicating that water flows downward into the aquifer system and that surficial aquifers help recharge deeper aquifer systems. Deeper bedrock aquifers are recharged through bedrock valleys, leakage through confining layers, fractures in tills and confining layers, improperly constructed wells and other areas where good hydraulic connections and unforeseen flowpaths exist with upper aquifer units.

As part of its *Groundwater/Surface Water Interaction Study* (Barr, 2015), the District identified areas for focused groundwater recharge via infiltrating stormwater. This analysis considered local geology and soils, depth to groundwater, proximity to surface waters, and volume of stormwater available. Water quality is also a concern when infiltrating stormwater to replenish drinking water aquifers. The 2015 analysis also considered existing drinking water supply management areas (DWSMAs) and aquifer vulnerability mapping performed as part of individual communities' Wellhead Protection Plans (WHPPs). Figure 1-7 presents the results of the focused recharge area assessment, with higher scores indicating preferred areas for groundwater recharge within the District. Complete results are available in the *Groundwater/ Surface Water Interaction Study* (Barr, 2015).

The analysis helps to rank areas of the District where focused infiltration projects should be considered. While the assessment considered as much information as possible, site specific data such as geologic borings, piezometers, and other engineering studies are necessary prior to implementing large-scale infiltration at a specific site.

Snail Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Round Lake
Kohlman Lake
Gervais Lake
Bennett Lake
Casey Lake
Keller Lake
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
Tanners Lake
Battle Creek Lake
U.S. Lock & Dam #2 Pool Lake
Pigs Eye Lake
Eagle (North Star) Lake
Carver Lake

94
35E
61
694
51
96
244
36
120
5
49
52
952A
110
156
494
3

RWMWD Jurisdictional Boundary

Major Subwatersheds

Creeks

Vulnerability to changes in groundwater system

Vulnerable

Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score Based on 2015 Groundwater/Surface Water Interaction Study

Areas not colored are not suitable for focused infiltration based on scoring

5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24

Least Suitable for Infiltration

Most Suitable for Infiltration

Source: Barr Engineering, 2015; Imagery: USDA; 2015

Figure 1-7

AREAS FOR FOCUSED GROUNDWATER RECHARGE
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000

1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:16 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-7 Areas for Focused Groundwater Recharge.mxd User: jrv

1.6.3 Groundwater Quality

The continued use of groundwater by municipalities, homeowners, and businesses indicates that most groundwater supplies are of sufficient quality for potable use. Unfortunately, long-term data for analyzing groundwater quality trends in the District are lacking. There is no comprehensive report summarizing groundwater quality conditions. The Minnesota Department of Health (MDH) tests water quality of several municipal drinking supply wells in Ramsey County, but often only after treatment. Only small-scale water quality studies and analyses have been performed in select areas for particular needs. A brief summary of some of these studies is presented in the 1996 *Ramsey County Ground Water Quality Protection Plan* (Ramsey Soil and Water Conservation District, 1996) and the 2009 draft *Ramsey County Groundwater Protection Plan* (Ramsey Conservation District, 2009).

The *Washington County Groundwater Plan 2014 – 2024* (Washington County Department of Public Health and Environment, 2014) notes the following sources of groundwater contamination: commercial and industrial waste disposal; landfills; leaking petroleum tanks; non-compliant septic systems; and fertilizer/pesticide applications, animal waste, and road salt application (see also Section 1.14). The plan also cites emerging contaminants including pharmaceuticals, industrial effluents, personal care products, fire retardants, and other items that are washed down drains and not able to be processed by municipal wastewater treatment plants or septic systems. The *Washington County Groundwater Plan 2014 – 2024* notes that there are locations within Washington County where contaminants have been found above established health risk limits; this adds financial and social costs to managing the affected water supply.

Wastewater collection facilities are available throughout the District, the entirety of which is included within the Metropolitan Urban Services Area (MUSA). Subsurface sewage treatment systems (SSTS) remain in some locations within the District, however, including some identified in the Fish Creek watershed (see Section 2.18). Failing or non-compliant SSTS pose a potential risk to groundwater quality.

In 1982, the MDH issued a well advisory in the region of the Washington County Landfill (located in Lake Elmo) because of groundwater contamination by volatile organic chemicals. A remedial groundwater treatment system was installed and operated from 1983 to 1986. The well advisory (now called a Special Well and Boring Construction Area (SWBCA)) remains in effect. More recently, perfluorochemicals (PFCs) have been detected in a number of Oakdale city wells within (wells 1, 2, 5 and 9) and near (wells 3 and 7) the RWMWD. PFCs have been detected in groundwater samples from monitoring wells at the Abresch disposal site (Oakdale) and the Washington County Landfill site (Lake Elmo). In response to the PFC contamination, the MDH expanded the SWBCA boundaries in 2007 west to Century Avenue and south to I-94. The expanded SWBCA now includes a portion of RWMWD. For the most up-to-date information on this topic, please refer to the MDH's website:
http://www.health.state.mn.us/divs/eh/wells/swca/#washington

1.6.4 Wellhead Protection and Pollution Prevention

In 1989 the state of Minnesota instituted the Minnesota Groundwater Protection Act, which identified the MDH as responsible for the protection of groundwater quality. Through its wellhead protection program, the MDH administers and enforces the Minnesota Water Well Code, which regulates activities such as well abandonment and installation of new wells, The MDH also administers the Wellhead Protection Program, which is aimed at preventing contaminants from entering the recharge zones of public well supplies. In 1997, the Wellhead Protection Program rules (Minnesota Rules 4720.5100 to 4720.5590) went into effect.

Cities that pump groundwater to supply their residents with drinking water are required to prepare wellhead protection plans (WHPPs). Through these wellhead protection plans, cities delineate drinking water supply management areas (DWSMA) for their municipal groundwater wells, assess the water supply's susceptibility to contamination from activities on the land surface, and establish management programs, such as identification and sealing of abandoned wells, and education/public awareness programs. The DWSMA represents the boundaries of the recharge area to the well and is the area to be protected and managed by the wellhead protection plan. The DWSMA (or portions) for North St. Paul, Oakdale, St. Paul Regional Water Services, Vadnais Heights, White Bear Lake, and Woodbury are located within RWMWD. Minnesota Rules 4720 requires that wellhead protection plans be submitted to watershed management organizations such as the RWMWD for review.

The MDH also provides guidance for evaluating infiltration projects in areas with vulnerable groundwater supplies; the guidance considers the presence of wellhead protection areas, aquifer characteristics, land use, and other factors.

As RWMWD and other units of government rely more heavily on infiltration practices to improve water quality and reduce stormwater volumes, the RWMWD will continue to consider the possible impacts of infiltrated stormwater on groundwater quality. The risk of contamination from infiltrated stormwater is especially high in wellhead protection areas (WHPA). The MDH developed guidelines for evaluating proposed stormwater infiltration projects in vulnerable wellhead protection areas (December, 2006). This guidance is available from the MDH website:
http://www.health.state.mn.us/divs/eh/water/swp/stormwater.pdf

These guidelines consist of six steps/questions (also shown on a flowchart) that focus on the location of the proposed infiltration site. For example, the first questions ask if the proposed infiltration site is in a vulnerable WHPA or DWSMA, and if so, if it is located inside a 1-year WHPA. Other questions focus on land use and spill containment. The RWMWD will apply this guidance (including future revisions/updates) and the results of its own *Groundwater/Surface Water Interaction Study* (Barr, 2015) to help evaluate the location of proposed infiltration projects.

1.6.5 North and East Metro Groundwater Management Area (GWMA)

In 2012, the Minnesota legislature established groundwater management areas (GWMAs) as a tool for the MDNR to address difficult groundwater-related resource challenges (Minnesota Statutes 103G.287). The MDNR identified the north and east Twin Cities metropolitan area (which includes the RWMWD) as an area of specific concern where groundwater resources are at risk of overuse and degraded quality.

From 2013 to 2015, the MDNR worked with a Project Advisory Team including city, township and county governments, industrial water users, the Metropolitan Council, and state and federal agencies to develop the *North and East Metro Groundwater Management Area Plan* (MDNR, November 2015).

That plan will guide the MDNR's efforts to manage groundwater appropriations sustainably in this area over a period of five years. The plan establishes sustainability goals to help appropriation permit holders plan for their future water use. This plan does not prescribe water management for any individual business or community. It proposes no immediate changes to particular permits. The MDNR plan describes specific actions the MDNR will take to meet these objectives and thereby achieve the overall goal of sustainable groundwater use. These actions include:

- Increase monitoring and evaluation of groundwater and groundwater-dependent natural resources
- Improve communications around water use and impact on natural systems
- Evaluate water appropriations relative to established sustainability thresholds
- Develop sustainability thresholds where they do not exist
- Improve the appropriations permitting process

At the end of the initial five-year implementation period, the MDNR will conduct a comprehensive review of the Plan and its results to determine future actions and any needed revisions.

The RWMWD cooperated with the MDNR in the development of the *North and East GWMA Plan*. The District's goals, actions, and signs of success related to groundwater resource management (see Strategic Overview) are consistent with the MDNR's plan. The District will continue to cooperate with the MDNR and other state and local agencies with jurisdiction over groundwater resources in the management of those resources.

1.7 Major Subwatersheds

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. For management purposes, the District has been broken down geographically into 25 subwatersheds. A subwatershed represents an area of land that drains directly to a common waterbody, such as Beaver Lake or Battle Creek. Figure 1-8 depicts the RWMWD subwatersheds and conceptually depicts the direction of flow from each subwatershed using arrows. The individual subwatersheds are described in greater detail in Section 2.0.

Subwatersheds are further broken down into individual drainage areas. These drainage areas are shown on the drainage patterns figure for each individual subwatershed in Section 2.0. For water quality modeling purposes, drainage areas are often grouped into larger drainage districts. These drainage districts are shown on the phosphorus contributions figures in Section 2.0.

The Phalen Chain of Lakes is a group of lakes and streams that are interconnected and all drain to Lake Phalen. The Phalen Chain of Lakes includes the following waterbodies (listed from upstream to downstream):

- Willow Creek
- Willow Lake
- Twin Lake
- Kohlman Creek
- Kohlman Lake
- Round Lake (Little Canada)
- Gervais Creek
- Gervais Lake
- Keller Lake
- Wakefield Lake
- Round Lake (Maplewood)
- Lake Phalen

The subwatersheds associated with these waterbodies cover the northern half of the District and are often grouped and considered the Phalen Chain of Lakes Watershed for management purposes (see Figure 1-8).

The Grass Lake Chain of Lakes is a group of lakes that are interconnected and all drain to the Grass Lake wetland. The Grass Lake Chain of Lakes includes the following waterbodies (listed generally from upstream to downstream):

- Bennett Lake
- Lake Emily
- Lake Owasso
- Lake Wabasso
- Shoreview Lake
- Snail Lake

The subwatersheds associated with these waterbodies cover the northeastern portion of the District and are often grouped and considered the Grass Lake Chain of Lakes Watershed for management purposes (see Figure 1-8).

Snail Lake
Grass Lake
Shoreview Pond
Lake Wabasso
Lake Emily
Twin Lake
Willow Creek
Gervais Creek
Kohlman Lake
Lake Owasso
Bennet Lake
Gervais Lake
Keller Lake
Kohlman Creek
Lake Phalen
Beaver Lake
St. Paul Beltline
Tanners Lake
St. Paul Beltline
Battle Creek
Battle Creek Lake
Mississippi River Bottomlands
Blufflands
Carver Lake
Fish Creek
Blufflands

RWMWD Jurisdictional Boundary
Major Subwatersheds
Flow Direction
Creeks

Source: Barr Engineering, 2015
Imagery: USDA; 2015

Figure 1-8

MAJOR SUBWATERSHEDS AND DRAINAGE PATTERNS
Ramsey-Washington Metro Watershed

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:16 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-8 Major Subwatersheds and Drainage Patterns.mxd User: jrv

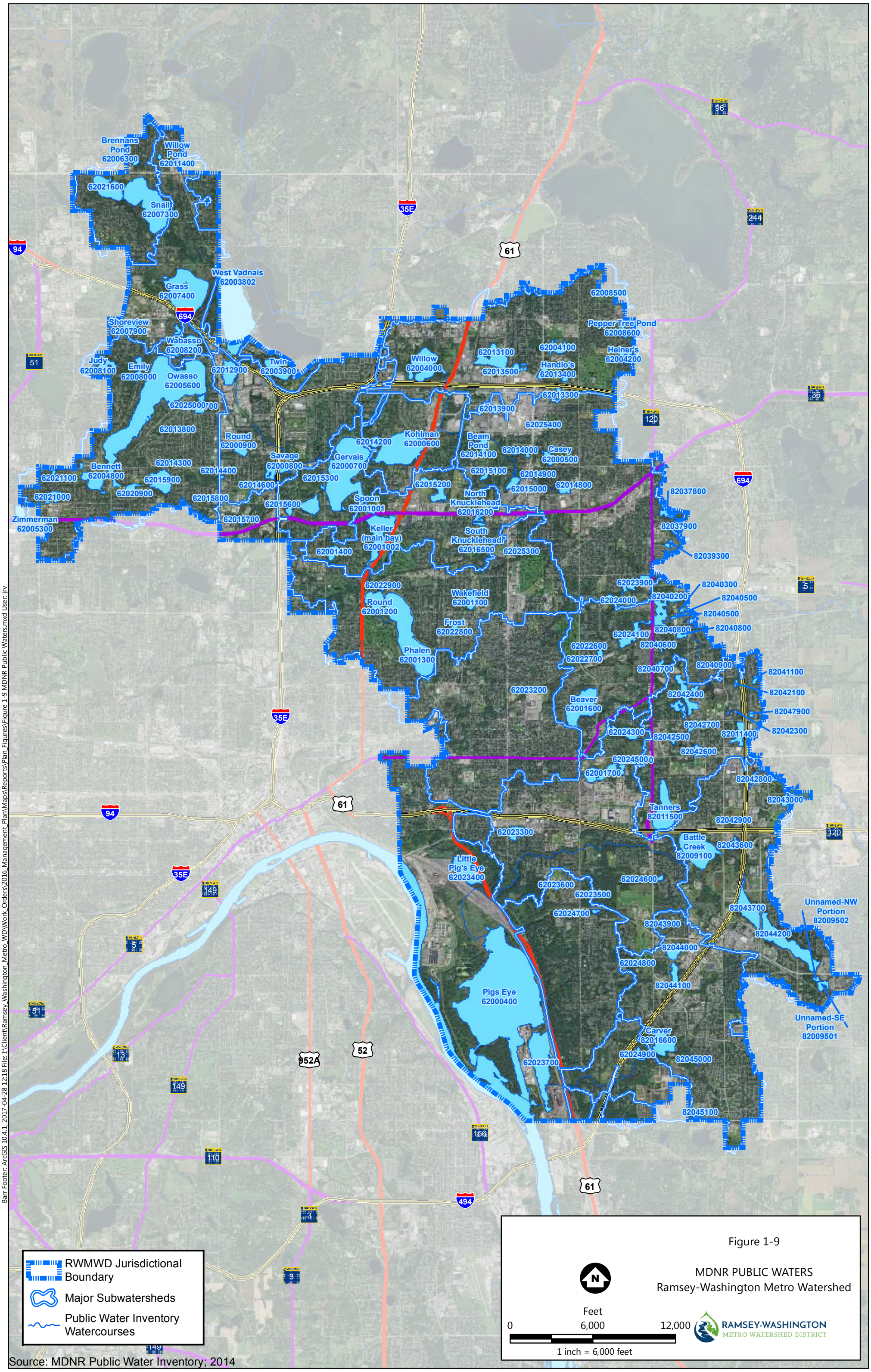
1.8 MDNR Public Waters

Figure 1-9 shows the MDNR public waters within RWMWD. The MDNR designates certain water resources as public waters to indicate those lakes, wetlands, and watercourses over which the MDNR has regulatory jurisdiction. By statute, the definition of public waters includes both "public waters" and "public waters wetlands." The collection of public waters and public waters wetlands designated by the MDNR is generally referred to as the public waters inventory, or PWI.

Public waters are all waterbasins and watercourses that meet the criteria set forth in Minnesota Statutes, Section 103G.005, Subd. 15 that are identified on public water inventory maps and lists authorized by Minnesota Statutes, Section 103G.201. Public waters wetlands include all type 3, type 4, and type 5 wetlands, as defined in U.S. Fish and Wildlife Service Circular No. 39, 1971 edition, that are 10 acres or more in size in unincorporated areas or 2.5 acres or more in size in incorporated areas (see Minnesota Statutes Section 103G.005, Subd. 15a and 17b.)

The MDNR uses county-scale maps to show the general location of the public waters and public waters wetlands under its regulatory jurisdiction. These maps are commonly known as public waters inventory (PWI) maps. PWI maps also show public waters watercourses and ditches. The regulatory boundary of these waters and wetlands is called the ordinary high water level (OHWL). A MDNR permit is required for work within designated public waters. PWI maps are available on a county-by-county basis. Additionally, county-by-county lists of these waters are available in tabular form. The MDNR also maintains a web-based mapping tool for viewing PWI maps. The PWI maps and lists are available on the MDNR's website: http://www.dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

The MDNR has identified public ditches, wetlands, basins, and watercourses subject to statewide buffer requirements (MN Statutes 103F.48). The MDNR maintains an inventory of these waterbodies that may be viewed at: https://arcgis.dnr.state.mn.us/gis/buffersviewer/. The District's role in implementing the buffer law is described in Section 3.2.1.2.


Brennans Pond 62006300
Willow Pond 62011400
62021600
Snail 62007300
West Vadnais 62003802
Grass 62007400
Shoreview 62007900
Wabasso 62008200
Judy 62008100
Emily 62008000
Owasso 62005600
62012900
Twin 62003900
62025000700
62013800
Round 62000900
Bennett 62004800
62014300
62021100
62015900
62014400
62020900
62021000
62015800
62015600
62015700
Zimmerman 62005300
Savage 62000800
Gervais 62000700
62014600
62015300
Spoon 62001001
Keller (main bay) 62001002
62001400
62022900
Round 62001200
Phalen 62001300
62023200
Frost 62022800
Wakefield 62001100
62014200
Kohlman 62000600
62015200
North Knucklehead 62016200
South Knucklehead 62016500
62025300
62008500
Pepper Tree Pond 62008600
62004100
Heiner's 62004200
62013100
Willow 62004000
62013500
Handlo's 62013400
62013300
62013900
62025400
Beam Pond 62014100
62014000
Casey 62000500
62015100
62014900
62015000
62014800
82037800
82037900
82039300
62023900
82040300
82040200
82040500
82040500
62024000
82040800
82040800
62024100
82040600
62022600
62022700
82040900
82040700
82041100
82042100
82042400
82047900
82042700
82042300
62024300
82042500
82011400
82042600
62024500
62001700
82042800
82043000
Tanners 82011500
82042900
62023300
Battle Creek 82009100
82043600
Little Pig's Eye 62023400
62023600
62024600
62023500
62024700
82043700
82043900
82044200
Unnamed-NW Portion 82009502
82044000
62024800
82044100
Pigs Eye 62000400
Unnamed-SE Portion 82009501
Carver 82016600
62024900
82045000
62023700
82045100
94
35E
694
61
51
96
244
36
120
5
149
952A
52
156
110
494
3
RWMWD Jurisdictional Boundary
Major Subwatersheds
Public Water Inventory Watercourses
Figure 1-9
MDNR PUBLIC WATERS
Ramsey-Washington Metro Watershed
N
Feet
0
6,000
12,000
1 inch = 6,000 feet
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT
Source: MDNR Public Water Inventory; 2014
Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:18 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-9 MDNR Public Waters.mxd User: jrv

1.9 District-Managed Lakes, Streams, and Facilities

The RWMWD manages 20 lakes (see Section 1.9.1) and five streams (see Section 1.9.2), which together comprise the "District-managed waters." The RWMWD is also responsible for managing a number of stormwater facilities; this is discussed in Section 1.9.3.

1.9.1 Lakes

The RWMWD manages lakes differently than wetlands, so it is important for the District to distinguish between the two. The District uses a water body's Cowardin classification (Cowardin, 1979) to categorize a water body as a lake or a wetland. The RWMWD categorizes as lakes those water bodies classified as lacustrine under the Cowardin system. Lacustrine systems include wetlands and deep water 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% areal coverage.
3. Total area exceeds 20 acres.

Basins or catchments less than 20 acres 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 2 meters (6.6 feet) in the deepest part of the basin.

The following twenty water bodies within the District are classified as lacustrine and thus will be managed by the District as lakes:

- Battle Creek Lake
- Beaver Lake
- Bennett Lake
- Carver Lake
- Eagle Lake
- Emily Lake
- Gervais Lake
- Keller Lake
- Kohlman Lake
- Lake Owasso
- Lake Phalen
- Round Lake (Maplewood)
- Round Lake (Little Canada)
- Shoreview Lake
- Snail Lake
- Tanners Lake
- Twin Lake
- Wabasso Lake
- Wakefield Lake
- Willow Lake

These lakes are depicted in Figure 1-10. Several of the above lakes were added to the District when the District incorporated a large area in the Grass Lake watershed as part of a major plan amendment in 2013, Several waterbodies within the District are often referred to as lakes by the public, but are not categorized as lacustrine. These waterbodies, such as Casey Lake, Grass Lake, Pigs Eye Lake and others, are managed by the RWMWD as wetlands. The District may pursue activities in waterbodies (or their watersheds) not included in the above list on a case-by-case basis as necessary to achieve District goals.

1.9.2 Streams

There are five District-managed streams:

- Fish Creek
- Battle Creek
- Gervais Creek
- Willow Creek
- Kohlman Creek

These streams are shown in Figure 1-10. Fish Creek and Battle Creek are perennial streams and have always been managed by the District as natural streams. Gervais Creek, Willow Creek, and Kohlman Creek are intermittent streams. All or portions of these intermittent streams were previously considered county public ditches: Gervais Creek (County Ditch 16), Willow Creek (County Ditch 18N), and Kohlman Creek (County Ditch 18S). County ditches are public drainage systems. They are established under Chapter 103E of Minnesota Statutes and are generally under the jurisdiction of the County. The District has assumed management authority over county public ditches located within the RWMWD, as allowed by Minnesota Statutes 103E.

The original function of public ditches was to provide drainage for agricultural lands. The District will continue to manage public ditches in a manner that recognizes their current use as urban drainage systems and as altered natural waterways. The RWMWD manages the streams to maintain stream stability, ensure adequate channel capacity to convey flow from the critical 100-year frequency storm event, keep the stream free of obstructions and pollution sources, enhance natural conditions for fish and wildlife, and restore the aesthetic value where appropriate. The RWMWD monitors District-managed streams for erosion or erosion potential to maintain stream stability and prevent the transport of additional sediment into the lakes and wetlands. Where erosion problems are identified, the RWMWD considers options to address the problems, giving preference to the use of bioengineering and native vegetation to stabilize the streambank (i.e., "soft-armoring" techniques) versus hard armoring methods used in the past. Section 4.1.7 contains more additional information on the RWMWD stream monitoring program.

1.9.3 District Facilities

Various units of government and private entities have jurisdiction over different parts of the stormwater system within the RWMWD. The stormwater system includes pipes, ponds, lakes, wetlands, ditches, streams, swales, and other drainageways.

The Minnesota Department of Transportation (MnDOT) is responsible for maintaining the stormwater systems within their rights-of-way, such as interstate highways (i.e., I-35E, I-94, I-494, and I-694), U.S. highways (i.e., Highway 10, and Highway 61), and state highways (i.e., Highway 5, Highway 36, and Highway 120). Ramsey and Washington counties are responsible for maintaining at least part of the stormwater systems within their rights-of-way, such as county roads and county state aid highways (e.g., County Road B, County Road C, Radio Drive, White Bear Avenue, and Valley Creek Road). The cities within the RWMWD have jurisdiction over the lateral (also called primary) stormwater systems (i.e., street gutters, pipes, and ditches) and are responsible for system maintenance and improvements. Cities generally design lateral stormwater systems with capacity to convey runoff from 5- or 10-year frequency storms without significant flooding, while protecting public health and safety for storms up to the 100-year frequency interval (these design levels are sometimes referred to as "level of service" and "level of protection." Owners of private stormwater systems are responsible for maintaining their facilities.

The RWMWD is responsible for management of all outflow (also called main, trunk, or secondary) conveyors, which collect flows from city lateral systems and move the water downstream. Outflow conveyers are managed to handle flows resulting from a critical 100-year frequency storm event and to prevent further degradation of downstream waterbodies.

In addition to the conveyances systems associated with the District-managed streams, the District also manages the St. Paul Beltline Storm Sewer Interceptor. In 1996, the RWMWD became the owner and operator of this major storm sewer system that collects a large percentage of stormwater runoff from St. Paul's east side, in addition to conveying runoff from the entire Phalen Chain of Lakes subwatershed and the Beaver Lake subwatershed to the Mississippi River. Other District facilities include outlet structures, ponds, and storm sewers between regional detention basins. All of the District facilities are shown on Figure 1-10.

The RWMWD is owner and operator of stormwater systems that require the District to obtain a National Pollutant Discharge Elimination System (NPDES) Storm Water (MS4) permit. The District facilities that come under the jurisdiction of the NPDES MS4 permit are noted on Figure 1-10. See Section 3.2.1.4 for more information about the RWMWD NPDES MS4 permit.

Snail Lake
Shoreview Lake
Wabasso Lake
Lake Emily
Owasso Lake
Twin Lake
Willow Lake
Bennett Lake
Round Lake
Gervais Lake
Kohlman Lake
Casey Lake
Keller Lake
Round Lake
Wakefield Lake
Lake Phalen
Beaver Lake
Suburban Pond
Tanners Lake
Battle Creek Lake
Pigs Eye Lake
Carver Lake
Eagle (North Star) Lake
U.S. Lock & Dam #2 Pool Lake

Black Tern Pond Outlet
Owasso Basin
Gervais Mill Pond
Gervais Creek Improvements
Gervais Beach Treatment Pond
Upper Chain Lake Level Monitoring Station
Keller Dam/Footbridge
Willow Creek Pipeline
Maplewood Mall Retrofit
Kennard Street Control Structure
Kohlman Basin
Casey Lake Outlet
White Bear Avenue Pipeline
Highway 36/61 Stormwater Project
PCU Environmental Learning Center
North St. Paul Urban Ecology Center
Wakefield Spent Lime Filter
Phalen Wetland Restoration
St. Paul Beltline
Maplewood Living Street Demonstration
Tanners Lake Alum Treatment/Permeable Weirs
Tanners Lake Outlet
5th Street Water Quality Pond
Tanners Lake Berm and Water Quality Pond
Tanners Lake I-94/Century Avenue Water Quality Treatment
ABI Water Quality Treatment
I-494 Sediment Pond
Vogel Manufacturing
Tamarack Swamp Water Quality Ponds
Battle Creek System
Tanners Lake Outlet Structure
Battle Creek Lake Flood Control Berm
Lower Afton Road Drainageway
Battle Creek Lake Level Monitoring Station
Valley Creek Road Filtration/Infiltration
Carver Ravine Water Quality Pond
Fish Creek
Carver Infiltration/Porous Pavement

RWMWD Jurisdictional Boundary
District Facility Areas
District Managed Lakes
Outfalls
Pollution Control Devices
Other Stormwater Structures

District Facilities

CIP
Project
District Managed Streams
Stormsewers/Culverts
Sediment/WQ Ponds

Source: RWMWD; 2015
Imagery: USDA; 2015

Figure 1-10

RWMWD-MANAGED LAKES, STREAMS, AND FACILITIES
Ramsey-Washington Metro Watershed

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:19 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-10 RWMWD-Managed Lakes, Streams, and Facilities.mxd User: jrv

1.10 Water Quality

1.10.1 Water Quality Goals

One of the primary goals of the RWMWD is to "maintain or improve surface water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits." In 1997, the RWMWD established beneficial use categories based on desired recreational activities for a waterbody. Through its 2007, the District managed lakes to achieve the desired recreational use category.

In the time since the District established its recreational use categories, the Minnesota Pollution Control Agency (MPCA) has updated eutrophication water quality standards for Minnesota lakes and streams. The MPCA established water quality goals and determined appropriate uses of the lakes and streams, as outlined in the guidance document *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* (MPCA, 2014). Standards for lakes vary by MPCA ecoregion and whether the MPCA classifies a lake as "shallow" or "deep." The MPCA defines "shallow" lakes as having a maximum depth of 15 feet or less or having at least 80% of the lake area shallow enough to support aquatic plants.

The RWMWD has adopted the MPCA eutrophication water quality standards applicable to lakes and streams within the District. These water quality standards are presented in Table 1-3. Some lakes within the District exhibit water quality better than the applicable eutrophication standards. In these cases, the District seeks to maintain the existing water quality. This concept is generally known as "non-degradation" or "anti-degradation."

Table 1-3 RWMWD Water Quality Standards

Water Quality Parameter	Water Quality Standard by MPCA Waterbody Type [1]		
	Shallow Lakes[2]	Deep Lakes[2]	Stream
Total Phosphorus (summer average, µg/L)	60	40	100
Chlorophyll *a* (summer average, µg/L)	20	14	18
Secchi Disc Transparency (summer average, m)	1.4	1.0	NA
Total Suspended Solids (mg/L)	NA	NA	30
Daily Dissolved Oxygen Flux (mg/L)	NA	NA	3.5
Biological Oxygen Demand (5 day) (mg/L)	NA	NA	2
Escherichia coli (# per 100 mL)	126 [3]	126 [3]	126 [3]
Chloride (mg/L)	230	230	230

[1] RWMWD standards are based on MPCA standards included in MN Rules 7050. Revisions to MN Rules 7050 will supersede RWMWD standards. Note that MN Rule 7050.0220 includes standards for additional parameters that are enforced by the MPCA.

[2] Shallow lakes have a maximum depth less than 15 feet or littoral area greater than 80% of the total lake surface area.

[3] 126 organisms per 100 mL as a geometric mean of not less than five samples within any month, nor shall more than 10% of all samples within a month exceed 1,260 organisms per 100 mL.

The MPCA also established water quality standards for parameters in addition to those presented in Table 1-3; these standards are published in Minnesota Rules 7050 and are applicable to RWMWD lakes, ponds, and streams. In addition to standards for individual chemical constituents (e.g., metals), the MPCA has also established standards for indices calculated from several metrics (e.g., Minnesota Index of Biological Integrity, or MIBI). Standards for several parameters included in Minnesota Rules 7050 vary according to the MPCA-determined designated use of the waterbody (e.g., drinking water, industrial use).

1.10.2 Impaired Waters

The federal Clean Water Act (CWA) requires states to adopt water quality standards to protect the nation's waters. Water quality standards designate beneficial uses for each waterbody and establish criteria that must be met within the waterbody to maintain the water quality necessary to support its designated use(s). Section 303(d) of the CWA requires each state to identify and establish priority rankings for waters that do not meet the water quality standards. The list of impaired waters, or sometimes called the 303(d) list, is maintained by the MPCA and updated by the state every two years. The MPCA's listing of waterbodies on the impaired waters 303(d) list depends upon their classification of a waterbody as a wetland, shallow lake, or deep lake. Generally, the MPCA does not list waterbodies classified as wetlands as impaired for biological indicators.

Several waterbodies within the RWMWD are listed on the 2014 MPCA impaired waters 303(d) list for a variety of impairments. For impaired waterbodies, the CWA requires an assessment that addresses the causes and sources of the impairment. This process is known as a total maximum daily load (TMDL) analysis. A TMDL is a threshold calculation of the amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL establishes the pollutant loading capacity within a waterbody and develops an allocation scheme amongst the various contributors, which include point sources, nonpoint sources and natural background, as well as a margin of safety. As a part of the allocation scheme, a waste load allocation (WLA) is developed to determine allowable pollutant loadings from individual point sources (including loads from storm sewer networks in MS4 communities), and a load allocation (LA) establishes allowable pollutant loadings from nonpoint sources and natural background levels in a waterbody.

There are currently ten lakes and one stream (Battle Creek) in the District watershed that are included on the MPCA's 2014 impaired waters 303(d) list. Locations of impaired waters are shown in Figure 1-11. Table 1-4 summarizes the impaired waters within the District. Current impaired waters listings are available from the MCPA website: www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/impaired-waters-list.html

Snail Lake

Lake Owasso

Kohlman Lake
Aquatic Life, Aquatic Recreation
Chloride, Nutrients

Gervais Lake
Aquatic Life
Chloride

Bennett Lake
Aquatic Rescreation
Nutrients

Wakefield Lake
Aquatic Life, Aquatic Recreation
Chloride, Nutrients

Phalen Lake

Beaver Lake

Tanners Lake
Aquatic Life
Chloride

Battle Creek
Aquatic Life
Chloride
Fish Bioassessments
Aquatic Macro
Invertebrate Bioassessments

Battle Creek Lake
Aquatic Life
Chloride

Carver Lake
Aquatic Life
Chloride

Eagle (North Star) Lake
Aquatic Consumption
PCBF

Mississippi River
Aquatic Life
Mercury in Water, PCBF, TSS

Fish Creek
Aquatic Recreation
E.coli

RWMWD Jurisdictional Boundary
Major Subwatersheds
Impaired Lakes (not Mercury)
Lake Impaired for Aquatic Consumption (Mercury in Fish Tissue; Addressed by 2007 Statewide TMDL, as well as other impairments)
Impaired Streams

Carver Lake ← Name/Public Waters ID
Aquatic Life ← Impaired Uses
Chloride ← Pollutant/Stressors

Source: MPCA, 2014
Imagery: USDA; 2015

Figure 1-11

IMPAIRED WATERS
Ramsey-Washington Metro Watershed

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:25 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-11 Impaired Waters.mxd User: jrv

Several of the lakes listed in Table 1-4 are impaired for mercury, and one lake (Eagle Lake/North Star Lake) is listed as impaired for 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, 2004). 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 by EPA in 2008) to address the problem.

The other lakes listed in Table 1-4 are impaired due to excess nutrients (phosphorus). The RWMWD has prepared Strategic Lake Management Plans (SLMPs) for these lakes. The findings of the SLMPs and subsequent water quality monitoring data were used in the completion of a Watershed Restoration and Protection Strategy (WRAPS) study and associated TMDL studies (see Section 1.10.5). The WRAPS study was performed from 2013 through 2015 in cooperation with the MPCA. Details of the strategies developed for specific waterbodies resulting from the WRAPS are described in the individual subwatershed sections included in Section 2.0.

Eight waterbodies in the District are included on the 2014 impaired waters 303(d) list with an impaired use of aquatic consumption due to mercury in fish tissue. These waterbodies are covered by the statewide mercury TMDL approved in 2007 (MPCA, 2007). These waterbodies include:

- Battle Creek Lake (listed in 2012)
- Beaver Lake (listed in 2002)
- Bennett Lake (listed in 2012)
- Carver Lake (listed in 1998)
- Eagle Lake (listed in 2008)
- Gervais Lake (listed in 1998)
- Lake Owasso (listed in 1998)
- Lake Phalen (listed in 2012)
- Snail Lake (listed in 2002)
- Tanners Lake (listed in 2002)

Battle Creek Lake, Beaver Lake, Carver Lake, Keller Lake, and Tanners Lake were previously listed as impaired for aquatic recreation due to nutrients/eutrophication, but have since been removed from the 303(d) impaired waters list based on new data as the result of corrective action in the watershed (e.g., stormwater treatment).

In the process of preparing the WRAPS for District lakes it was found that recent water quality data indicated that Keller Lake, Beaver Lake, Battle Creek Lake and Carver Lake had improved to the point where they met state water quality standards and were removed from the 2014 Impaired Waters list (303d list).

Table 1-4 Impaired Waters within the RWMWD (based on 2014 Impaired Waters List)

Waterbody	Impaired Use	Pollutant or Stressor	Year Listed	TMDL Study Target Start	TMDL Study Target Completion	TMDL Study Approved
Battle Creek	Aquatic Life	Chloride	2008	2009	2015[1]	--
	Aquatic Life	Aquatic Macroinvertebrate Bioassessments	2014	2011	2015	--
	Aquatic Life	Fish Bioassessments	2014	2011	2015	--
Battle Creek Lake	Aquatic Life	Chloride	2014	2009	2015[1]	
Bennett Lake	Aquatic Recreation	Nutrients/ Eutrophication	2006	2012	2015	--
Carver Lake	Aquatic Life	Chloride	2014	2009	2015[1]	--
Eagle (North Star) Lake	Aquatic Consumption	PCB in fish tissue	1998	1998	2025	
Fish Creek	Aquatic Recreation	*Escherichia coli*	2014	2011	2015	--
Kohlman Lake	Aquatic Recreation	Nutrients/ Eutrophication	2002	--	--	2010
	Aquatic Life	Chloride	2014	2009	2015[1]	--
Tanners Lake	Aquatic Life	Chloride	2014	2009	2015[1]	
Wakefield Lake	Aquatic Recreation	Nutrients/ Eutrophication	2002	2011	2015	--

Note: Data based on 2014 MPCA Impaired Waters 303(d) List.

[1] Addressed by the Twin Cities Metro Area Chloride Management Plan, anticipated to be finalized in 2016.

1.10.3 RWMWD Nutrient Classifications

In order to better prioritize management activities and ensure progress towards its goal of achieving quality surface water, the RWMWD has further classified its waterbodies with consideration of existing nutrient water quality and applicable eutrophication water quality standards. The District limits its water quality classification system to considering eutrophication criteria due to the District's primary water quality role in addressing lake and stream eutrophication. In addressing other criteria, the District will play other supportive roles, as outlined in the RWMWD WRAPS Report's "Strategies and Actions" table.

The RWMWD has established the following nutrient waterbody classifications:

Stable classification indicates a waterbody that:

- Has water quality that consistently meets applicable MPCA eutrophication standards and has a statistically stable (or improving) trend.

At Risk classification indicates a waterbody that meets one or more of the following criteria:

- Has water quality that is very close to MPCA eutrophication water quality standards but could potentially be listed as impaired in the future.
- Has only recently been delisted from the MPCA's impaired waters list for excess nutrients.
- Has summer average total phosphorus concentrations that do not meet MPCA standards but is not considered impaired because the lake's response variables (chlorophyll *a* and Secchi Disc transparency) do not exceed MPCA standards. These waterbodies are typically macrophyte dominated lakes that could shift to algal dominated (and thus, be considered impaired) in the future.
- Has water quality that meets MPCA eutrophication standards, but exhibits a statistically significant (i.e., 95% confidence) degrading trend in total phosphorus, chlorophyll *a*, or Secchi disc transparency.
- Does not meet MPCA eutrophication standards, but has not yet been listed on the MPCA's Impaired Waters List.

Impaired classification indicates a waterbody that:

- Does not currently meet the MPCA eutrophication water quality standards and is currently listed on the MPCA's Impaired Waters List for excess nutrients.

NA classification indicates a waterbody that:

- Does not have sufficient water quality data to determine a nutrient water quality classification.

Waterbody nutrient classifications for District-managed lakes are presented in Table 1-5. A waterbody's nutrient water quality classification generally determines the type and extent of District activities performed with the intent to improving or protecting water quality, as follows:

- **Impaired** waterbodies have TMDL studies that identify District activities (and activities implemented by others) that are recommended for future implementation in order for the lake to ultimately achieve its water quality goal.
- For **At-Risk** waterbodies, specific water quality improvement projects may be identified in the District's implementation program (see Table 4-1). In other cases, subwatershed-wide feasibility studies are prescribed to seek out retrofit opportunities for future implementation, if warranted.
- For **Stable** waterbodies, District-wide activities will continue to be performed in these watersheds. Specific water quality improvement projects are generally not identified for these waterbodies in the District's implementation program.

Note that the Board of Managers may choose to implement specific water quality improvement activities or projects in pursuit of District goals regardless of a waterbody's current nutrient water quality classification, as circumstances and opportunities warrant.

Table 1-5 Waterbody Nutrient Classifications of District Managed Lakes and Creeks

Waterbody	Nutrient Water Quality Classification
Lakes	
Battle Creek Lake	At Risk
Beaver Lake	At Risk
Carver Lake	At Risk
Keller Lake	Stable
Wakefield Lake	Impaired
Bennett Lake	Impaired
Emily Lake	At Risk
Lake Owasso	At Risk
Shoreview Lake	At Risk
Snail Lake	Stable
Wabasso Lake	Stable
Lake Phalen	Stable
Kohlman Lake	Impaired
Gervais Lake	Stable
Tanners Lake	Stable
Round Lake (in Little Canada)	At Risk
Round Lake (in Maplewood)	Stable
Twin Lake	Stable
Willow Lake	Stable
Eagle Lake (North Star Lake)	NA
Streams	
Battle Creek	Impaired
Fish Creek	At Risk
Gervais Creek	At Risk
Kohlman Creek	At Risk
Willow Creek	NA

1.10.4 Water Quality Monitoring and Studies

The District performs ongoing water quality monitoring of its District-managed resources, including lakes. Additional lake monitoring may be performed as part of targeted projects and studies. Monitoring results for specific lakes are described in individual subwatershed sections in Section 2.0. Past studies and assessments for individual lakes and subwatersheds are described in individual subwatershed sections in Section 2.0.

The water quality studies that have been completed for water bodies within the RWMWD are summarized in Table 1-6). Additional information related to these water quality studies and projects implemented by the RWMWD can be found on their website at: http://www.rwmwd.org/

1.10.5 District Water Quality Studies

1.10.5.1 Strategic Lake Management Plans

Prior to the RWMWD WRAPS effort, the District 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 preliminary water quality goals, determine whether the lake met applicable water quality goals at the time of study, and identify water quality improvement measures throughout the watershed that would help achieve the goals for each lake.

Through the mid-2000s, several SLMPs were completed (see Table 1-6) addressing the highest priority lakes in the RWMWD. For many of the remaining lakes, it was determined that the comprehensive and detailed nature of a SLMP may not be required or appropriate due to the available data and/or the designated uses of the lake. For these lakes, less intensive studies were planned to evaluate available information pertaining to the water quality of the lake. For many lakes, lake status reports had been completed that compiled all the existing data available for each lake.

In 2012 the District began participating in a new watershed-based approach promoted by the MPCA to develop restoration plans (for lakes requiring TMDLs) and protection plans (for lakes that meet water quality standards). This is known as a Watershed Restoration and Protection Strategies (or WRAPS) study. The WRAPS process essentially supersedes the SLMPs; much of the analysis performed for the SLMPs has informed or been incorporated into the WRAPS.

Table 1-6 Summary of Selected Water Quality Studies for RWMWD

Waterbody	Water Quality Study
Battle Creek Lake	Battle Creek Lake Watershed Management Plan (1995); Battle Creek Lake Lake Status Report (2009); Current watershed and water quality evaluated as part of RWMWD WRAPS
Battle Creek	Current watershed and water quality evaluated as part of RWMWD WRAPS Stressor Identification study and TSS TMDL completed as part of this RWMWD WRAPS
Beaver Lake	Beaver Lake Strategic Lake Management Plan (2005); Current watershed and water quality evaluated as part of RWMWD WRAPS
Bennett Lake	Current watershed and water quality evaluated as part of RWMWD WRAPS Bennett Lake TP TMDL completed as a part of this RWMWD WRAPS
Carver Lake	Carver Lake Strategic Lake Management Plan (2000); Carver Lake Infiltration Study (2008); Current watershed and water quality evaluated as part of this RWMWD WRAPS
Casey Lake	Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report (2007)
Gervais Creek	Monitoring Underway, Future Study Planned
Gervais Lake	Phalen Chain of Lakes Strategic Lake Management Plan (2004), Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations (2005), Phalen Chain of Lakes Carp Population Study (2006)
Eagle Lake	No Study Planned/Completed
Lake Emily	Current watershed and water quality evaluated as part of this RWMWD WRAPS
Fish Creek	Sediment Source Loading to Fish Creek and Ponds (2007), Bacteria source assessment completed as part of this RWMWD WRAPS Fish Creek E. coli TMDL completed as a part of this RWMWD WRAPS
Keller Lake	Phalen Chain of Lakes Strategic Lake Management Plan (2004), Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations (2005), Internal Phosphorus Load Study: Kohlman and Keller Lakes (2005), Phalen Chain of Lakes Carp Population Study (2006), Current watershed and water quality evaluated as part of RWMWD WRAPS
Kohlman Creek	Kohlman Creek Subwatershed Infiltration Study (2007)
Kohlman Lake	Phalen Chain of Lakes Strategic Lake Management Plan (2004), Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations (2005), Internal Phosphorus Load Study: Kohlman and Keller Lakes (2005), Phalen Chain of Lakes Carp Population Study (2006), Kohlman Lake Total Maximum Daily Load Report (2010), Kohlman Lake Total Maximum Daily Load Implementation Plan (2010)
Lake Owasso	Lake Owasso Use Attainability Analysis (2009); Current watershed and water quality evaluated as part of this RWMWD WRAPS
Lake Phalen	Phalen Chain of Lakes Strategic Lake Management Plan (2004), Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations (2005), Phalen Chain of Lakes Carp Population Study (2006)
Round Lake (Maplewood)	Round Lake (in Maplewood) Strategic Lake Management Plan (2007)

Table 1-6 Summary of Selected Water Quality Studies for RWMWD

Waterbody	Water Quality Study
Round Lake (Little Canada)	Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report (2007)
Savage Lake	Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report (2007)
Shoreview Lake	Monitoring Underway, Future Study Planned
Snail Lake	Current watershed and water quality evaluated as part of this RWMWD WRAPS
Tanners Lake	Diagnostic/Feasibility Study of Water Quality Problems and Restorative Measures for Tanners Lake (1993).
Twin Lake	Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report (2007)
Lake Wabasso	Current watershed and water quality evaluated as part of this RWMWD WRAPS
Wakefield Lake	Wakefield Lake Strategic Lake Management Plan (2008); Current watershed and water quality evaluated as part of RWMWD WRAPS Wakefield TP TMDL completed as a part of this RWMWD WRAPS
Willow Creek	Monitoring Underway. Future Study Planned
Willow Lake	Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report (2007)

1.10.5.2 Watershed Restoration and Protection Strategies (WRAPS)

Along with the Watershed Approach to monitor the state's surface waters at a major watershed scale, the MPCA developed a process to identify and address threats to water quality in each of these watersheds. This process is called WRAPS, or the Watershed Restoration and Protection Strategy. WRAPS has four major steps or phases. Step 1 is to monitor water bodies and collect data. Outcomes of this step include the creation of a Monitoring and Assessment Report and a Stressor Identification Report on the watershed's biota (fish, bugs, etc.). Step 2 includes evaluating the data to determine the health of the waters. The third step is to develop a WRAPS report and a Total Maximum Daily Load (TMDL) report that provide details on water quality issues and identify what needs to be done to clean up streams and lakes that are impaired and to protect those that are at risk of becoming impaired. The fourth step is for restoration and protection projects to be implemented in the watershed. Various local units of government, including watershed districts, municipalities, and soil and water conservation districts, take the lead in developing and carrying out implementation plans based on what is learned during the earlier steps of the process. Civic engagement and public participation are core elements of all steps throughout the process.

In 2012, the RWMWD began working with the MPCA on a WRAPS within the District. The study was completed in 2016. The WRAPS initially addressed all of the waterbodies in the District; Eagle Lake was omitted from further detailed analysis due to the influence of the Mississippi River.

The early tasks of the RWMWD WRAPS study focused on data collection, including the organization of existing water quality data and collection and analysis of lake sediment cores. This work included assessments of ponds and wetlands for the development of water quality models, as well as a determination of which waterbodies are classified as shallow lakes versus wetlands. The MPCA's determination of lakes versus wetlands is significant, as the water quality criteria presented in Table 1-3 are not applicable to wetlands.

A stressor identification study was completed for Battle Creek as part of the RWMWD WRAPS report identifying total suspended solids as the primary stressor (see Section 2.15). Subsequently, the District worked with the MPCA to complete a TMDL for Battle Creek (see Section 1.10.5.3).

The RWMWD WRAPS study included watershed and in-lake modeling. Watershed pollutant loading models (P8) were used to estimate the pollutant loading to each lake in the study. . The results of the P8 watershed modeling, along with estimates of loading from other external sources, such as discharges from upstream lakes, were used as inputs into mass balance models to evaluate the in-lake response to phosphorus, including estimation of internal loading.

The lake modeling was used to estimate the phosphorus load reductions needed for impaired waters to meet applicable water quality standards and understand where pollutant loads may be addressed to help improve and/or protect water quality of non-impaired waters.

The District developed management actions that will protect or improve water quality conditions for the non-impaired waterbodies included in the WRAPS (actions for impaired waterbodies were developed as part of the RWMWD TMDL report). The District assessed the feasibility of the various best management practice (BMP) options and conducted public meetings to educate stakeholders about the strategies. The WRAPS implementation program includes restoration and protection strategies to be performed by several agencies, including the District. Restoration and protection projects identified in the WRAPS report for which the District is the lead agent are included in this Plan in the applicable individual subwatershed management sections (Section 2.0) and the RWMWD implementation table (Table 4-1); items in the implementation table stemming from the WRAPS are identified as such.

The most current versions of the RWMWD WRAPS report is available from the MPCA website: https://www.pca.state.mn.us/water/tmdl/ramsey-washington-metro-watershed-district-watershed-restoration-and-protection-strategy

1.10.5.3 Total Maximum Daily Load (TMDL) Studies

Recently the District worked with the MPCA to develop a RWMWD TMDL for impaired waterbodies assessed as a part of the RWMWD WRAPS project. The RWMWD TMDL completed in 2015 includes Wakefield and Bennett Lakes (both impaired due to excess nutrients), Fish Creek (impaired due to *E. coli)*, and Battle Creek (impaired due to total suspended solids). The RWMWD TMDL is expected to be approved by the US Environmental Protection Agency (EPA) in 2016. A TMDL for Kohlman Lake was previously completed in 2010.

For the impaired lakes, lake modeling was used to estimate the phosphorus load reductions that would be required from various external and internal sources to meet the applicable water quality standards.. Once load reduction targets were established, the District developed management actions that will achieve the TMDL allocations for each of the impaired waterbodies, and protect the water quality of the remaining waterbodies.

Management actions identified and prioritized for implementation in the TMDL report are included in this Plan in the applicable individual subwatershed management sections (Section 2.0) and the RWMWD implementation table (Table 4-1). Implementation items resulting from the RWMWD TMDL are noted as such in Table 4-1.

Recently, the MPCA worked with the District and other stakeholders in the 7-County Twin Cities Metropolitan Area (TCMA) to assess the level of chloride in water resources, including lakes, streams, wetlands and groundwater. The study identified 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, documented in the *Twin Cities Metropolitan Area Chloride Management Plan* (MPCA, 2015). The District will assist cities in implementing the recommendations included in the TCMA Chloride Management Plan through its public information and education (PIE) program (see Section 4.1.4.3).

Additional details and waste load allocations for impaired waters calculated as part of the TMDL studies described in this Section are documented in the approved TMDL reports available from the MPCA website: https://www.pca.state.mn.us/water/tmdl-projects

1.10.6 MDNR Fisheries Information and Management

The Minnesota Department of Natural Resources (MDNR) has developed an ecological management classification system for Minnesota lakes (Schupp, 1992). The lakes have been classified into 44 types, based on variables relating to lake size, depth, chemical composition of the lake and the length of the growing season. Table 1-7 describes the ecological classification for each of the District-managed lakes and summarizes MDNR fishery management activities in the lake. Four ecological classes determined by MDNR Fisheries are found in the District: 24, 30, 40, and 41. Class 24 and 30 are good permanent fishery lakes; adjoining Class 40 and 41 lakes can be upgraded with implementation of specific management practices.

In addition to fisheries surveys performed by the MDNR, the District performs fisheries surveys on several District-managed lakes as part of its ongoing carp management activities (add cross-reference). Fisheries data applicable to specific waterbodies are described in individual subwatershed sections (Section 2.0).

Table 1-7 Minnesota DNR Fisheries Management Classifications

Waterbody	MDNR ID No.	Fisheries Report Date(s)	Description[1]	Comments
Battle Creek Lake	82-0091	2004, 2014	Very (v.) large, shallow, v.high littoral, v.hard, turbid, irreg.	Has aerator. Stocked for bluegill (2001, 2005, 2006), black crappie (2007),northern pike (2002), and walleye (2013)
Beaver Lake	62-0016	2000, 2005, 2010	Large, shallow, v.high littoral, v.hard, turbid	Has aerator. Stocked annually for catfish. Bluegill stocked as needed. Occasionally stocked for walleye and yellow perch.
Bennett Lake	62-0048	2011		Has aerator. Stocked nearly annually for bluegill and catfish.
Carver Lake	82-0439, 82-0166	1998, 2014	v.small, hard, turbid, irreg.	
Eagle Lake (a.k.a. North Star Lake)	62-0237	1991		Backwater lake of the Mississippi River, potential winterkill effects
Emily Lake	62-0080	2006		No public access. Not stocked.
Gervais Lake	62-0007	2000, 2011	Deep, hard	Stocked in even years for walleye (1994-2014) and nearly annually for tiger muskellunge (2000-2013)
Keller Lake	62-0010	2001	Large, shallow, v.high littoral, v.hard, turbid	Stocked for channel catfish (2001)
Kohlman Lake	62-0006	2000, 2005	Large, shallow, v.high littoral, v.hard, turbid	No public access. No active fish management.
Lake Owasso	62-0059	2012		Stocked for walleye and muskellunge biennially, and largemouth bass (2014)
Lake Phalen	62-0013	2004, 2009	Deep, hard	Stocked for walleye biennially, tiger muskellunge (2001, 2003, 2004, 2006, 2007, 2009, 2011, 2013), and channel catfish (2000,2002)
Shoreview Lake	62-0079	NA		
Snail Lake	62-0073	2010		Stocked for walleye approximately biennially, black crappie (2014), and largemouth bass (2014)
Round Lake (Maplewood)	62-0012	1981		
Round Lake (Little Canada)	62-0009	NA	MDNR manages as a kids fishing pond	
Tanners Lake	82-0115	2000, 2011	v.small, hard, turbid, irreg.	Stocked for walleye biennially, channel catfish (2000-2010, 2013)
Twin Lake	62-0039	1996	v.small, hard, turbid, irreg.	
Wabasso Lake	62-0082	2005		Fishery is not actively managed.

Table 1-7 Minnesota DNR Fisheries Management Classifications

Waterbody	MDNR ID No.	Fisheries Report Date(s)	Description[1]	Comments
Wakefield Lake	62-0011	2001, 2011	MDNR manages as a kids' fishing pond	Stocked annually for Bluegill, for black bullhead (2002), black crappie (2002-2004, 2007, 2009, 2010), , northern pike (2002, 2004, 2008, 2010, 2014), and yellow perch (2008, 2013, 2014)
Willow Lake	62-0040	1987	Large, shallow, v.high littoral, v.hard, turbid	Has aerator; H.B. Fuller Co. maintains

[1] Based on MDNR Fishery Ecological Class (Schupp, 1992).

1.10.7 Aquatic Invasive Species

Changes in the ecology of aquatic plants, animals, and microorganisms may 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 District (see Section 4.1.6).

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 (Minnesota Statutes Chapter 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. Aquatic invasive species pose a threat to natural resources and local economies that depend on them.

The MDNR established the Invasive Species Program in 1991 to prevent the spread of invasive species and manage invasive aquatic plants and wild animals (Minnesota Statutes 84D). As part of its Invasive Species Program, the MDNR maintains a list of waters infested with specific AIS (MDNR Designation of Infested Waters, 2015 as amended). The MDNR 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
- Lake Wabasso

The MDNR'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 aquatic invasive species 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. In addition, many RWMWD lakes suffer from an overabundance of filamentous green algae (FGA). FGA forms dense, sometime noxious, green mats of filamentous algae that interfere with recreation, and can affect water oxygen levels through respiration.

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.

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. In order to allow continued use of the water augmentation system that pumps water from Sucker Lake into Snail Lake, a screening facility that prevents the migration of zebra mussels into Snail Lake was installed in 2009.

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.

The RWMWD limits its management of AIS to instances where the AIS have a demonstrated negative effect on water quality. Past studies and management actions targeting AIS are described in the individual subwatershed sections where the study/action was performed (Section 2.0). Planned AIS management actions and programs are described in the Strategic Overview and RWMWD implementation program (see Table 4-1).

1.11 Wetlands

The wetlands in the RWMWD are an important community and ecological asset. These resources provide significant wildlife habitat and refuge, while also supplying aesthetic, recreational, and water quality treatment benefits. It is the goal of the RWMWD to manage wetlands and the associated natural resources to create and preserve healthy ecosystems. To protect these valuable resources, the RWMWD continues to manage wetlands to achieve no net loss of acreage, functions, and value. The RWMWD serves as the Local Government Unit (LGU) responsible for administration of the Wetland Conservation Act (WCA) rules for all cities in the District, except the City of St. Paul, and except for on Minnesota Department of Transportation projects (see Section 4.1.2 for more information).

1.11.1 Wetland Conservation Act (WCA)

The purpose of the WCA (Minnesota Rules 8420) is to maintain and protect Minnesota's wetlands and the benefits they provide. To retain the benefits of wetlands and reach the legislation's goal of no-net-loss of wetlands, WCA requires anyone proposing to drain, fill, or excavate a wetland to first try to avoid disturbing the wetland; second, to try to minimize any impact on the wetland; and, finally, to replace any lost wetland acres, functions, and values. Certain wetland activities are exempt from the act, allowing projects with minimal impact or projects located on land where certain pre-established land uses are present to proceed without regulation.

The WCA rules require that drained and filled wetlands be replaced at replacement ratios of between 1:1 and 2.5:1 (depending upon the location of impact, location of replacement, and timing of replacement). LGUs, including the RWMWD, may have more restrictive wetland regulations. The MDNR is included in enforcement of the WCA and is responsible for identification, protection, and management of calcareous fens.

The Minnesota Legislature has amended the WCA several times since its inception, mostly to accommodate varying needs of different geographic areas in Minnesota. The current WCA rule was effective August 2009 with subsequent WCA statute changes effective in August 2011 and June 2012. More information about WCA guidance is provided at the BWSR website: http://www.bwsr.state.mn.us/wetlands/wca/index.html

As part of administering the WCA rules, the RWMWD is responsible for making determinations on the accuracy of wetland delineations, wetland functions and values assessments, and wetland replacement plans, often with review and input by a Technical Evaluation Panel (TEP). For all projects proposing to impact more than 10,000 square feet of wetland, the District must send a copy of the application to the TEP, MDNR and any persons who have requested notification. The parties notified are invited to submit comments during a review period that must be at least 15 days long (per Minnesota Statute 103G).

1.11.2 Wetland Inventory & Assessment

It is important to understand the extent, function and value of existing wetlands to provide a basis for wetland protection, management, and restoration efforts. Nationally, the U.S. Fish and Wildlife Service (USFWS) is responsible for mapping wetlands across the country, including those in Minnesota. Using the National Aerial Photography Program (NAPP) in conjunction with limited field verification, the USFWS identifies and delineates wetlands, produces detailed maps on the characteristics and extent of wetlands, and maintains a national wetlands database as part of the National Wetland Inventory (NWI). The NWI is periodically updated based on available imagery.

The RWMWD began the development of its own wetland inventory in 1987 and expanded its understanding in 1996 by performing function and value assessments of the wetlands within the District. The RWMWD completed a review and revision of the 1996 assessments from 2003 to 2005 to identify possible changes in the wetland functions and/or values over time and to apply an updated assessment methodology (i.e., MnRAM 3.0).

The objective of the RWMWD wetland inventory was to identify wetlands by type (U.S. Fish and Wildlife Service Circular 39 or Cowardin classification (Cowardin, 1979)), size, location and landscape setting, and wetland functions. This information was collected and/or updated through field visits to each wetland. The wetland assessment process involves evaluating the existing and potential functional capacity of each wetland based on inventory data and other information such as vegetative community, soils, hydrology, ecologic characteristics, and cultural uses. Over 750 wetlands were assessed by RWMWD staff in the 2003 and 2004 field seasons. The District-managed lakes and streams were not assessed as part of the wetland assessment. Some water quality ponds were included in the inventory, but not assessed for function and value. The District completed an assessment of the Grass Lake subwatersheds in 2014 using the MnRAM. In addition to District wetland assessments, the RWMWD requires project proposers submitting plans to the District to perform an inventory of wetlands located within the proposed project site. The RMWWD wetland inventory is presented in Figure 1-12.

The Minnesota Routine Assessment Method for Evaluating Wetland Functions, Version 3.0 (MnRAM 3.0) was used for the 2003-2005 wetland assessments. Whereas the 1996 inventory was focused primarily on qualitative data, the 2003-2005 assessment followed national and local trends toward a more quantitative approach. MnRAM 3.0 was developed to convert qualitative observations and conclusions about wetlands into a numeric rating system, to better assist local governments in making wetland management decisions.

The MnRAM 3.0 methodology is designed to provide an organized, consistent procedure to document observations and conclusions about wetland processes. MnRAM 3.0 consists of a worksheet to be used during wetland site visits, and a database within which all the data is entered and stored. The database calculates functional indices for the wetlands and provides an efficient and flexible means of storing and analyzing wetland data. For additional information about MnRAM, see the Minnesota Board of Water and Soil Resources (BWSR) website at: www.bwsr.state.mn.us.

1.11.3 Wetland Management Classification

The wetlands within the District have are classified for management purposes, based on the observations and conclusions of the 2003-2005 wetland inventory and assessment. The MnRAM 3.0 documentation includes recommendations for wetland management categories. Documentation available from the BWSR website (www.bwsr.state.mn.us) illustrates the MnRAM 3.0 process for deriving a wetland management classification by using the functional indices for each wetland. The RWMWD used the MnRAM 3.0 "Basic Protection" standard flowchart for classification, which places wetlands into one of four categories. The four RWMWD wetland categories (and corresponding MnRAM categories) are defined as follows (based on the MnRAM 3.0 guidance available from the BWSR website: http://www.bwsr.state.mn.us/wetlands/mnram/index.html):

- **Manage A** (MnRAM 3.0 Preserve) – This category is for exceptional and highest-functioning wetlands or those sensitive wetlands receiving conveyed stormwater runoff that have yet retained a medium level of vegetative diversity/integrity. These wetlands are those that should be preserved in (or improved to) their most pristine or highest functional capacity with wide, natural buffers, in perpetuity.

- **Manage B** (MnRAM 3.0 Manage 1) – In this category are high-quality wetlands that should be protected from development and other pressures of increased use, including indirect effects. Maintaining natural buffers will help to retain the significant function these wetlands provide.

- **Manage C** (MnRAM 3.0 Manage 2) – Manage C wetlands provide medium functional levels and the wetland extent should be maintained. Maintaining natural buffers will help to retain the significant function these wetlands provide. These wetlands often provide optimal restoration opportunity.

The MnRAM 3.0 wetland management classification includes a fourth class (MnRAM 3.0 Manage 3 or RWMWD Utilize in the 1996 inventory) which includes wetlands that have been substantially disturbed and do not fit into any of the other management classifications. This classification is not currently used by the District. Four wetlands were classified as MnRAM 3.0 Manage 3 following the MnRAM methodology in the 2005 inventory. The four wetlands that fell into the MnRAM 3.0 Manage 3 category were then rolled up into the MnRAM 3.0 Manage 2/RWMWD Manage C (third) category.

The 2005 inventory resulted in a good distribution of wetlands within the top three categories. In the 2005 inventory, the RWMWD made a concerted effort to distinguish between constructed water quality ponds, wetlands created for mitigation purposes, and natural wetlands, as many constructed water quality ponds were classified as wetlands in the 1996 inventory. The RWMWD evaluated each of the Utilize wetlands inventoried in 1996 and identified if they were historical wetlands or were created in upland areas for stormwater treatment. This effort resulted in most of the wetlands classified in 1996 as the lowest classification (MnRAM 3.0 Manage 3 or RWMWD "Utilize") being recognized (and classified) as water quality ponds, and not classified as wetlands. Those areas found to be wetlands prior to their use for stormwater treatment were assessed as wetlands using MnRAM 3.0. The RWMWD treats these as jurisdictional wetlands under WCA, even if they currently function as stormwater treatment ponds. Mitigation wetlands received the highest wetland management classification (Manage A).

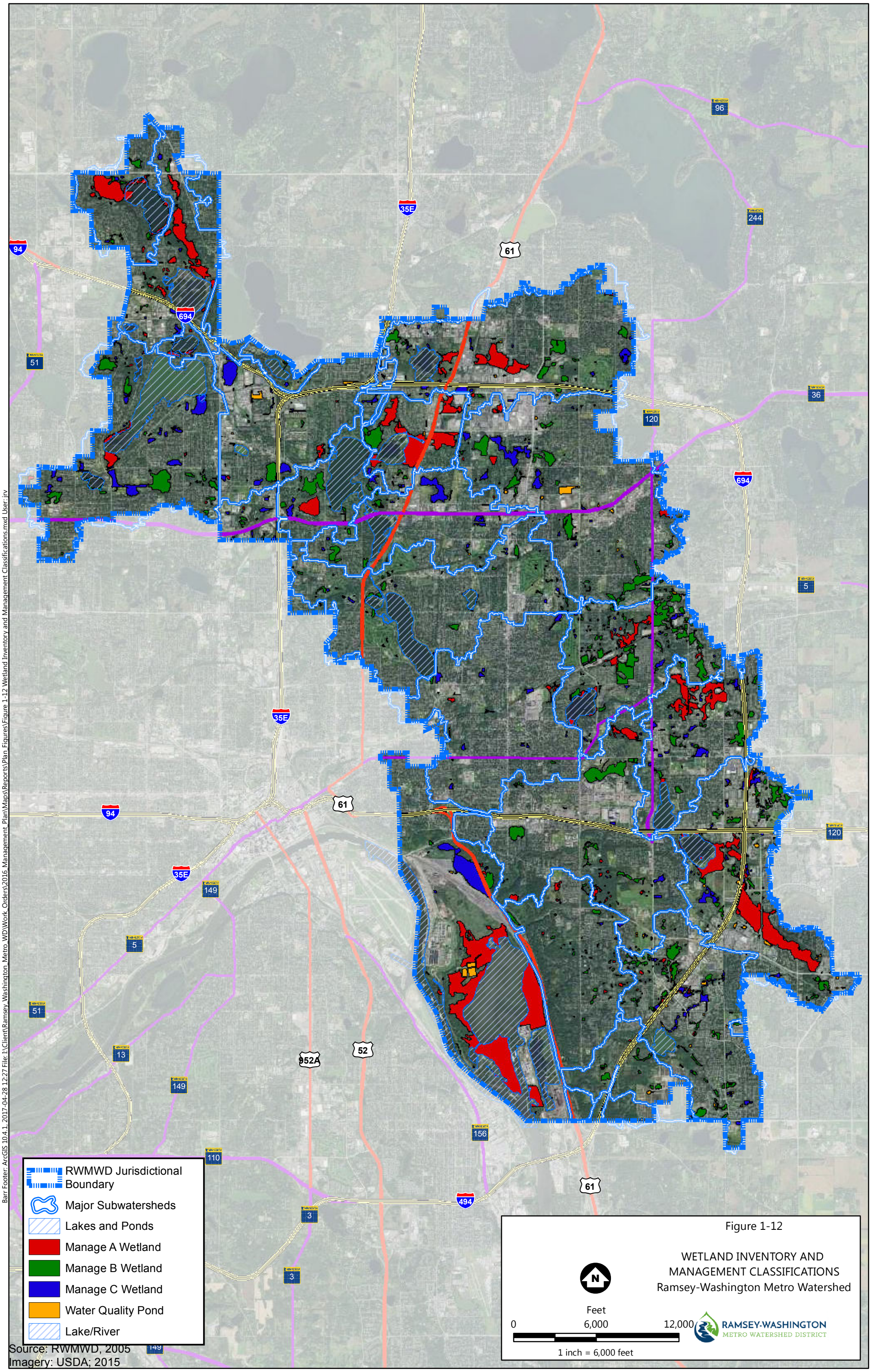
Figure 1-12 shows the RWMWD wetland management classifications for all of the wetlands assessed by the RWMWD. The RWMWD uses the wetland management classifications in the District permitting and regulatory programs (see Section 4.1.2). The RWMWD established wetland management standards for each classification. The wetland management standards are incorporated into the RWMWD rules and regulations and are summarized in Table 1-8. These standards define the minimum and average no disturb buffer required for each wetland class and the necessary pretreatment of stormwater prior to discharge into a wetland. The standards also do not allow stormwater BMPs within the wetland buffer.

Table 1-8 RWMWD Wetland Buffer and Water Quality Requirements

RWMWD Wetland Classification	Buffer Requirements[1]		Water Quality Pretreatment Requirements
	Minimum "No Disturb" Buffer (ft)	Average "No Disturb" Buffer (ft)	Total Suspended Sediment (TSS)
Manage A	37.5	75	90% removal[2]
Manage B	25	50	90% removal[2]
Manage C	12.5	25	90% removal[2]
Water Quality Pond	10	10	NA

[1] Cities may have more stringent wetland buffer requirements than those required by the District.

[2] Pretreatment must achieve 90% TSS removal from the runoff generated by a NURP water quality storm (2.5" rainfall). Runoff volume reduction BMPs may be considered and included in this requirement.


RWMWD Jurisdictional Boundary
Major Subwatersheds
Lakes and Ponds
Manage A Wetland
Manage B Wetland
Manage C Wetland
Water Quality Pond
Lake/River
Source: RWMWD, 2005
Imagery: USDA; 2015
Figure 1-12
WETLAND INVENTORY AND MANAGEMENT CLASSIFICATIONS
Ramsey-Washington Metro Watershed
N
Feet
0
6,000
12,000
1 inch = 6,000 feet
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT
Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:27 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-12 Wetland Inventory and Management Classifications.mxd User: jrv

1.12 Water Quantity and Flooding

Since its creation in 1975, the District has addressed water level and flooding issues through its capital improvement program (CIP) projects, District actions, and programs (e.g., its permitting program). The District's rules permitting program address issues such as minimum building elevations and stormwater runoff rate control to prevent or minimize the impact of flooding issues in the future.

1.12.1 District Flood Control Projects

The District has cooperated with developers and local municipalities to construct many project to address flooding issues. Many of these projects incorporate secondary benefits for water quality, habitat improvement, or other uses. Some notable District flood control projects include:

- Battle Creek Project 1 (St. Paul and Maplewood)
- Battle Creek Lake Area Flood Protection (Woodbury)
- Phalen/Keller Outlet Project (St. Paul)
- Target Pond (North St. Paul)
- Beltline Interceptor Rehabilitation (St. Paul)
- Tanners Lake Emergency Response Plan (Oakdale)
- Gervais Lake Emergency Response Plan (Little Canada)
- Battle Creek Lake Emergency Response Plan (Woodbury)
- McKnight Basin Emergency Response Plan (Maplewood)

District flood control facilities are also shown among the District-managed facilities shown in Figure 1-10. The RWMWD is generally responsible for maintenance of District flood control projects and facilities unless a maintenance agreement has been reached with another entity (see Section 1.9.3). Individual flood control projects are described in greater detail in the respective subwatershed Section (Section 2.0).

1.12.2 Flood Insurance Studies and Regulatory Water Levels

1.12.2.1 FEMA-established Floodplains

The Federal Emergency Management Agency (FEMA) performs flood insurance studies (FIS) and develops floodplain maps to determine areas prone to flooding during the 100-year (and sometimes 500-year) storm events. The water level corresponding to the 100-year storm event is referred to as the Base Flood Elevation (or BFE) and is the basis for the mapped floodplain extent. Each of the cities within the RWMWD has a FIS. The FIS, together with a city's floodplain ordinance, allow the city to take part in the national flood insurance program (NFIP). Homeowners within FEMA-designated floodplains are required to purchase flood insurance. In some cases, homes within FEMA-designated floodplains on the FEMA floodplain maps may actually not be in the floodplain. To waive the mandatory flood insurance requirements for their homes, residents must remove their homes from the FEMA-designated floodplain by obtaining a Letter of Map Amendment (LOMA). Note that these programs are implemented

independently of the District and are described herein for informational purposes. FEMA-established floodplains and 100-year flood levels are available from FEMA at: https://msc.fema.gov/portal

The cities within the District have prepared local water management plans. These plans have more detailed information regarding storm sewer systems and localized flooding issues. Additional flooding information is also available from the Flood Insurance Studies (FIS) for the cities within the RWMWD.

1.12.2.2 District-established Floodplains

Through the adoption of this Plan, this District establishes 100-year flood levels for all District-managed waterbodies (see Section 2.0) based on hydrologic and hydraulic modeling using Atlas 14 precipitation data (see Section 1.2). These District 100-year water surface elevations published in this Plan (or subsequent studies) may differ from the FEMA-determined base flood elevations for individual waterbodies (in part due to the FIS within the District having been adopted prior to the publication of Atlas 14). When District studies identify differences between District-established flood levels and FEMA-established flood levels, the District will inform affected land-owners through mailings, meetings, or other procedures.

The District's permitting program (see Section 4.1.2) establishes minimum building elevations relative to the District-established 100-year flood levels and requires a District permit for activities located within the 100-year floodplain. Note that all 100-year water surface elevations presented in this Plan, including those presented in figures included in the subwatershed sections (Section 2.1 through Section 2.25), are District-established flood levels.

1.12.3 Water Quantity Modeling

Water quantity modeling is necessary to establish flood levels and determine floodplain extents, design hydraulic structures adequate to meet their intended functions, and assess hydraulic impacts of projects proposed by the District and other entities.

From 2014 to 2015, the RWMWD began updated its hydrologic and hydraulic model (Figure 1-13). Updates to the District's model included:

- Incorporating rainfall depths published in Atlas 14
- Verifying watershed delineation
- Updating storage volumes using new LiDAR data
- Incorporating municipal storm sewer data and projects permitted by the District

The updated model allows the district to identify areas at risk of flooding, including areas not previously identified. The updated model will also allow the district to more effectively prioritize infrastructure improvement projects to address these flood-prone areas.

The District's model was originally developed in the early to mid-1990s. During that time, several different elevation datasets were used to delineate subwatersheds. As part of the model update, watershed delineation was verified using the MDNR's 2011 LiDAR dataset. The resolution (1x1 meter) of the dataset

allowed for a higher level of refinement in subwatershed delineation than was achievable with previous datasets, and using one elevation dataset allowed for consistency throughout the district. Watershed delineation also accounted for redevelopment, best management practice (BMP) installations, and other permitted projects that have occurred since the last model update.

District staff worked with municipalities to compile and incorporate storm sewer data for projects that had not been incorporated into the previous model. Large BMPs (e.g., large detention ponds) were incorporated directly into the hydraulic model. Smaller BMPs (e.g., residential rainwater gardens) were implicitly incorporated into the model as an initial abstraction within the subwatershed where the BMP was located.

The recent modeling also incorporates Atlas 14 (NOAA, 2013), which establishes precipitation depths for rainfall events of various return frequencies and durations (see Section 1.2). Previous analyses were based on precipitation data published in NOAA's Technical Paper 40 (TP40), originally published in 1961. Compared to TP40, Atlas 14 shows larger precipitation depths throughout the Twin Cities metro area. The 2-year, 24-hour and 100-year, 24-hour events were simulated in the District's model using the larger Atlas 14 precipitation depths. Modifications were made to the model to convey the additional stormwater runoff through the stormwater system. These modifications included adding overland flow conduits and extending storage curves.

Following updates to the district's model, the 100-year rainfall event was evaluated to calculate revised flood levels in water bodies throughout the district. Revised flood levels for all subwatersheds are published in this Plan in the subwatershed sections (see Section 2.0). The updated results will be used to identify flood-prone areas and allow the District to plan for more realistic flood conditions. The District will work with municipalities to address flooding and other stormwater management issues identified by the modeling results. The District will also reference model results during the permitting of future projects.

Snail Lake
Grass Lake
Lake Wabasso
Twin Lake
Gervais Creek
Kohlman Lake
Willow Creek
Lake Owasso
Gervais Lake
Keller Lake
Kohlman Creek
Lake Phalen
Beaver Lake
St. Paul Beltline
Tanners Lake
Battle Creek
Battle Creek Lake
Blufflands
Carver Lake
Fish Creek
Blufflands

94
35E
694
61
51
96
244
36
120
5
3
149
52
952A
13
110
156
494

RWMWD Jurisdictional Boundary
Major Subwatersheds
Hydrologic Model Subwatersheds

Modeled Areas

XP-SWMM
Barr Watershed Model
Not Modeled

Imagery: USDA; 2015

Figure 1-13

HYDROLOGIC/HYDRAULIC MODELING EXTENT
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000

1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:29 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-13 Hydrologic Modeling Extent.mxd User: irv

1.13 Natural Communities and Rare Features

Through its Natural Heritage and Nongame Research Program (NHNRP), the MDNR 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 MDNR maintains the Natural Heritage Information System (NHIS) as a statewide database of these resources. The MDNR limits publication of spatial attributes and locations of these items to protect rare features or species from damage or collection.

The MDNR's Minnesota County Biological Surveys for Ramsey County (1994, with Anoka County) and Washington County (1990) identify pre-settlement vegetation. Prior to settlement, the RWMWD was covered by two major natural communities. A predominantly oak forest interrupted by tall grass prairie and marsh covered the watershed along the Mississippi River corridor, the portion of the District now in St. Paul, and in the Grass Lake area. A dense deciduous forest known as the "Big Woods" covered most of the north and eastern portions of the district and the area between St. Paul and Grass Lake. Elm, sugar maple, and basswood are representative Big Woods tree species. Although scattered remnants of this forest are still present throughout much of its original range, the only concentrated areas of Big Woods remaining within the RWMWD are in Battle Creek Regional Park and the Fish Creek Open Space. Other natural communities present in the District prior to settlement include wet prairie (concentrated around lakes) and conifer bogs and swamps.

Sites of biological significance are identified by the Minnesota County Biological Survey. There is one "scientific and natural area" (SNA) identified by the MDNR within the RWMWD: 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 the Battle Creek Lake subwatershed, is the largest and most ecologically diverse wetland in the District, and is classified as a site of high biodiversity significance (see Figure 1-14). 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. Other areas of biodiversity significance are located throughout the watershed (see Figure 1-14). RWMWD actively manages many other important habitat areas, as described in the Natural Resources portion of its website (www.rwmwd.org).

Numerous locations throughout the RWMWD watershed are identified as part of the MDNR's NHIS databased, indicating the presence of rare plants, animals, or communities (see Table 1-9).

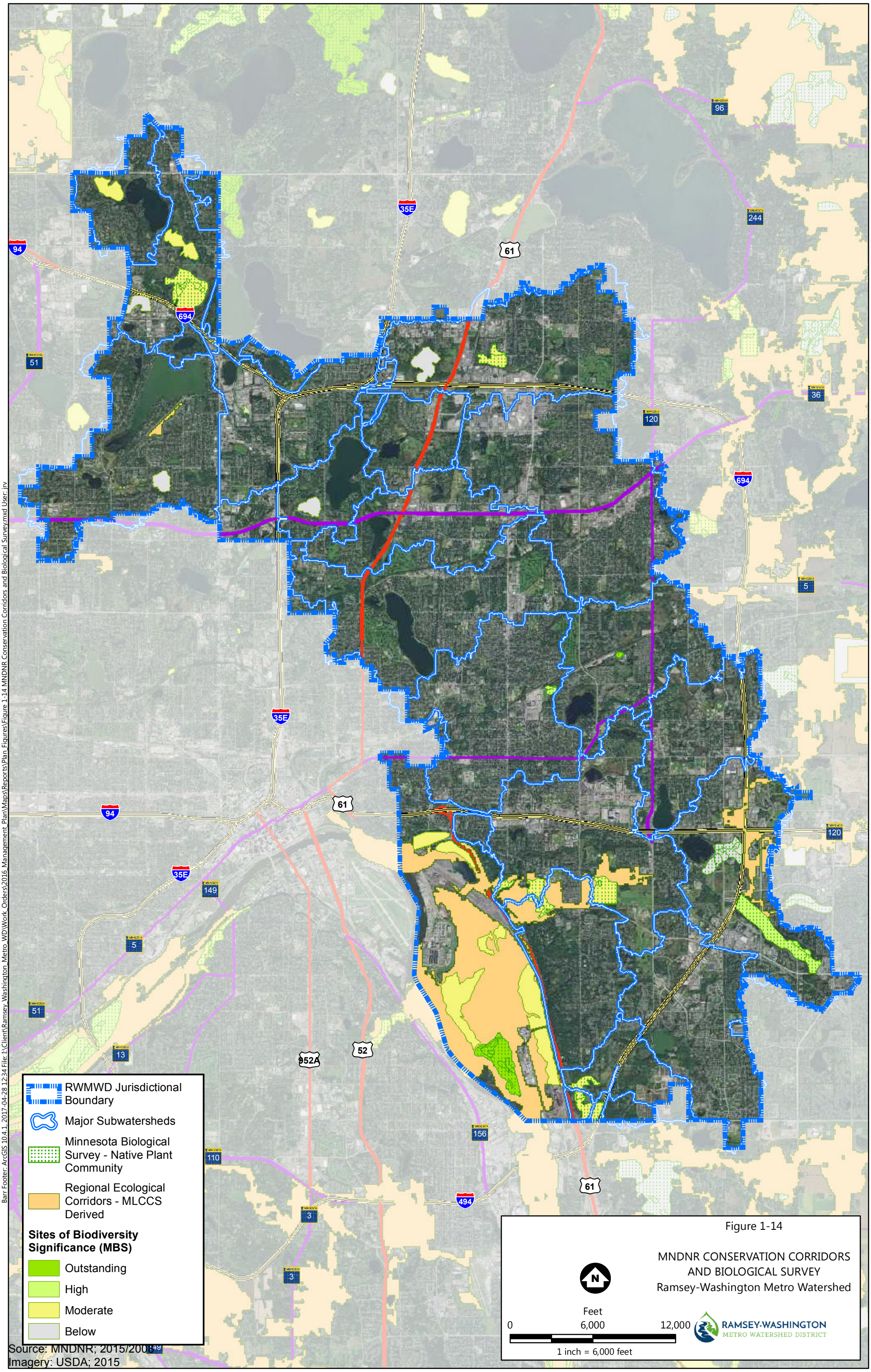
Table 1-9 NHIS Database Species within the RWMWD

Vertebrate Animal	Invertebrate Animal	Vascular Plant	Terrestrial Community
Bald Eagle	Ebonyshell	Autumn Fimbristylis	Alder - (Maple - Loosestrife) Swamp
Black Buffalo	Fawnsfoot	Black Huckleberry	Dry Sand - Gravel Prairie (Southern)
Blanding's Turtle	Hickorynut	Clinton's Bulrush	Lake Bed
Blue Sucker	Monkeyface	Club-spur Orchid	Mesic Prairie (Southern)
Lake Sturgeon	Rock Pocketbook	Cowbane	Native Plant Community, Undetermined Class
Least Darter	Wartyback	Half Bristly Bramble	Northern Mixed Cattail Marsh
Paddlefish		Kitten-tails	Prairie Rich Fen
Pugnose Shiner		Tall Nut-rush	Red Oak - Sugar Maple - Basswood - (Bitternut Hickory) Forest
Red-shouldered Hawk		Tooth-cup	Red Oak - White Oak Forest
Western Foxsnake		Tubercled Rein-orchid	Sand Beach (Inland Lake)
		White Wild Indigo	Seepage Meadow/Carr
		Yellow Pimpernel	Tamarack Swamp (Southern)
			Wet Prairie (Southern)
			Willow - Dogwood Shrub Swamp

Other rare features – categories include:

Colonial Waterbird Nesting Site – Animal Assemblage

Proglacial River Composite (Quaternary) – Other (Ecological)


RWMWD Jurisdictional Boundary
Major Subwatersheds
Minnesota Biological Survey - Native Plant Community
Regional Ecological Corridors - MLCCS Derived
Sites of Biodiversity Significance (MBS)
Outstanding
High
Moderate
Below
Source: MNDNR; 2015/2008
Imagery: USDA; 2015
Figure 1-14
MNDNR CONSERVATION CORRIDORS AND BIOLOGICAL SURVEY
Ramsey-Washington Metro Watershed
N
Feet
0
6,000
12,000
1 inch = 6,000 feet
RAMSEY-WASHINGTON METRO WATERSHED DISTRICT
Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:34 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 1-14 MNDNR Conservation Corridors and Biological Survey.mxd User: jrv

1.14 Pollutant Sources

The sources of water pollution in the RWMWD are many and varied. There are many permitted sites, hazardous waste generators, and contaminated sites within the District. The MPCA maintains a database of these sites, which includes permitted sites (air, industrial stormwater, construction stormwater, wastewater discharge), hazardous waste generating sites, leak sites, petroleum brownfields, tank sites, unpermitted dump sites, and sites enrolled in the Voluntary Investigation and Cleanup (VIC) program. This information is available online through the MPCA's What's In My Neighborhood program. The presence of potentially contaminated or hazardous waste sites should be considered as sites are redeveloped and BMPs are implemented. The presence of soil contamination at many of these sites, if not removed, may limit or prevent infiltration as a stormwater management option

In contrast to sites with known hazards, non-point source pollution cannot be traced to a single source or pipe. Instead, pollutants are carried from land to water in stormwater or snowmelt runoff, in seepage through the soil, and in atmospheric transport. Discharge from stormwater pipes is considered a non-point source discharge as the pollutants coming from the pipe are generated across the watershed contributing to the pipe, not at a single location. Point sources frequently discharge continuously throughout the year, while non-point sources discharge in response to precipitation or snowmelt events. For most waterbodies, non-point source runoff, especially stormwater runoff, is the major contributor of pollutants. Table 1-10 summarizes the principal pollutants found in stormwater runoff and provides example sources and possible impacts of each pollutant.

Some areas within the RWMWD are served by subsurface sewage treatment systems (SSTS). Failing or substandard SSTS may be a non-point source of pollutants. Improperly sited, installed or maintained systems may achieve inadequate treatment of sewage. In addition to the public health risks of untreated or inadequately treated sewage (e.g., contamination of wells), sewage contains the nutrient phosphorus, which if discharged into waterbodies can cause excessive algae and aquatic plant growth leading to degradation in water quality. The MPCA implements an SSTS regulatory program to manage the environmental and public health impacts of SSTS.

As part of their MS4 responsibilities, cities maintain illicit discharge detection and elimination (IDDE) programs to minimize discharge of prohibited materials to stormwater systems. Ramsey County provides medicine and household hazardous material drop off sites to promote proper disposal of hazardous materials.

More information about potential pollutant sources is available from the MPCA website: http://www.pca.state.mn.us/index.php/data/wimn-whats-in-my-neighborhood/whats-in-my-neighborhood.html

Table 1-10 Pollutants Commonly Found in Stormwater

Stormwater Pollutant	Examples of Sources	Related Impacts
Nutrients: Nitrogen, Phosphorus	Decomposing grass clippings, leaves and other organics, animal waste, fertilizers, failing septic systems, atmospheric deposition	Algal growth, reduced clarity, other problems associated with eutrophication (oxygen deficit, release of nutrients and metals from sediments)
Sediments: Suspended and Deposited	Construction sites, other disturbed and/or non-vegetated lands, eroding streambanks and shorelines, road sanding	Increased turbidity, reduced clarity, lower dissolved oxygen, deposition of sediments, smothering of aquatic habitat including spawning sites, sediment and benthic toxicity
Organic Materials	Leaves, grass clippings	Oxygen deficit in receiving waterbody, fish kill, release of nutrients.
Pathogens: Bacteria, Viruses	Domestic and wild animal waste, failing septic systems	Human health risks via drinking water supplies, contaminated swimming beaches
Hydrocarbons: Oil and Grease, PAHs (Naphthalenes, Pyrenes)	Tar-based pavement sealant, 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
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
Chlorides	Road salting and uncovered salt storage	Toxicity of water column and sediment
Polycyclic Aromatic Hydrocarbons (PAH's)	Tar based pavement sealant	Carcinogenic to humans
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 Engineering Company, 2001).

2.0 Major Subwatersheds

This Section of the RWMWD Plan presents detailed information for each of the 25 major subwatersheds within the RWMWD. The information provided for each subwatershed includes general information about the subwatershed, past studies, land use, drainage patterns and District-managed waterbodies. Also included for each subwatershed is a summary of the past and future management activities related to four of the RWMWD goals: (1) achieve quality surface water; (2) manage risk of flooding; (3) support sustainable groundwater; and (4) achieve healthy ecosystems.

Table 2.0-1 lists the 25 major subwatersheds of the RWMWD in the order they appear in this Plan. Subwatershed locations are shown in Figure 2-1.

The first nine subwatershed sections (Section 2.1 – Section 2.9) are in the Phalen Chain of Lakes Watershed. The Phalen Chain of Lakes Watershed encompasses 20.6 square miles and covers the northern half of the RWMWD. This watershed contains a chain of five major lakes (Kohlman, Gervais, Keller, Round-Maplewood, and Phalen) along with several smaller lakes (Willow, Twin, Round- Little Canada, Wakefield), three streams (Willow Creek, Kohlman Creek, and Gervais Creek), and many wetlands. The subwatersheds associated with these waterbodies are often grouped and considered the Phalen Chain of Lakes Watershed for management purposes. For purposes of this plan, the Phalen Chain of Lakes Watershed is separated into the following eight subwatersheds: Twin Lake, Gervais Creek, Gervais Lake, Willow Creek, Kohlman Creek, Kohlman Lake, Keller Lake and the Lake Phalen subwatershed. These eight subwatersheds are described at the outset of this Section of the plan.

The major lakes within the Phalen Chain of Lakes Watershed and the surrounding park lands are highly valued and heavily used recreational resources for residents within the entire eastern Twin Cities metro area. Lake Phalen and Gervais Lake feature heavily used public swimming beaches. These lakes and Keller Lake are also excellent fishing lakes and average several times the fishing pressure of lakes within the metropolitan area. The chain of lakes and parks provide important areas for walking, biking, skiing, picnicking and other kinds of recreation. The Phalen Chain of Lakes Watershed lies within a major flyway for migrating waterfowl and song birds and provides significant habitat for other birds and wildlife in an urban setting.

The last seven subwatershed sections (Section 2.19 – Section 2.25) are in the Grass Lake Area. The Grass Lake Area was incorporated into the RWMWD in 2013 after the dissolution of the Grass Lake Watershed Management Organization (GLWMO). The Grass Lake Area covers 8.9 square miles and drains to Vadnais Lake. All other subwatersheds in the District ultimately drain to the Mississippi River. The subwatersheds included in the Grass Lake Area include: Grass Lake, Bennett Lake, Shoreview Lake, Snail Lake, Lake Owasso, Lake Wabasso, and Lake Emily.

Table 2.0-1 Numerical Listing of 25 Major RWMWD Subwatersheds

Section	Subwatershed Name
2.1	Willow Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.2	Kohlman Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.3	Kohlman Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.4	Twin Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.5	Gervais Creek Subwatershed (Phalen Chain of Lakes Watershed)
2.6	Gervais Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.7	Keller Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.8	Lake Phalen Subwatershed (Phalen Chain of Lakes Watershed)
2.9	Wakefield Lake Subwatershed (Phalen Chain of Lakes Watershed)
2.10	Beaver Lake Subwatershed
2.11	St. Paul Beltline Storm Sewer Subwatershed
2.12	Mississippi River Bottomlands Subwatershed
2.13	Tanners Lake Subwatershed
2.14	Battle Creek Lake Subwatershed
2.15	Battle Creek Subwatershed
2.16	Blufflands Subwatershed
2.17	Carver Lake Subwatershed
2.18	Fish Creek Subwatershed
2.19	Grass Lake (Grass Lake Area)
2.20	Bennett Lake (Grass Lake Area)
2.21	Shoreview Lake (Grass Lake Area)
2.22	Snail Lake (Grass Lake Area)
2.23	Lake Owasso (Grass Lake Area)
2.24	Lake Emily (Grass Lake Area)
2.25	Lake Wabasso (Grass Lake Area)

Snail Lake
Grass Lake
Shoreview Pond
Lake Wabasso
Lake Emily
Twin Lake
Willow Creek
Gervais Creek
Kohlman Lake
Lake Owasso
Bennet Lake
Gervais Lake
Keller Lake
Kohlman Creek
Lake Phalen
Beaver Lake
St. Paul Beltline
Tanners Lake
St. Paul Beltline
Battle Creek
Battle Creek Lake
Mississippi River Bottomlands
Blufflands
Carver Lake
Fish Creek
Blufflands

94
35E
694
61
96
244
51
36
120
5
149
52
952A
18
110
156
494
3

RWMWD Jurisdictional Boundary
Major Subwatersheds
Creeks

Source: Barr Engineering, 2015
Imagery: USDA; 2015

Figure 2-1

MAJOR SUBWATERSHEDS AND DRAINAGE PATTERNS
Ramsey-Washington Metro Watershed

N

Feet
0 6,000 12,000
1 inch = 6,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:35 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Plan_Figures\Figure 2-1 Major Subwatersheds.mxd User: jrv

2.1 Willow Creek Subwatershed

2.1.1 General Description

The Willow Creek subwatershed includes 2,923 acres in the cities of While Bear Lake, Vadnais Heights, Gem Lake, and Maplewood (see Figure 2.1-1). The Willow Creek subwatershed is located entirely within Ramsey County and is tributary to the Phalen Chain of Lakes. Much of the watershed is located north of Interstate-694 and east of Highway 61 in the city of White Bear Lake. This area forms the headwaters of Willow Creek, a District-managed stream that flows west.

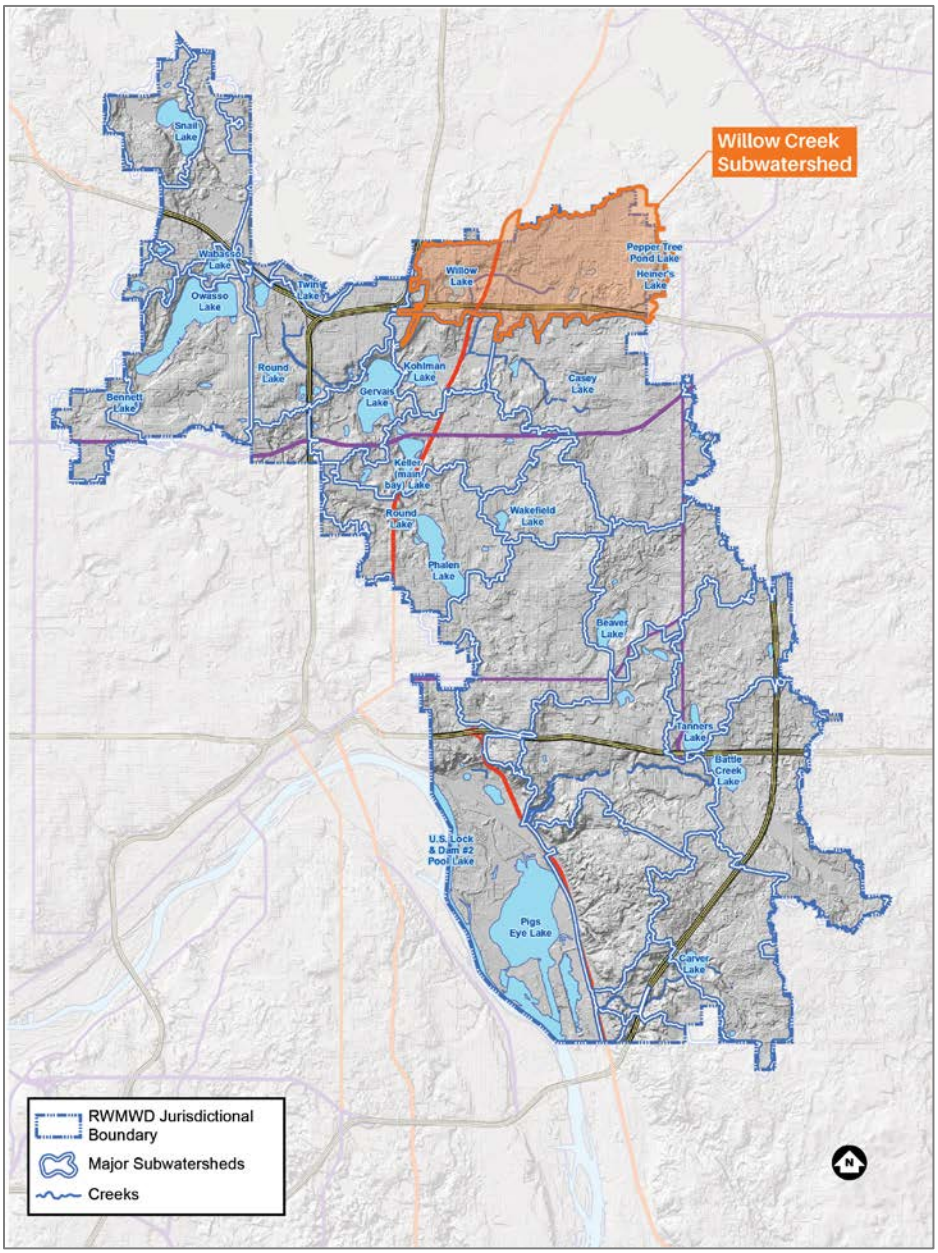


Figure 2.1-1 Willow Creek Location Map

Willow Creek is an intermittent (i.e., occasionally dry) stream previously classified as a county ditch (County Ditch 18). Willow Creek has historically been, and continues to be, managed as a stormwater conveyance system by the RWMWD.

Willow Lake (MDNR# 62-0040P) is located north of Interstate 694 (I-294) and west of Highway 61 in the city of Vadnais Heights. Willow Lake is tributary to Willow Creek. The lake has a total surface area of 75 acres and a maximum depth of 6 feet. The lake is entirely surrounded by private land with no public access. There is an aerator in Willow Lake that is operated by the H.B. Fuller Company, the current landowner.

Table 2.1-1 Willow Creek Subwatershed Facts

Tributary Area (Direct)	2,923 acres
Tributary Area (Total)	2,923 acres
Downstream Watershed	Kohlman Lake
MDNR Designation	62-0040P
Lake Surface Area[1]	75
Lake Maximum Depth[1]	6 ft
Lake Outlet Type[1]	48" RCP
Lake Outlet Elevation[1]	880.5 ft
100-Year Flood Level[1]	886.3 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake
MS4s in the Direct Tributary Area	Gem Lake, Maplewood, Vadnais Heights, White Bear Lake, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Lake data refers to Willow Lake

2.1.1.1 Past Studies

The following list is a summary of past studies related to the Willow Creek subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *Kohlman Basin Feasibility Study*. Prepared for RWMWD by Barr Engineering, 1993.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.

- *Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report*. Prepared for RWMWD by Barr Engineering, 2007.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.1.1.2 Land Use

Based on the Metropolitan Council 2010 land use data, the portion of the subwatershed lying east of White Bear Avenue is predominantly occupied by single-family residences (see Figure 2.1-2). There is some commercial and higher-density residential land use adjacent to Interstate 694. North of I-694 is Manitou Ridge Golf Course and a park. The land west of White Bear Avenue and east of Highway 61 is predominantly single-family residential area, with some light industrial and office development area, and open space along Willow Creek. Based on the 2010 Metropolitan Council land use data, the land west of Highway 61 is largely light industrial and office development, with significant open space surrounding Willow Lake. The areas immediately adjacent to Highway 61, I-694, and White Bear Avenue are largely commercial developments.

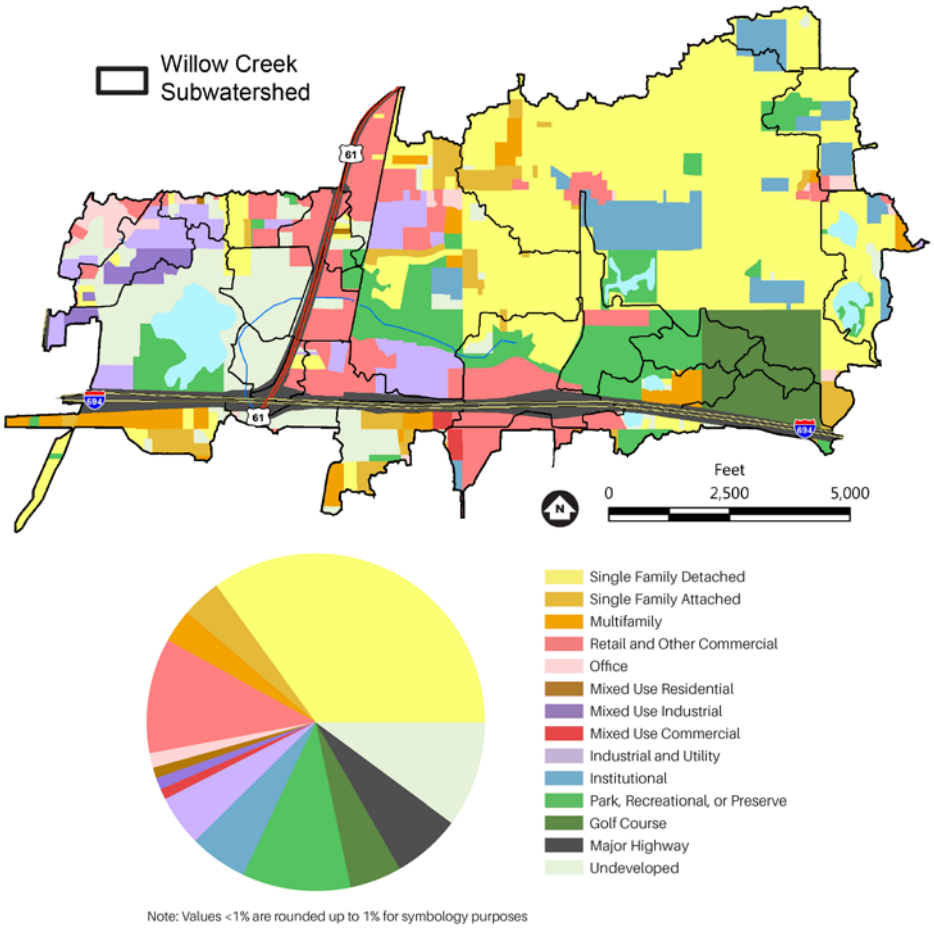


Figure 2.1-2 Breakdown of land uses throughout the Willow Creek Subwatershed (2010 Metropolitan Council)

The Willow Creek subwatershed is nearly fully developed. Future land use conditions are not expected to differ significantly from existing land use conditions. Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site. Cities may have lower thresholds for volume reduction for redevelopment projects.

2.1.1.3 Drainage Patterns and Waterbodies

East of Highway 61, the Willow Creek subwatershed generally drains from east to west into Willow Creek (County Ditch 18), which flows west underneath Highway 61 before turning south and east towards the intersection of Interstate 694 and Highway 61. Much of the subwatershed west of Highway 61 drains into Willow Lake. Willow Lake outlets on the east side into Willow Creek through a 48" reinforced concrete pipe (outlet elevation 880.5 feet). The combined outflow from the Willow Creek subwatershed continues to flow south, merging with Kohlman Creek at the Kohlman Basin and eventually discharging into Kohlman Lake.

The Willow Creek subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.1-6). Figure 2.1-6 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Willow Creek subwatershed include Willow Creek and Willow Lake.

Wetlands within the Willow Creek subwatershed are shown in Figure 2.1-6 according to the RWMWD wetland management classification (see 1.11.3).

2.1.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for District-managed waterbodies in the Willow Creek subwatershed: Willow Lake and Willow Creek.

2.1.2.1 Historic Water Quality

Willow Creek

The RWMWD is aware of very limited water quality data for Willow Creek. From 1977 to 1989, the District monitored stream water quality at the junction of Willow Creek and Kohlman Creek (the Ditch 18 station at Beam Avenue and Highway 61 in Maplewood) to assess the quality of water discharged to Kohlman Lake. Measured parameters included chlorides, dissolved oxygen, fecal coliform, nitrates, pH, specific conductance, suspended solids, temperature, total phosphorus, turbidity, and flow. *An Evaluation of District Water Quality Data Collected from 1977 through 1989* (RWMWD, 1990) summarized the monitoring data. The 1997 RWMWD Plan states that, dissolved oxygen, pH, temperature, and fecal coliform counts all met then-current MPCA standards, with some increases in fecal coliform counts during a rapid urbanization period of 1984 to 1989. Suspended solids and turbidity generally met then-current

MPCA standards during this monitoring period. Stream water quality monitoring at the Ditch 18 location was discontinued after the 1990 evaluation.

More recent water quality data for Willow Creek is not available from the MPCA's Environmental Data Access website. In 2014, the MPCA adopted region-based eutrophication water quality standards for streams, including a revised total suspended solids standard (see Minnesota Rules 7050). 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.

Willow Lake

At the time of this Plan, the RWMWD has assigned a water quality classification of "Stable" to Willow Lake. Willow Lake water quality was not assessed as part of the RWMWD WRAPS study (see Section 1.10.5.2). The current classification is based on available historical water quality that meets applicable MPCA standards and does not exhibit a declining trend.

Willow Lake has been monitored intermittently since 1981, and is not currently monitored by the RWMWD or Ramsey County. Limited data is available from the MPCA's Environmental Data Access website. Figure 2.1-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.1-2 summarizes these historic nutrient-related water quality parameters for Willow Lake relative to MPCA standards.

Table 2.1-2 Willow Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Willow Lake (1981-2001) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	47 [1]
Chlorophyll-a (µg/L)	≤ 20	8 [2]
Secchi disk transparency (m)	≥ 1.0	1.8 [3]

[1] Total phosphorus data from 1981 – 1985, 1996, and 1998 – 2001

[2] Chlorophyll *a* data from. 1981 – 1985, and 1999 – 2001

[3] Secchi disc data from 1982, 1984, 1985, 1996, and 1998 – 2001

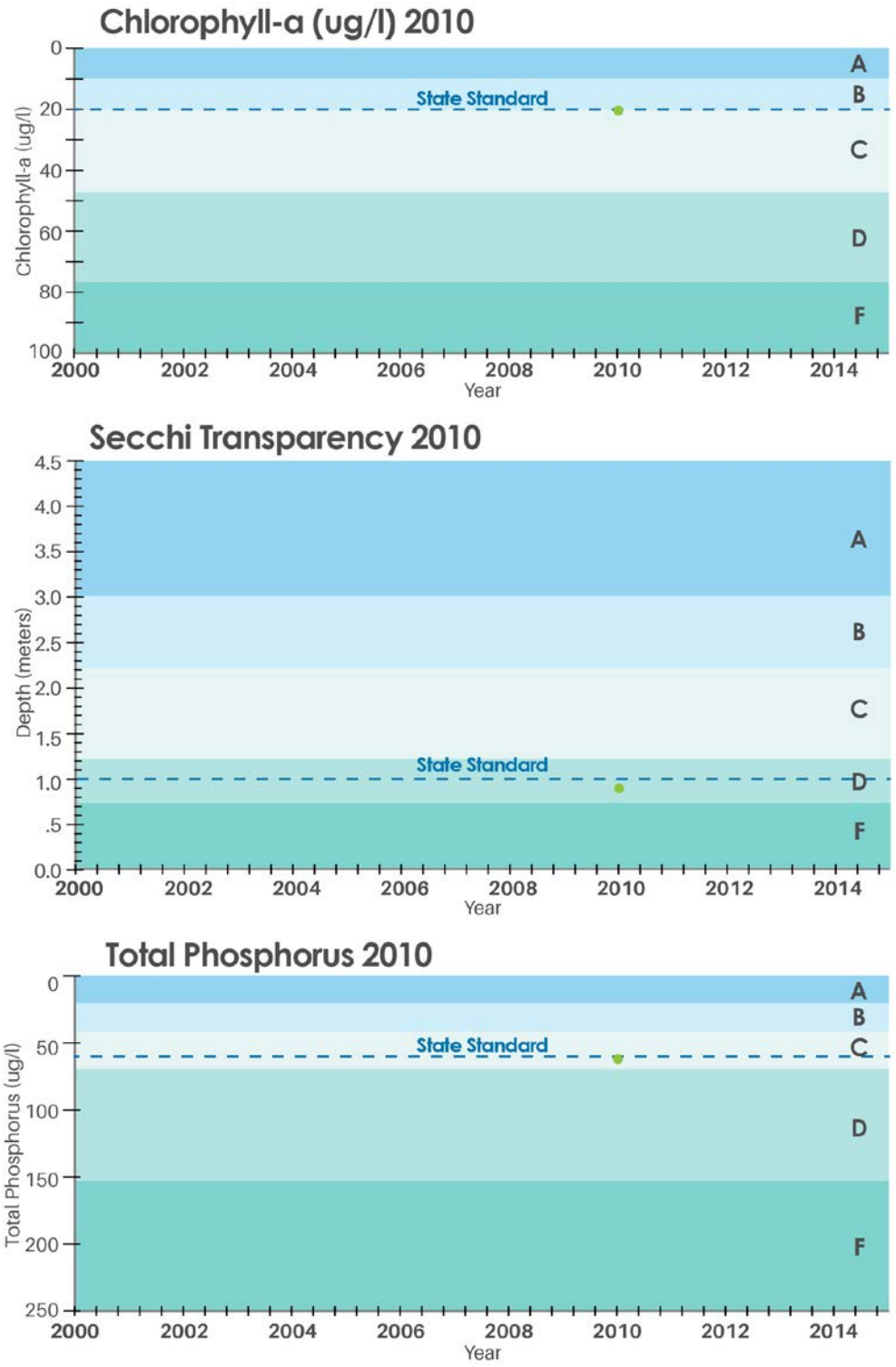


Figure 2.1-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Willow Lake (2010)

2.1.2.2 State of the Fishery

The MDNR last assessed the Willow Lake fish population in 1987. According to the assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is comprised of panfish species, gamefish species, and rough fish species. Over half of the fish caught were bluegill and sunfish species, and nearly a third were black bullheads. Largemouth bass and muskellunge made up the rest of the fishery. Approximately half of the fish caught were between 6 and 8 inches long, and a few were larger than 15 inches (mostly muskellunge).

2.1.2.3 State of the Macrophyte Community

On June 24, 2010, District staff conducted a macrophyte survey of Willow Lake. The results of this survey are summarized below in Figure 2.1-4; 106 sites were surveyed for macrophytes. Of these, 106 had vegetation, indicating that Willow Lake is a highly macrophyte-dominated lake.

Where white waterlily, coontail and filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Willow Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Also, curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

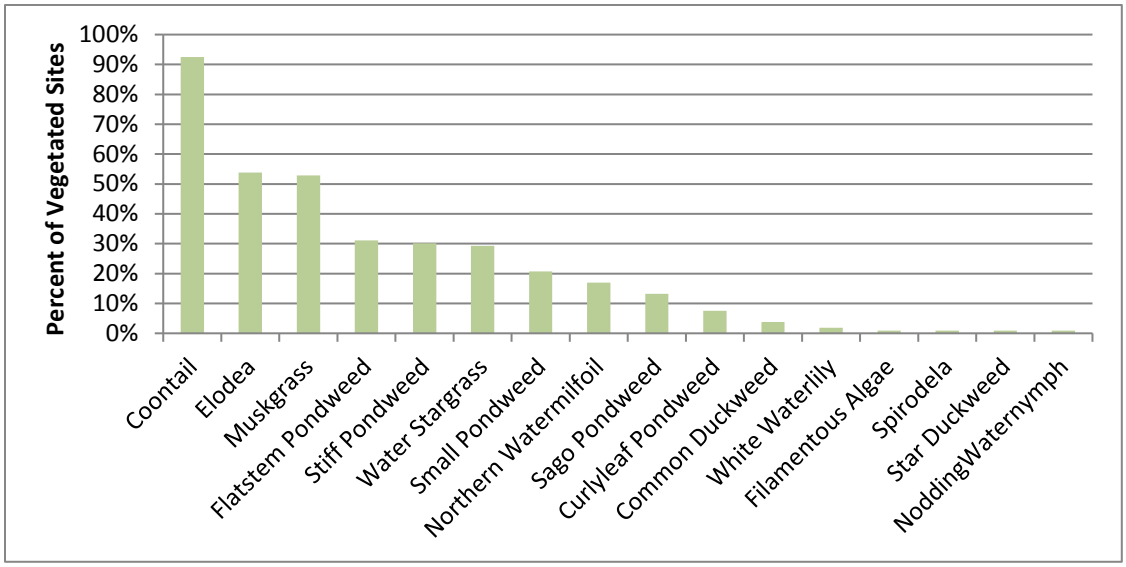


Figure 2.1-4 June, 2010 Willow Lake Macrophyte Survey Results

2.1.2.4 Water Quality Goals

The water quality goals for Willow Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.1-2. Water quality goals for Willow Creek are consistent with the MPCA's stream eutrophication standards (see Section 1.10.1).

The RWMWD strives to ensure that the watercourse and banks of Willow Creek are stable to minimize erosion and sediment problems. In 2003, the District completed a capital improvement project to alleviate

erosion and pipe capacity issues along Willow Creek at Highway 61. Prior to that project, existing drainage conditions were causing significant erosion, which transported silt and sediment into a high quality wetland on the HB Fuller Property, downstream of Highway 61 (subwatershed NB18-19, see Figure 2.1-6). Projects implemented in the Willow Creek subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown Figure 2.1-5.

The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion and other stream degradation problems.

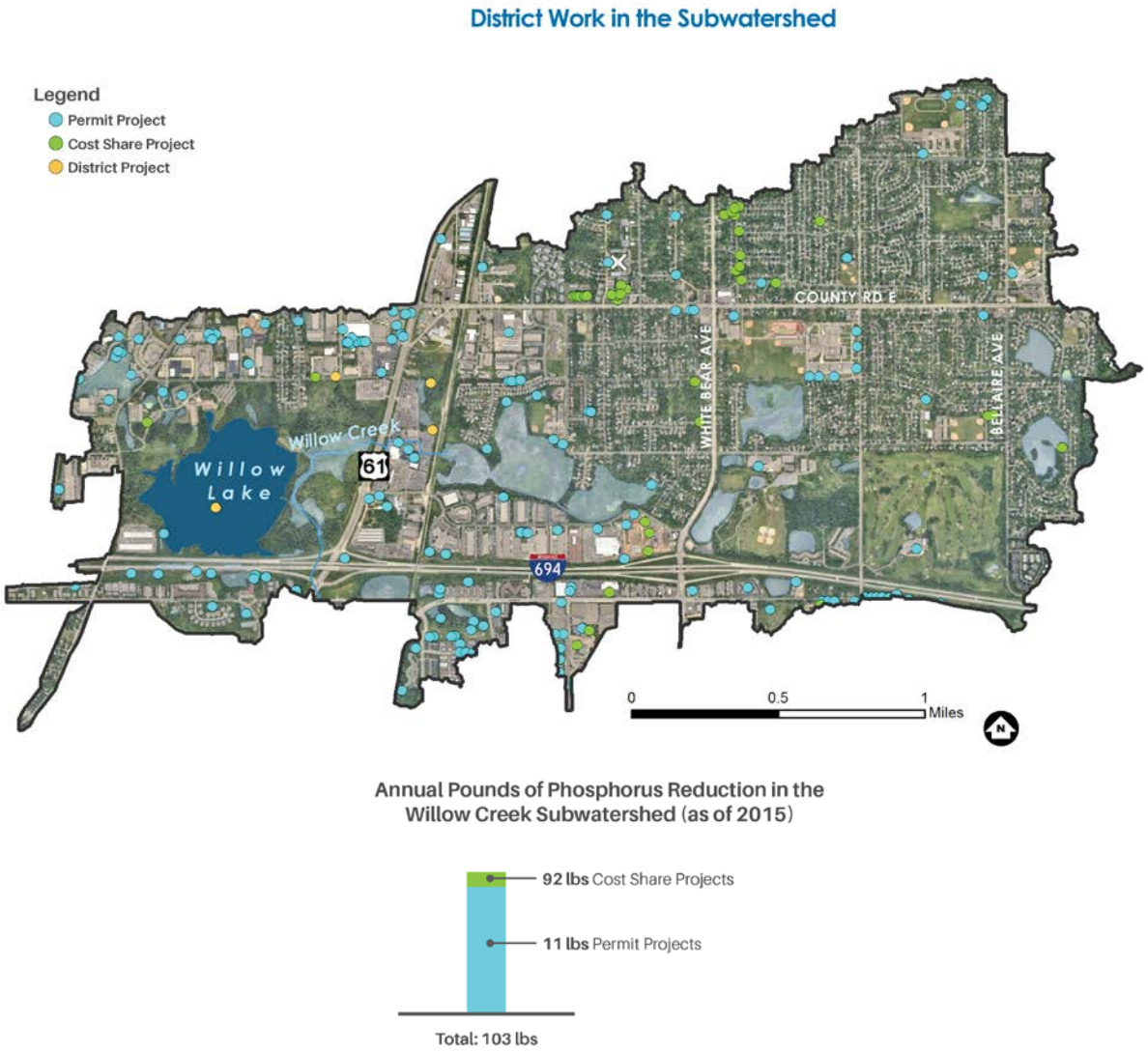


Figure 2.1-5 District work in the Willow Creek Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.1.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The RWMWD studied the Willow Creek subwatershed in 1988 to guide the RWMWD in improving water management activities in the Phalen Chain of Lakes Watershed. The Phalen Chain of Lakes Surface Water Management Plan (RWMWD, 1988) identified potential flooding areas and recommended solutions. All of the flooding issues identified in that study have been addressed. In 2003, the District completed the Willow Creek Drainage Improvement Project. This pipe replacement and erosion repair project was completed to alleviate erosion and pipe capacity problems along Willow Creek.

In 2015, the District supported this goal by updating their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Willow Creek subwatershed are the new 100-year flood elevations shown in Figure 2.1-6. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.1.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Willow Creek subwatershed are shown in Figure 2.1-7, indicating areas where the lake levels of waterbodies in the Willow Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.1.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

Willow Creek (formerly County Ditch 18 North) was historically and continues to be managed as a stormwater conveyance system. Presently, Willow Creek does not exhibit characteristics of a natural stream. The RWMWD will strive to incorporate natural resource management measures such as the use of

bioengineering and native vegetation to stabilize the streambanks as improvement projects are implemented along Willow Creek in the future.

Since 1998, RWMWD has partnered with H.B. Fuller Company to manage rain gardens, prairie, and natural buffer areas around Willow Lake and numerous wetlands on the H.B. Fuller campus. For several years, the H.B. Fuller rain gardens served as a demonstration project on how to manage stormwater runoff from large parking areas. In 2006, RWMWD staff provided technical assistance with the design and revegetation of a gully on H.B. Fuller property caused by stormwater runoff from a commercial area. The plan included appropriate native plant community types that are consistent with the management of the campus grounds. The District anticipates a continued long-term partnership with this high-profile corporation.

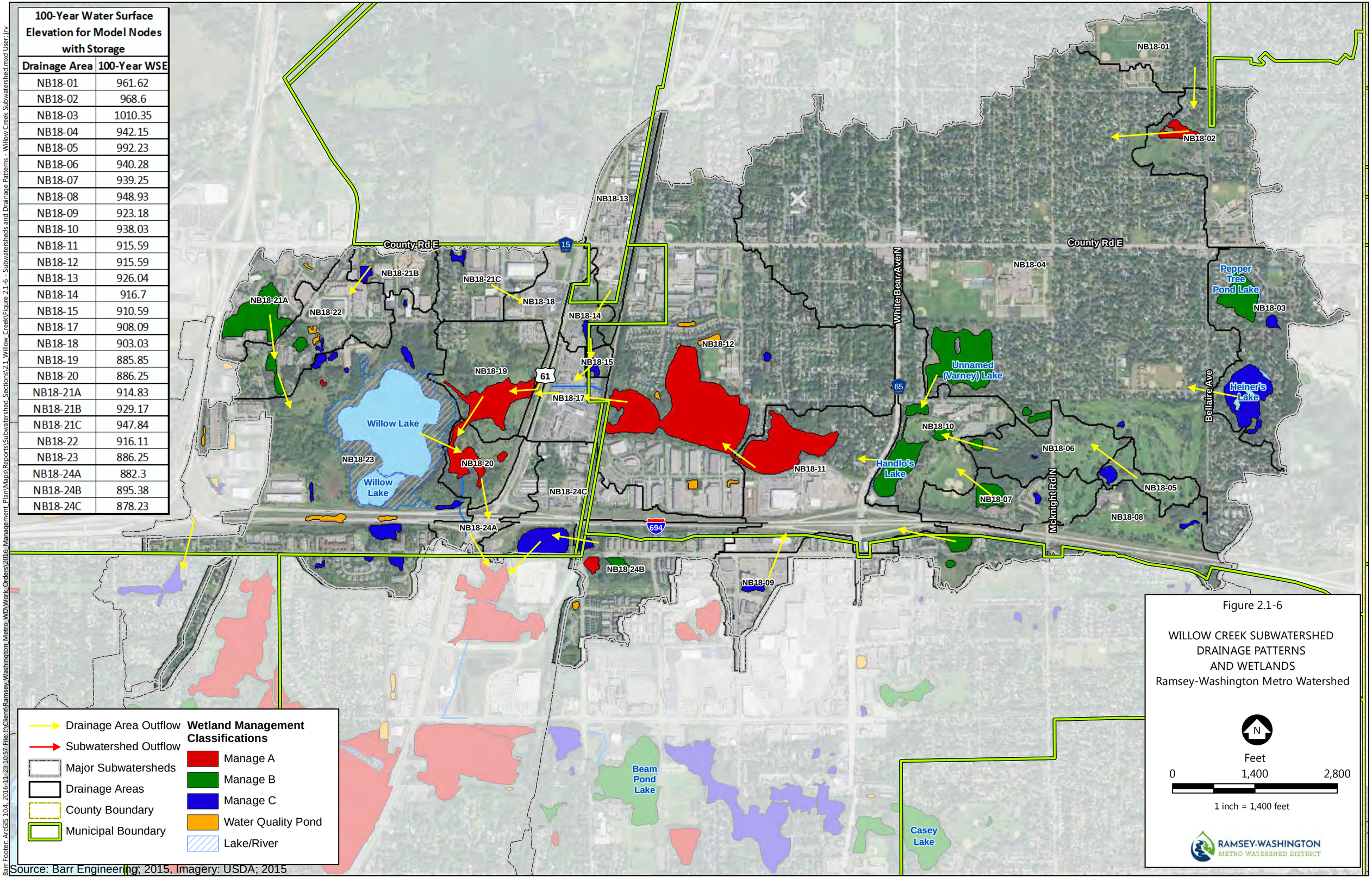
2.1.6 Future Implementation Activities

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Willow Creek subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Willow Creek subwatershed are identified (see Table 2.1-3). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.1-3 Willow Creek Subwatershed Implementation Activities

Activity ID No.	Willow Creek Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
WC-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
NB18-01	961.62
NB18-02	968.6
NB18-03	1010.35
NB18-04	942.15
NB18-05	992.23
NB18-06	940.28
NB18-07	939.25
NB18-08	948.93
NB18-09	923.18
NB18-10	938.03
NB18-11	915.59
NB18-12	915.59
NB18-13	926.04
NB18-14	916.7
NB18-15	910.59
NB18-17	908.09
NB18-18	903.03
NB18-19	885.85
NB18-20	886.25
NB18-21A	914.83
NB18-21B	929.17
NB18-21C	947.84
NB18-22	916.11
NB18-23	886.25
NB18-24A	882.3
NB18-24B	895.38
NB18-24C	878.23



Source: Barr Engineering, 2015, Imagery: USDA, 2015

Figure 2.1-6

WILLOW CREEK SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

N

Feet

0 1,400 2,800

1 inch = 1,400 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 10:57 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.1_Willow_Creek\Figure_2.1-6_-_Subwatersheds_and_Drainage_Patterns_-_Willow_Creek_Subwatershed.mxd User: jrv

Barr Footer: ArcGIS 10.4, 2016-11-28 15:08 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.1_Willow_Creek\Figure 2.1-7 - Priority Infiltration Areas - Willow Creek Subwatershed.mxd User: jrv

NB18-01
NB18-02
NB18-13
NB18-04
NB18-21B
NB18-21C
NB18-21A
NB18-22
NB18-18
NB18-14
NB18-12
NB18-15
NB18-19
61
NB18-17
Pepper Tree Pond
NB18-03
Unnamed (Varney)
Heiner's Lake
Willow Lake
NB18-10
NB18-06
NB18-23
NB18-20
NB18-11
Handlo's Lake
Willow Lake
NB18-24C
NB18-05
NB18-07
65
NB18-08
35E
NB18-24A
NB18-24B
NB18-09
20
Kohlman Lake
Markham Pond
Casey Lake

Drainage Areas
County Boundary
Municipal Boundary
Creeks

Vulnerability to Changes in Groundwater System

Vulnerable
Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.1-7

WILLOW CREEK SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

N

Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.2 Kohlman Creek Subwatershed

2.2.1 General Description

The Kohlman Creek subwatershed covers 3,563 acres including much of North St. Paul, a portion of Maplewood, and the western edge of Oakdale (see Figure 2.2-1). Most of the Kohlman Creek subwatershed is located in Ramsey County, with a small portion on the far eastern side in Washington County. The Kohlman Creek subwatershed is an upstream part of the larger Phalen Chain of Lakes Watershed. The subwatershed includes the area tributary to Kohlman Creek (formerly County Ditch 18 South) located south of Beam Avenue in Maplewood and east of the Burlington Northern railroad tracks.

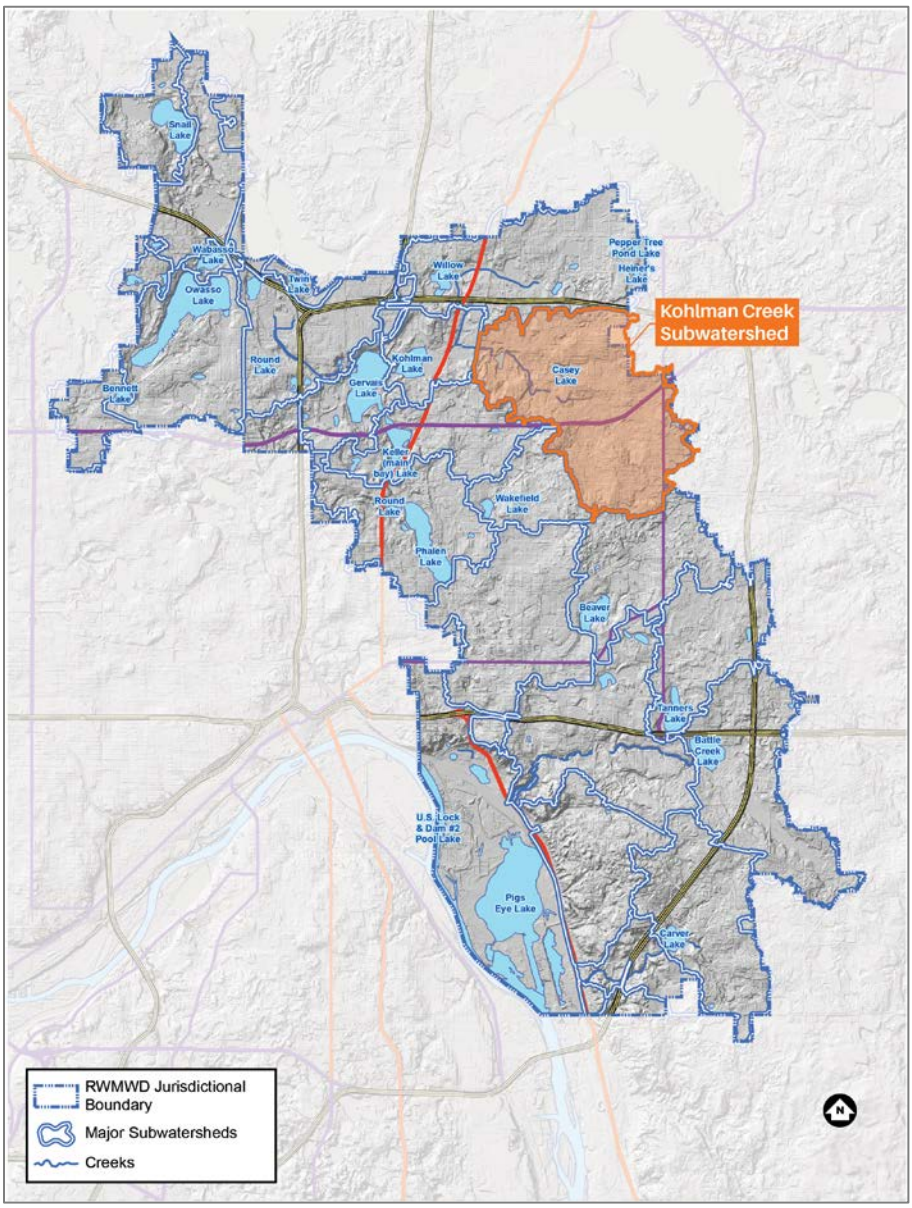


Figure 2.2-1 Kohlman Creek Location Map

Kohlman Creek is an intermittent stream that was previously considered a county ditch (County Ditch 18 South). The stream begins at PCU Pond (formerly called Target Pond), which was constructed in 1995 to provide stormwater detention for downstream flood control. Kohlman Creek generally flows from southeast to northwest and eventually discharges into Kohlman Basin in the Kohlman Lake subwatershed. Kohlman Creek has historically been, and continues to be, managed as a stormwater conveyance system by the RWMWD. Most of the creek remains in its natural state.

The District-managed waterbodies within the Kohlman Creek subwatershed include Kohlman Creek. Several wetlands are present in the Kohlman Creek subwatershed, including Casey Lake (see Figure 2.2-4). Although its name implies that Casey Lake is a lake, it is not classified as lacustrine under the Cowardin system, and therefore is not classified as a District-managed lake (see Section 1.9.1).

Table 2.2-1 Kohlman Creek Subwatershed Facts

Tributary Area (Direct)	**3,653 acres**
Tributary Area (Total)	**3,653 acres**
Downstream Watershed	**Kohlman Lake**
MS4s in the Direct Tributary Area	**Maplewood, North St. Paul, Oakdale, Ramsey County, Washington County**
RWMWD Nutrient Water Quality Classification[1]	**At Risk**

[1] Data for Kohlman Creek

2.2.1.1 Past Studies

The following list is a summary of past studies related to Kohlman Creek and the Kohlman Creek subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *An Evaluation of District Water Quality Data Collected from 1977 through 1989*. Prepared for RWMWD by Barr Engineering, 1990.
- *Technical Specifications for Casey Lake Outlet Structures*. Prepared for RWMWD by Barr Engineering, 1991.
- *Kohlman Basin Feasibility Study*. Prepared for RWMWD by Barr Engineering, September 1993.
- *Target Pond Feasibility Study*. Prepared for RWMWD by Barr Engineering, April 1993.
- *Kohlman Basin Project: Preliminary Design Report*. Prepared for RWMWD by Barr Engineering, 1996.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.

- *Draft Kohlman and Keller Lakes Total Maximum Daily Load Report*. Prepared for RWMWD by Barr Engineering, July 2005.
- *Internal Phosphorus Load Study: Kohlman and Keller Lakes*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Status Report*. Prepared for RWMWD by Barr Engineering, 2007.
- *Kohlman Creek Subwatershed Infiltration Study*. Prepared for RWMWD by Barr Engineering, 2007.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District*. Barr Engineering Co., Draft 2016.

2.2.1.2 Land Use

The Kohlman Creek subwatershed is nearly fully developed. Based on the Metropolitan Council 2010 land use data, the majority of the Kohlman Creek subwatershed east of White Bear Avenue consists of single family residential land use (see Figure 2.2-2). Commercial, light industrial, office and institutional land uses have developed along 7th Avenue and Highway 36 in North St. Paul, and along White Bear Avenue in Maplewood. Park, recreation, or preserve land uses are also present in the watershed, including Casey Park east of Casey Lake. The area in the extreme southeast corner of the subwatershed in Maplewood is not significantly developable because most of the area is open space owned by either Ramsey County or the City of Maplewood.

The Section of the subwatershed west of White Bear Avenue and north of Beam Avenue is occupied by a large commercial area (Maplewood Mall). Other development in this area includes a hospital, commercial areas, and office buildings. Future land use projections estimate that this area will likely be entirely commercial and office land use in the future based on 2030 land use projections (see Figure 1-5). Overall, future land use is not expected to differ significantly from existing land use conditions. Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

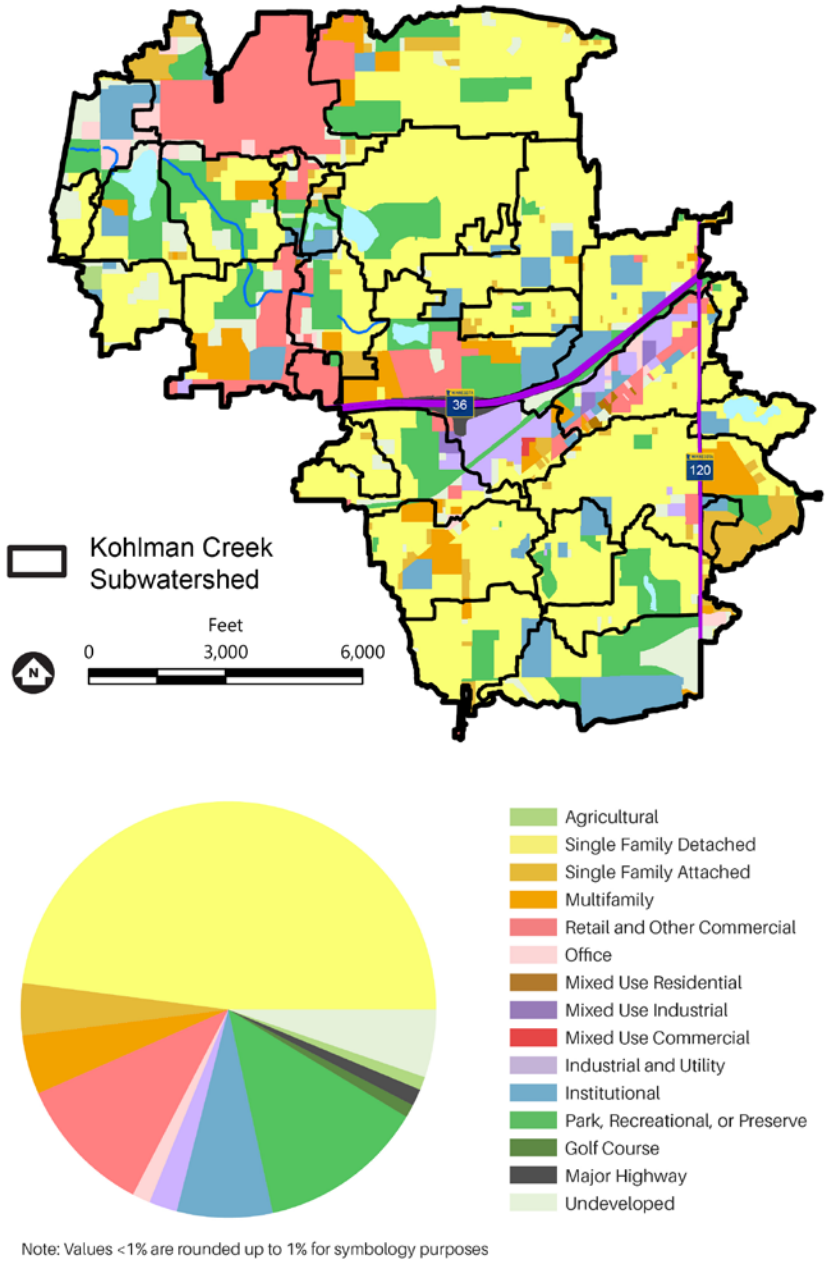


Figure 2.2-2 Breakdown of land uses throughout the Kohlman Creek Subwatershed (2010 Metropolitan Council)

2.2.1.3 Drainage Patterns and Waterbodies

The Kohlman Creek subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.2-4). Figure 2.2-4 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Kohlman Creek subwatershed include only Kohlman Creek.

Wetlands within the Kohlman Creek subwatershed are shown in Figure 2.2-4 according to the RWMWD wetland management classification (see Section 1.11.3).

2.2.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Kohlman Creek. Although not a District-managed lake, the RWMWD has also included Casey Lake in its past studies and management actions.

2.2.2.1 Historical Water Quality

From 1977 to 1989, the District monitored stream water quality at the junction of Willow Creek and Kohlman Creek (the Ditch 18 station at Beam Avenue and Highway 61 in Maplewood) to assess the quality of water discharged to Kohlman Lake. Measured parameters included chlorides, dissolved oxygen, fecal coliform, nitrates, pH, specific conductance, suspended solids, temperature, total phosphorus, turbidity, and flow. *An Evaluation of District Water Quality Data Collected from 1977 through 1989* (RWMWD, 1990) summarized the monitoring data. The 1997 RWMWD Plan states that, dissolved oxygen, pH, temperature, and fecal coliform counts all met then-current MPCA standards, with some increases in fecal coliform counts during a rapid urbanization period of 1984 to 1989. Suspended solids and turbidity generally met then-current MPCA standards during this monitoring period. Stream water quality monitoring at the Ditch 18 location was discontinued after the 1990 evaluation.



Kohlman Creek Monitoring Station

The RWMWD installed a water quality monitoring station on Kohlman Creek in 2007. The station allows the District to continuously monitor flows in Kohlman Creek into the Phalen Chain of Lakes. This data allows the District to evaluate the effectiveness of District and city stormwater management programs and projects. The station collects year-round water quality and flow rate samples and data.

Kohlman Creek was monitored in 2010 for biological indicators (data available from the MPCA's Environmental Data Access website). In 2014, the MPCA adopted region-based eutrophication water quality standards for streams, including a revised total suspended solids standard (see Minnesota Rules 7050). 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.

2.2.2.2 Water Quality Goals

Water quality goals for Kohlman Creek are consistent with the MPCA's stream eutrophication standards (see Section 1.10.1). The RWMWD strives to ensure that the watercourse and banks of Kohlman Creek are stable to minimize erosion and sediment problems. In 1998, the District completed a capital improvement project in conjunction with the Ramsey County Soil and Water Conservation District (now called the Ramsey Conservation District, or RCD) to stabilize severely eroded banks immediately upstream of Kohlman Basin. The eroding creek banks were contributing considerable sediment and nutrient loads to the creek and downstream waterbodies.

The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion, and other stream degradation problems.

2.2.2.3 Water Quality Projects

The District has implemented several water quality improvement projects within the Kohlman Creek subwatershed. Projects implemented through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.2-3. The following Section summarizes selected water quality improvement projects in the Kohlman Creek subwatershed.

Maplewood Mall Stormwater Retrofit

The Maplewood Mall stormwater retrofit project, constructed from 2009 to 2012, incorporates an array of best management practices to significantly reduce the amount of polluted stormwater runoff leaving the parking lot and entering Kohlman Lake.



Maplewood Mall Stormwater Retrofit

Along with 55 rainwater gardens, 3 porous paver crosswalks, an enhanced sand filter, and a cistern that captures mall roof runoff for irrigation, the system features more than a mile of rock trenches planted with 200 trees. The large-scale system captures and treats 67% of the stormwater runoff from the 35-acre lot (20 million gallons in an average year of precipitation). By intercepting, filtering, or infiltrating the first inch of runoff, it removes over 60% of the phosphorus that would otherwise flow into impaired Kohlman Lake. In addition, public art and educational components were incorporated to educate mall visitors about the importance of managing urban stormwater and about the connection between the Mall, the Phalen Chain of Lakes and the Mississippi River.

The project was recognized with two prestigious awards. The Mall project received the Grand Award for the American Council of Engineering Companies**.** The

second award was the Project of the Year award from the Minnesota Association of Watershed Districts. Staff has been presenting this project at major conferences and workshops. The project was also summarized in an article published in *Land & Water* magazine in 2012.

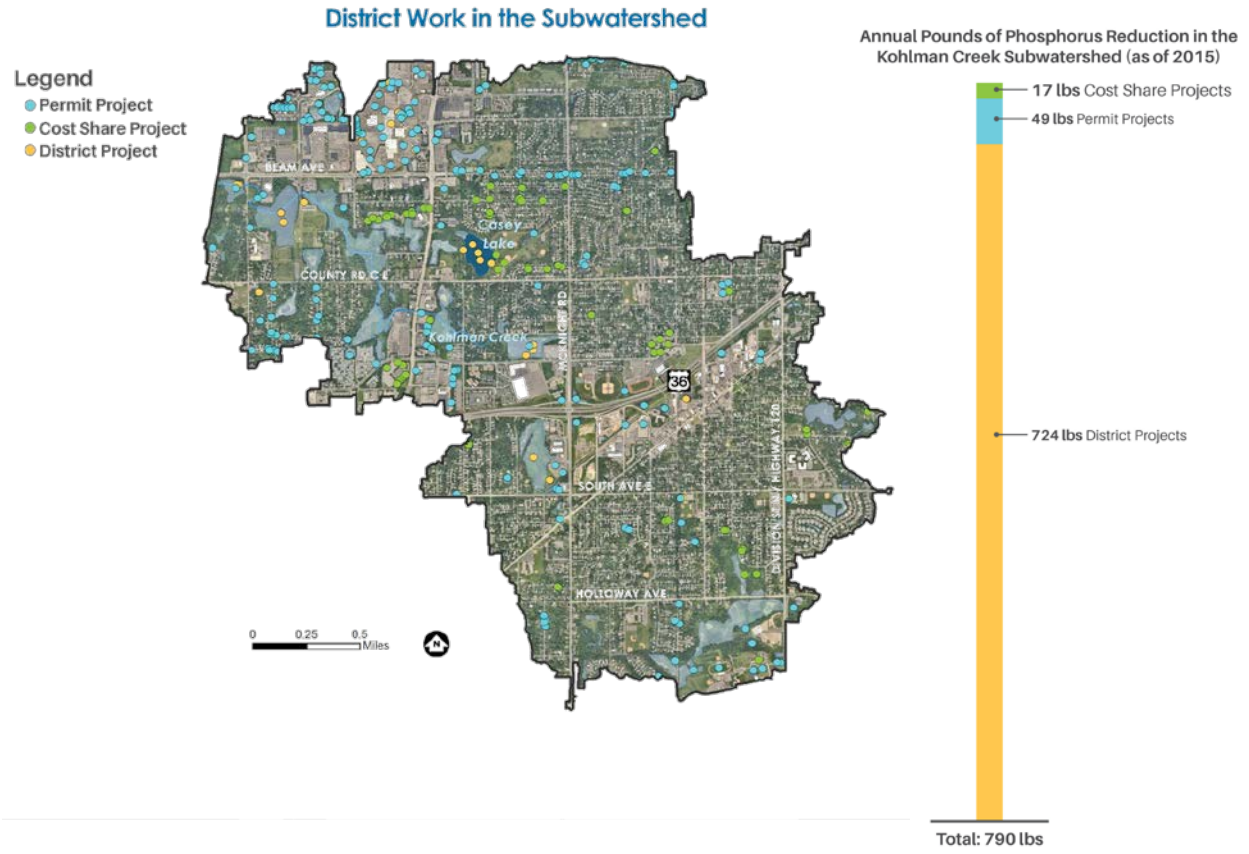


Figure 2.2-3 District work in the Kohlman Creek Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.2.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The RWMWD studied the Kohlman Creek subwatershed in 1988 to guide the RWMWD in improving water management activities in the Phalen Chain of Lakes Watershed. Further hydrologic modeling was performed as part of the *Target Pond Feasibility Study* (1993) to identify potential flooding problems and recommend improvements. Following those studies, several capital improvement projects were implemented in the subwatershed for flood control purposes, including:

- **Casey Lake Outlet –** In 1992, the RWMWD replaced a dilapidated and eroded weir with a new outlet that achieved the discharge and storage targets established in the 1988 Phalen Management Plan.

- **Kennard Street Control Structure –** In 1993, the District installed a control structure at this location, in conjunction with an ongoing library construction project, to manage discharge rates in Kohlman Creek.

- **PCU Pond (formerly Target Pond) –** In 1995, the RWMWD completed construction of a pond to reduce the risk of flooding along White Bear Avenue. The project provided needed additional storage volume within an existing basin. The bottom of the existing basin and the outlet elevation were lowered by 6 feet. Due to the new outlet depth, the project included the installation of a piped outlet to replace the previous open channel. At the request of the adjacent property owners, the RWMWD restored the stream channel on top of the new pipe and provided a lift station to restore the previous base level stream flow. The project also included the construction of a low weir at a downstream wetland to stabilize erosion at the outlet.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Kohlman Creek subwatershed are the new 100-year flood elevations shown in Figure 2.2-4. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.2.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Kohlman Creek subwatershed are shown in Figure 2.2-5, indicating areas where the water levels of waterbodies in the Kohlman Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.2.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

Kohlman Creek (formerly County Ditch 18 South) was historically and continues to be managed as a stormwater conveyance system. Kohlman Creek follows the historic creek path, but it has been highly

altered as a result of past development activities. Only the portion of the creek from Kohlman Lake to Hazelwood Avenue was improved as an official county ditch in the 1920s. The RWMWD will strive to incorporate natural resource management measures such as the use of bioengineering and native vegetation to stabilize the streambanks as improvement projects are implemented along Kohlman Creek in the future.

An example of this integrated approach to natural resource management is the Kohlman Creek Bank Stabilization Project completed in 1998. The RWMWD and Ramsey Conservation District used the bank stabilization project as a demonstration site for application of bioengineering stabilization techniques. The project included reshaping the creek banks to a stable slope, seeding and mulching the slopes and installing a stilling pool at the upper end of the project to slow water flows.

In 2005, RWMWD staff and City of Maplewood staff partnered on a project to stabilize creek banks upstream of the Kohlman Basin Project. Stabilization was needed because of the inadvertent removal of reed canary grass by a contractor working on an adjacent property. The unplanned removal of reed canary grass left the stream banks bare, which resulted in severe bank erosion along some creek segments. District staff designed the restoration project, and installation was conducted by City of Maplewood, MDNR Conservation Corps, and RWMWD staff. .

In 1997-1999, the RWMWD partnered with the City of North St. Paul, the Minnesota Pollution Control Agency, the Metropolitan Council, the Ramsey Conservation District, the MDNR, and the University of Minnesota to create the North St. Paul Urban Ecology Center. An undeveloped site that was previously farmed and ditched was restored to a diverse wetland ecosystem, a valuable open space resource for the City of North St. Paul, and an educational resource for the area schools. The project included open water basins, a meandering channel through the wetland, trails, and a boardwalk. In 2000, the RWMWD worked jointly on a research project with the University of Minnesota, MN DNR, and the MnDOT to determine effective methods to control reed canary grass, an invasive, non-native plant. One of the study areas was the North St. Paul Urban Ecology Center.

The RWMWD manages the aquatic, transitional, and upland areas of the PCU Pond (formerly Target Pond) to restore and sustain a variety of native plant communities. Management measures include prescribed burns, mowing, and spot herbicide applications. The RWMWD monitors this site several times per year to determine appropriate vegetation management activities. The pond buffer is several acres in size and offers high quality habitat in the watershed. The RWMWD will continue to actively manage this site and promote it as a unique, high quality habitat in the watershed.

In 2007, the City of North St. Paul expanded the shoreline buffer in the park adjacent to Casey Lake and approached the Watershed District for assistance with ecological restoration. The Watershed District designed and managed the project, and the City of North St. Paul, the Ramsey County Correctional Facility - Greenhouse Operations, Ramsey County Master Gardeners and 350 students from Cowern, Richardson, Farnsworth, and St. Peters all had a hand in the shore restoration project. Two stone lake access points were installed with funding assistance from the MDNR. The mature shoreland buffer is a beautiful and functional addition to this popular neighborhood park.

In the winter of 2012-13, a pond draw-down killed all of the invasive carp in Casey Lake. The University of Minnesota carp research program identified Casey Lake as a major nursery for common carp. Fish in this system have the potential to migrate into the Phalen Chain of Lakes. The reduction in carp in this system caused a dramatic improvement in water clarity. In the spring of 2013, the MDNR stocked bluegills and bass in Casey Lake to keep carp levels low and improve the fishery. An aeration system has been installed to keep the game fish alive over the winter months when oxygen in the water can reach critically low levels.

2.2.6 Future Implementation Activities

The District has identified several implementation activities recommended for the Kohlman Creek subwatershed (see Table 2.2-2). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Kohlman Creek subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.2-2 Kohlman Creek Subwatershed Implementation Activities

Activity ID No.	Kohlman Creek Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
KC-1*	Implement improvements described in the Markham Ecosystem Restoration Report (2013)	**2017-2026**	**$2,000,000**	**WQ2, WQ18, EC3, IE7, IE17, MO6, MO21**	**Tier 1**
KC-2	Study the effect of increasing flood storage in upstream areas on improving flood resiliency in Kohlman Creek and implement recommended projects	**2018-2022**	**$2,000,000**	**FL9, IE7, IE17, MO6, MO21**	**Tier 1**
KC-3*	Manage Macrophytes in Casey Lake Wetland	**2017-2026**	**$100,000**	**EC4, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100 Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	100-Year WSE
SB18-02	995.32
SB18-03	995.32
SB18-04	977.55
SB18-06B	938.21
SB18-07	939.81
SB18-08	940.83
SB18-09	922.63
SB18-09A	938.16
SB18-10	913.45
SB18-11A	923.08
SB18-11B	916.03
SB18-11C	927.42
SB18-12	930.61
SB18-13	890.04
SB18-14B	886.33
SB18-15B	947.3
SB18-16	904.52
SB18-17A	880.13
SB18-17B	881.25
SB18-18	936.67
SB18-19	936.67
SB18-21	936.67
SB18-22	947.22
SB18-24	957.62
SB18-25	994.71
SB18-27	1011.42
SB18-29	1006.15
SB18-30	1006.15

- Drainage Area Outflow
- Subwatershed Outflow
- Major Subwatersheds
- Drainage Areas
- County Boundary
- Municipal Boundary

Wetland Management Classifications

- Manage A
- Manage B
- Manage C
- Water Quality Pond
- Lake/River

SB18-14A
SB18-15B
Lydia ve E
SB18-17A
Beam Ave E
SB18-11C
SB18-11B
Markham Pond
SB18-13
SB18-12
Mcknight Rd N
SB18-17B
SB18-14B
SB18-11A
Casey Lake
SB18-19
SB18-15A
17th Ave E
SB18-16
White ear ve N
SB18-09
SB18-25
SB18-22
SB18-21
SB18-10
SB18-18
SB18-09A
SB18-24
SB18-26
SB18-27
North Knucklehead Lake
SB18-06B
SB18-08
SB18-07
McknightRd N
SB18-05
SB18-29
SB18-30
SB18-04
SB18-06A
SB18-03
Century Ave N
Holloway Ave E
SB18-01
SB18-02
Wakefield Lake

Source: Barr Engineering; 2015, Imagery: USDA; 2015

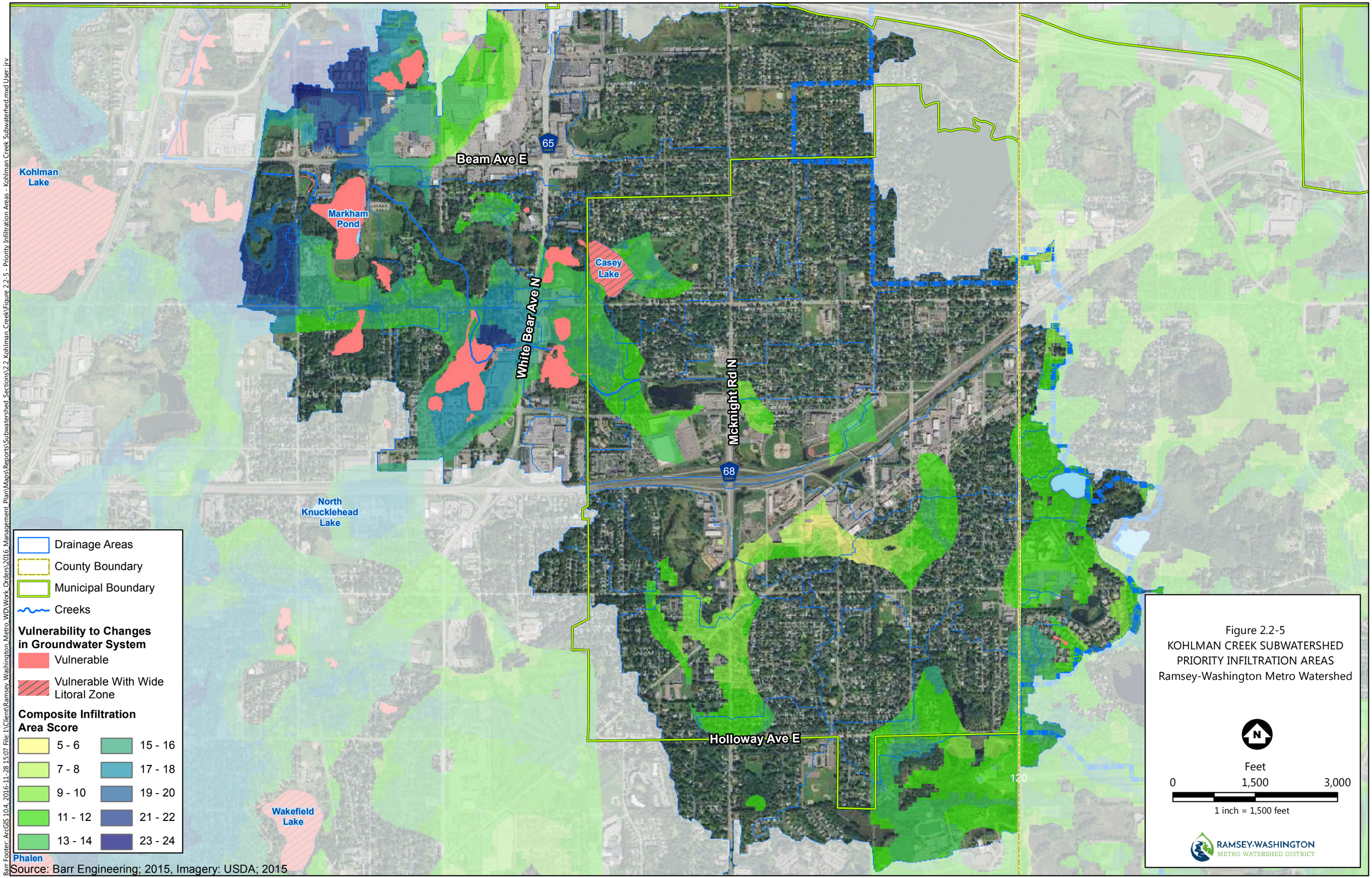
Figure 2.2-4

KOHLMAN CREEK SUBWATERSHED DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4 2016-11-23 14:56 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed Sections\2.2 Kohlman Creek\Figure 2.2-4 - Subwatersheds and Drainage Patterns - Kohlman Creek Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4, 2016-11-28 15:07 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.2_Kohlman_Creek\Figure 2.2-5 - Priority Infiltration Areas - Kohlman Creek Subwaterhed.mxd User: jrv

2.3 Kohlman Lake Subwatershed

2.3.1 General Description

The Kohlman Lake subwatershed directly tributary to Kohlman Lake (i.e., not tributary to another District-managed waterbody prior to reaching Kohlman Lake) is 1,017 acres. The direct watershed includes portions of the cities of Maplewood, Vadnais Heights, and Little Canada and is entirely within Ramsey County (see Figure 2.3-1). The direct subwatershed consists of the area tributary to Kohlman Lake that is not drained by the Willow Creek or Kohlman Creek subwatersheds. The total area tributary to Kohlman Lake increases to 7,495 acres when the Willow Creek and Kohlman Creek subwatersheds are included.

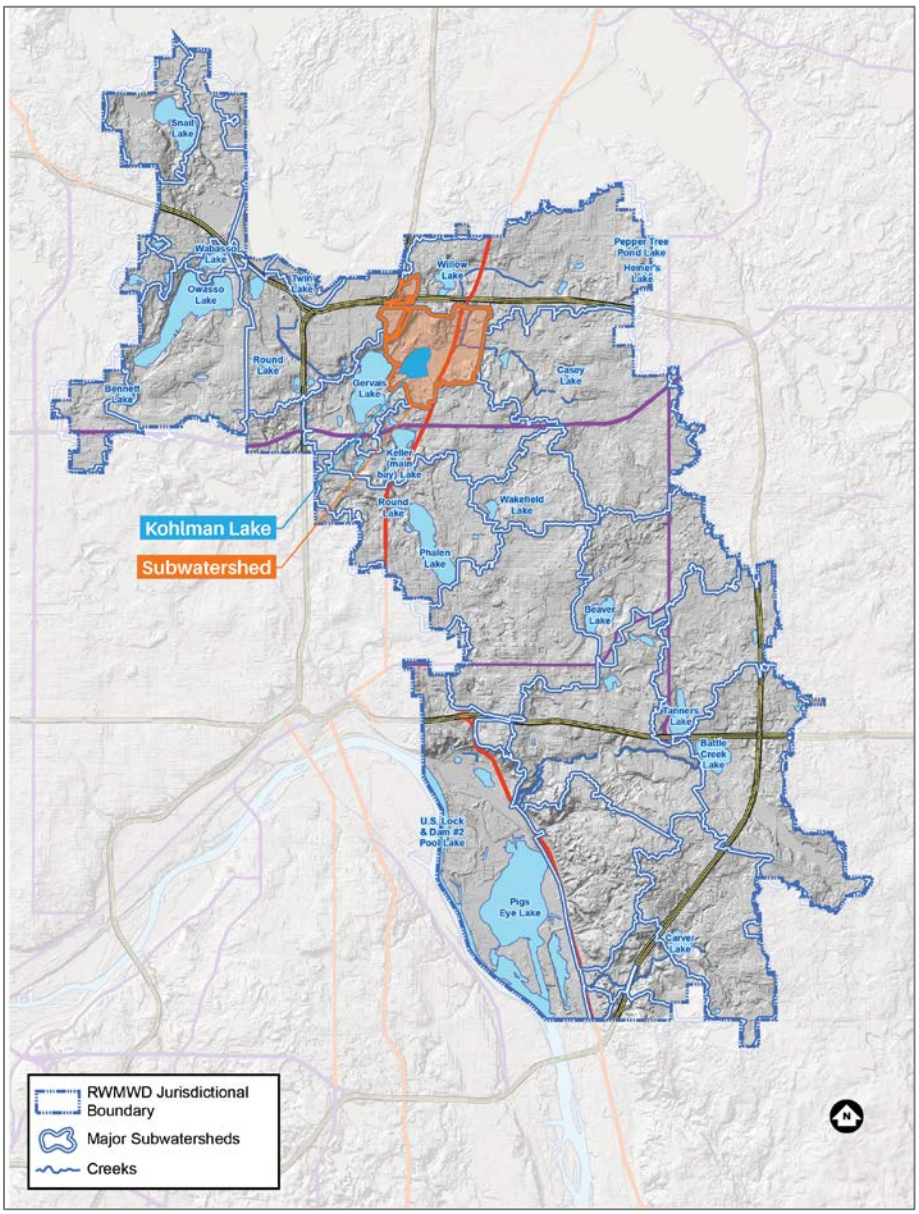


Figure 2.3-1 Kohlman Lake Location Map

The District-managed waterbodies within the subwatershed include Kohlman Lake and portions of Willow Creek and Kohlman Creek. The Kohlman Lake subwatershed also includes numerous wetlands, including Kohlman Basin, which is a large wetland upstream of Kohlman Lake that provides significant water quality treatment of inflows from Willow Creek and Kohlman Creek. County Ditch 7A, which flows to Kohlman Lake via a wetland, drains the northwestern part of this subwatershed. The outlet from Kohlman Lake is a channel that is connected to Gervais Lake.

Kohlman Lake is a District-managed lake in the city of Maplewood. It has a surface area of 74 acres and a maximum depth of approximately 9 feet and a mean depth of 4 feet. Most of the lake is less than 6-feet deep, with the littoral area comprising 74 acres or 100% of the lake (MDNR Lake Data). By MPCA definition, Kohlman Lake is considered a shallow lake (a maximum depth of less than 15 feet and/or at least 80% of the lake less than 15-feet deep). Kohlman Lake is used primarily for motorboating, canoeing, fishing, picnicking, wildlife habitat, and viewing. There is no direct public boat access to Kohlman Lake, although the lake can be accessed via Lake Gervais.

Table 2.3-1 Kohlman Lake Subwatershed Facts

Tributary Area (Direct)	1,009 acres
Tributary Area (Total)	7,495 acres
Downstream Watershed	Gervais Lake
MDNR Designation	62-0006P
Lake Surface Area[1]	74 acres
Lake Mean Depth[1]	4 ft
Lake Maximum Depth[1]	9 ft
Lake Outlet Type[1]	Stream channel under Keller Parkway Bridge to Gervais Lake
Lake Outlet Elevation[1]	857.7
100-Year Flood Level[1]	861.8
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake; Impaired for Aquatic Recreation (excess nutrients); Impaired for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Little Canada, Maplewood, Vadnais Heights, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Impaired

[1] Lake data refers to Kohlman Lake

2.3.1.1 Past Studies

The following list is a summary of past studies related to Kohlman Lake and the Kohlman Lake subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *Draft Kohlman Basin Feasibility Study*. Prepared for RWMWD by Barr Engineering, September, 1993.
- *Draft County Ditch 7A Feasibility Study*. Prepared for RWMWD by Barr Engineering, 1994.
- *Kohlman Basin Project: Preliminary Design Report*. Prepared for RWMWD by Barr Engineering, 1996.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.
- *Draft Kohlman and Keller Lakes Total Maximum Daily Load Report*. Prepared for RWMWD by Barr Engineering, July 2005.
- *Internal Phosphorus Load Study: Kohlman and Keller Lakes*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Draft Kohlman Basin Area Water Quality Enhancements Study*. Prepared for RWMWD by Barr Engineering, October 2006.
- *Draft Phalen Chain of Lakes Carp Population Study*. Prepared for RWMWD by Barr Engineering, November 2006.
- *Kohlman Lake Total Maximum Daily Load Report*. Prepared by the MPCA. 2010.
- *Kohlman Lake Total Maximum Daily Load Implementation Plan*. Prepared by the MPCA. 2010.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District*. Barr Engineering Co., Draft 2016.

2.3.1.2 Land Use

The current land use in this subwatershed is primarily single-family residential and undeveloped land occupied by wetlands (see Figure 2.3-2). Some commercial development is present along Highway 61. Based on the Metropolitan Council future land use projections for 2030, some additional commercial development is anticipated east of Highway 61 (see Figure 1-5). New development and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

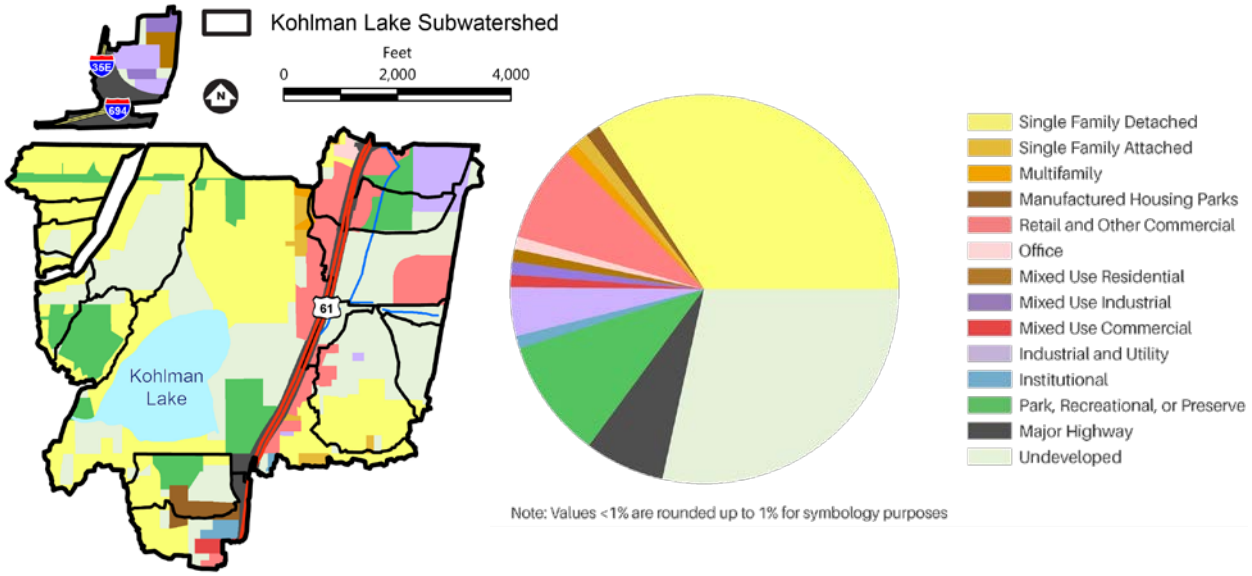


Figure 2.3-2 Breakdown of land uses throughout the Kohlman Lake Subwatershed (2010 Metropolitan Council)

2.3.1.3 Drainage Patterns and Waterbodies

The Kohlman Lake subwatershed receives inflow from the Willow Creek subwatershed and the Kohlman Creek subwatershed. Flows from Willow Creek and Kohlman Creek discharge into the Kohlman Basin, a large wetland located south of Beam Avenue between Highway 61 and the Burlington Northern railroad tracks (see Figure 2.3-8). This basin provides significant water quality treatment of stormwater prior to discharge into Kohlman Lake. The outlet from Kohlman Lake (and the Kohlman Lake subwatershed) is a channel that is connected to Gervais Lake. The water surface elevation in the channel is governed by the control structure downstream of Keller Lake under normal hydraulic conditions; the Keller Lake control structure has an outlet elevation of 858 feet.

The Kohlman Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.3-8). Figure 2.3-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Kohlman Lake subwatershed include only Kohlman Lake.

Wetlands within the Kohlman Lake subwatershed are shown in Figure 2.3-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.3.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Kohlman Lake.

2.3.2.1 Historical Water Quality

Kohlman Lake is used primarily for motorboating, canoeing, fishing, picnicking, and viewing. Other recreational uses include limited wildlife habitat. The Ramsey County Department of Public Works staff samples the water quality of Kohlman Lake about 7 times per year on average, between the months of May and September. Figure 2.3-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Kohlman Lake was listed on the MPCA 303(d) Impaired Waters List in 2002 with a use of aquatic recreation impaired due to excessive nutrients, specifically phosphorus (see Section 1.10.2). Table 2.3-3 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Kohlman Lake relative to MPCA standards.

Table 2.3-2 Kohlman Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Kohlman Lake (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	69.2
Chlorophyll-a (µg/L)	≤ 20	22.2
Secchi disk transparency (m)	≥ 1.0	1.3

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Kohlman Lake water quality data. The results of these analyses are shown in Table 2.3-3.

Table 2.3-3 Trend Analysis Results for Kohlman Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Kohlman Lake	1981 – 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	Improving*	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

Sediment cores were taken from the lake in 2009 to assess the lake's internal phosphorus loading potential from sediment release. The sediment cores were also used to evaluate the water quality in the lake before European settlement. Fossilized algae in the lake were used to reconstruct the historical water quality of Kohlman Lake. By analyzing the types of diatom fossils in the core, scientists from the St. Croix Watershed Research Station were able to tell that, since the time of European settlement, sedimentation rates in Kohlman Lake have doubled and the lake has been a productive (i.e., eutrophic) since the early 1800s, although the diatom community assemblages have shifted throughout its history.

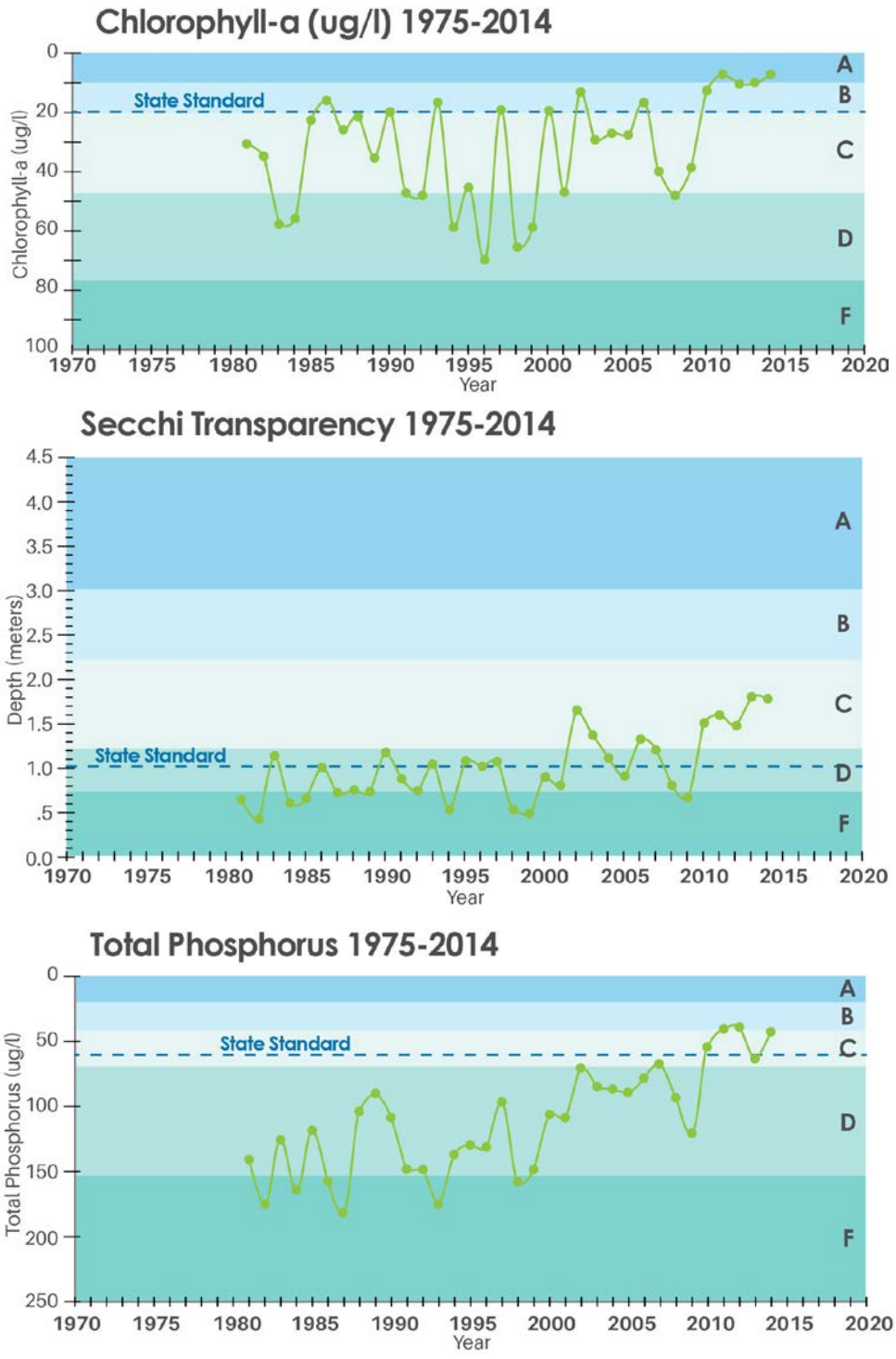


Figure 2.3-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Kohlman Lake (1975-2014)

2.3.2.2 State of the Fishery

In 1992, the MDNR classified Kohlman Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Kohlman Lake is a Class 40 lake, which signifies a small, shallow lake that is subject to occasional winterkill (Schupp, 1992).

The MDNR assessed the Kohlman Lake fish population in 2000 and again in 2005. According to the latest assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is primarily comprised of bluegill sunfish and black crappie. Other species present include black bullhead, hybrid sunfish, largemouth bass, tiger muskellunge, walleye, yellow bullhead, and yellow perch. No active fish management is performed on Kohlman Lake by the MDNR due to the lack of direct public access (public access to the lake is possible via the channel from Lake Gervais).

During an evaluation of the Phalen Chain of Lake's carp population in 2006 by the University of Minnesota's Sorensen Lab, carp were present Kohlman Lake. Common carp are an invasive species that can negatively impact lake water quality (see Section 1.10.7).

2.3.2.3 State of the Macrophyte Community

On September 15, 2016, District staff conducted a macrophyte survey of Kohlman Lake. The results of this survey are summarized below in Figure 2.3-4. A total of 99 sites were surveyed for macrophytes. Of these, 96 had vegetation, indicating that Kohlman Lake is a highly macrophyte-dominated lake.

Where filamentous algae and coontail were found in the lake, they were present in high abundance relative to other macrophyte species in Kohlman Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating an aesthetic and recreational nuisance. Also, curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer. Starting in spring of 2008, curlyleaf pondweed and Eurasian watermilfoil have been actively managed in Kohlman Lake. A March, 2016 survey found curlyleaf pondweed in the lake at 17 of 120 sites sampled (15%). Spot-treatment of curlyleaf pondweed was performed in 2016. Curlyleaf pondweed was found at 3% of sites sampled in a May, 2016 survey.

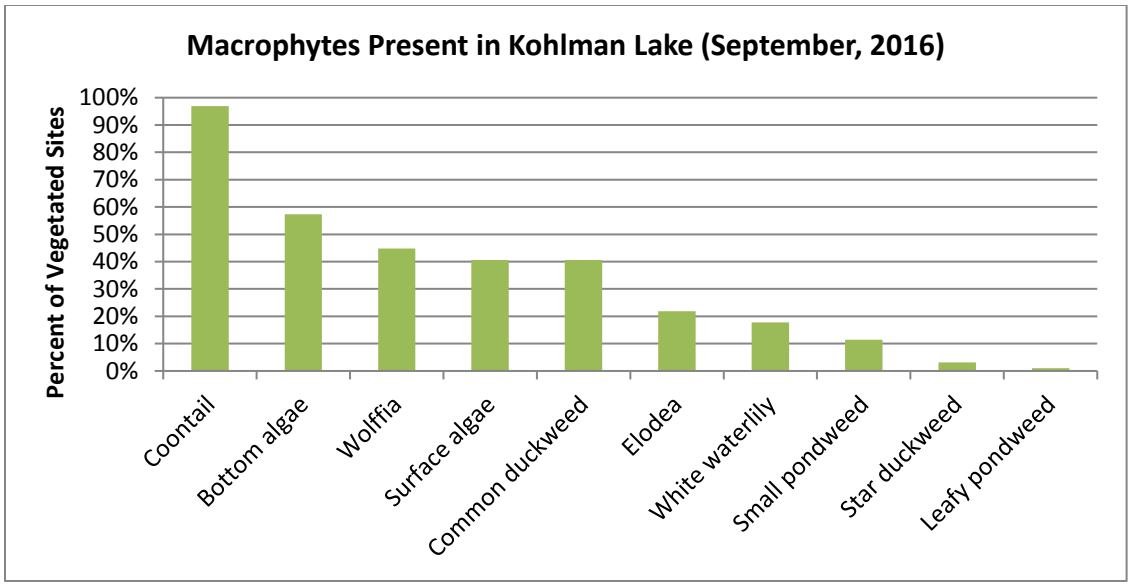


Figure 2.3-4 September, 2016 Kohlman Lake Macrophyte Survey Results

Beginning in 2015, the District began a study to assess the overall effect of macrophyte harvesting on water quality in Kohlman Lake. This study seeks to provide an overall improved understanding of the effect of dense aquatic plant stands and the harvesting of these stands on several water quality and physical parameters such as dissolved oxygen, lake temperature, phytoplankton growth, and phosphorus release from sediments.

2.3.2.4 Water Quality Modeling

The District performed water quality modeling of the Kohlman Lake subwatershed as part of developing the *Phalen Chain of Lakes Strategic Lake Management Plan* (SLMP) in 2004. The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future best management practices (BMPs). The water quality models developed for Kohlman Lake were updated as part of the total maximum daily load (TMDL) study process, which was completed in 2010. The water quality models developed for Kohlman Lake are described in detail in the *Kohlman Lake TMDL Report* (MPCA, 2010). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the entire Kohlman Lake subwatershed, including Kohlman Creek and Willow Creek. Modeled results were calculated for a range of climatic conditions to evaluate the variability of runoff and phosphorus loading under different hydrologic conditions.

The model results were used to estimate the amount of phosphorus reaching Kohlman Lake from various drainage districts. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.3-5 shows the main drainage districts contributing flow and phosphorus loading to Kohlman Lake.

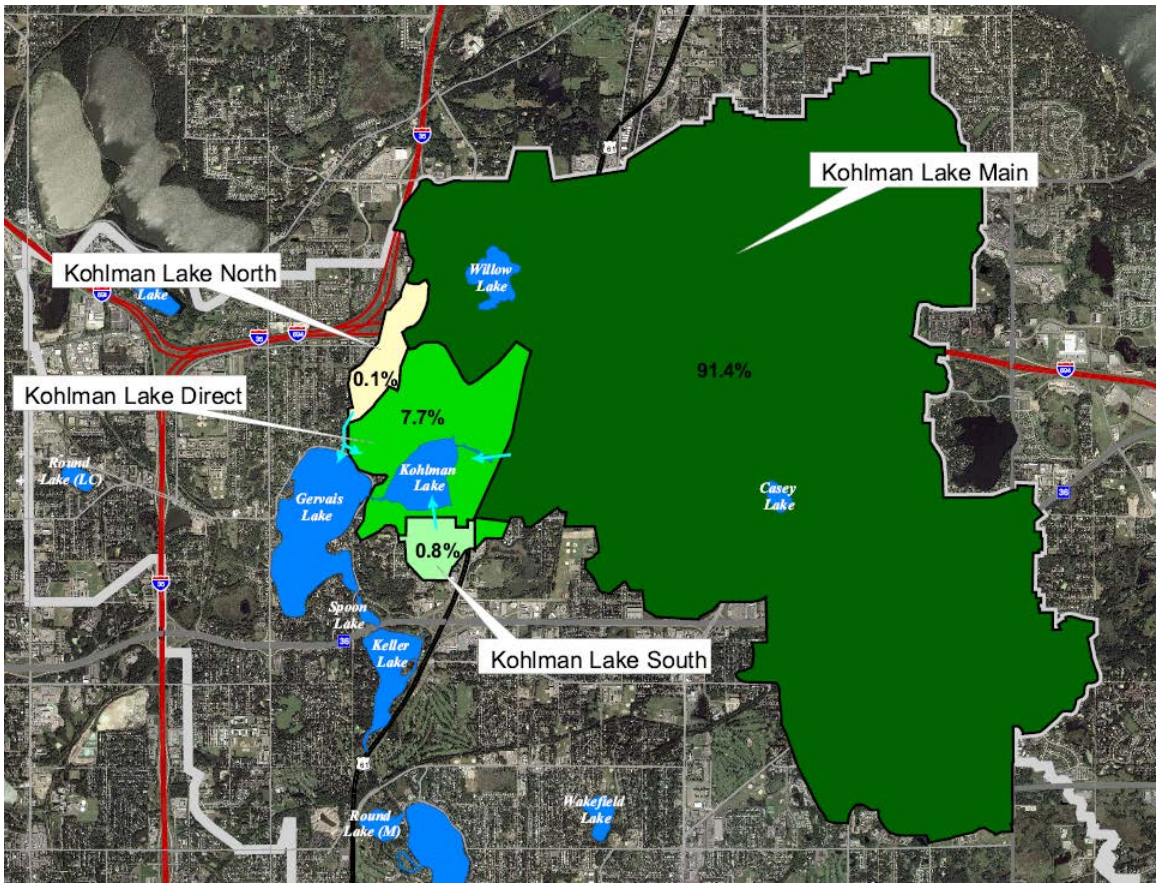


Figure 2.3-5 Drainage districts in the Kohlman Lake subwatershed and upstream tributary watersheds

The drainage districts to Kohlman Lake and their estimated percentage of watershed phosphorus loading (based on the 2010 TMDL report) are summarized below:

- **Kohlman Lake Main Drainage District –** This 6,829-acre drainage district east of Kohlman Lake represents the largest portion of the area tributary to Kohlman Lake. This district includes the Willow Creek subwatershed, the Kohlman Creek subwatershed, and the portion of the Kohlman Lake subwatershed that drains to Kohlman Basin. The Kohlman Lake Main drainage area, which comprises 90% of the area tributary to Kohlman Lake, contributes 88.7% of the annual watershed phosphorus load to the lake under average climatic conditions. Runoff from this drainage district flows through a series of ponds, wetlands and/or storm sewers, and Kohlman Basin prior to reaching Kohlman Lake.

- **Kohlman Lake North Drainage District –** This 106-acre drainage district north of the lake represents a very small portion (1.4%) of the area tributary to Kohlman Lake. Runoff from this drainage district flows to a flow splitter, where the flow is routed either to Kohlman or Gervais Lake, depending on the water level in the flow splitter. Runoff from the north drainage district contributes 3.8% of the annual phosphorus load from the watershed in an average year.

- **Kohlman Lake South Drainage District –** This 82-acre drainage district south of the lake also represents a very small portion (1.1%) of the total area tributary to Kohlman Lake. Runoff from this drainage district is routed to two ponds without outlets, so discharge from this district only occurs under overflow conditions. Runoff from the south drainage district contributes 0.5% of the annual phosphorus load from the watershed in an average year.

- **Kohlman Lake Direct Drainage District –** This 541-acre drainage district consists of the area that drains directly to Kohlman Lake without passing through a retention pond. The Kohlman Lake Direct drainage district, which comprises about 7% of the area tributary to Kohlman Lake, contributes approximately 7% of the watershed phosphorus loading annually. Runoff from this area drains directly to Kohlman Lake without passing through a detention pond, therefore receiving minimal treatment before reaching the lake.

Through analysis of water quality data, sediment data, and calibration of the in-lake model, it was determined that Kohlman Lake does receive internal phosphorus loading at times throughout the summer. Modeling results indicated that the internal phosphorus loading in Kohlman Lake contributes 5 to 40% of the summer average total phosphorus concentration. To better quantify the internal phosphorus source(s) and loading rates, the RWMWD completed an additional study. The *Internal Phosphorus Load Study: Kohlman and Keller Lakes* (Barr, 2005) determined that phosphorus loading from the sediment was a significant source of internal loading to Kohlman Lake. It was found that the loading rate of phosphorus from Kohlman Lake's sediments is extremely high, which is likely due to the fact that the lake received wastewater effluent until the 1960s.

The pie chart shown in Figure 2.3-6 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads (June 1, 2001-September 30, 2001 growing season).

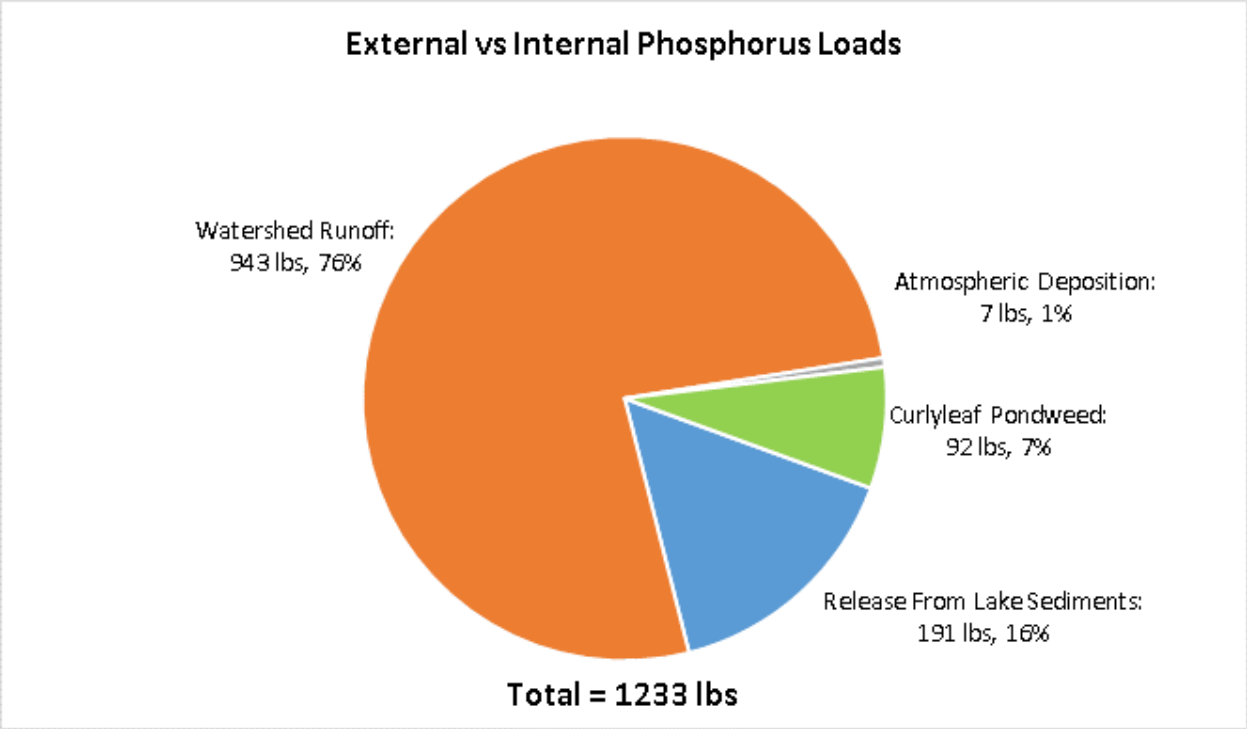


Figure 2.3-6 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Kohlman Lake

2.3.2.5 Water Quality Goals

The water quality goals for Kohlman Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.3-2.

Table 2.3-4 summarizes the beneficial use data for Kohlman Lake as well as the status of total maximum daily load studies (TMDLs) for the various impairments (if applicable, see Section 1.10.2) and the RWMWD nutrient water quality classification of the lake. The data included in Table 2.3-4 is based on data available through the MPCA's Environmental Data Access website.

Kohlman Lake was listed on the MPCA 303(d) Impaired Waters List in 2002 with a use of aquatic recreation impaired due to excessive nutrients, specifically phosphorus (see Section 1.10.2). The *Kohlman Lake Total Maximum Daily Load Report* was finalized in January 2010. The MPCA approved the *Kohlman Lake Total Maximum Daily Load Implementation Plan* in May 2010. The TMDL Report (Barr Engineering, 2010) summarizes the growing season total phosphorus budget for the critical conditions for Kohlman Lake, including the wasteload allocations by MS4s and load allocations. The Kohlman Lake TMDL calls for a 22% reduction in total phosphorus from the tributary watershed (called a "wasteload" reduction), and a 90% reduction in the lake's internal load (called a "load" reduction). The baseline year by which this reduction will be measured is 2001.

Table 2.3-4 Assessment status of Kohlman Lake

Lake ID	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Water Quality Classification*
Kohlman Lake 62-0006	Imp (Excess Nutrients)	IF	Imp (Chloride)	Nutrient TMDL completed in 2010. TCMA Chloride TMDL completed February 2016.	Impaired

* RWMWD nutrient water quality classifications are described in Section 1.10.3
Imp = Impaired
IF = the data collected was insufficient to make a finding
NA = not assessed

The *Kohlman Lake TMDL Implementation Plan* identified strategies to reduce phosphorus loading to Kohlman Lake. Some of these strategies have been implemented. Items identified in the TMDL Implementation Plan that have not yet been implemented have been included in the RWMWD WRAPS implementation table and incorporated in the District's implementation program (see Table 4-1).

2.3.2.6 Tracking TMDL Implementation Progress

The Kohlman Lake TMDL Report (Barr Engineering, 2010) calls for a 209 lbs per growing season reduction in phosphorus through projects implemented after 2001. Progress towards this goal has been achieved, and will continue, through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.3-7. The level shown on the "Phosphorus Reduction" bar in Figure 2.3-7 indicates the District's progress toward the Kohlman Lake phosphorus reduction goal as of December 31, 2015 as a result of District efforts. Selected water quality projects implemented by the District are described in this section

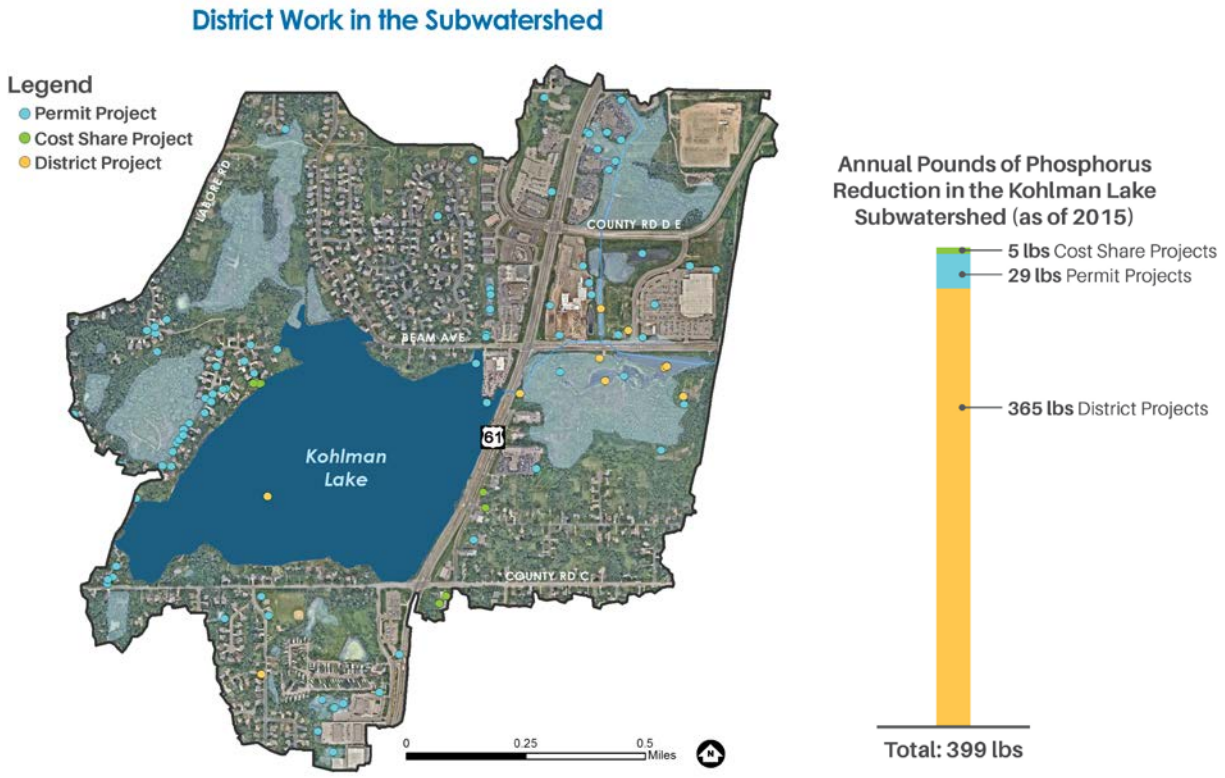


Figure 2.3-7 District work in the Kohlman Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

Beam Avenue Enhanced Sand Filter

The Kohlman Lake TMDL Study identified the need to reduce soluble (dissolved) phosphorus from the watershed runoff in order to meet water quality goals for Kohlman Lake. Reducing dissolved phosphorus is difficult and limited to a few management practices. One relatively new filtration media is called "enhanced sand". Sand filters have been used for years to remove solids and some pollutants from stormwater, but by adding iron aggregate to the sand, the filter can remove dissolved phosphorus as well through a bond between iron and phosphorus. The District installed this half-acre enhanced sand filter north of Beam Avenue and west of Country View Lane in 2007 and has been monitoring it ever since. To date, research indicates that it is functioning as intended.

Kohlman Basin Permeable Limestone Barrier



Kohlman Basin Permeable Limestone Barrier

In 2007, "permeable limestone barriers" were installed on the downstream side of the existing permeable weirs (constructed in 1996) that spread Kohlman Creek flow across the Kohlman Basin wetland. The permeable limestone barrier is an engineered combination of large and small size crushed limestone rock. As flows pass through the barrier, the soluble phosphorus binds with the calcium in the limestone and settles in the wetland. Over time the limestone will dissolve, putting calcium into the water. Calcium is one of a few phosphorus-binding elements (along with aluminum and iron) found in sediment.

Co-precipitation of calcium carbonate and phosphate can occur at elevated pH and calcium concentrations in the water column. Because algae and other aquatic plants can increase the pH in shallow water, wetlands are ideally suited for calcium binding by phosphorus in this manner. Also, additional settling of calcium to the sediments downstream of the barrier increases the sediment's ability to immobilize phosphorus as well.

2.3.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District has implemented several capital improvement projects in the subwatershed with flood control benefits, including:

- **Kohlman Basin capital improvement project** – Although the Kohlman Basin project is primarily a water quality improvement project, the project did affect water quantity and flood levels by providing detention upstream of Kohlman Lake. The project involves diversion of the creek flows into a sedimentation basin and then through a wetland area south of Beam Avenue. A pipeline was installed through what was then a golf course and driving range to bring Willow Creek flows to the sedimentation basin near the previous Ramsey County Compost Site at the east end of the wetland area. Water is then directed into the wetland area and over a series of permeable weirs installed in the wetland to spread the stormwater flows through the wetland vegetation. The project was completed in several phases between 1996 and 2001. The project has been modified since its original construction to include an additional pond along the pipe route.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Kohlman Lake subwatershed are the

new 100-year flood elevations shown in Figure 2.3-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.3.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Kohlman Lake subwatershed are shown in Figure 2.3-9, indicating areas where the water levels of waterbodies in the Kohlman Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.3.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

One of the RWMWD's first residential lake shoreland ecological restoration sites is located on Kohlman Lake. In 1998, District staff consulted with the landowner on the restoration design. This site has been a useful demonstration project for other shoreland owners on Kohlman and other area lakes, promoting interest in the District's cost share BMP program (see Section 4.1.3).

This Kohlman Basin site is several acres in size and offers high-quality wildlife habitat in the watershed. As part of the design and construction of Kohlman Basin, the District revegetated the stormwater ponding system with a variety of native plant community types. RWMWD staff manages the site so it sustains a high diversity of native plant species. Management includes prescribed burns, mowing, and spot herbicide applications. Sites are monitored several times per year to determine the most effective vegetation management activities. RWMWD staff has explored establishing native emergent plant stands in Kohlman Basin able to withstand urban stormwater stressors, as well as the impacts from plant-eating animals. The RWMWD will continue to actively manage this site and promote it as a relatively high-quality urban natural area.

The RWMWD Natural Resources Program will continue to be involved in the management of Kohlman Lake. RWMWD staff has emphasized carp control and macrophyte management to help achieve the RWMWD's water quality goals for this lake and other lakes in the Phalen Chain of Lakes. The RWMWD

sees this as an integrated resource management opportunity and will continue to coordinate its activities in the watershed to align with the District's goal to achieve healthy ecosystems.

2.3.6 Future Implementation Activities

Based on the Kohlman Lake TMDL Report and several feasibility studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals for Kohlman Lake (Table 2.3-5). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Kohlman Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

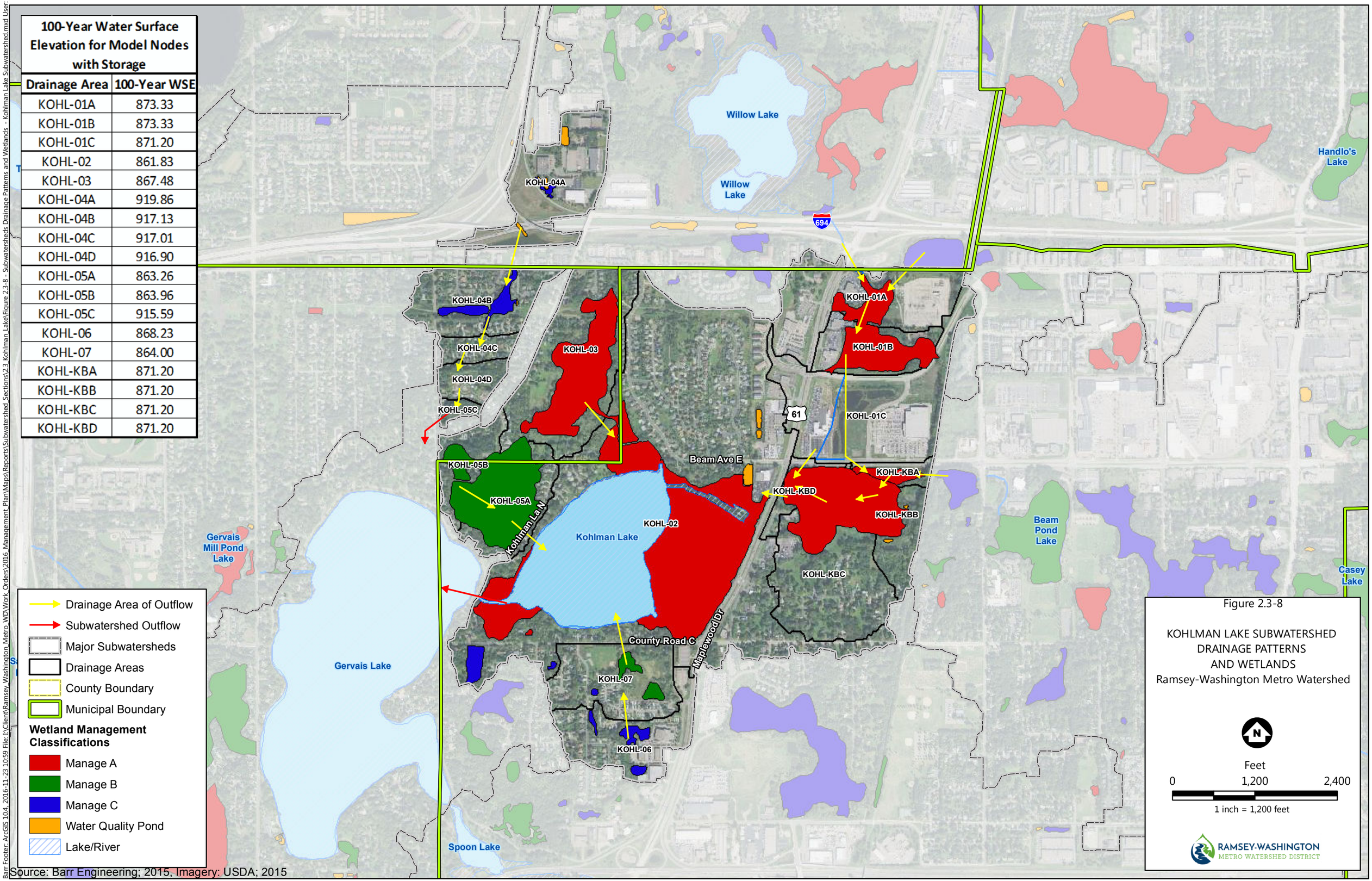
Table 2.3-5 Kohlman Lake Subwatershed Implementation Activities

Activity ID No.	Kohlman Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
KL-1*	Implement a shoreline management study and assist homeowners with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
KL-2*	Research options for control of Kohlman Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
KL-3*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Kohlman Lake.	**2017-2026**	**$200,000**	**WQ2, EC3, EC5**	**Tier 2**
KL-4*	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**$240,000 (representative of management cost throughout the Phalen Chain of Lakes)**	**WQ2, EC3, EC5**	**Tier 2**
KL-5	Visually inspect the connection between Kohlman Lake and Gervais Lake and assess its condition	**2017**	**$2,000**	**EC4**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
KOHL-01A	873.33
KOHL-01B	873.33
KOHL-01C	871.20
KOHL-02	861.83
KOHL-03	867.48
KOHL-04A	919.86
KOHL-04B	917.13
KOHL-04C	917.01
KOHL-04D	916.90
KOHL-05A	863.26
KOHL-05B	863.96
KOHL-05C	915.59
KOHL-06	868.23
KOHL-07	864.00
KOHL-KBA	871.20
KOHL-KBB	871.20
KOHL-KBC	871.20
KOHL-KBD	871.20



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.3-8

KOHLMAN LAKE SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,200 2,400
1 inch = 1,200 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 10:59 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.3_Kohlman_Lake\Figure 2.3-8 - Subwatersheds Drainage Patterns and Wetlands - Kohlman Lake Subwatershed.mxd User: jrv

Barr Footer: ArcGIS 10.4 2016-11-28 15:06 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.3_Kohlman_Lake\Figure 2.3-9 - Priority Infiltration Areas - Kohlman Lake Subwatershed.mxd User: jrv

Twin Lake
Willow Lake
Willow Lake
Unnamed (Varney)
Handlo's Lake
694
61
Beam Ave E
Kohlman Ln N
Kohlman Lake
Gervais Mill Pond
Gervais Lake
County Road C
Maplewood Dr
Markham Pond
Casey Lake
Spoon Lake
Keller (Main Bay) Lake
North Knucklehead Lake

Drainage Area
County Boundary
Municipal Boundary
Creeks

Vulnerability to Changes in Groundwater System
- Vulnerable
- Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.3-9

KOHLMAN LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

N

Feet
0 1,200 2,400
1 inch = 1,200 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

2.4 Twin Lake Subwatershed

2.4.1 General Description

The Twin Lake subwatershed is located in the northwest portion of the RWMWD. The Twin Lake subwatershed covers 192 acres in the cities of Little Canada and Vadnais Heights. The subwatershed is an upstream part of the larger Phalen Chain of Lakes Watershed and includes Twin Lake, a District-managed lake.

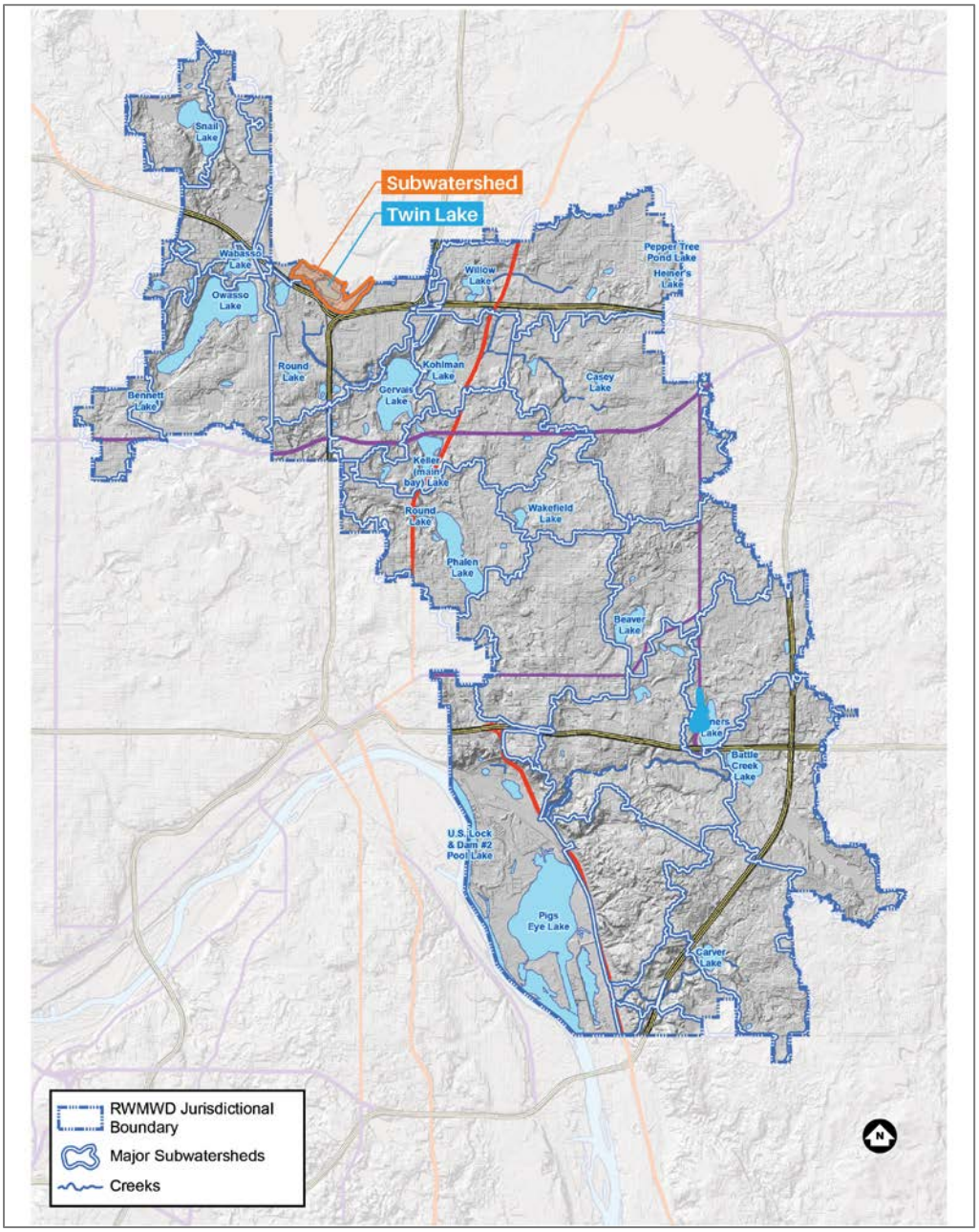


Figure 2.4-1 Twin Lake Location Map

Twin Lake has a total surface area of 35.5 acres, and a maximum depth of 33 feet. Twin Lake is classified as a deep lake by the MPCA. Twin Lake is a landlocked lake with no primary surface outlet, a high water level overflow discharges to Gervais Creek. There is no public access to Twin Lake, which is primarily used for canoeing, wildlife habitat, viewing, occasional jet skiing and fishing.

Table 2.4-1 Twin Lake Subwatershed Facts

Tributary Area (Direct)	192 acres
Tributary Area (Total)	192 acres
Downstream Watershed	Gervais Creek
MDNR Designation[1]	62-0039P
Lake Surface Area[1]	35.5 acres
Lake Maximum Depth[1]	33 ft
Lake Outlet Type[1]	None (Landlocked)
Lake Outlet Elevation[1]	881 (high water overflow)
100-Year Flood Level[2]	-- (land-locked)
Lake Littoral Area[1]	44%
MPCA Designations[1]	Deep Lake
MS4s in the Direct Tributary Area	Little Canada, Vadnais Heights, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Lake data refers to Twin Lake

[2] 100-year flood level for land-locked basins not established (see Section 1.12.3)

2.4.1.1 Past Studies

The following list is a summary of past studies related to Twin Lake and/or its tributary subwatershed.

- *Hydrologic Analysis of Lakes and Open Space in Ramsey County*. Barr Engineering, 1975.
- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *Twin Lake Hydrologic Study*. Prepared for RWMWD by Barr Engineering, November 1993.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.
- *Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report*. Prepared for RWMWD by Barr Engineering, 2007.

2.4.1.2 Land Use

Based on the Metropolitan Council 2010 land use data, the subwatershed is predominantly covered by open water from Twin Lake, low-density residential development, a manufactured housing park, and open space (Figure 2.4-2). Estimated future land use within the watershed is entirely low-density residential, based on the Metropolitan Council future land use projections for 2030 (see Figure 1-5). New development and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

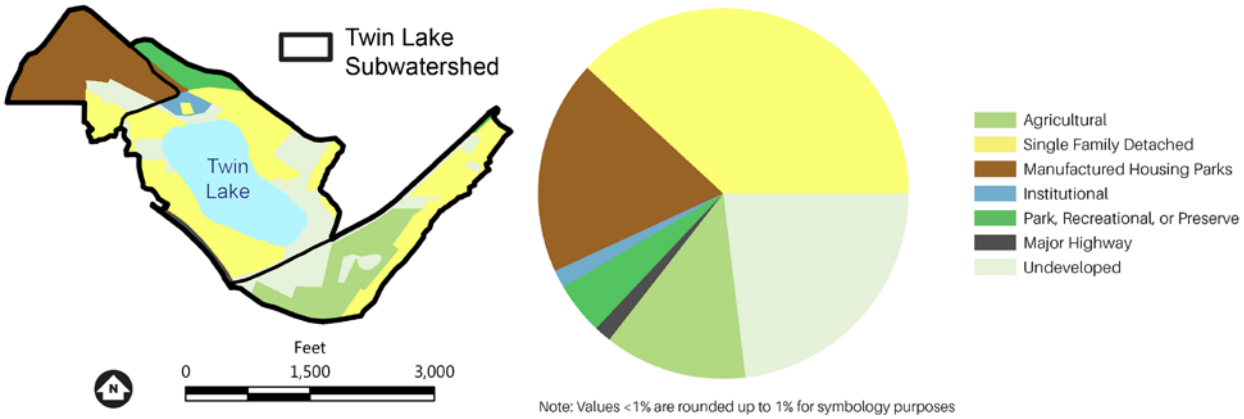


Figure 2.4-2 Breakdown of land uses throughout the Twin Lake Subwatershed (2010 Metropolitan Council)

2.4.1.3 Drainage Patterns and Waterbodies

The Twin Lake subwatershed is an upstream part of the larger Phalen Chain of Lakes Watershed (see Figure 1-8). There is a natural overflow from Vadnais Lake, located just north of Twin Lake, to Twin Lake. Vadnais Lake and its tributary watershed are not included in the RWMWD, due in part to the infrequency of flows from Vadnais Lake to Twin Lake. According to the *Twin Lake Hydrologic Study* (1993), overflows from Vadnais Lake are possible, but rare because the St. Paul Regional Water Services draws water from Vadnais Lake, thus controlling water levels. If Twin Lake rises high enough, water would flow from the lake to the wetland north of I-694, through a culvert underneath I-694 that discharges to Gervais Creek (formerly County Ditch 16).

The Twin Lake subwatershed has been divided into three drainage areas for hydrologic modeling and management purposes (see Figure 2.4-5). Figure 2.4-5 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Twin Lake subwatershed include only Twin Lake.

Wetlands within the Twin Lake subwatershed are shown in Figure 2.4-5 according to the RWMWD wetland management classification (see Section 1.11.3).

2.4.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Twin Lake.

2.4.2.1 Historical Water Quality

The water quality of Twin Lake has historically been good in comparison with other metropolitan lakes. This is largely due to the regional topography and local geology which isolates the lake hydrologically from nearby waterbodies and local drainage areas. The water quality of Twin Lake is sampled by the Ramsey County Department of Public Works about seven times per year on average, between the months of May and September. Figure 2.4-3 shows the summer average (May through September) total phosphorus, chlorophyll *a*, and Secchi disc measurements for the lake's period of record. The summer average values for 2002 were calculated using data obtained from STORET. The 2002 summer average for Secchi disc transparency was calculated using the only two data points available (late July and late August).

Table 2.4-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Twin Lake relative to MPCA standards.

Table 2.4-2 Twin Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Twin Lake (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	22.1
Chlorophyll-a (µg/L)	≤ 14	6.2
Secchi disk transparency (m)	≥ 1.4	2.9

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Twin Lake water quality data. The results of these analyses are shown in Table 2.4-3.

Table 2.4-3 Trend Analysis Results for Twin Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Twin Lake	1996 – 2012	Secchi Depth	No Trend	Improving*
		Total Phosphorus	No Trend	No Trend
		Chlorophyll *a*	No Trend	Improving*

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

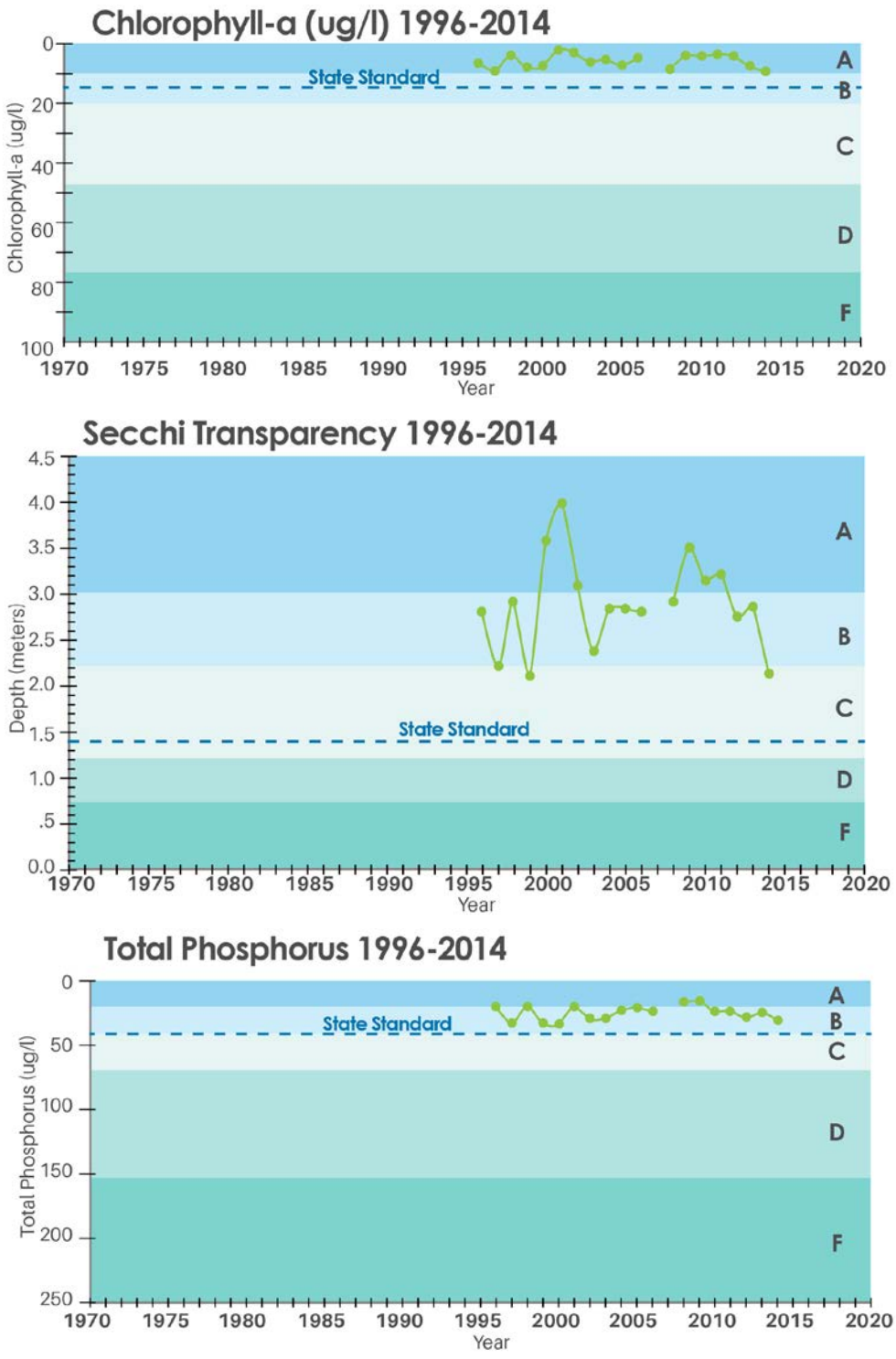


Figure 2.4-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Twin Lake (1996-2014)

2.4.2.2 State of the Fishery

The MDNR assessed the Twin Lake fish population in 1996. The assessment is available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html). Twin Lake did not experience winter kill for several years prior to the survey. The survey found that Bluegills were the most abundant species sampled, but they were small with an average size of 4.5 inches and fewer than 10% being over 6 inches. Low to moderate numbers of small (5 to 8 inch) black crappie were also present. Moderate numbers of northern pike were sampled with lengths ranging from 23 to 30 inches. Largemouth bass were also sampled, but not in high numbers. However, the sampling techniques used were not effective on bass, so numbers could be higher than sampling results indicate. Bass were small – lengths ranged from 5 to 9 inches. Low to moderate numbers of yellow perch, hybrid sunfish, pumpkinseed, and green sunfish were also present, but were generally small.

2.4.2.3 Water Quality Goals

The water quality goals for Twin Lake are consistent with the MPCA's deep lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.4-2. The RWMWD will continue to evaluate Twin Lake water quality data for trends and adjust its water quality classification and management activities accordingly.

Based on recommendations from the *Twin Lake Hydrologic Study* (1993), the RWMWD will strive to keep Twin Lake segregated from nearby drainage systems, such as the I-694 drainage system and possible overflows from Vadnais Lake. If overflow from Vadnais Lake is expected, the flow should be diverted around Twin Lake to avoid impacts to the water quality in Twin Lake and possible introduction of invasive species such as Eurasian watermilfoil.

Projects implemented in the Twin Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.4-4.

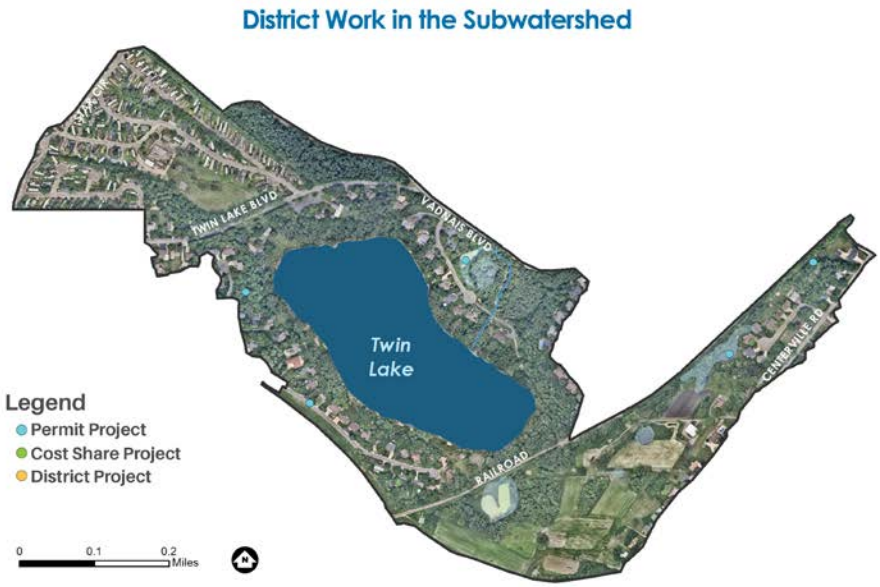


Figure 2.4-4 District work in the Twin Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.4.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

In 1993, the *Twin Lake Hydrologic Study* (Barr Engineering, 1993) investigated flooding potential, established the maximum allowable normal water level for the lake, and identified strategies to prevent flooding and degradation of the water quality of Twin Lake. The 1993 study referenced a 1975 report, which suggested that a 63 cubic feet per second (cfs) flood flow may need to be periodically directed from Vadnais Lake to the Twin Lake subwatershed. If an outflow of 63 cfs from Vadnais Lake is necessary, it is recommended that the flow be diverted around Twin Lake to reduce the potential for flooding and protect the water quality of Twin Lake. It was suggested that the potential flow be diverted through wetlands west of Twin Lake, under I-694, and into the Gervais Creek system. Further study of this route would be necessary to assess the impacts on the Gervais Creek system.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Twin Lake subwatershed are the new 100-year flood elevations shown in Figure 2.4-5. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

Under normal hydrologic conditions, Twin Lake remains landlocked. The predicted 100-year flood level for Twin Lake is 873.8 feet. When the water level of Twin Lake becomes extremely high (881 feet), water would flow from the lake to the wetland north of I-694, through the culvert under I-694 and into the Gervais Creek system. If regular discharge from Vadnais Lake is expected in the future, the District may consider installing an additional culvert through an existing dike that guards the entrance to the I-694 culvert to allow increased capacity from Twin Lake at a lower elevation. Another option may be to pump water from Twin Lake to lower the risk of potential flooding. A permit from MNDOT would be required before an additional culvert could be placed. If RWMWD should decide to proceed with installing an additional culvert, the District will discuss the work with MNDOT before applying for a permit.

2.4.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Twin Lake subwatershed are shown in Figure 2.4-6, indicating areas where the water levels of waterbodies in the Twin Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.4.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to seek opportunities to integrate natural resource benefits into its activities within the Twin Lake subwatershed.

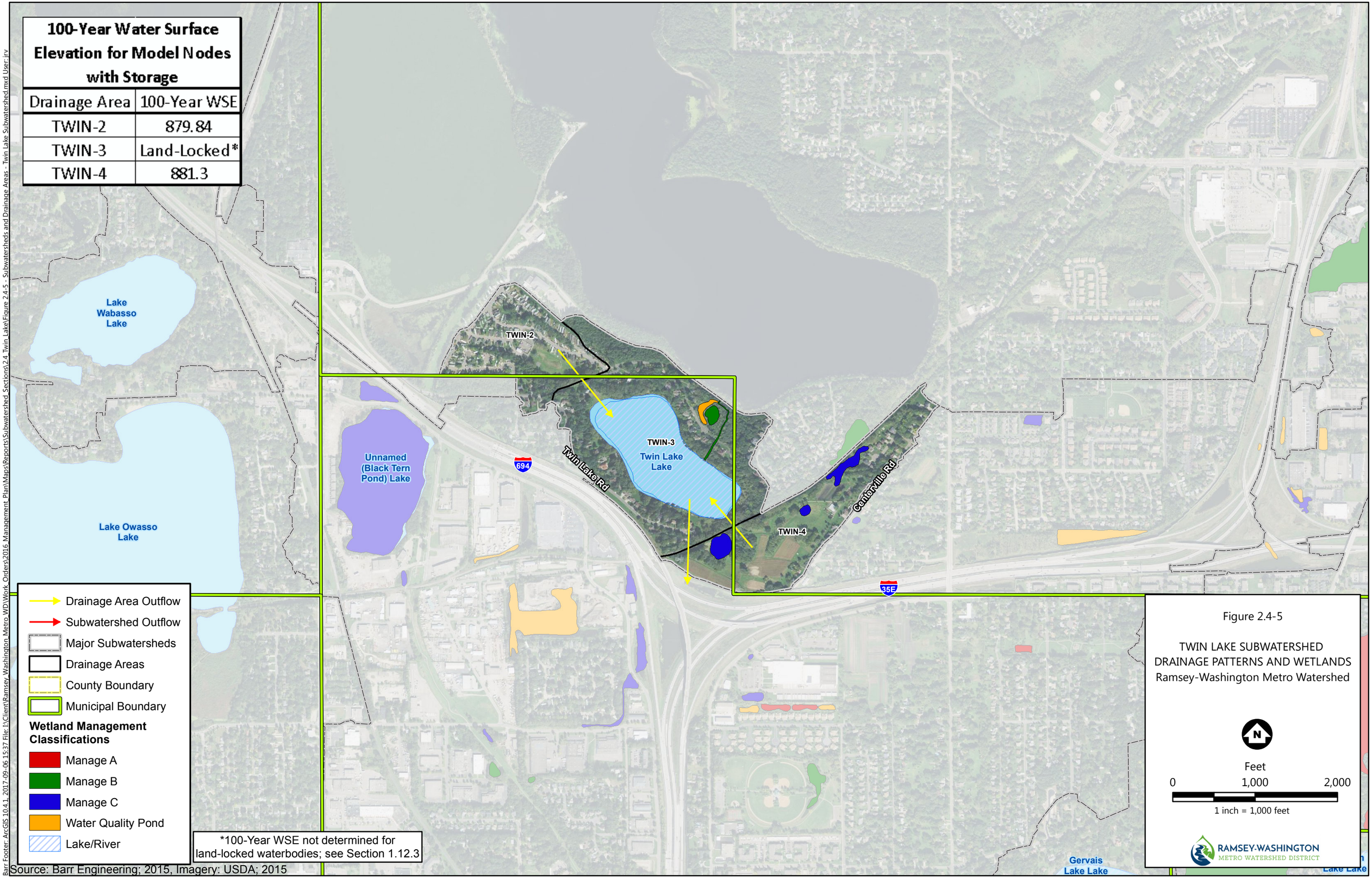
2.4.6 Implementation Program

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Twin Lake subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Twin Lake subwatershed are identified (see Table 2.4-4). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.4-4 Twin Lake Subwatershed Implementation Activities

Activity ID No.	Twin Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
TL-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
TWIN-2	879.84
TWIN-3	Land-Locked*
TWIN-4	881.3



*100-Year WSE not determined for land-locked waterbodies; see Section 1.12.3

Source: Barr Engineering; 2015, Imagery: USDA; 2015

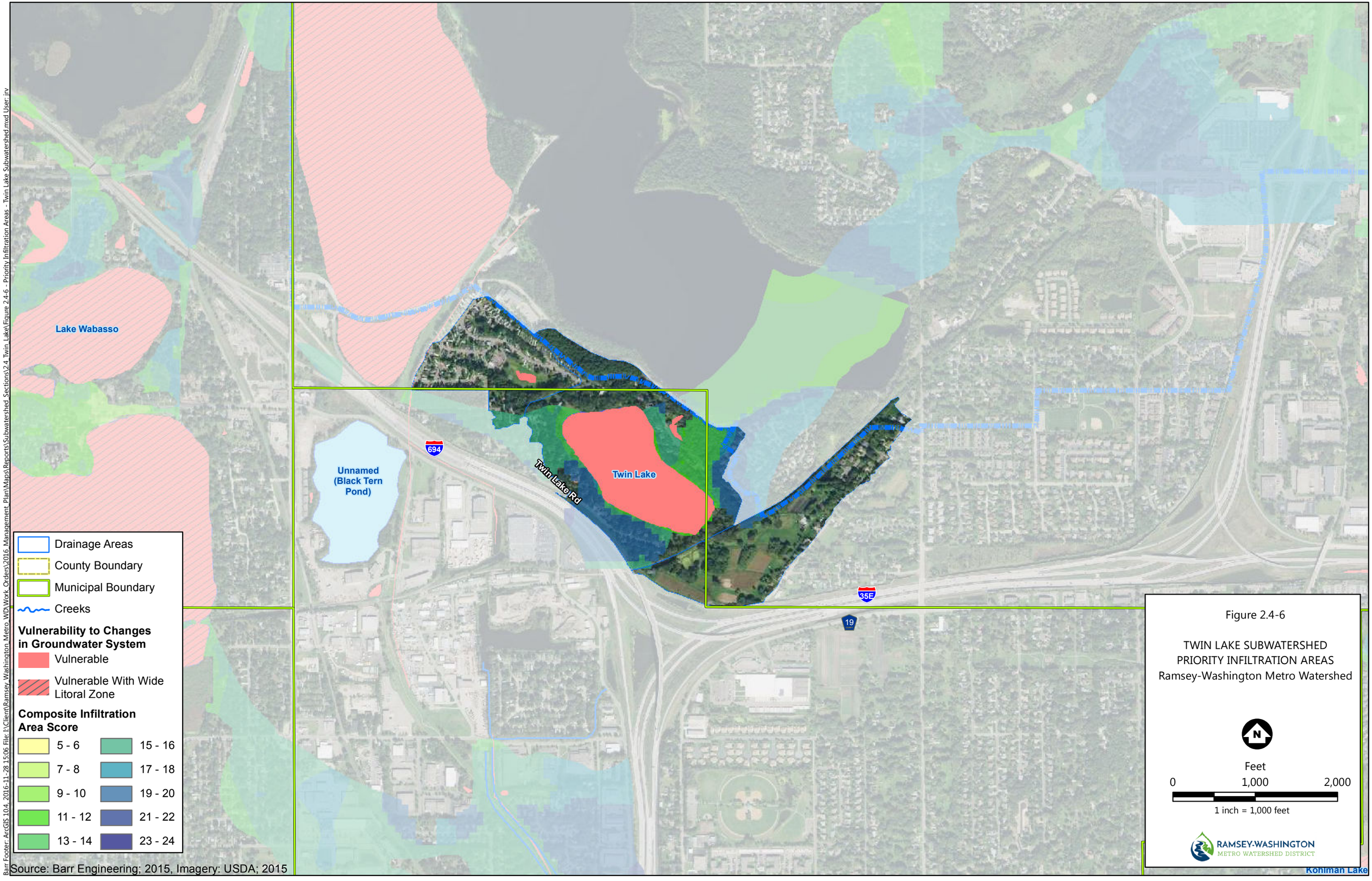
Figure 2.4-5

TWIN LAKE SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,000 2,000
1 inch = 1,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-09-06 15:37 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.4 Twin Lake\Figure 2.4-5 - Subwatersheds and Drainage Areas - Twin Lake Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4 2016-11-28 15:06 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.4_Twin_Lake\Figure 2.4-6 - Priority Infiltration Areas - Twin Lake Subwatershed.mxd User: jrv

2.5 Gervais Creek Subwatershed

2.5.1 General Description

The Gervais Creek subwatershed spans 1,847 acres and includes portions of Vadnais Heights and Little Canada. The total subwatershed area increases to 2,039 acres when the Twin Lake subwatershed is included (see Section 2.4), although discharge from the Twin Lake subwatershed to Gervais Creek is rare. The entire Gervais Creek subwatershed is located in Ramsey County. The Gervais Creek subwatershed is part of the larger Phalen Chain of Lakes watershed.

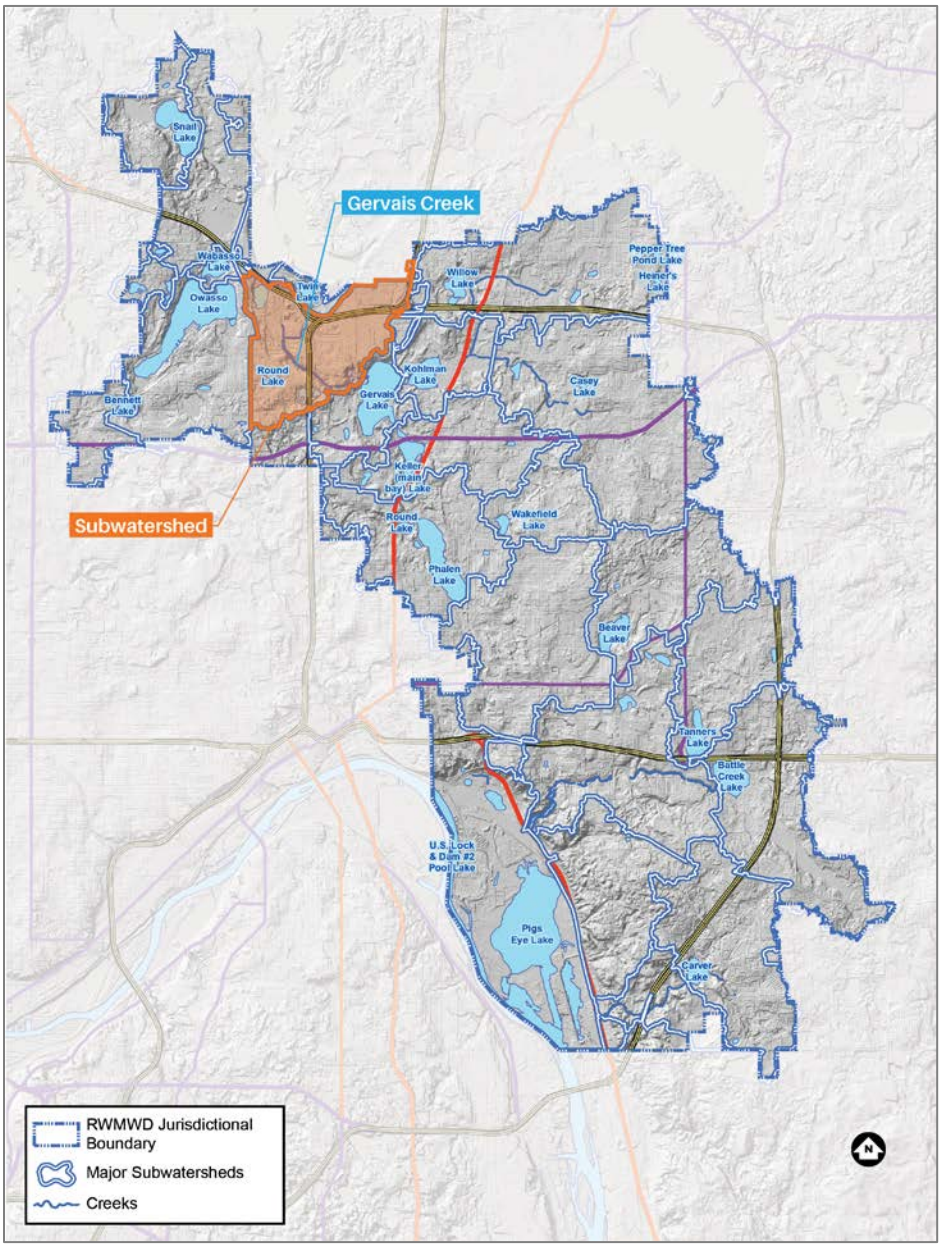


Figure 2.5-1 Gervais Creek Location Map

Gervais Creek is an intermittent stream that was previously managed as a county ditch (County Ditch 16). The subwatershed includes the entire area that drains to Gervais Creek under normal conditions, including County Ditch 7B. Gervais Creek originally extended north to Twin Lake, but now is cut off by I-694 and no longer exists north of the interstate. The county ditch system was historically managed by Ramsey County as a stormwater conveyance system, and continues to be managed by the RWMWD as a stormwater system. The RWMWD is responsible for the portion of the creek between Gervais Lake and Owasso Basin, and east to I-35E at I-694.

Table 2.5-1 Gervais Creek Subwatershed Facts

Tributary Area (Direct)	1,847 acres
Tributary Area (Total)	2,039 acres
Downstream Watershed	Gervais Lake
MDNR Designation[1]	62-0009P
Lake Surface Area[1]	12 acres
Lake Maximum Depth[1]	6.6 ft
Outlet Type[1]	24 inch Reinforced Concrete Pipe
Outlet Elevation[1]	901.1 ft [1]
100-Year Flood Level[1]	907.5 ft [1]
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake
MS4s in the Direct Tributary Area	Little Canada, Vadnais Heights, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	At Risk (Round Lake)

[1] Data for Round Lake (Little Canada)

The District-managed waterbodies within the Gervais Creek subwatershed include Round Lake in Little Canada and Gervais Creek. Two important regional stormwater detention basins, Owasso Basin and Gervais Mill Pond, are also located within the Gervais Creek subwatershed. The subwatershed also includes numerous wetlands, including Black Tern Pond, a large wetland in the northwest corner of the subwatershed, and Savage Lake. Although its name implies that Savage Lake is a lake, it is not classified as lacustrine under the Cowardin system, and therefore is not classified as a District-managed lake (see Section 1.9.1).

Round Lake (MDNR# 62-0009P) is a District-managed lake located in Little Canada, south of Little Canada Road and east of North Rice Street. The lake is surrounded by intensive residential and commercial development and is a popular neighborhood resource. The lake is primarily used for canoeing, picnicking and aesthetic viewing, although swimming is also desired. The lake has a drainage area of 195 acres and a

total surface area of 12 acres. Round Lake is classified as a shallow lake by the MPCA (a maximum depth of less than 15 feet and/or at least 80% of the lake less than 15-feet deep).

2.5.1.1 Past Studies

The following list is a summary of past studies related to the Gervais Creek subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *Owasso Basin Hydrologic Study*. Prepared for RWMWD by Barr Engineering, 1990.
- *Gervais Mill Pond Feasibility Study*. Prepared for RWMWD by Barr Engineering, November 1991.
- *Kohlman and Gervais Lake Diagnostic Study*. Prepared for RWMWD by Barr Engineering, 1994.
- *Addressing the Water Quality Benefits of Smaller Wet Detention Ponds*. Prepared for RWMWD by Barr Engineering, 1995.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Casey Lake, Round Lake (in Little Canada), Savage Lake, Twin Lake, and Willow Lake Lake Status Report*. Prepared for RWMWD by Barr Engineering, 2007.

2.5.1.2 Land Use

The Gervais Creek subwatershed is fully developed. Existing land use is shown in Figure 2.5-2. Interstates 35E and 694 cut across the subwatershed. The northwest portion of the subwatershed, south of I-694, contains industrial and commercial areas and a high-density manufactured-home court. Multiple-family and single-family residential areas are scattered throughout the subwatershed. Undeveloped areas in the southeast and southwest corners of the I-35E and I-694 interchange are considered fully developed, with industry surrounded by wetlands. Scattered areas of open space north of I-694 are also considered fully developed due to the predominance of wetlands. Metropolitan Council future land use projections for 2030 (see Figure 1-5) indicate that little change is expected in land use in the future. Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

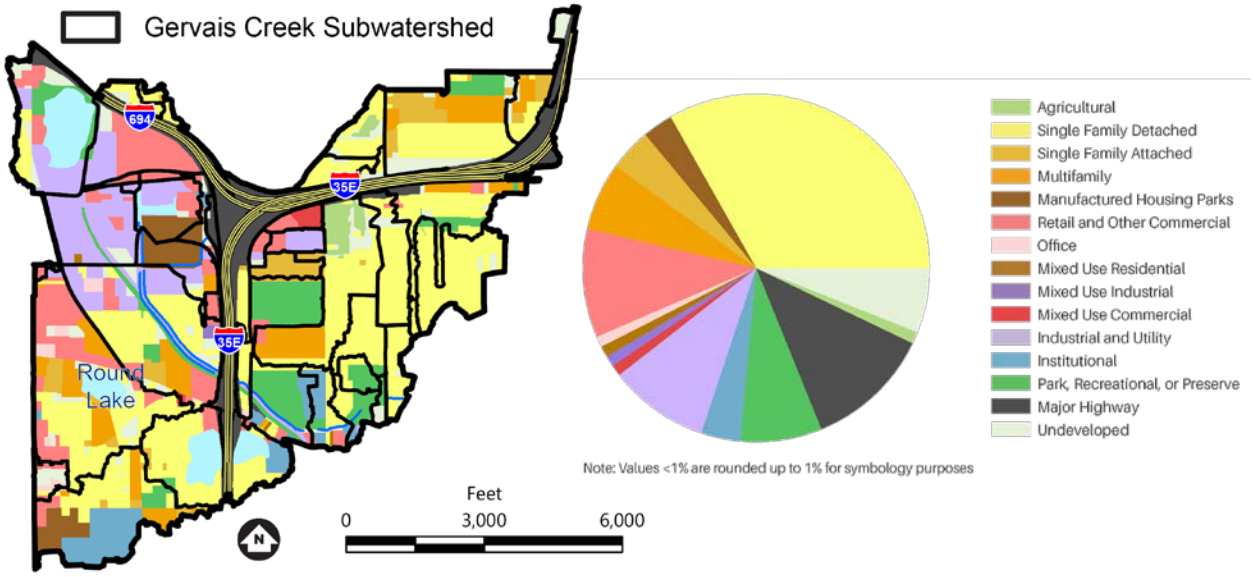


Figure 2.5-2 Breakdown of land uses throughout the Gervais Creek Subwatershed (2010 Metropolitan Council)

2.5.1.3 Drainage Patterns and Waterbodies

The Gervais Creek subwatershed is part of the larger Phalen Chain of Lakes Watershed. The stormwater system within the Gervais Creek subwatershed is comprised of stormwater detention ponds, wetlands, storm sewers, drainage ditches, and overland flow paths, which all eventually drain to Gervais Creek (see Figure 2.5-4). The Twin Lake subwatershed is upstream of the Gervais Creek subwatershed. However, Twin Lake is generally considered landlocked and is not expected to overflow to Gervais Creek except during very large storms or snowmelt periods greater than the 100-year frequency, 30-day snowmelt event (1997 RWMWD Plan). The Gervais Creek subwatershed discharges to Gervais Lake and the Gervais Lake subwatershed.

The RWMWD's installation of an outlet from the previously-landlocked Black Tern Pond resulted in a change in the drainage patterns from the 1997 Plan. Because of the project, the pond now discharges to Owasso Basin, and is part of the Gervais Creek subwatershed.

As part of the I-694/I-35E "Unweave the Weave" project, a 4 cubic feet per second (cfs) high overflow outlet was constructed from West Vadnais Lake to Owasso Basin. The construction of this outlet adds potential tributary area to the Gervais Creek watershed; however, outflows from West Vadnais Lake to Owasso Basin are not expected to occur except in extreme hydrologic conditions. The RWMWD owns and operates the system; the RWMWD, Ramsey County, and St. Paul Regional Water Services have entered into an agreement for the operation and maintenance of the pipe.

The Gervais Creek subwatershed has been divided into three drainage areas for hydrologic modeling and management purposes (see Figure 2.5-4). Figure 2.5-4 indicates the direction of flow from each drainage

area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Gervais Creek subwatershed include Gervais Creek and Round Lake in Little Canada.

Wetlands within the Gervais Creek subwatershed are shown in Figure 2.5-4 according to the RWMWD wetland management classification (see Section 1.11.3).

2.5.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Round Lake and Gervais Creek. Although not a District-managed lake, the RWMWD has also included Savage Lake in some of its past studies and management actions.

2.5.2.1 Historical Water Quality

Round Lake (Little Canada)

Round Lake (Little Canada) is used primarily for canoeing, picnicking, and aesthetic viewing, although swimming is also desired. Limited historical water quality data is available for Round Lake, as the lake is not monitored by the RWMWD or Ramsey County. Round Lake was monitored as part of the MPCA's Citizen Lake Monitoring Program (www.pca.state.mn.us) in 1995, 1996, 2010, and 2011. Based on the MPCA data, Round Lake had a Secchi disc transparency depth of 1.7 feet in 1995 and 2.0 feet in 1996; Secchi disc transparencies in 2010 and 2011 ranged from approximately 1 to 1.5 feet. These values are consistent with satellite imagery acquired between 1999 and 2000 that indicated that the lake's transparency depth is less than 1.5 feet (Minnesota Lake Finder, www.dnr.state.mn.us). Summer average total phosphorus in 2010 and 2011 was 207 µg/L and 166 µg/L, respectively (see Table 2.5-2). These measurements define Round Lake as eutrophic, and exceed applicable MPCA and RWMWD nutrient water quality standards (see Section 1.10.1). The RWMWD has classified Round Lake as an "At-Risk" water body based on its current water quality data and exclusion from the MPCA's Impaired Waters 303(d) List (see Section 1.10.3).

A survey of Round Lake (Little Canada) in 2010 detected no submersed aquatic vegetation.

Table 2.5-2 Round Lake (Little Canada) historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Round Lake (2010-2011) Growing Season Average[1]
Total Phosphorus (µg/L)	≤ 60	187
Chlorophyll-a (µg/L)	≤ 20	90
Secchi disk transparency (m)	≥ 1.0	0.3

[1] Data from 2010 and 2011 MPCA monitoring

Gervais Creek

The RWMWD installed a water quality monitoring station on Gervais Creek in 2007. The station allows the District to continuously monitor flows in Gervais Creek into the Phalen Chain of Lakes. This data allows the District to evaluate the effectiveness of District and city stormwater management programs and projects. The station collects year-round water quality and flow rate samples and data. Biological monitoring of the creek was performed by the MDNR in 1999 and the MPCA in 2010. 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 for nutrients. Thus, the District has assigned a RWMWD nutrient water quality classification of At Risk to Gervais Creek.



Gervais Creek Monitorina Station

2.5.2.2 Water Quality Improvement Projects

Based on recommendations from the *Phalen Chain of Lakes Surface Water Management Plan*, several significant capital improvement projects were implemented in the Gervais Creek subwatershed to improve the water quality of the stream and downstream waterbodies. Brief descriptions of these projects are provided below.

- **Owasso Basin capital improvement project** – Built in 1990 and 1991, this project included the construction of a multi-purpose regional facility designed to treat stormwater runoff from a large area in the northwest portion of the Gervais Creek subwatershed, including the majority of the I-694/I-35E "commons" area. The project also provides a significant amount of stormwater storage. In 2005, MnDOT began construction of the I-694/I-35E "Unweave the Weave" project. Approved plans for the project include 13 stormwater ponds that will remove 60% of the total phosphorus loading carried by runoff from the existing "commons" area. At the completion of the "Unweave the Weave" project, the District removed an existing diversion structure at Country Drive to allow low flows from the existing "commons" area to bypass Owasso Basin. This allows

the basin to provide treatment for the highly industrial local drainage area for smaller runoff events. The basin still serves as a regional flood storage area for larger runoff events.

- **Gervais Mill Pond capital improvement project** – This water quality treatment project, built in 1993 and 1994, involved construction of a three-cell open water treatment system to provide nutrient removal of flows from Gervais Creek, prior to discharge into Gervais Lake. A trail system that includes three bridges and two fishing piers was also constructed. Since completion of the original project, much of the area disturbed as a part of the construction has been restored with native vegetation.

2.5.2.3 Water Quality Goals

The water quality goals for Round Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.5-2. Water quality goals for Gervais Creek are consistent with the MPCA's stream eutrophication standards (see Section 1.10.1).

The RWMWD strives to ensure that the watercourse and banks of Gervais Creek are stable to minimize erosion and sediment problems. The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion and other stream degradation problems. Projects implemented in the Gervais Creek subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.5-3.

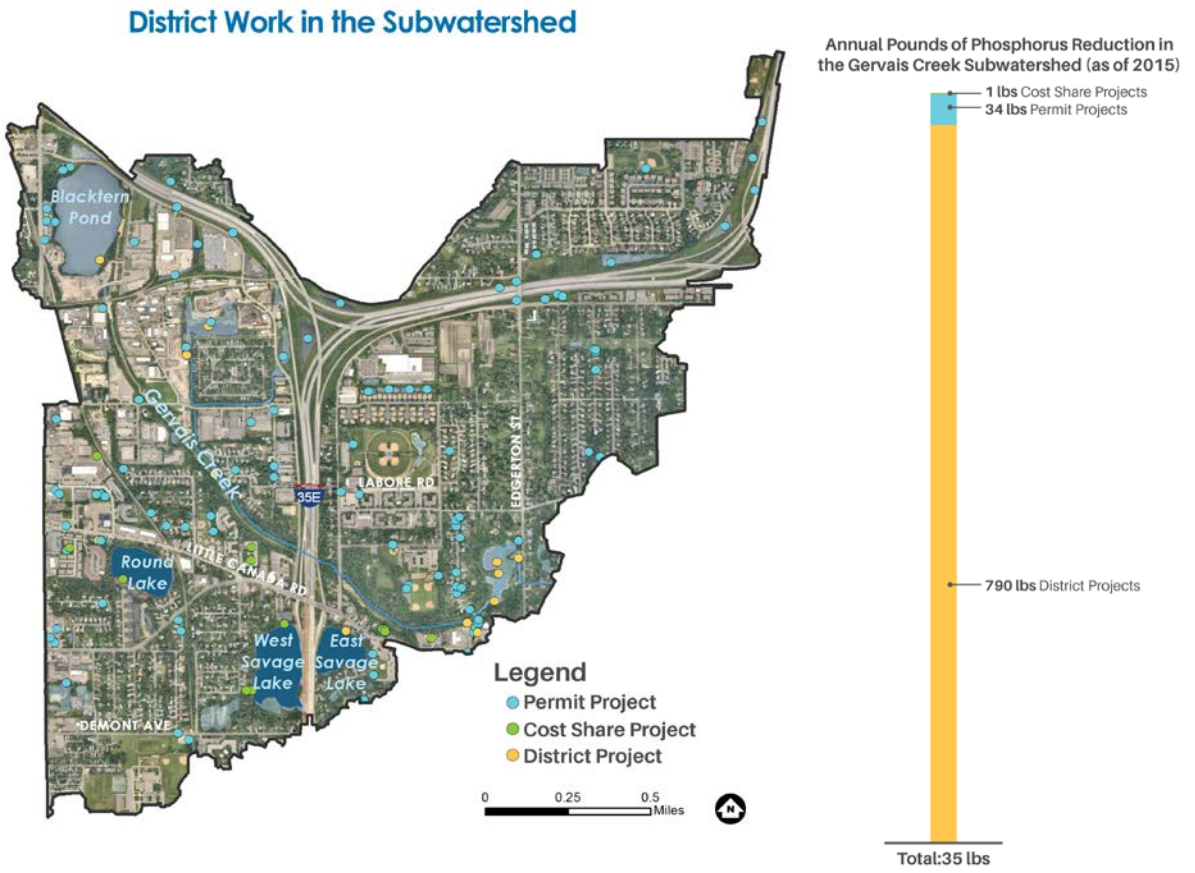


Figure 2.5-3 District work in the Gervais Creek Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.5.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District performed hydrologic and hydraulic modeling for the Gervais Creek subwatershed as part of the Phalen Chain of Lakes Surface Water Management Plan (Phalen Management Plan) (1988) to identify potential flooding problems and recommend improvements. The District has implemented several capital improvement projects in the subwatershed with flood control benefits, including:

- **Owasso Basin capital improvement project** – This project was completed based on recommendations from the Phalen Management Plan. This multi-purpose regional facility provides a significant amount of stormwater storage that resulted in the removal of numerous nearby mobile homes and businesses from the 100-year floodplain. .

- **Owasso Low-Flow Capital Improvement Project** – This project was completed in 1993. This project involved the installation of a low flow pipeline from the outlet of Owasso Basin to the

I-35E culvert in Gervais Creek. The primary flow conveyor over this stretch is an open ditch with very little elevation change. Pre-project conditions allowed small amounts of vegetation and debris to accumulate in this Section of the ditch, which elevated normal water levels in Owasso Basin, resulting in increased flooding in and around Owasso Basin. An analysis determined that installing this low flow pipeline to maintain the normal water level was more cost effective than cleaning the ditch frequently.

- **Black Tern Pond Outlet** – In 2001, the RWMWD installed an outlet from Black Tern Pond, in response to a request from the City of Little Canada. Before the project, the basin was landlocked and occasionally flooded the frontage road. RWMWD received a permit from the MDNR for the outlet structure.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Gervais Creek subwatershed are the new 100-year flood elevations shown in Figure 2.5-4. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.5.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Gervais Creek subwatershed are shown in Figure 2.5-5, indicating areas where the water levels of waterbodies in the Gervais Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.5.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD is involved in numerous habitat management areas throughout the District. The Gervais Mill Pond is one of these sites. Project objectives included improving water quality treatment, creating a

natural wetland appearance and a park amenity for the City of Little Canada, and increasing wildlife and fish habitat. The RWMWD project included the construction of three interconnected wetlands, bridges, trails, and fishing piers. The two large pools are up to 10-feet deep. The MDNR also manages Gervais Mill Pond as a children's fishing pond. The District continues to maintain Gervais Mill Pond as a managed natural area. RWMWD staff actively monitors the vegetation communities and performs appropriate management tasks. Buckthorn has been aggressively controlled in the forested patches and reed canary grass has been reduced along the shore. White water lily, bulrush, and other emergent species were planted and are now established along the pond perimeter. District staff partnered with the City of Little Canada to conduct prescribed burns. The RWMWD will continue to promote this site as one of the exceptional multi-use natural areas in the watershed.

In 2004, the District partnered with the City of Little Canada to establish native vegetation around a new stormwater detention facility called Marketplace Pond. With the assistance of the RWMWD Natural Resources Board (dissolved in December 2006) and funding from the Ramsey Conservation District, patches of emergent vegetation were established around the pond perimeter. The three main goals of this revegetation project were to increase the habitat quality of the pond shore, reduce geese abundance, and increase the aesthetics of the pond. District staff cooperates with the City to perform maintenance activities related to the upland prairie areas.

Another RWMWD habitat management site in the Gervais Creek subwatershed is Lakeside Pond. This stormwater treatment pond is located between Little Canada Road and the Lakeside Apartments near Round Lake in Little Canada. The pond, which is subject to a fairly large and voracious population of Canada Geese, was previously maintained by the city as turf grass nearly to the water's edge. In conjunction with the City of Little Canada, a buffer was planted around the perimeter of the pond. The goals of the buffer were to filter runoff, beautify the pond, reduce the burden of maintenance, and discourage excessive goose populations by creating a vegetative barrier around the pond. The buffer was planted with a variety of native plants conducive to the differing hydrologic conditions of the pond.

RWMWD staff has communicated with shoreland owners on Savage Lake regarding vegetation management around shoreline areas. The RWMWD also promotes its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas.

The RWMWD will continue to seek opportunities to integrate natural resource benefits into its activities within the Gervais Creek subwatershed.

2.5.6 Future Implementation Activities

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Gervais Creek subwatershed (see Table 2.5-3). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Gervais Creek subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.5-3 Gervais Creek Subwatershed Implementation Activities

Activity ID No.	Gervais Creek Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
GC-1	Continue to coordinate with DNR and Little Canada to improve habitat in Gervais Mill Park and maintain the urban fishing pond status.	**Continuous**	**$1,500 (average annual cost)**	**EC6**	**Tier 3**
GC-2*	Research options for control of Round Lake's (Little Canada) internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$50,000**	**MO13**	**Tier 2**
GC-3	Prepare and implement a plan for increasing flood resiliency around Owasso Basin	**2018-2020**	**$500,000**	**WQ8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
CD16-01	911.52
CD16-02	908.57
CD16-03a	914.15
CD16-03b	903.8
CD16-03c	914.97
CD16-04	908.46
CD16-05a	881.25
CD16-05b	876.56
CD16-05c	901.62
CD16-05d	876.56
CD16-05e	876.56
CD16-05f	879.44
CD16-05g	889.09
CD16-05i	876.56
CD16-05j	876.56
CD16-05k	876.56
CD16-05m	881.3
CD16-05n	877.42
CD16-05o	898.59
CD16-05p	893.62
CD16-05q	891.97
CD16-06	893.62
CD16-07	897.97
CD16-08a	893.62
CD16-08b	894.71
CD16-09	875.06
CD16-10	948.49
CD16-11	907.49
CD16-12	870.49
CD16-13	869.94
CD16-14	906.79
CD16-15	898.33
CD16-16	897.73
CD16-18A	867.06
CD16-18B	867.06
CD16-18C	867.03
CD16-18D	864.13
CD16-19	863.88
CD16-20	887.4

- Drainage Area Outflow
- Subwatershed Outflow
- Major Subwatersheds
- Drainage Areas
- County Boundary
- Municipal Boundary

Wetland Management Classifications

- Manage A
- Manage B
- Manage C
- Water Quality Pond
- Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

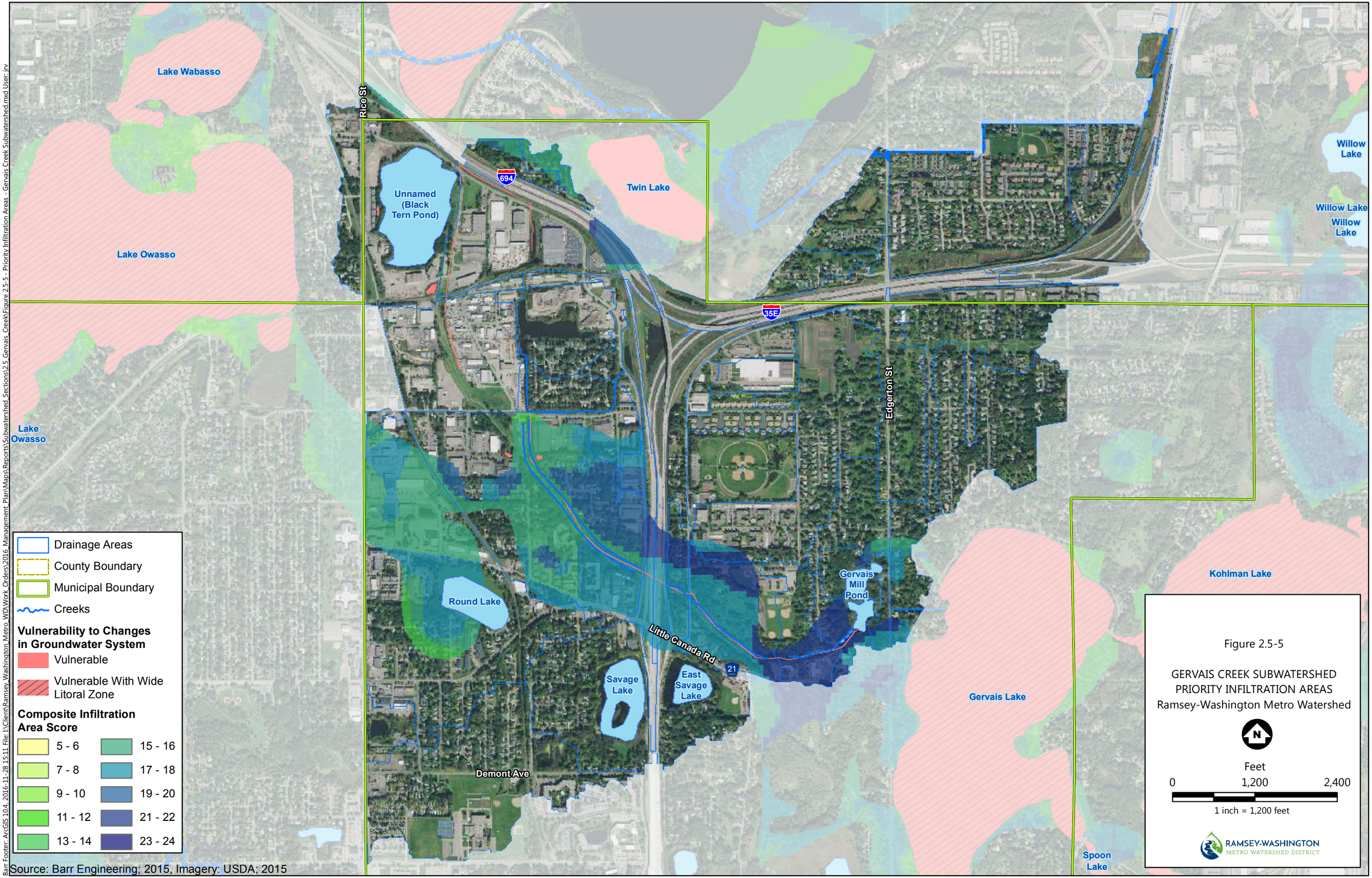
Figure 2.5-4

GERVAIS CREEK SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,200 2,400
1 inch = 1,200 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 11:01 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed Sections\2.5_Gervais_Creek\Figure 2.5-4 - Subwatersheds and Drainage Patterns -Gervais Creek Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4, 2016-11-28 15:11 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.5_Gervais_Creek\Figure 2.5-5 - Priority Infiltration Areas - Gervais Creek Subwatershed.mxd User: jrv

2.6 Gervais Lake Subwatershed

2.6.1 General Description

The subwatershed directly tributary to Gervais Lake includes 893 acres within the cities of Maplewood and Little Canada in Ramsey County (see Figure 2.6-1). Outflows from the upstream Gervais Creek subwatershed (see Section 2.5) and Kohlman Lake subwatershed (see Section 2.3) contribute an additional 2,039 acres and 7,495 acres to the total watershed area, respectively (see Figure 1-8). Thus, the total drainage area to Gervais Lake is 10,427 acres.

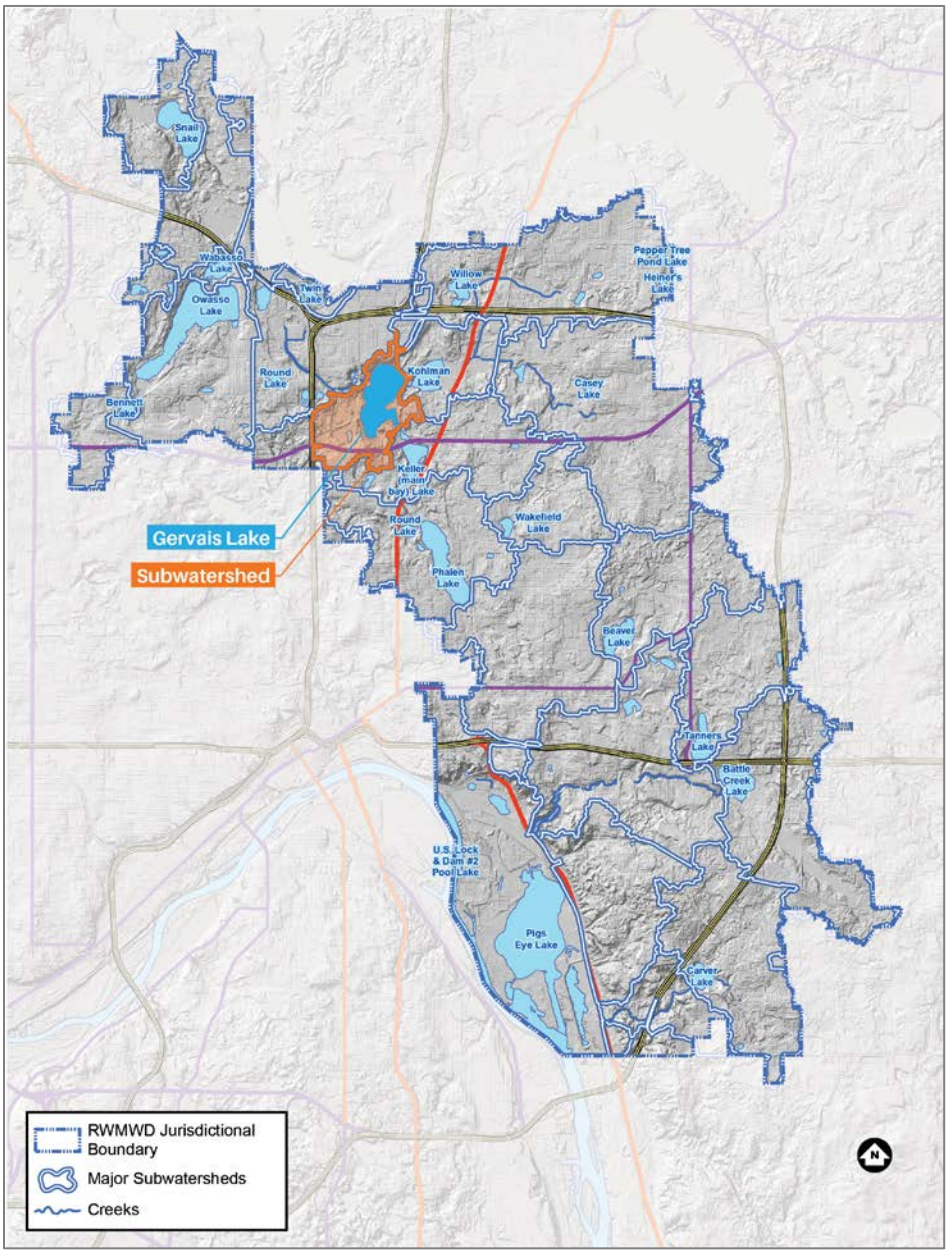


Figure 2.6-1 Gervais Lake Location Map

Gervais Lake is the only District-managed waterbody within the Gervais Lake subwatershed. Gervais Lake is located mostly in the city of Little Canada, with a very small portion located in the city of Maplewood. Gervais Lake is the largest lake in the Phalen Chain of Lakes with a surface area of 234 acres, a maximum depth of approximately 41 feet and a mean depth of approximately 22 feet. According to the MDNR Lake Finder website, the littoral area, defined as the portion of the lake that is less than 15 feet in depth, comprises approximately 91 acres or 39% of the lake. By MPCA definition, Gervais Lake is considered a deep lake. The lake is used primarily for recreational activities, such as swimming, skiing, and speed-boating. Other recreational uses include limited wildlife habitat. The lake has boating access (from the Spoon Lake boat access) and a Ramsey County Parks swimming beach.

Table 2.6-1 Gervais Lake Subwatershed Facts

Tributary Area (Direct)	893 acres
Tributary Area (Total)	10,427 acres
Downstream Watershed	Keller Lake
MDNR Designation[1]	62-0007P
Lake Surface Area[1]	234 acres
Lake Mean Depth[1]	22 ft
Lake Maximum Depth[1]	41 ft
Lake Outlet Type[1]	Stream channel under Arcade Street Bridge
Lake Outlet Elevation[1]	855.5 ft
100-Year Flood Level[1]	861.8 ft
Lake Littoral Area[1]	39%
MPCA Designations[1]	Deep Lake ; Impaired for Aquatic Consumption (mercury food consumption advisory), at risk of Aquatic Life impairment (chloride)
MS4s in the Direct Tributary Area	Little Canada, Maplewood, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Data for Gervais Lake

2.6.1.1 Past Studies

The following list is a summary of past studies related to Gervais Lake and the Gervais Lake subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan.* Prepared for RWMWD by Barr Engineering, November 1988.
- *Kohlman and Gervais Lake Diagnostic Study.* Prepared for RWMWD by Barr Engineering, 1994.
- *Addressing the Water Quality Benefits of Smaller Wet Detention Ponds.* Prepared for RWMWD by Barr Engineering, 1995.

- *Draft Phalen Chain of Lakes Strategic Lake Management Plan.* Prepared for RWMWD by Barr Engineering, October 2004.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas.* Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations.* Prepared for RWMWD by Barr Engineering, October 2005.
- *Draft Phalen Chain of Lakes Carp Population Study.* Prepared for RWMWD by Barr Engineering, November 2006.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.6.1.2 Land Use

The existing land use in this subwatershed is predominantly low-density residential, based on the Metropolitan Council's 2010 land uses dataset (see Figure 2.6-2). The subwatershed is fully developed and no change in land use is expected prior to 2030 (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

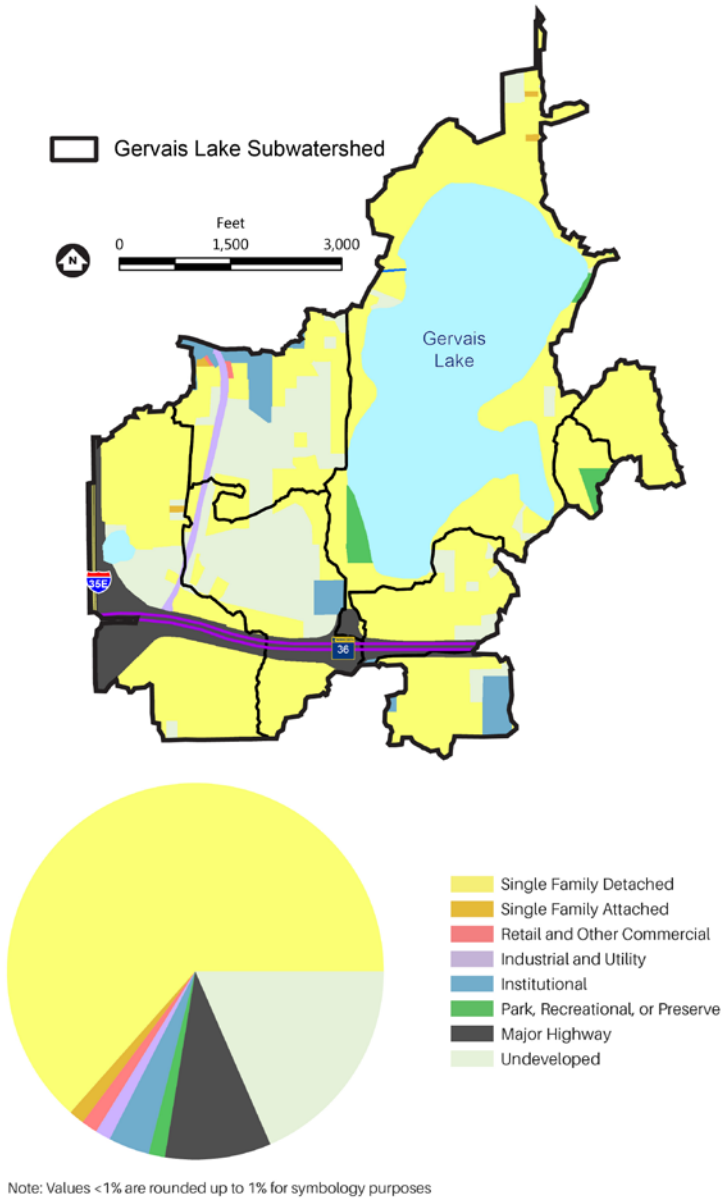


Figure 2.6-2 Breakdown of land uses throughout the Gervais Lake Subwatershed (2010 Metropolitan Council)

2.6.1.3 Drainage Patterns and Waterbodies

The Gervais Lake subwatershed receives incoming flows from the Gervais Creek subwatershed and Kohlman Lake subwatershed (see Figure 2.6-7). Flows from Gervais Creek (formerly County Ditch 16) are treated in Gervais Mill Pond, located just west of Edgewater Street (Ramsey CSAH 58) between Little Canada Road and Labore Road, prior to flowing into the Gervais Lake subwatershed. Inflow from Kohlman Lake enters Gervais Lake along the northeast shoreline. In addition to flows from upstream subwatersheds, Gervais Lake receives runoff from several storm sewer outfalls and culverts at various

locations along the lakeshore, and sheet flow runoff from the lake's immediate drainage area. The outlet from Gervais Lake (and the Gervais Lake subwatershed) is a channel that is connected to Spoon Lake, which subsequently drains to Keller Lake. The channel typically holds water at an elevation of 858 feet (the elevation of the control structure downstream of Keller Lake).

The Gervais Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.6-7). Figure 2.6-7 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Gervais Lake subwatershed include only Gervais Lake.

Wetlands within the Gervais Lake subwatershed are shown in Figure 2.6-7 according to the RWMWD wetland management classification (see Section 1.11.3).

2.6.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Gervais Lake.

2.6.2.1 Historical Water Quality

Gervais Lake is used primarily for recreational activities such as swimming, skiing, and speed-boating. Other recreational uses include limited wildlife habitat. As noted above, Gervais Lake receives flows from Gervais Creek, Kohlman Lake, storm sewer outfalls and culverts, and sheet flow runoff from the immediate drainage area.

According to the *Draft Phalen Chain of Lakes SLMP* (Barr, 2004), Gervais Lake is dimictic, meaning it generally mixes only twice a year – once in the spring and once in the fall. Although total phosphorus is sometimes released from the lake's sediments, this phosphorus generally remains near the lake bottom and is not mixed throughout the water column during summer months; thus it is not available to algae in the surface waters.

The Ramsey County Department of Public Works staff samples the water quality of Gervais Lake about 7 times per year on average, between the months of May and September. Figure 2.6-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.6-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Gervais Lake relative to MPCA standards. The RWMWD has assigned a water quality classification of "Stable" to Gervais Lake based on recent water quality data (see Section 1.10.3).

Table 2.6-2 Gervais Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Gervais Lake (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	27.7
Chlorophyll-a (µg/L)	≤ 14	9.6
Secchi disk transparency (m)	≥ 1.4	2.3

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Gervais Lake water quality data. The results of these analyses are shown in Table 2.6-3.

Table 2.6-3 Trend Analysis Results for Gervais Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Gervais Lake	1981 – 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

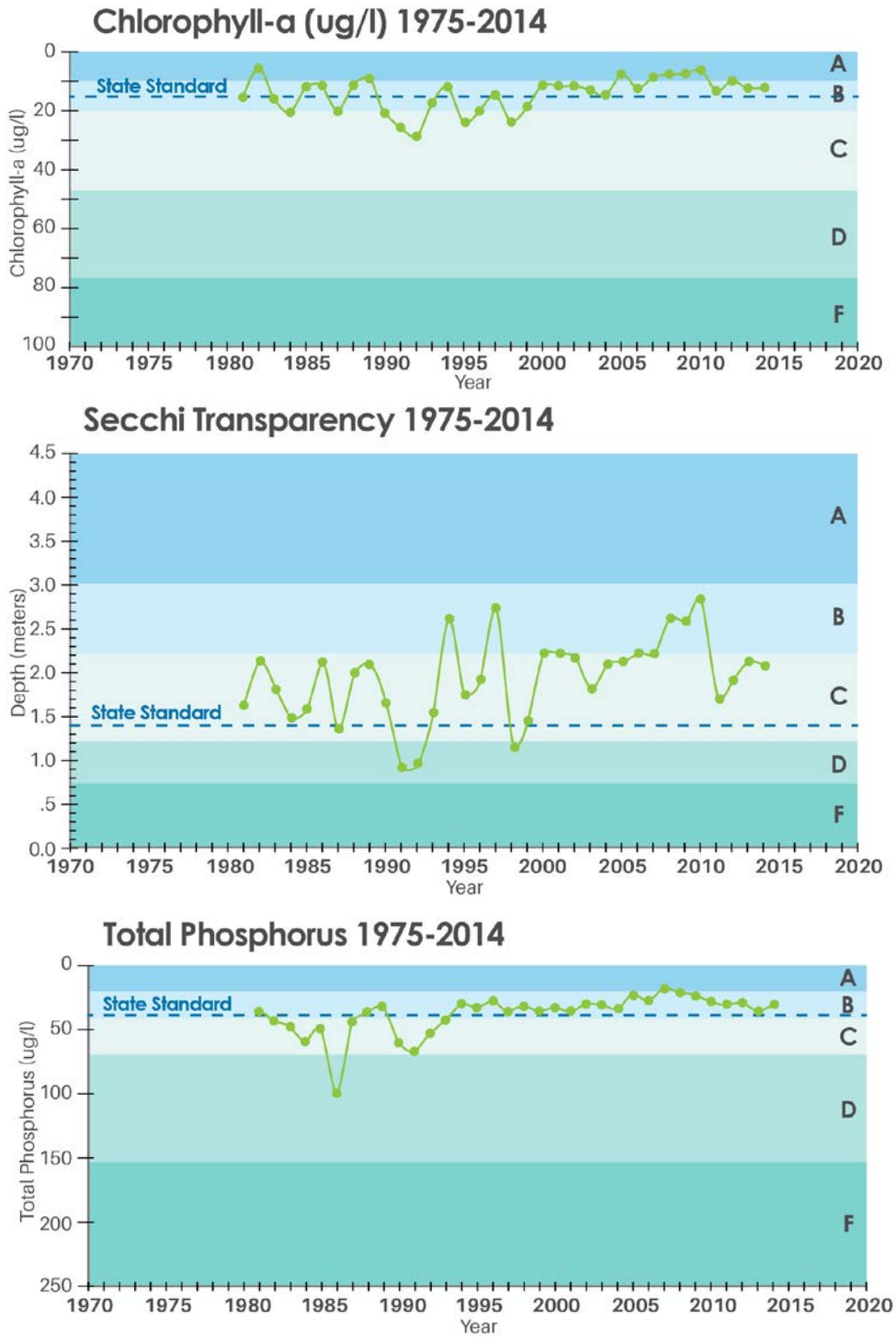


Figure 2.6-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Gervais Lake (1975-2014)

2.6.2.2 State of the Fishery

In 1992, the MDNR classified Gervais Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Gervais Lake is a Class 24 lake, which signifies a good permanent fishery lake (Schupp, 1992).

The MDNR actively manages the fishery in Gervais Lake for walleye (since 1994) and tiger muskellunge (since 1984), stocking walleye in even-numbered years and tiger muskellunge in odd-numbered years. In addition to its stocking activities, the MDNR periodically assesses the Gervais Lake fish population. The last MDNR survey was performed in 2011. According to the assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is comprised of panfish species, gamefish species, rough fish species, and other fish species.

Among gamefish, walleye were sampled below the median level for abundance and mean weight in the 2011 gill net catch. While the gill net catch rate for walleye was down from that observed in 2009, it has remained within the normal interquartile range for abundance since 1995. The average size of walleye sampled in 2011 was 12.7 inches and 0.8 pounds. About 10% of all walleye captured in 2011 measured 15.0 inches or longer. The average size of tiger muskellunge captured in 2011 was 35.7 inches and 11.5 pounds and growth rates were found to be average. Northern pike were captured above the median level for abundance and mean weight. The gill net catch rate for northern pike was the highest recorded for this lake since 1980. The average size of northern pike captured was 25.55 inches and 4.21 pounds. Largemouth Bass also appear to have a significant presence in Gervais Lake as they were sampled above the median level for abundance in both gill and trap nets.

Bluegills were the most abundant fish captured in the survey, making up approximately 80% of the fish caught during the survey catch. Nearly all the bluegills caught were between 6 and 8 inches long, with an average length of 6.7 inches and weight of 0.24 lbs. Yellow Perch were sampled above the third quartile level for abundance in gill nets with catch rates being up from those observed in 2005. Other species identified in the 2011 survey include black bullhead, black crappie, common carp, golden shiner, hybrid sunfish, pumpkinseed, white sucker, and yellow bullhead.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Gervais Lake based on the presence of mercury and perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

During an evaluation of the Phalen Chain of Lake's carp population in 2006 by the University of Minnesota's Sorensen Lab, carp were present in Gervais Lake. Common carp are an invasive species that can negatively impact lake water quality (see Section 1.10.7).

2.6.2.3 State of the Macrophyte Community

On August 26, 2013, District staff conducted a macrophyte survey of Gervais Lake. The results of this survey are summarized below in Figure 2.6-4. In total, 107 sites were surveyed for macrophytes. Of these, 82 had vegetation, indicating that Gervais Lake has some areas of open water outside of its littoral zone.

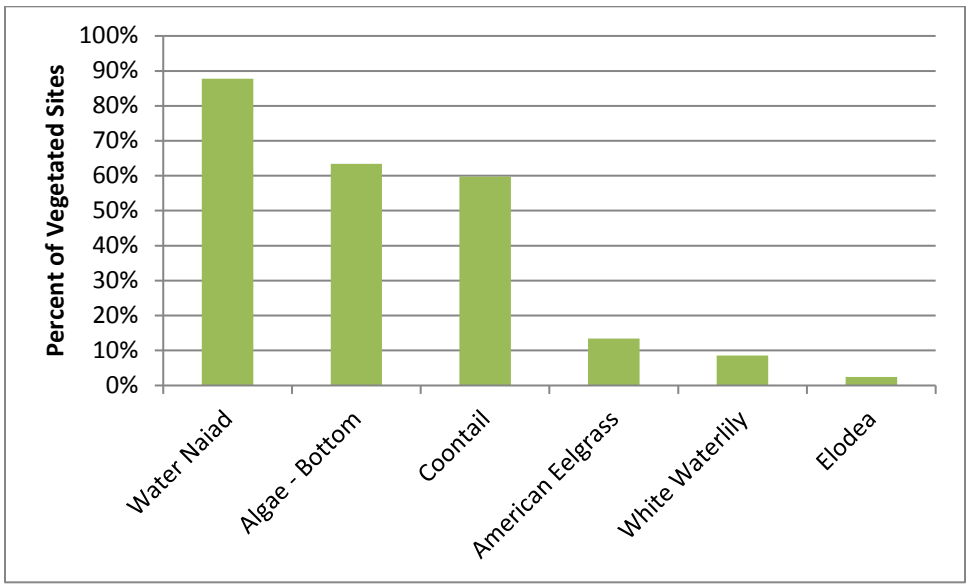


Figure 2.6-4 August, 2013 Gervais Lake Macrophyte Survey Results

Where white waterlily and Water Naiad were found in the lake, they were present in high abundance relative to other macrophyte species in Gervais Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Although curlyleaf pondweed was not detected in the late summer survey, it is known to be present in the lake. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.6.2.4 Water Quality Modeling

The District performed water quality modeling of the Gervais Lake subwatershed as part of developing the *Phalen Chain of Lakes Strategic Lake Management Plan* (SLMP) in 2004. The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future best management practices (BMPs). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the entire Gervais Lake subwatershed, including upstream watersheds tributary to Gervais Lake. Model results were calculated for a range of climatic conditions to evaluate the variability of runoff and phosphorus loading under different hydrologic conditions.

The model results were used to estimate the amount of phosphorus reaching Gervais Lake from various drainage districts. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.6-5 shows the main drainage districts contributing flow and phosphorus loading to Gervais Lake.

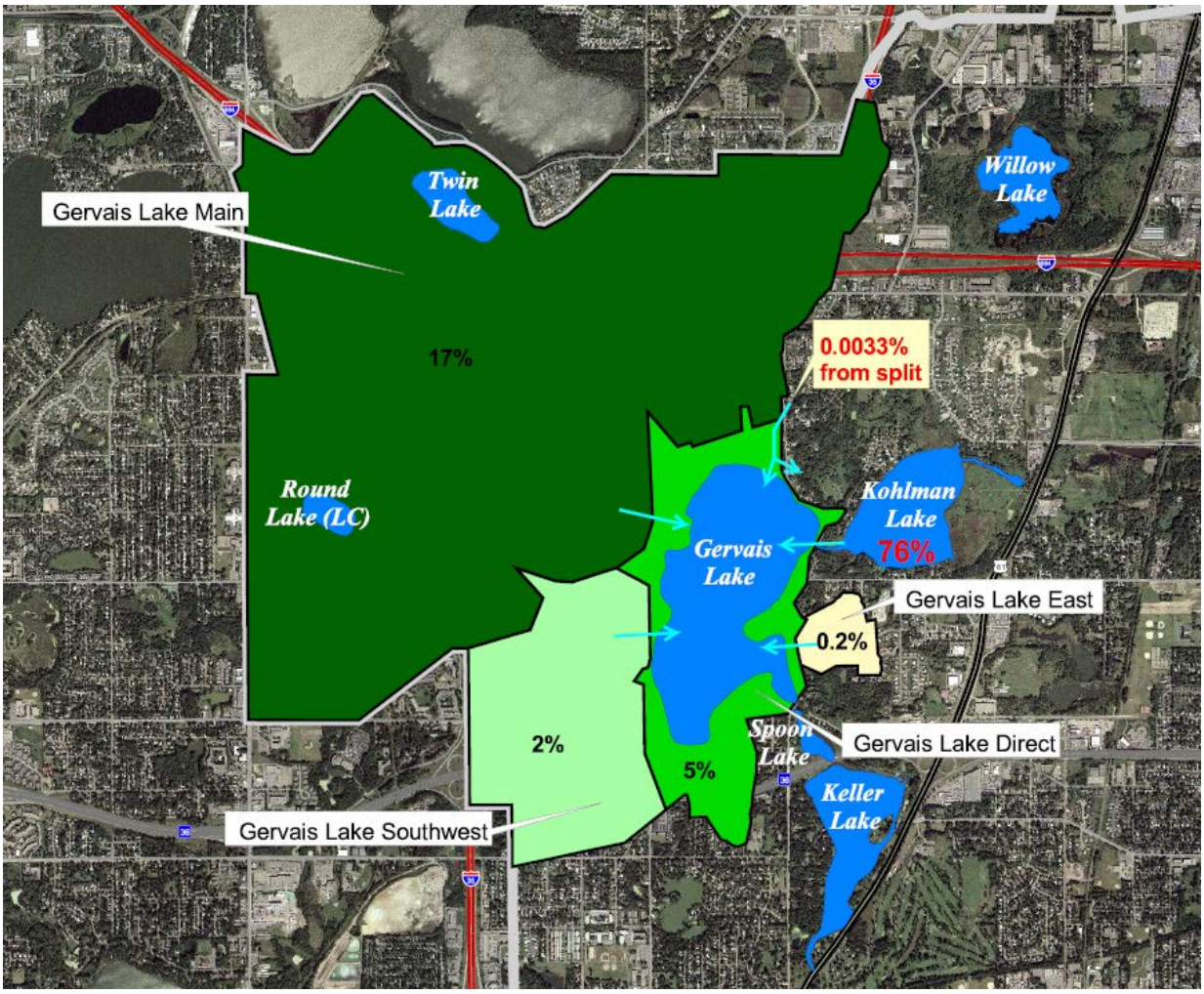


Figure 2.6-5 Drainage districts in the Gervais Lake subwatershed and upstream tributary watersheds

The area tributary to Kohlman Lake (Kohlman Lake Drainage District) is not depicted on Figure 2.6-5, although it makes up a large portion of the larger Gervais Lake tributary area. These main drainage districts to Gervais Lake are summarized below:

- **Gervais Creek Subwatershed Drainage District** – This 2063-acre drainage district northwest of the lake represents approximately 20% of the total area tributary to Gervais Lake, and includes the Gervais Creek and Twin Lake subwatersheds. Runoff from this drainage district flows through a series of ponds, wetlands, and/or storm sewers before reaching Gervais Lake.

- **Gervais Lake East Drainage District** – This 42-acre drainage district east of the lake represents a very small portion (less than 1%) of the area tributary to Gervais Lake. Runoff from this drainage district flows to a single detention pond before reaching Gervais Lake.

- **Gervais Lake Southwest Drainage District**—This 370-acre drainage district south and southwest of the lake represents about 4% of the area tributary to Gervais Lake. Runoff from this drainage district flows through a series of ponds, wetlands and/or storm sewers before reaching Gervais Lake.

- **Gervais Lake Direct Drainage District**—This 467-acre drainage district consists of the area that drains directly to Gervais Lake without passing through a detention pond. This area represents approximately 4% of the total area tributary to Gervais Lake.

- **Kohlman Lake Drainage District** – This 7,534-acre drainage district consists of the Willow Creek, Kohlman Creek and Kohlman Lake subwatersheds, and represents approximately 72% of the total area tributary to Gervais Lake. Flows from this district enter Lake Gervais via a channel from Kohlman Lake.

An in-lake mass balance water quality model was also completed as a part of the SLMP to assess the impact of watershed loading and internal phosphorus loading on the water quality of Gervais Lake. The in-lake model used the stormwater runoff volumes and areal total phosphorus loading rates estimated by the P8 model, in conjunction with lake-specific parameters such as average lake depth, lake volume, and flushing rate, to calculate daily in-lake total phosphorus concentrations. The in-lake model was calibrated using lake-specific water quality data collected throughout the summer of 2002.

Through analysis of the data and calibration of the in-lake model, it was determined that Gervais Lake rarely destratifies during the summer months. Therefore, internal phosphorus loading was assumed negligible during the summer months.

After development and calibration of the P8 models and in-lake water quality models, they were used as a predictive tool to evaluate the impact of various water quality improvement projects on the water quality of Gervais Lake and the other lakes within the Phalen Chain of Lakes Watershed.

2.6.2.5 Water Quality Goals

The water quality goals for Gervais Lake are consistent with the MPCA's deep lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.6-2. The RWMWD will continue to evaluate Gervais Lake water quality data for trends and adjust its water quality classification and management activities accordingly. Projects implemented in the Gervais Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.6-6.

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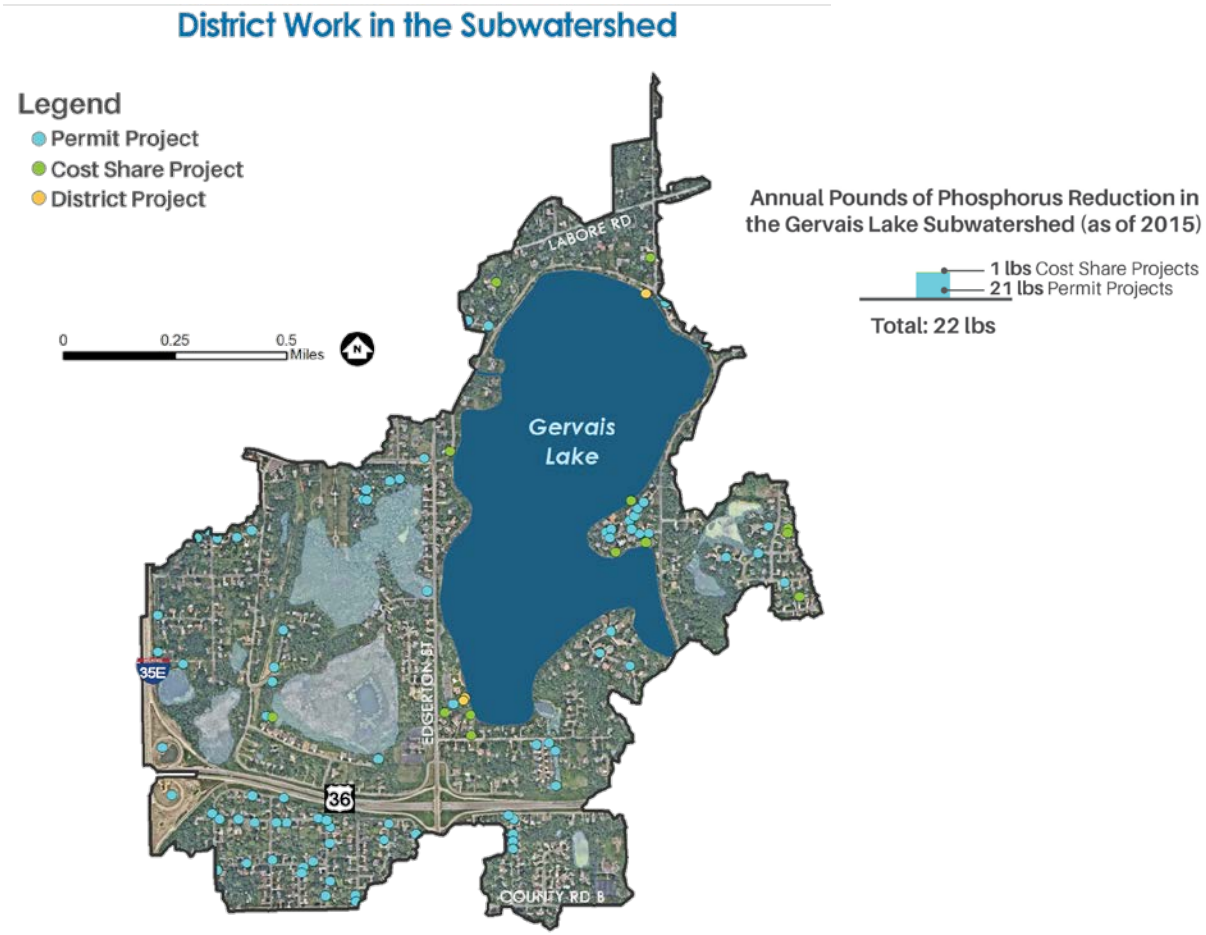


Figure 2.6-6 District work in the Gervais Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.6.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District has implemented capital improvement projects in the subwatershed with flood control benefits, including the Gervais Beach Treatment Pond/County Road B2 Drainage Project, completed in 2001. The project was designed to address two drainage issues on the south side of Lake Gervais: 1) a storm sewer at the southwest corner of Lake Gervais was causing sedimentation, and 2) storm sewers and ditches adjacent to a low point along County Road B2 were not conveying water to the lake, resulting in standing water and localized flooding problems for several homeowners.

To address the first issue, the District worked with the Lake Homeowners Association to develop a plan to divert the storm sewer flows into a new pond on the county beach/park property. The pond was designed to treat the stormwater and provide a new wetland area adjacent to the lake. Lake association members

also expressed concern about high water (flood) levels, the bigger "bounce" on the lake, and the extended duration of high water levels on the lake.

The District addressed the second issue in coordination with a Ramsey County road resurfacing project on the county road. Attempts to alleviate the County Road B2 drainage issue with small modifications over the previous decade proved unsuccessful. Therefore, the RWMWD and Ramsey County completed a comprehensive analysis of the area's drainage and designed a long-term solution to the problems. New catch basins, pipes and ditches were constructed to more efficiently route stormwater and avoid inappropriate low points in the system. After development of the plan, the City, County and District entered into an agreement to share in the costs of the project elements.

Although the District has completed a number of projects to reduce the risk of flooding, there remain some low structures in the Gervais Lake subwatershed that were constructed before the formation of the District that remain at risk. The District has been working with the cities of Maplewood and Little Canada to prepare emergency response plans to protect these homes if needed. An important part of the emergency response plan is an early warning system that alerts emergency response teams to begin sandbagging operations. To provide this early warning, the District installed an automatic lake level monitoring station at Gervais Lake to allow the cities and the District to remotely monitor lake levels. Several of these stations throughout the District were modified in 2010 to provide a call-out feature to automatically warn cities when the lake reaches a critical water level.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Gervais Lake subwatershed are the new 100-year flood elevations shown in Figure 2.6-7. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.6.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Gervais Lake subwatershed are shown Figure 2.6-8, indicating areas where the water levels of waterbodies in the Gervais Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.6.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD is involved in numerous habitat management areas in throughout the District. One of these sites is associated with the Gervais Beach Stormwater Project (see Section 2.6.3), which involved construction of a new pond on Ramsey County's Gervais Beach Park property. The pond is immediately north and east of a parking lot and playground, so it is highly visible. However, recreational use is limited due to the small amount of upland. Increased wildlife habitat has been provided by planting shrubs and other native vegetation, and by the shallow, still water of the pond. The site is now providing habitat to butterflies, frogs, turtles, and various species of waterfowl and songbirds.

From 1998-2000, the RWMWD partnered with the Gervais Lake Association and the University of Minnesota's Department of Entomology on the Gervais Lake Shoreland Restoration Project. Three turf grass sites along the northeast shore of Gervais Lake were converted to sustainable landscapes and stable, natural shoreland, demonstrating the effectiveness of native plants in controlling shoreline erosion. The Gervais Lake Shoreland Restoration Project was one of the first of its kind in the Twin Cities metropolitan area. The Gervais Lake sites were used by the MDNR and other agencies to promote the ecological shore restoration concept. The RWMWD strives to maintain its strong partnership with the MDNR and other agencies to promote and develop new shoreland restoration technologies.

The District will continue to work with Gervais Lake Association members and other residents regarding issues related to achieving healthy ecosystems. Gervais Lake Association members have expressed concerns about the methods used to control shoreline erosion and the overabundance of aquatic plants in the lake. The lake association has contracted with a company to treat the lake for Eurasian watermilfoil. The District will continue to work with the Gervais Lake Association to promote BMPs, including proper shore management, to their members and others in this subwatershed. The RWMWD also promotes its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas.

The RWMWD will continue to seek opportunities to integrate natural resource benefits into its activities within the Gervais Lake subwatershed.

2.6.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Gervais Lake subwatershed (see Table 2.6-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Gervais Lake subwatershed (e.g., implementation of the RWMWD permit program). Both

tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.6-4 Gervais Lake Subwatershed Implementation Activities

Activity ID No.	Gervais Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
GL-1	Implement the Gervais Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**WQ19, FL5, FL9**	**Tier 2**
GL-2	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Gervais Lake.	**2017-2026**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
GL-3	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
GERV-01	879.01
GERV-02	867.69
GERV-03	864.65
GERV-04	861.81
GERV-05a	861.81
GERV-05b	881.4
GERV-06a	873.36
GERV-06b	868.23

Round Lake
Savage Lake
East Savage Lake
Gervais Mill Pond Lake
Keller Pkwy
22
Arcade St
Gervais Lake
GERV-04
Kohlman Lake
Forest St
58
GERV-03
Mc Menemy St
Edgerton St
GERV-06a
GERV-06b
GERV-02
GERV-05a
Spoon Lake
36
GERV-01
Keller (main bay) Lake
GERV-05b

- Drainage Area Flow
- Subwatershed Outflow
- Major Subwatersheds
- Drainage Areas
- County Boundary
- Municipal Boundary

Wetland Management Classifications

- Manage A
- Manage B
- Manage C
- Water Quality Pond
- Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.6-7

GERVAIS LAKE SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,000 2,000
1 inch = 1,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 11:01 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.6_Gervais_Lake\Figure 2.6-7 - Subwatersheds and Drainage Patterns - Gervais Lake Subwatershed.mxd User: jrv

South Owasso Blvd

Edgerton St

Gervais Mill Pond

Round Lake

Gervais Lake

Kohlman Lake

Savage Lake

East Savage Lake

Demont Ave

Spoon Lake

Keller (Main Bay) Lake

Drainage Areas

County Boundary

Municipal Boundary

Creeks

Vulnerability to Changes in Groundwater System

Vulnerable

Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.6-8

GERVAIS LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

N

Feet

0 1,000 2,000

1 inch = 1,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-29 11:20 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.6_Gervais_Lake\Figure 2.6-8 Priority Infiltration Areas - Gervais Lake Subwatershed.mxd User: jrv

2.7 Keller Lake Subwatershed

2.7.1 General Description

The subwatershed directly tributary to Keller Lake includes 1,577 acres in the cities of Little Canada and Maplewood within Ramsey County. Keller Lake is within the Phalen Chain of Lakes (between Gervais Lake and Lake Phalen). The total drainage area upstream of Keller Lake is 12,004 acres, and drains additional portions of the cities of Gem Lake, North St. Paul, Oakdale, Vadnais Heights, and White Bear Lake (see Figure 2.7-1).

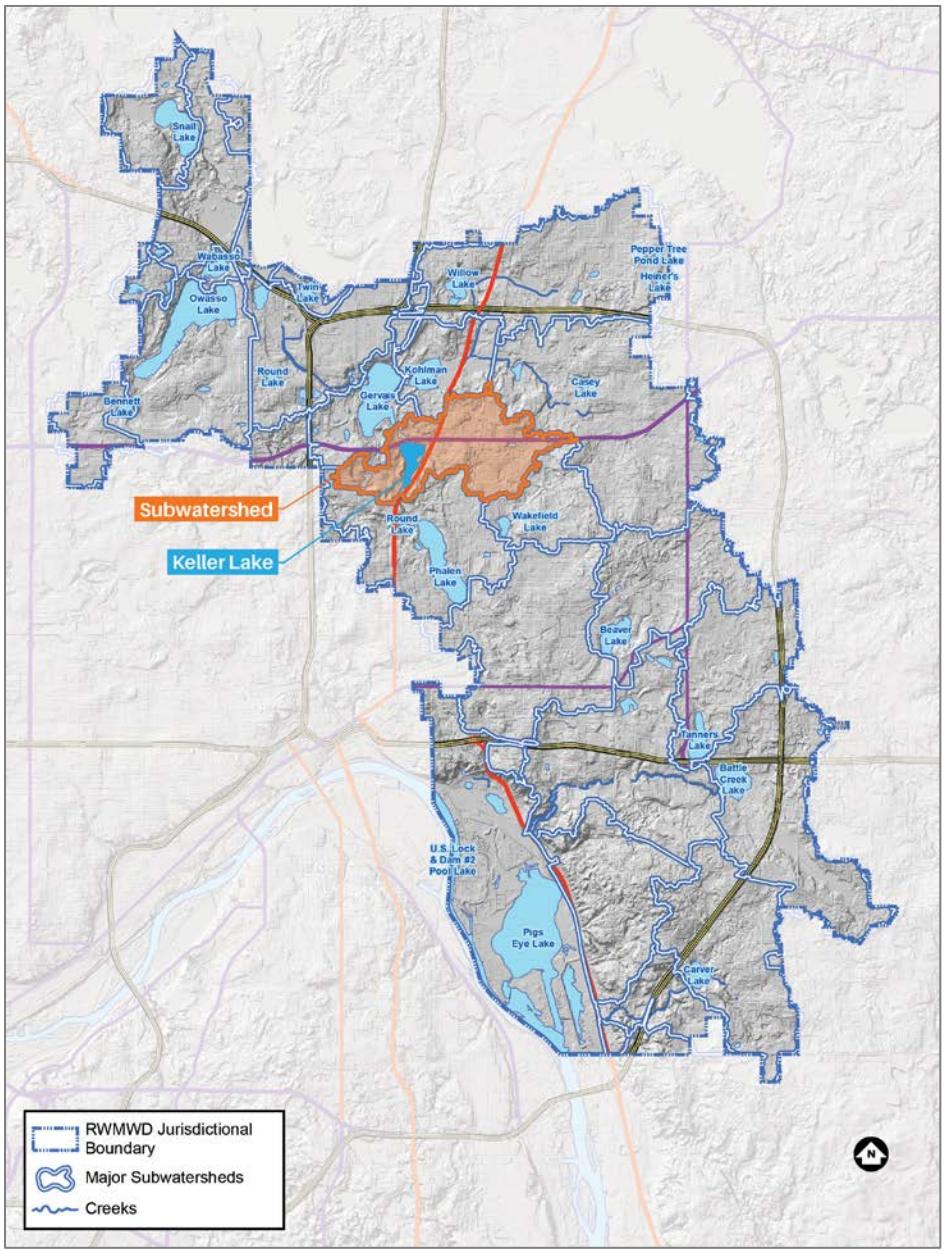


Figure 2.7-1 Keller Lake Location Map

Keller Lake is the only District-managed waterbody within the subwatershed. Spoon Lake is a wetland that connects Gervais Lake and Keller Lake. Although Spoon Lake is often considered a lake by local residents, the wetland is not classified as lacustrine under the Cowardin system, and therefore is not classified as a District-managed lake (see Section 1.9.1).

Keller Lake has a surface area of 72 acres, a maximum depth of about 8 feet, and a mean depth of 4 feet. Most of the lake is less than 6-feet deep with the littoral area covering the entire lake surface. The MPCA classifies Keller Lake as a shallow lake (maximum depth of less than 15 feet and/or at least 80% of the lake less than 15-feet deep). Keller Lake is a fishing lake used primarily for motor boating, canoeing, fishing, picnicking, and viewing. Keller Lake provides limited wildlife habitat. Parks are located around Spoon Lake (wetland located immediately upstream of Keller Lake) and along the east shoreline of Keller Lake.

Table 2.7-1 Keller Lake Subwatershed Facts

Tributary Area (Direct)	1,577 acres
Tributary Area (Total)	12,004 acres
Downstream Watershed	Lake Phalen
MDNR Designation[1]	62-0010P
Lake Surface Area[1]	72 acres
Lake Mean Depth[1]	4 ft
Lake Maximum Depth[1]	8 ft
Lake Outlet Type[1]	48 ft weir under pedestrian bridge
Lake Outlet Elevation[1]	858.0 ft
100-Year Flood Level[1]	861.8 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake ; At risk of Aquatic Life impairment (chloride)
MS4s in the Direct Tributary Area	Little Canada, Maplewood, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Data for Keller Lake

2.7.1.1 Past Studies

The following list is a summary of past studies related to Keller Lake and the Keller Lake subwatershed.

- *Phalen Chain of Lakes Surface Water Management Plan.* Prepared for RWMWD by Barr Engineering, November 1988.
- *Phalen Outlet Hydraulic Study.* Prepared for RWMWD by Barr Engineering, February 1990.

- *Draft Phalen Chain of Lakes Strategic Lake Management Plan.* Prepared for RWMWD by Barr Engineering, October 2004.
- *Draft Kohlman and Keller Lakes Total Maximum Daily Load Report.* Prepared for RWMWD by Barr Engineering, July 2005.
- *Internal Phosphorus Load Study: Kohlman and Keller Lakes.* Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas.* Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations.* Prepared for RWMWD by Barr Engineering, October 2005.
- *Highway 36 and 61 Intersection Enhanced Sand Filtration and Menards' Parking Lot Pervious Pavement, Feasibility Report.* Prepared for RWMWD by Barr Engineering, October 2006.
- *Draft Phalen Chain of Lakes Carp Population Study.* Prepared for RWMWD by Barr Engineering, November 2006.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.7.1.2 Land Use

The direct Keller Lake subwatershed is nearly fully developed (see Figure 2.7-2). The area west of Keller Lake is predominantly low-density residential land use, with some higher density residential and institutional land uses. Low-density residential land use constitutes a significant portion of the area east of Keller Lake. Commercial and industrial/utility land use exists primarily along Highway 36 and Highway 61. The northern part of the Keller Golf Course is in the Keller Lake subwatershed (southeast of Keller Lake). The east shoreline of Keller Lake and the entire shoreline of Spoon Lake have been developed as park land. Significant land use changes are not expected in the Keller Lake subwatershed based on the Metropolitan Council's 2030 estimated land use data (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

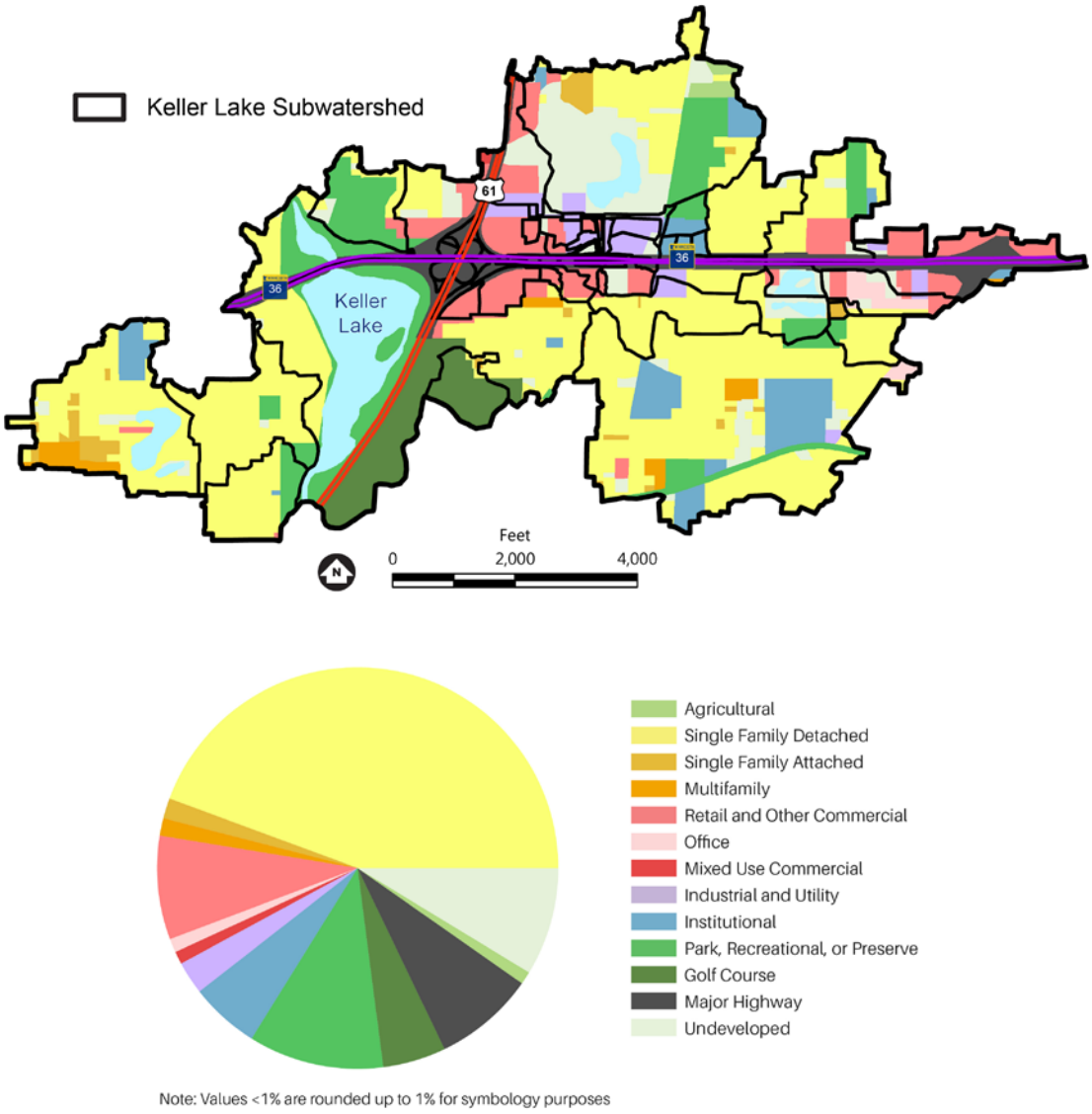


Figure 2.7-2 Breakdown of land uses throughout the Keller Lake Subwatershed (2010 Metropolitan Council)

2.7.1.3 Drainage Patterns

The Keller Lake subwatershed receives incoming flows from the Gervais Lake subwatershed. Discharge from Gervais Lake flows through Spoon Lake and then to Keller Lake. In addition to flows from Gervais Lake, Keller Lake receives runoff from several storm sewer outfalls and culverts at various locations along the lakeshore. Much of the runoff from the direct subwatershed drains towards the intersection of Highway 36 and Highway 61 before discharging to the northeast side of Keller Lake (see Figure 2.7-7). Keller Lake also receives sheet flow runoff from the lake's immediate drainage area.

The outlet from Keller Lake (and the Keller Lake subwatershed) is a channel that is connected to Lake Phalen. The channel typically holds water at an elevation of 858 feet (the elevation of the control structure downstream of Keller Lake). During high-water conditions, the control structure downstream of Keller

Lake may govern water levels in Gervais Lake and Kohlman Lake (i.e., the entire system becomes tail water-controlled).

The Keller Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.7-7). Figure 2.7-7 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Keller Lake subwatershed include only Keller Lake.

Wetlands within the Keller Lake subwatershed are shown in Figure 2.7-7 according to the RWMWD wetland management classification (see Section 1.11.3).

2.7.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Keller Lake.

2.7.2.1 Historical Water Quality

Keller Lake is used primarily for fishing, motor boating, canoeing, picnicking, and viewing. Other recreational uses include limited wildlife habitat. Keller Lake receives flows from Gervais Lake, as well as runoff entering the lake from storm sewer outfalls and culverts at various locations along the shoreline, and sheet flow runoff from the immediate drainage area.

Keller Lake is polymictic (i.e., it mixes multiple times throughout the year). The lake stratifies only for short periods throughout the growing season, followed by destratification that mixes the water column. At times, this mixing can bring phosphorus that is released from the lake sediment higher into the water column, making more phosphorus available to algae. Another internal source of phosphorus to Keller Lake is curlyleaf pondweed. This macrophyte proliferates in the early-summer and dies off in mid-summer, releasing substantial amounts of phosphorus into the water column.

The Ramsey County Department of Public Works staff samples the water quality of Keller Lake about 7 times per year on average, between the months of May and September. Figure 2.7-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Keller Lake was listed on the MPCA 303(d) Impaired Waters List in 2002 with a use of aquatic recreation impaired due to excessive nutrients, specifically phosphorus (see Section 1.10.2). However, more recent water quality indicates Keller Lake is meeting applicable standards, and Keller Lake was removed from the impaired waters list ("de-listed") in 2012.

Table 2.7-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Keller Lake relative to MPCA standards. The RWMWD has assigned a water quality classification of "Stable" to Keller Lake based on recent water quality data (see Section 1.10.3).

Table 2.7-2 Keller Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Keller Lake (2001-2010) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	51
Chlorophyll-a (µg/L)	≤ 20	21.2
Secchi disk transparency (m)	≥ 1.0	1.2

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Keller Lake water quality data. The results of these analyses are shown in Table 2.7-3.

Table 2.7-3 Trend Analysis Results for Keller Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Keller Lake	1981 – 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	Improving
		Chlorophyll-*a*	Improving	Improving*

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

Following the initial listing of Keller Lake on the MPCA's Impaired Waters 303(d) List in 2002, the District began preparing a TMDL study for Keller Lake, using the Phalen Chain of Lakes SLMP (2004) as a basis. The District also performed more detailed water quality monitoring of Keller Lake, collecting data at various lake depths throughout the growing season. The increase of phosphorus concentrations observed during the temporarily stratified conditions in late August and early September, 2002 indicate the presence of internal sediment loading in Keller Lake. To better quantify the internal phosphorus source(s) and loading rates, the RWMWD completed an additional study. Through the *Internal Phosphorus Load Study: Kohlman and Keller Lakes* (Barr, 2005), it was found that the loading rate of phosphorus from Keller Lake's sediments was relatively low, indicating that the internal phosphorus loading in Keller Lake was likely due to the die-off of curlyleaf pondweed (see Section 2.7.2.3).

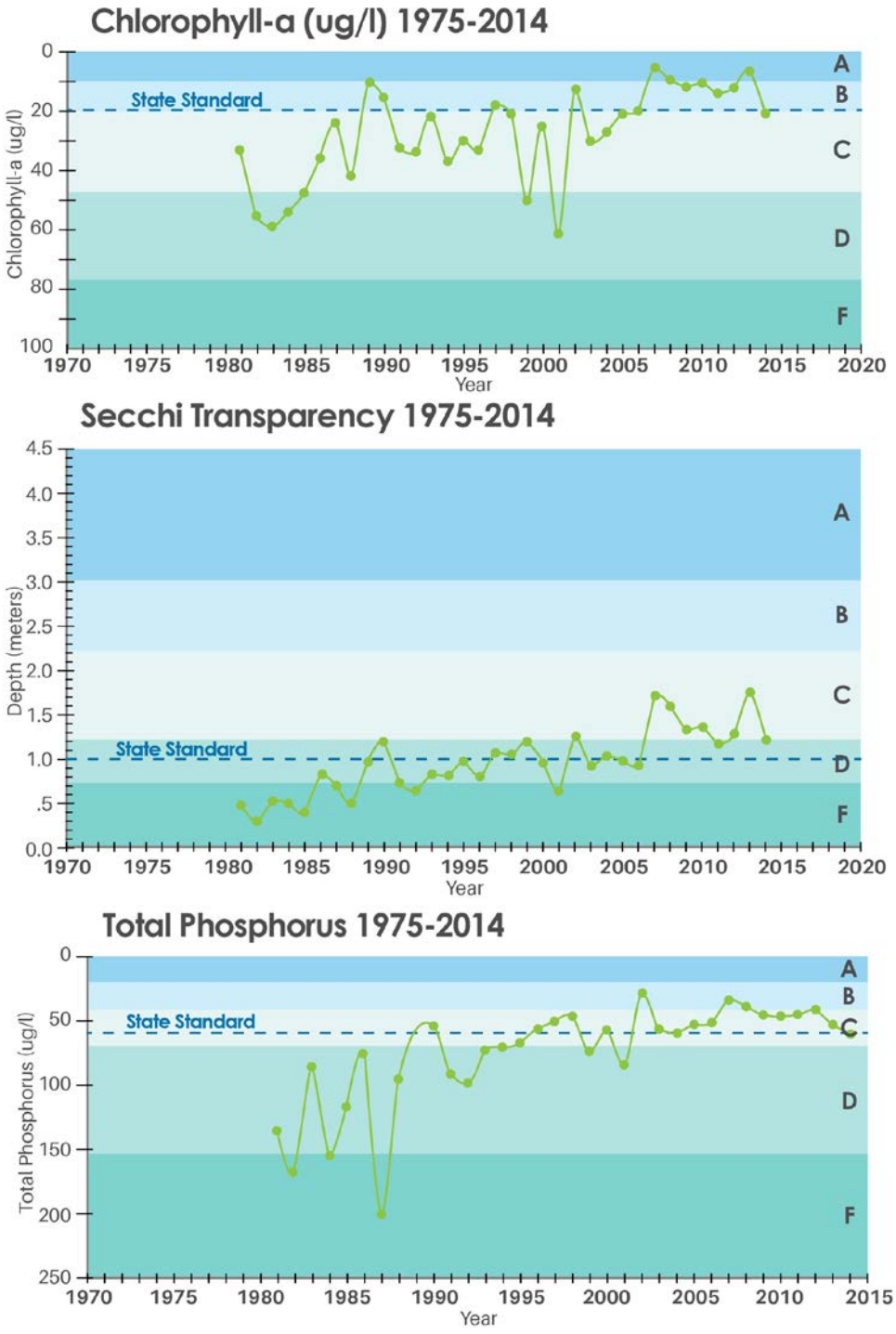


Figure 2.7-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Keller Lake (1975-2014)

2.7.2.2 State of the Fishery

In 1992, the MDNR classified Keller Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Keller Lake is a Class 40 lake, which signifies a small, shallow lake that is subject to occasional winterkill (Schupp, 1992).

The Keller Lake fish population was last assessed by the DNR on July 9, 2001. According to the assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is comprised of panfish species, gamefish species, rough fish species, and other fish species. Based on the survey, the fish population in Keller Lake is dominated by bluegills, which make up over 90% of the trapnet catch. Black crappies were more numerous in the 2001 survey compared with previous surveys, but were still small, with an average length of 6.2 inches. The yellow perch populations were average and were small. Black and yellow bullheads were present in low numbers, but were large in size. A few walleyes were sampled during the survey. Although walleye are not stocked in this lake, they can travel downstream from Gervais Lake or upstream from Lake Phalen. The quantity of largemouth bass sampled dropped since the previous survey, but the average size had increased.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Keller Lake based on the presence of perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

During an evaluation of the Phalen Chain of Lake's carp population in 2006 by the University of Minnesota's Sorensen Lab, carp were present in Keller Lake. Common carp are an invasive species that can negatively impact lake water quality (see Section 1.10.7).

2.7.2.3 State of the Macrophyte Community

The District performed a macrophyte survey of Keller Lake in 2005. During the June 2005 survey, five submersed plant species were identified. Curlyleaf pondweed, an invasive, non-native was the most abundant plant species found, covering 82.6% of lake's littoral zone. Eurasian watermilfoil, which is also an invasive, non-native macrophyte, dominated 30.4% of the water body's littoral zone (since aquatic plants often overlap each other it is possible to obtain an overall areal coverage greater than 100%). The abundance of both of these macrophytes impairs many of lake's functions and values. Only one floating leaf species, white water lily, was encountered during the survey and covered approximately 4.3% of the lake's littoral zone.

In 2005, five species within the lake's vegetated open-water area had individual percent coverages greater than 10%. However, Eurasian watermilfoil and curlyleaf pondweed cover comprised greater than 50% of the aquatic bed community.

2.7.2.4 Water Quality Modeling

The District performed water quality modeling of the Keller Lake subwatershed as part of developing the *Phalen Chain of Lakes Strategic Lake Management Plan* (SLMP) in 2004. The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future

best management practices (BMPs). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the entire Keller Lake subwatershed, including upstream watersheds tributary to Keller Lake. An in-lake mass balance model was used to assess the impact of watershed loading on the lake and determine the amount of internal phosphorus loading in Keller Lake. Model results were calculated for a range of climatic conditions to evaluate the variability of runoff and phosphorus loading under different hydrologic conditions.

The model results were used to estimate the amount of phosphorus reaching Keller Lake from various drainage districts. The Keller Lake watershed can be described in terms of four different "drainage districts." A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.7-4 shows the main drainage districts contributing flow and phosphorus loading to Keller Lake.

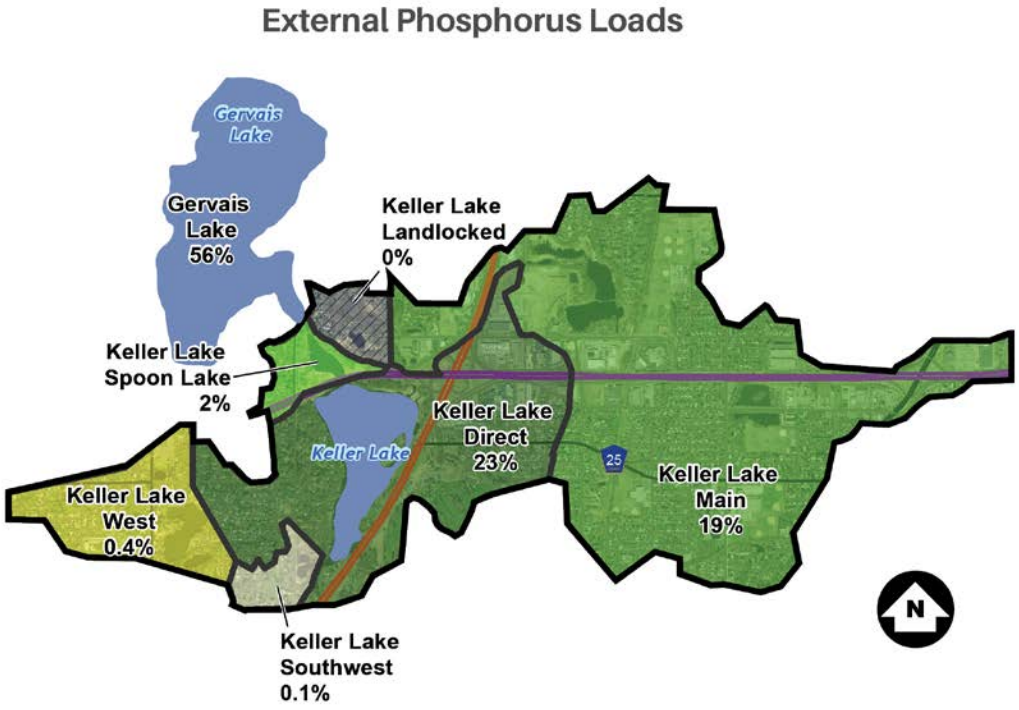


Figure 2.7-4 Drainage districts in the Keller Lake subwatershed and upstream tributary watersheds

These main drainage districts to Keller Lake are summarized below:

- **Keller Lake Main Drainage District—**This 803-acre drainage district east and northeast of the lake represents approximately 7% of the area tributary to Keller Lake. Runoff from this drainage district flows through a series of ponds, wetlands and/or storm sewers before reaching Keller Lake.

- **Keller Lake Spoon Lake Drainage District—**This 44-acre drainage district north of the lake includes the surface area of Spoon Lake, and represents a small portion (less than 1%) of the total area tributary to Keller Lake. Runoff from this drainage district flows through Spoon Lake before reaching Keller Lake.

- **Keller Lake West Drainage District**—This 140-acre drainage district west of the lake represents a small portion (1%) of the area tributary to Keller Lake. Runoff from this drainage district flows through a series of detention ponds, and/or storm sewers before reaching Keller Lake.

- **Keller Lake Southwest Drainage District**—This 39-acre drainage district southwest of the lake represents a small portion (less than 1%) of the area tributary to Keller Lake. Runoff from this drainage district flows to a single pond located less than 50 feet from the lake. This pond does not have an outlet, so runoff from this drainage district reaches the lake only when the pond overflows.

- **Keller Lake Direct Drainage District**—This 442-acre drainage district, representing nearly 4% of total area tributary to Keller Lake, consists of the area that drains directly to Keller Lake without passing through a detention pond.

- **Gervais Lake Drainage District** – This 10,427-acre drainage district includes the Willow Creek subwatershed, Kohlman Creek subwatershed, Kohlman Lake subwatershed, Twin Lake subwatershed, Gervais Creek subwatershed, and the Gervais Lake subwatershed, and represents approximately 88% of the total area tributary to Keller Lake.

An in-lake mass balance water quality model was also completed as a part of the SLMP to assess the impact of watershed loading and internal phosphorus loading on the water quality of Keller Lake. The in-lake model used the stormwater runoff volumes and areal total phosphorus loading rates estimated by the P8 model, in conjunction with lake-specific parameters such as average lake depth, lake volume, and flushing rate, to calculate daily in-lake total phosphorus concentrations. The in-lake model was calibrated using lake-specific water quality data collected throughout the summer of 2002.

Through analysis of the data and calibration of the in-lake model, it was determined that Keller Lake does receive internal phosphorus loading at times throughout the summer. Modeling results indicated that the internal phosphorus loading in Keller Lake contributes 40% to 80% of the summer average total phosphorus concentration on average. To better quantify the internal phosphorus source(s) and loading rates, the RWMWD completed an additional study. Through the *Internal Phosphorus Load Study: Kohlman and Keller Lakes* (Barr, 2005), it was found that the loading rate of phosphorus from Keller Lake's sediments was relatively low, indicating that the internal phosphorus loading in Keller Lake was likely due to the die-off of curlyleaf pondweed. Due to the relatively low sediment internal phosphorus loading rate and the low water residence time of the lake, treatment or dredging of the sediment in Keller Lake was not recommended. The pie chart shown in Figure 2.7-5 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads.

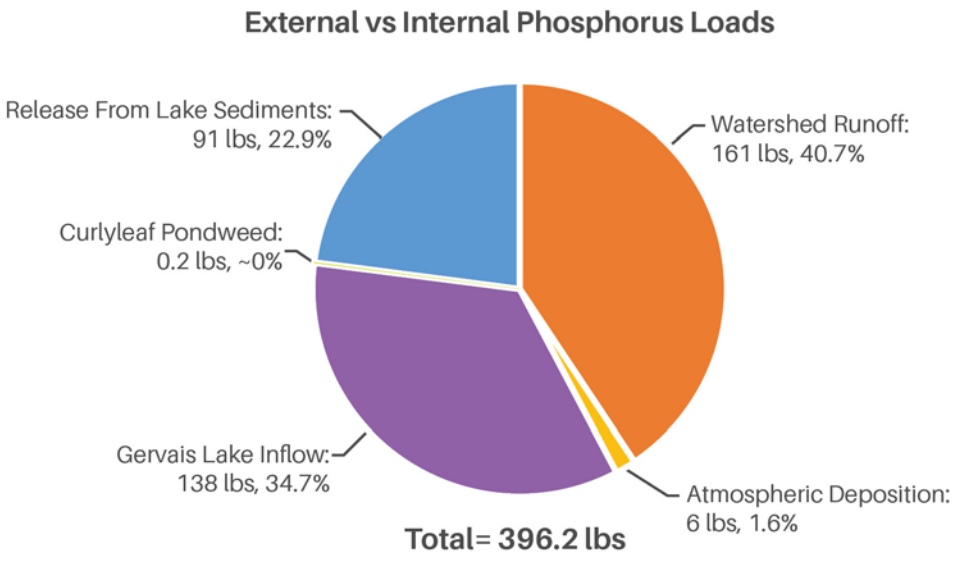


Figure 2.7-5 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Keller Lake

After development and calibration of the P8 models and in-lake water quality models, they were used as a predictive tool to evaluate the impact of various water quality improvement projects on the water quality of Keller Lake.

2.7.2.5 Water Quality Goals

The water quality goals for Keller Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.7-2. The RWMWD will continue to evaluate Keller Lake water quality data for trends and adjust its water quality classification and management activities accordingly. Projects implemented in the Keller Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.7-6.

One particular project implemented by the District was the Highway 36/61 Stormwater Retrofit Project. Approximately 70 acres of commercial, residential, and highway land drain to Keller Lake through the Highway 36 cloverleaf interchange with Highway 61. In 2013 and 2014, the District developed options for treating stormwater runoff from this highly developed area to improve runoff to Keller Lake and its associated wetlands. Stormwater from the tributary area is routed through an enhanced sand filter cell and two wetland treatment basins designed to remove phosphorus-rich sediment and other contaminants. These improvements in water quality are intended to reduce pollutant levels in Keller Lake as well as the downstream Lake Phalen. This project was a joint cooperative project with the City of Maplewood and the Minnesota Department of Transportation (MnDOT).

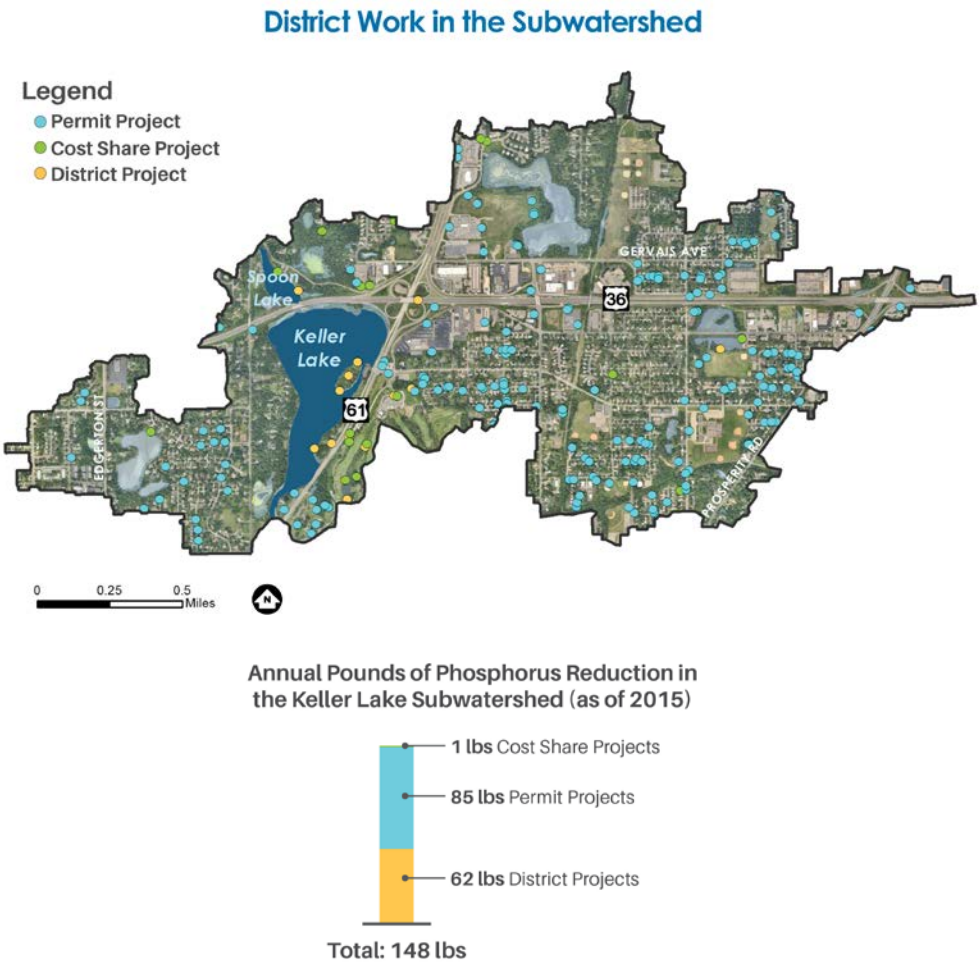


Figure 2.7-6 District work in the Keller Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.7.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District performed hydrologic and hydraulic modeling for the Keller Lake subwatershed as part of the *Phalen Chain of Lakes Surface Water Management Plan* (Phalen Management Plan) (1988) to identify potential flooding problems and recommend improvements.

To alleviate some of the flooding problems identified in the Phalen Management Plan, the RWMWD completed the Phalen Outlet capital improvement project. This regional flood control project included the installation of two new outlets and associated pipeline from Lake Phalen to the Beltline Interceptor. The project also included a new fixed-weir structure downstream of Keller Lake that controls the flows from the Upper Chain of Lakes (Kohlman, Gervais, and Keller Lakes). The entire system lowered the flood level of each of the four lakes, removing numerous homes and business from the 100-year flood plain delineated at the time of study (note that the District established new 100-year flood levels in 2015, described below).

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Keller Lake subwatershed are the new 100-year flood elevations shown in Figure 2.7-7. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.7.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Keller Lake subwatershed are shown in Figure 2.7-8, indicating areas where the water levels of waterbodies in the Keller Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.7.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD is involved in numerous habitat management areas throughout the District. One of these sites is located within Keller Golf Course, which is a public course operated by Ramsey County. An environmentally friendly grounds management program was created for the course, which won a RWMWD Landscape Ecology Award Program (LEAP, see Section 4.1.4) award in 2002 for prairie restoration activities and excellent maintenance practices. In 2004, the RWMWD partnered with Keller Golf Course and Ramsey County to create a natural buffer around a high quality wetland on the golf course property. The wetland supports a diverse aquatic plant community, and District monitoring found this wetland to have the highest frog densities (especially northern leopard frog) of any wetland sampled in the watershed. A variety of wading birds is also quite common. The shoreland buffer was planted with a flower-intensive mixture of native plants. Golf course patron feedback has been overwhelmingly positive. This restoration project has added natural beauty and the RWMWD will work to preserve this unique water feature. This is the first golf course in RWMWD to adopt the concept of native buffers around natural water features. Since 2004, the golf course has established "no-play" areas on the course that are part of the Phalen Chain of Lakes natural areas corridor. In 2013, the District and Ramsey County received

additional funding from the Ramsey Conservation District to restore 7 additional acres of "no-play" area. Another 7 acres were restored in 2014. Restoration efforts included pond and wetland buffer areas, prairie, and woodland.

In 2006, the City of Maplewood and the RWMWD cooperated on a restoration project to improve shoreland buffer areas around a high quality wetland in Sherwood Park. The wetland supports plant and invertebrate communities and also slows stormwater runoff from ball fields. The restored areas serve as a high quality natural shore where park patrons will enjoy a variety of native flower species. The RWMWD promotes this project as an example to inform District residents on how to implement their own shoreland restorations. This effort is an example of the RWMWD's Natural Resources and Education programs coordinating with City efforts to promote best management practices.

In 2010-12, the District, Ramsey County, and MDNR partnered on an ecological restoration project that treated over 2,000 feet of Keller Lake shoreline. The Keller Shoreline restoration project is part of a comprehensive effort to create high quality shorelines throughout the entire chain of lakes. The main objectives were to place a soil cap over the rock baskets, eliminate invasive weeds and create a native upland buffer, establish emergent vegetation along the base of the shore slope, and install several access points. Adult volunteers and local school groups assisted with native plant installation. This gave students an opportunity to learn about and participate in the ecological restoration. The restoration areas are supporting over 75 species of native plants, and invasive weed coverage is minimal. The access points are now a popular way for park patrons to enjoy and use the lake.

In 2015, the District began a project to restore Keller Creek. Keller Creek is an integral part of the Phalen Chain of Lakes, flowing from Keller Lake into Round Lake and Lake Phalen. It is a component of a regionally vital fish and wildlife corridor, connecting restored habitats at Lake Phalen, the Phalen Golf Course and Round Lake with those at Keller Lake, Keller Golf Course, and Lake Gervais. Much of the creek shore is owned by the MDNR, but is actively managed by Ramsey County. The District, along with Ramsey County, authored a 4-year restoration plan to restore native plant communities along the creek. This restoration project is being funded by MDNR, the District, and Ramsey County Parks. Students from area schools, Ramsey County Master Gardeners and other volunteers are assisting with the restoration, and Conservation Corps of Minnesota and Youth Outdoors crews lend a hand with site preparation and removal of invasive plants, like buckthorn and burdock.

Initial restoration work addressed the east bank of the creek, between Frost Avenue and Highway 61. Invasive plant species were removed, eroding creek banks protected with coconut (coir) logs and brush bundles, two wet meadow areas were created and thousands of native flowers and grasses were planted by hundreds of volunteers. Along with the water-and-wildlife-friendly improvements, the preexisting (and mostly unusable) large stone access next to the weir was reconfigured to improve safety for fishing and portaging. In 2016, restoration work on the west bank of the creek is planned, followed by additional restoration activities on stretches south of Frost Avenue in the next few years.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Keller Lake subwatershed.

2.7.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Keller Lake subwatershed (see Table 2.7-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Keller Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.7-4 Keller Lake Subwatershed Implementation Activities

Activity ID No.	Keller Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
KeL-1	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Keller Lake.	**Continuous**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
KeL-2*	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage			
Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
134	877.87	KELL-03b	861.8
146	877.87	KELL-07	868.97
157	879.24	KELL-08	861.8
200	906.8	KELL-08b	861.8
402	879.39	KELL-09	897.86
403	879.39	MENARDS-1	872.51
408	873.69	MHCB18A	906.31
421	881.11	N_KNUCKLE	906.8
422	883.91	NE-2	870.04
425	881.33	NE-3	874.29
427	881.63	NE-4	866.04
510	895.03	NW-1	866.73
545	877.72	Pond100	871.13
546	883.2	Pond400	879.39
550	893.28	PP	864
585	911.7	S_ditch	909.89
205A	906.26	S_KNUCKLE	906.26
CB2	906.26	SE-2	863.5
EX105	886.29	SE-3	864.06
EX115	889.91	SF	864
Gerten	876.01	SW-1	863.04
KELL-01	859.7	SW-2	861.94
KELL-02	861.8	TU1	877.72
KELL-03	867.34		

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Source: Barr Engineering, 2015, Imagery: USDA; 2015

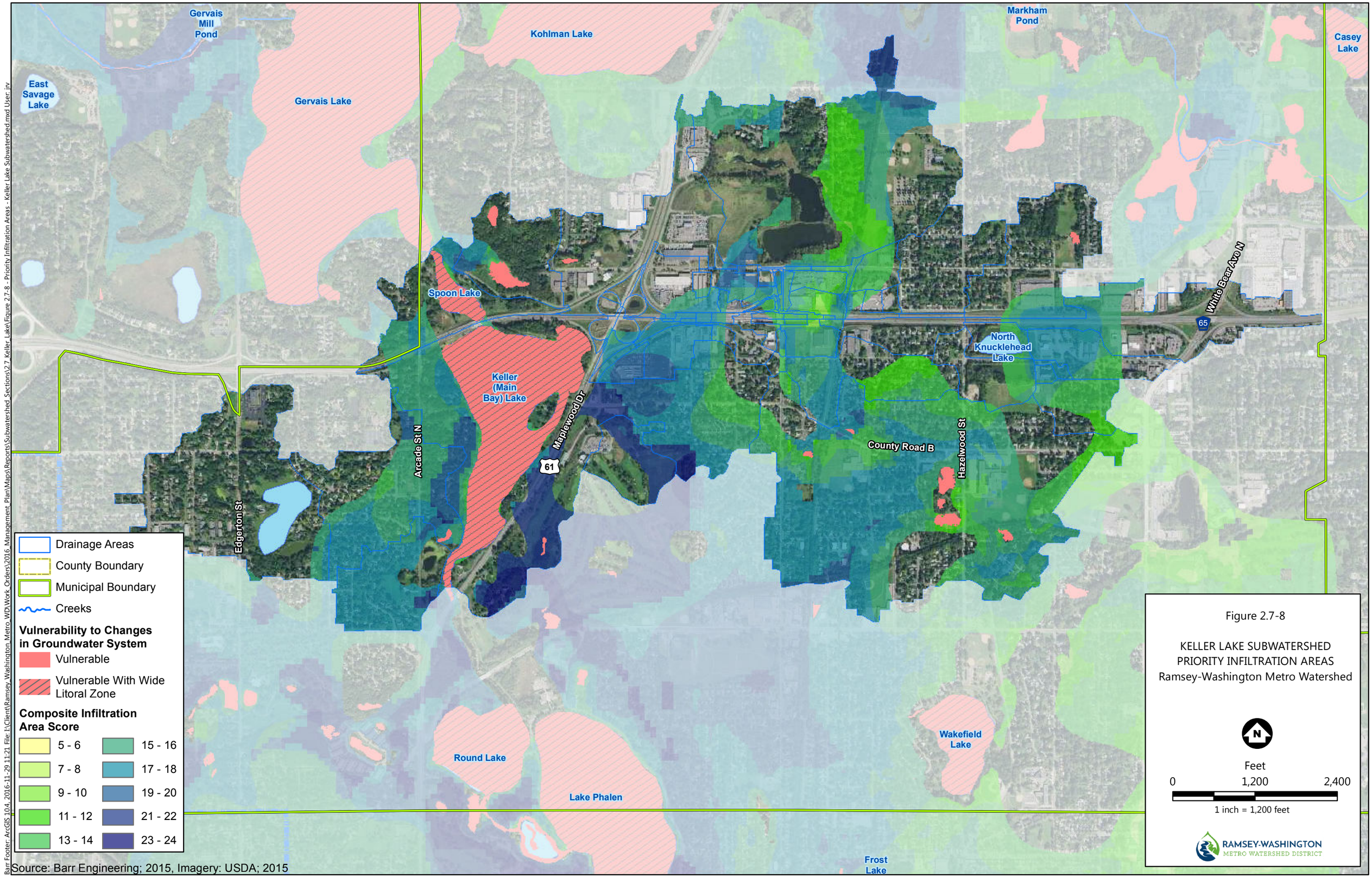
Figure 2.7-7

KELLER LAKE SUBWATERSHEDS
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,200 2,400
1 inch = 1,200 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 11:02 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed Sections\2.7 Keller_Lake\Figure 2.7-7 - Subwatersheds and Drainage Patterns - Keller Lake Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.7-8

KELLER LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

Feet
0 1,200 2,400
1 inch = 1,200 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4 2016-11-29 11:21 File: I:\Client\Ramsey Washington Metro WD\Work Orders\2016 Management Plan\Maps\Reports\Subwatershed Sections\2.7 Keller Lake\Figure 2.7-8 - Priority Infiltration Areas - Keller Lake Subwatershed.mxd User: jrv

2.8 Lake Phalen Subwatershed

2.8.1 General Description

The Lake Phalen subwatershed includes 1,995 acres in the cities of Maplewood and St. Paul in Ramsey County (see Figure 2.8-1). This includes area that drains to Round Lake in the city of Maplewood which is located immediately upstream of Lake Phalen. An additional 948 acres tributary to Wakefield Lake was included in the Lake Phalen subwatershed in the 2007 RWMWD Plan, but has been separated as its own subwatershed in this Plan (see Section 2.9). In addition to inflow from the Wakefield Lake subwatershed, Round Lake and Lake Phalen receive inflow from 12,004 acres via Keller Lake (see Section 2.7). The total drainage area tributary to Lake Phalen is 14,947 acres.

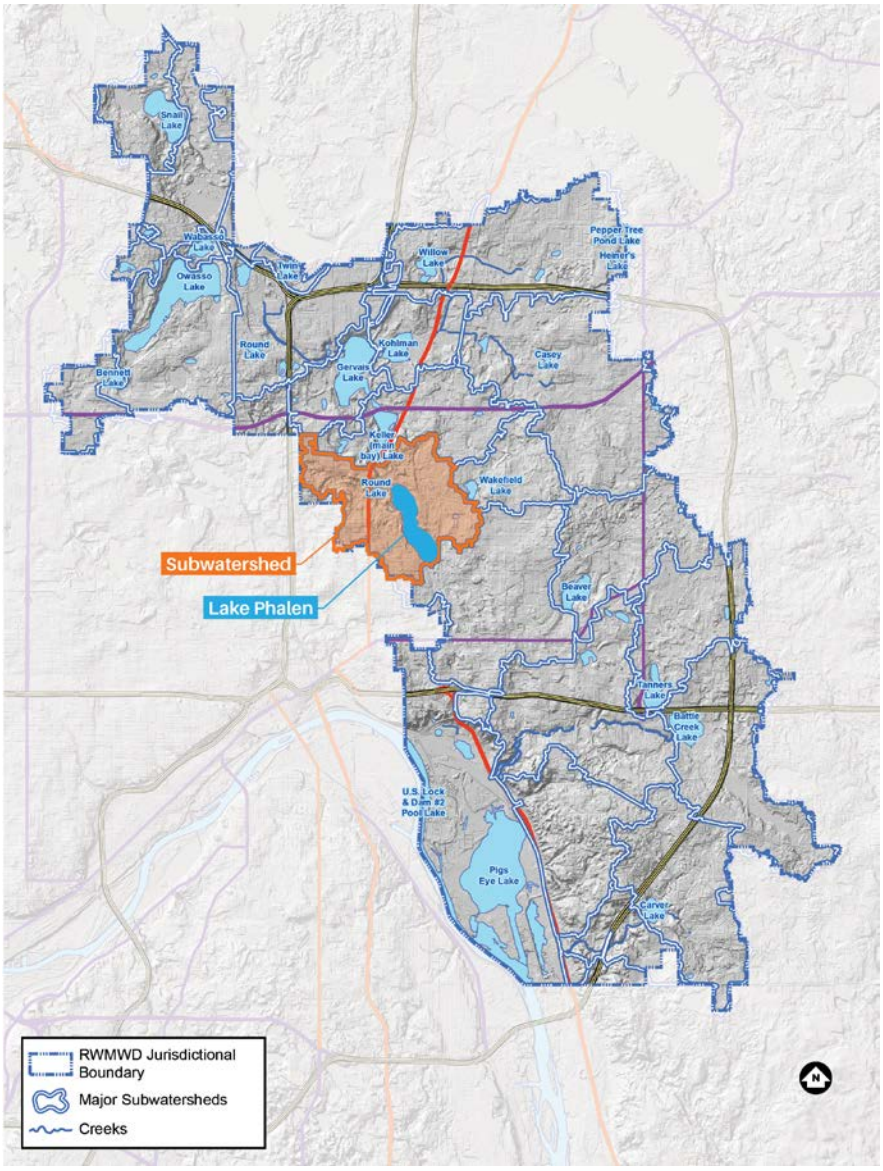


Figure 2.8-1 Lake Phalen Location Map

Lake Phalen is the farthest downstream lake in the Phalen Chain of Lakes (Kohlman, Gervais, Keller, Round, Phalen). The District-managed waterbodies within the Lake Phalen subwatershed include Lake Phalen and Round Lake (Maplewood). County Ditch 17, which is contained almost entirely within underground pipe, flows into Wakefield Lake from the east.

Table 2.8-1 Lake Phalen Subwatershed Facts

	Lake Phalen	Round Lake (Maplewood)
Tributary Area (Direct)	1,995 acres	600 acres
Tributary Area (Total)	14,947 acres	13,552 acres
Downstream Watershed	St. Paul Beltline	St. Paul Beltline
MDNR Designation	62-0013P	62-0012P
Lake Surface Area	200 acres	30 acres
Lake Mean Depth	22 ft	--
Lake Maximum Depth	95 ft	8 ft
Lake Outlet Type	3 flared end sections; weir in control structure; overflow weir	Channel to Lake Phalen
Lake Outlet Elevation	857.3 ft	Connected to Lake Phalen
100-Year Flood Level	861.8 ft	861.8 ft
Lake Littoral Area	40%	100%
MPCA Designations	Deep Lake ; Impaired for Aquatic Consumption (mercury food consumption advisory)	Shallow Lake
MS4s in the Direct Tributary Area	Maplewood, St. Paul, Ramsey County	Maplewood, St. Paul, Ramsey County
RWMWD Nutrient Water Quality Classification	Stable	Stable

Lake Phalen is located mostly in the city of St. Paul, with the northern portion located in the city of Maplewood. The lake is a MDNR public water (MDNR# 62-0013P), with a surface area of approximately 200 acres, a maximum depth of approximately 95 feet and a mean depth of approximately 22 feet. According to the MDNR Lake Finder website, the littoral area, defined as the portion of the lake that is less than 15 feet in depth, comprises approximately 80 acres or 40% of the lake. The lake is used primarily for recreational activities such as swimming, fishing, picnicking, and viewing. Lake Phalen is surrounded by Ramsey County parkland. The lake has public boating access and a swimming beach.

Round Lake is a District-managed lake located in Maplewood (see Figure 2.8-1). The lake flows to Lake Phalen via two different channels – one on the northeast side of Round Lake, and one south of Round Lake, east of the Phalen pavilion, which are both on the northwest side of Lake Phalen. The lake is a MDNR public water (MDNR# 62-0012P) with a surface area of approximately 30 acres and a maximum depth of approximately 8 feet. Round Lake is considered a shallow lake (a maximum depth of less than

15 feet and/or at least 80% of the lake less than 15-feet deep). Round Lake is surrounded by Ramsey County parkland and primarily used for canoeing, picnicking, wildlife habitat, and aesthetic viewing.

2.8.1.1 Past Studies

The following list is a summary of past studies related to Lake Phalen and/or its tributary subwatershed.

- *Report to RWMWD on the Water Quality of Beaver and Wakefield Lakes*. Ramsey County Department of Public Works, March 1985.
- *Phalen Chain of Lakes Surface Water Management Plan*. Prepared for RWMWD by Barr Engineering, November 1988.
- *Phalen Outlet Hydraulic Study*. Prepared for RWMWD by Barr Engineering, February 1990.
- *Draft Phalen Chain of Lakes Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2004.
- *Phalen Chain of Lakes Study of Untreated Tributary Drainage and Other Improvement Areas*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Phalen Chain of Lakes Summary Report and Final Lake Management Recommendations*. Prepared for RWMWD by Barr Engineering, October 2005.
- *Draft Phalen Chain of Lakes Carp Population Study*. Prepared for RWMWD by Barr Engineering, November 2006.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District*. Barr Engineering Co., Draft 2016.

2.8.1.2 Land Use

The Lake Phalen subwatershed is fully developed. The major land uses west of Lake Phalen include significant open space uses (a cemetery, two golf courses, Phalen Park) and single-family residential development (see Figure 2.8-2). The area east of Lake Phalen is predominantly single-family residential. Some commercial, office and light-industrial uses along Frost Avenue. The Phalen Golf Course and the south part of Keller Golf Course lie in the area west and north of Lake Phalen.

The Metropolitan Council's estimated 2030 land use anticipates limited land use changes in the future (see Figure 1-5). Anticipated land uses changes in the Lake Phalen subwatershed include the conversion of single-family residential land uses to urban residential land uses within the city of St. Paul. Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

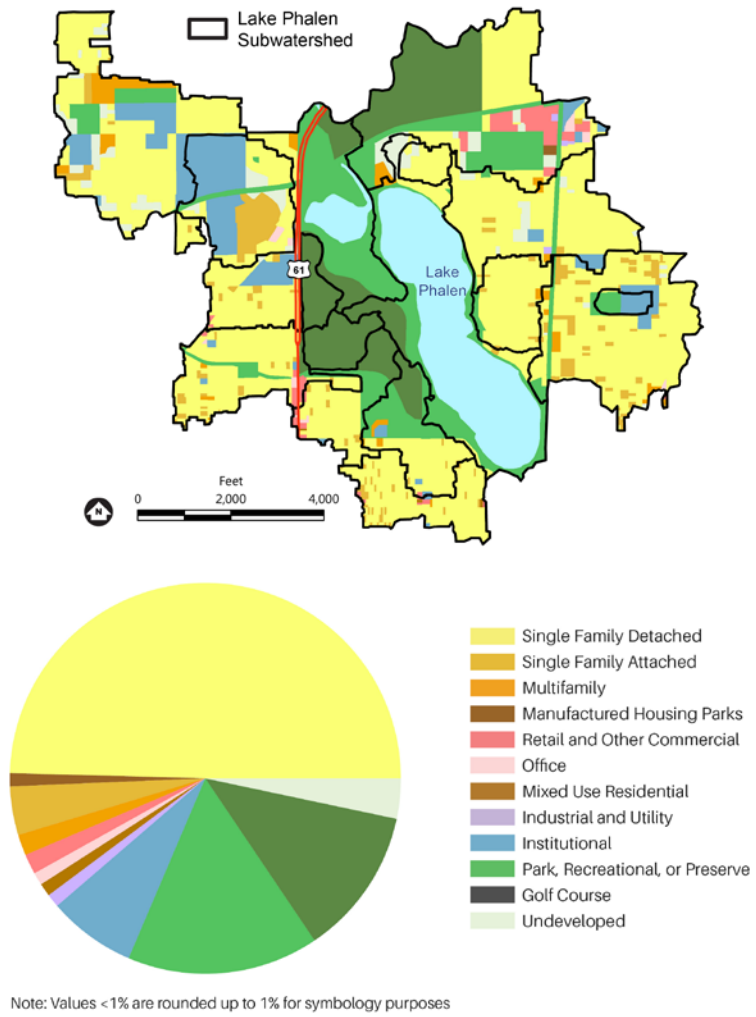


Figure 2.8-2 Breakdown of land uses throughout the Lake Phalen Subwatershed (2010 Metropolitan Council)

2.8.1.3 Drainage Patterns and Waterbodies

The Lake Phalen subwatershed receives incoming flow from the Keller Lake subwatershed. Discharge from Keller Lake flows over a weir and through a channel to Round Lake, which flows into Lake Phalen. In addition to flows from Keller Lake via Round Lake, Lake Phalen receives runoff from several storm sewer outfalls and culverts at various locations along the lakeshore (include discharge from the Wakefield Lake subwatershed), and sheet flow runoff from the lake's immediate drainage area (see Figure 2.8-9). Lake Phalen has two main outlets designed to keep the lake at an elevation of 857.5 MSL; one on the southeast side and one on the southwest side of the lake. The outlets are designed so that if the lake bounces higher during storm events, water is conveyed via a higher-capacity overflow weir and the lake is quickly drawn back down to the normal water level.

The Lake Phalen subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.8-9). Figure 2.8-9 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Lake Phalen subwatershed include Lake Phalen and Round Lake (Maplewood).

Wetlands within the Lake Phalen subwatershed are shown in Figure 2.8-9 according to the RWMWD wetland management classification (see Section 1.11.3).

2.8.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for District-managed waterbodies in the Lake Phalen subwatershed: Lake Phalen and Round Lake (Maplewood).

2.8.2.1 Historic Water Quality

Lake Phalen

Lake Phalen is used primarily for recreational activities such as swimming, fishing, picnicking, and viewing. Lake Phalen receives flows from Keller Lake via Round Lake, as well as runoff from storm sewer outfalls and culverts at various locations along the shoreline, and sheet flow runoff from the immediate drainage area. Lake Phalen is dimictic, meaning it generally mixes only twice a year – once in the spring and once in the fall.

The Ramsey County Department of Public Works staff samples the water quality of Lake Phalen about 7 times per year on average, between the months of May and September. Figure 2.8-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.8-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Lake Phalen relative to MPCA standards. The RWMWD has assigned a water quality classification of "Stable" to Lake Phalen based on recent water quality data (see Section 1.10.3).

Table 2.8-2 Lake Phalen historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Lake Phalen (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	23.2
Chlorophyll-a (µg/L)	≤ 14	6.6
Secchi disk transparency (m)	≥ 1.4	2.9

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Lake Phalen water quality data. The results of these analyses are shown in Table 2.8-3. While recent data show a degrading trend in Secchi depth, the trend is not statistically significant.

Table 2.8-3 Trend Analysis Results for Lake Halen's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Lake Phalen	1981 – 2012	Secchi Depth	Improving*	Degrading*
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving*	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

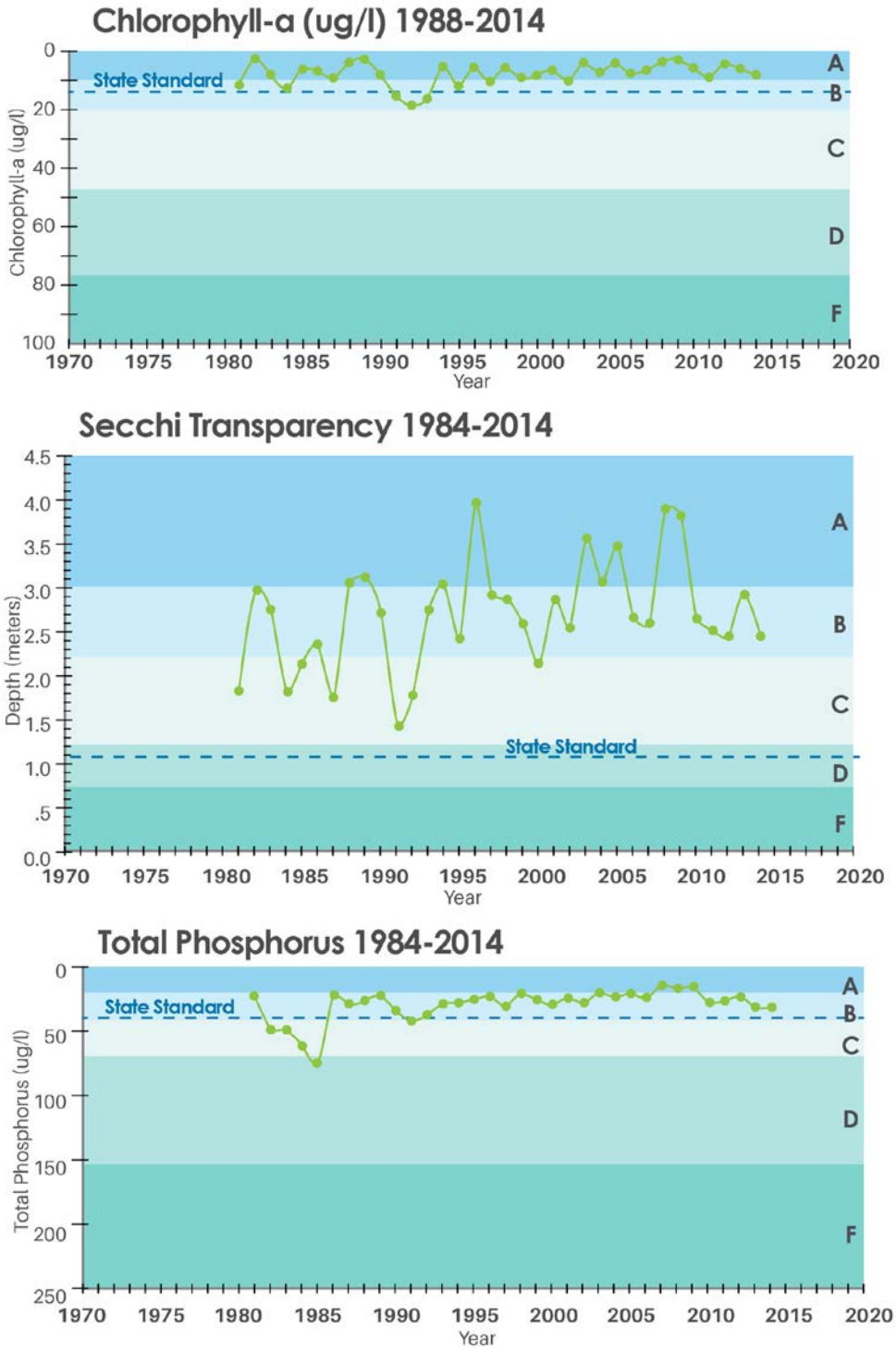


Figure 2.8-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Lake Phalen (1984-2014)

Round Lake (Maplewood)

Round Lake is used primarily for canoeing, picnicking, wildlife habitat, and viewing. Round Lake receives runoff from storm sewer outfalls and culverts along the shoreline, and sheet flow runoff from the immediate drainage area. The Ramsey County Department of Public Works staff samples the water quality of Round Lake about 7 times per year on average, between the months of May and September. Figure 2.8-4 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.8-4 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Round Lake relative to MPCA standards.

Round Lake was listed on the MPCA 303(d) Impaired Waters List in 2002 with a use of aquatic recreation impaired due to excessive nutrients, specifically phosphorus (see Section 1.10.2). However, water quality data from 1991-2000 demonstrated average water quality at or better than MPCA shallow lakes standards. In December of 2008, the RWMWD submitted a request to the MPCA to remove Round Lake from the impaired waters list in the 2010 assessment cycle, and Round Lake was removed from the impaired waters list. The RWMWD has assigned a water quality classification of "Stable" to Round Lake based on recent water quality data (see Section 1.10.3).

Table 2.8-4 Round Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Round Lake (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	39.9
Chlorophyll-a (µg/L)	≤ 20	9.2
Secchi disk transparency (m)	≥ 1.0	2.6

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Round Lake water quality data. The results of these analyses are shown in Table 2.8-3. While recent data show a degrading trend in Secchi depth, the trend is not statistically significant.

Table 2.8-5 Trend Analysis Results for Round Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Round Lake	1981 – 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

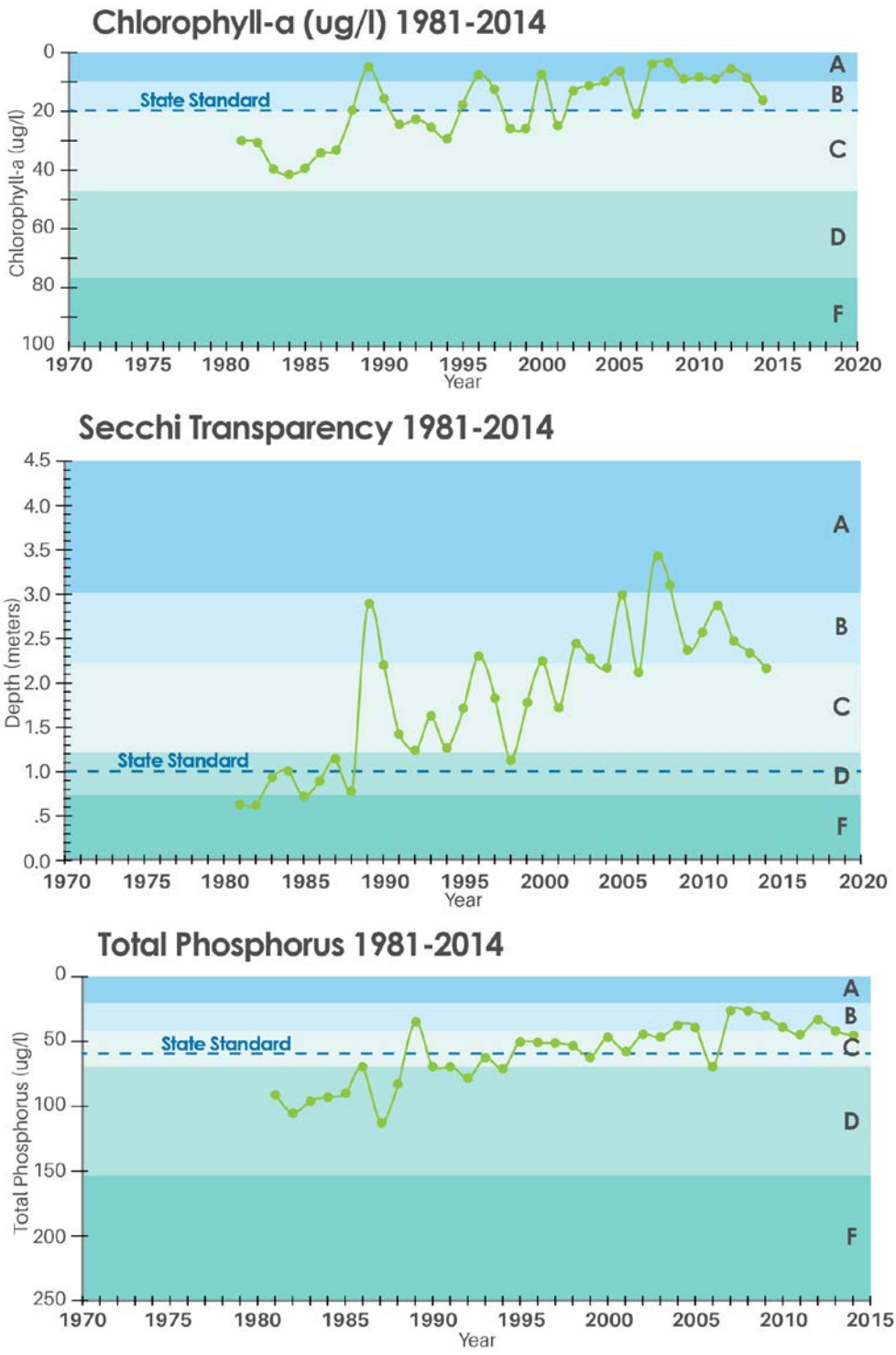


Figure 2.8-4 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Round Lake (1981-2014)

2.8.2.2 State of the Fishery

In 1992, the MDNR classified Lake Phalen and other Minnesota lakes relative to fisheries. According to its ecological classification, Lake Phalen is a Class 24 lake, which is a good permanent fishery lake (Schupp, 1992).

The MDNR actively manages the fishery in Lake Phalen for walleye and tiger muskellunge, stocking walleye in even-numbered years and tiger muskellunge in odd-numbered years. In addition to its stocking activities, the MDNR periodically assesses the Lake Phalen fish population. The last MDNR survey was performed in 2009. According to the assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is comprised of panfish species, gamefish species, rough fish species, and other fish species.

The MDNR stocks walleye fingerlings biennially on even numbered years at a rate of 4.0 pounds per littoral acre (approximately 320 lbs total). Despite doubling the stocking rate since 2002, walleye have been sampled in relatively low abundance during the last two MDNR assessments. The average size of walleye in the 2009 gill net catch was 19.9 inches in length and 2.8 pounds. Growth rates for walleye were found to be average. Northern pike were sampled within the normal range for abundance in 2009, but well below the catch rates of previous assessments. The average size of northern pike sampled in 2009 was 18.7 inches and 1.7 pounds. Growth rate of sampled northern pike was average. Although muskellunge are still being stocked, none were captured during the 2009 assessment. While yellow perch were sampled with the normal range for abundance, the gill net catch rates in 2009 were the lowest recorded on this lake since 1984 and the fish averaged only 6.4 inches in length. Very few black crappies were sampled during the 2009 assessment, but captured fish averaged 7.1 inches long and 0.18 pounds. Bluegill were captured in relatively high abundance in 2009, but the catch rate was about one-half of that recorded in 2004. Other species identified in the 2009 survey include black bullhead, common carp, green sunfish, hybrid sunfish, pumpkinseed, white sucker, and yellow bullhead.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Lake Phalen based on the presence of mercury and perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

During an evaluation of the Phalen Chain of Lake's carp population in 2006 by the University of Minnesota's Sorensen Lab, carp were present in Lake Phalen. Common carp are an invasive species that can negatively impact lake water quality (see Section 1.10.7).

The MDNR does not manage the fishery of Round Lake. No fisheries data is available for Round Lake.

2.8.2.3 State of the Macrophyte Community

On September 4, 2015, District staff conducted a macrophyte survey of Lake Phalen. The results of this survey are summarized below in Figure 2.8-5. In total, 139 sites were surveyed for macrophytes. Of these, 129 had vegetation, indicating that Lake Phalen is a macrophyte-dominated lake with a diverse macrophyte community.

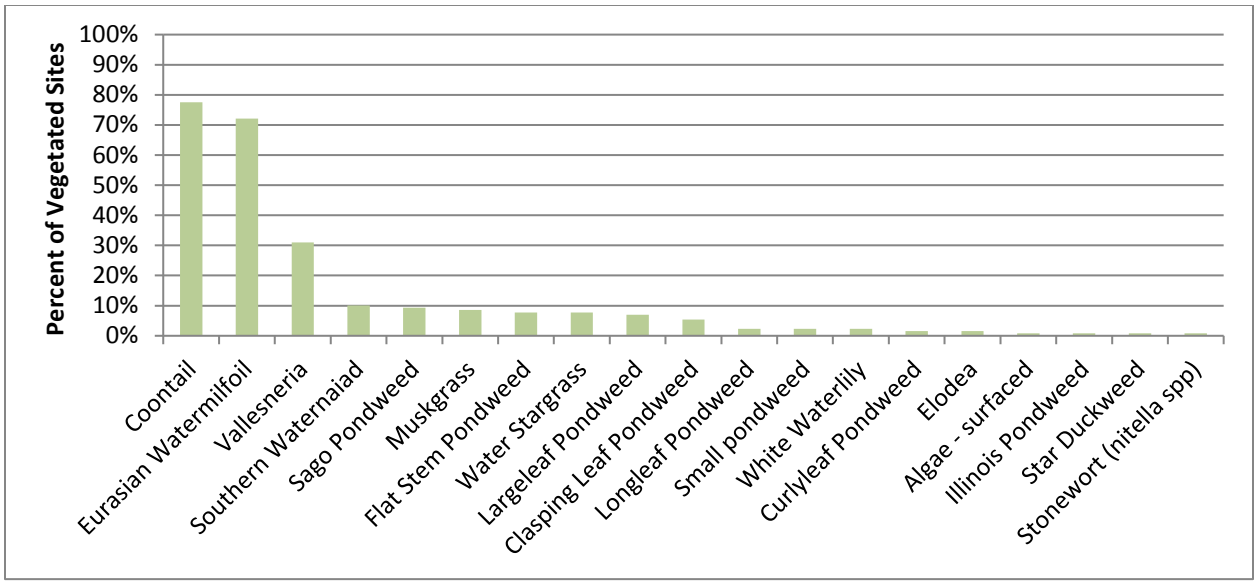


Figure 2.8-5 September, 2015 Lake Phalen Macrophyte Survey Results

Where Filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Lake Phalen. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer. Eurasian Watermilfoil is also an invasive species.

On August 31, 2011, District staff conducted a macrophyte survey of Round Lake (Maplewood). The results of this survey are summarized below in Figure 2.8-6. In total, 96 sites were surveyed for macrophytes. Of these, 84 had vegetation, indicating that Round Lake (Maplewood) is a macrophyte dominated lake.

Where coontail was present at all surveyed sites in high abundance relative to other macrophyte species in Round Lake (Maplewood). Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance.

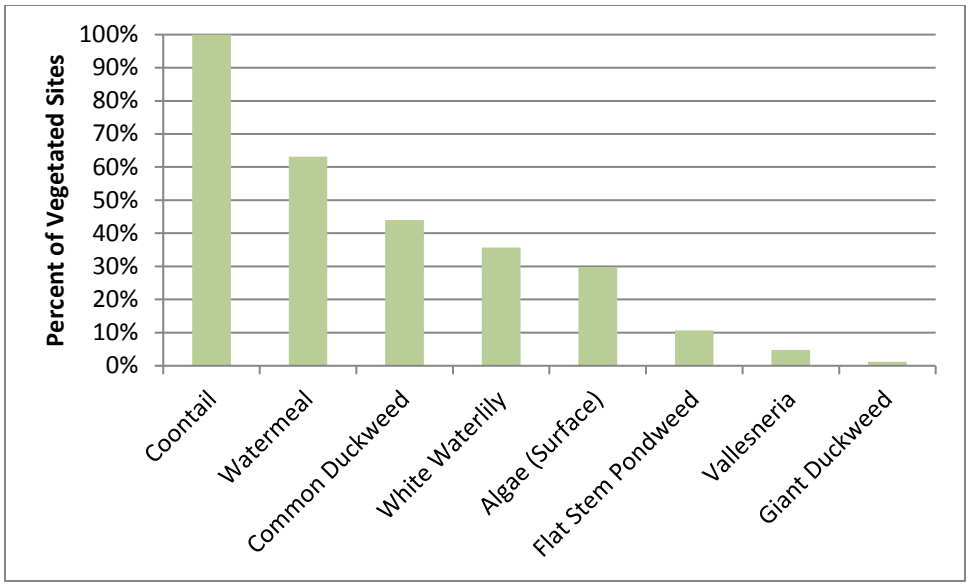


Figure 2.8-6 August, 2011 Round Lake (Maplewood) Macrophyte Survey Results

2.8.2.4 Water Quality Modeling

The District performed water quality modeling of the Lake Phalen subwatershed as part of developing the *Phalen Chain of Lakes Strategic Lake Management Plan* (SLMP) in 2004. The water quality models were developed to estimate the sources of phosphorus to Lake Phalen. The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future best management practices (BMPs). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the entire Lake Phalen subwatershed, including upstream watersheds tributary to Lake Phalen. An in-lake mass balance model was used to assess the impact of watershed loading on the lake. Model results were calculated for a range of climatic conditions to evaluate the variability of runoff and phosphorus loading under different hydrologic conditions.

The model results were used to estimate the amount of phosphorus reaching Lake Phalen from various drainage districts. The Lake Phalen watershed can be described in terms of 4 different "drainage districts." A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.8-7 shows the main drainage districts contributing flow and phosphorus loading to Lake Phalen. The area tributary to Keller Lake (Keller Lake Drainage District) is not depicted on Figure 2.8-7, although it makes up a large portion of the larger Lake Phalen tributary area. There is a landlocked area (384 acres) located northwest of Round Lake within the Lake Phalen subwatershed.

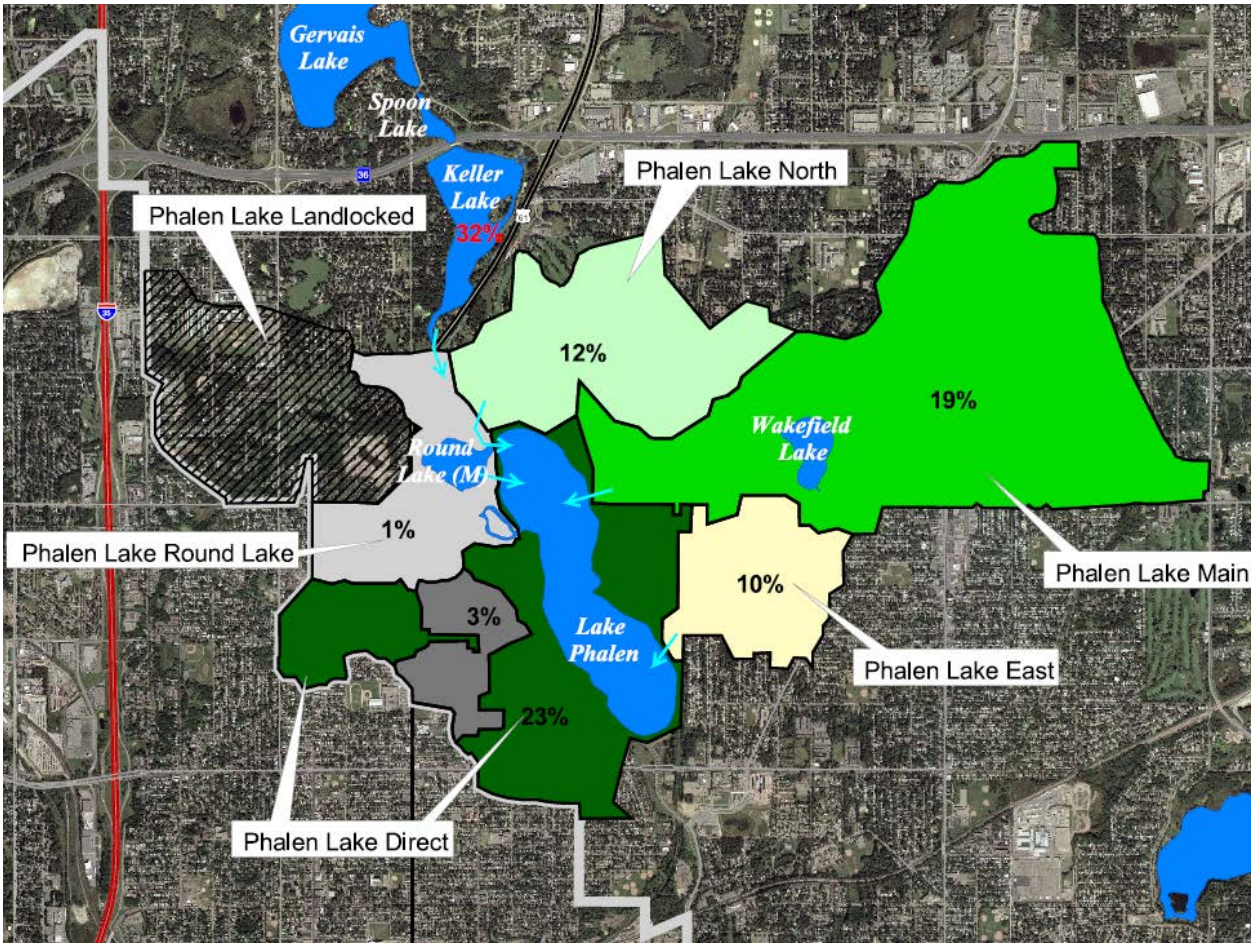


Figure 2.8-7 Drainage districts in the Lake Phalen subwatershed and upstream tributary watersheds

These main drainage districts to Lake Phalen are summarized below:

- **Lake Phalen Main Drainage District—**This 1,081-acre drainage district northeast of the Lake Phalen represents approximately 7% of the total area tributary to Lake Phalen. Runoff from this drainage district flows through a series of ponds and wetlands (including Wakefield Lake), and storm sewers before reaching Lake Phalen.

- **Lake Phalen Round Lake Drainage District—**This 242-acre drainage district northwest of the lake represents a small portion (2%) of the area tributary to Lake Phalen. Runoff from this drainage district flows through Round Lake before reaching Lake Phalen via two different channels – one on the northeast side of Round Lake, and one south of Round Lake, east of the Phalen pavilion.

- **Lake Phalen North Drainage District—**This 369-acre drainage district north of the lake represents a small portion (3%) of the area tributary to Lake Phalen. Runoff from this drainage district flows through a series of ponds and wetlands before reaching Lake Phalen.

- **Lake Phalen East Drainage District—**This 204-acre drainage district east of the lake represents a small portion (1%) of the area tributary to Lake Phalen. Runoff from this drainage district flows through a single, small retention pond before reaching Lake Phalen.

- **Lake Phalen West Drainage District—**This 106-acre drainage district west of the lake represents a small portion (1%) of the area tributary to Lake Phalen. Runoff from this drainage district flows through retention ponds in the Lake Phalen Regional Golf Course before reaching Lake Phalen.

- **Lake Phalen Direct Drainage District**—This 629-acre drainage district consists of the area that drains directly to Lake Phalen without passing through a detention pond. It represents approximately 4% of the total tributary area to Lake Phalen.

- **Keller Lake Drainage District**—This 11,944-acre drainage district consists of a number of subwatersheds tributary to Keller Lake, including Willow Creek, Kohlman Creek, Kohlman Lake, Twin Lake, Gervais Creek, Gervais Lake, and Keller Lake subwatersheds, and represents 82% of the total area tributary to Lake Phalen. Flows from the Keller Lake drainage district enter Lake Phalen through Spoon Lake.

An in-lake mass balance water quality model was also completed as a part of the SLMP to assess the impact of watershed loading and internal phosphorus loading on the water quality of Lake Phalen. The in-lake model used the stormwater runoff volumes and areal total phosphorus loading rates estimated by the P8 model, in conjunction with lake-specific parameters, such as average lake depth, lake volume, and flushing rate, to calculate daily in-lake total phosphorus concentrations. The in-lake model was calibrated using lake-specific water quality data collected throughout the summer of 2002.

Through analysis of the data and calibration of the in-lake model, it was determined that Lake Phalen rarely de-stratifies during the summer months. Therefore, internal phosphorus loading was assumed negligible during the summer months.

After development and calibration of the P8 models and in-lake water quality models, they were used as a predictive tool to evaluate the impact of various water quality improvement projects on the water quality of Lake Phalen.

2.8.2.5 Water Quality Goals

The water quality goals for Lake Phalen are consistent with the MPCA's lake eutrophication standard for shallow or deep lakes in the North Central Hardwoods Forest Ecoregion, shown in Table 2.8-2 and Table 2.8-4. The RWMWD will continue to evaluate water quality data in Lake Phalen and Round Lake for trends and adjust its water quality classification and management activities accordingly. Projects implemented in the Lake Phalen subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.8-8.

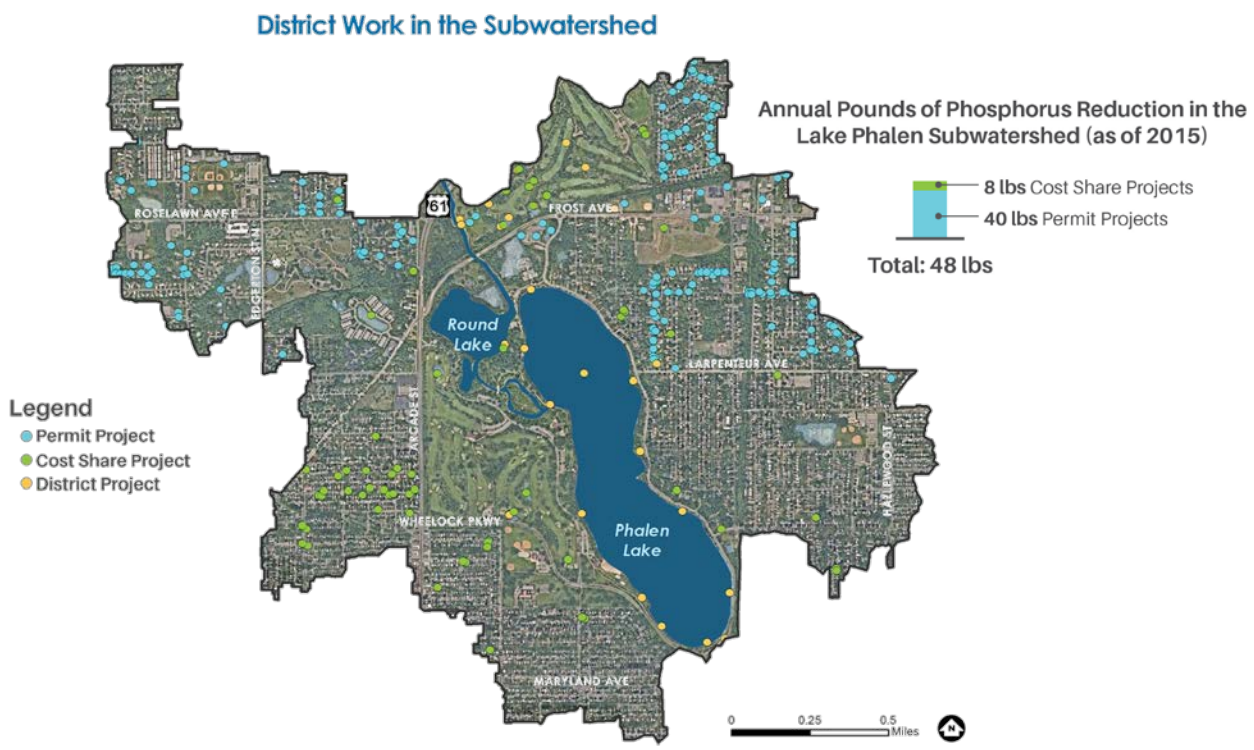


Figure 2.8-8 District work in the Lake Phalen Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.8.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District performed hydrologic and hydraulic modeling for the Lake Phalen subwatershed as part of the *Phalen Chain of Lakes Surface Water Management Plan* (Phalen Management Plan) (1988) to identify potential flooding problems and recommend improvements.

To alleviate some of the flooding problems identified in the Phalen Management Plan, the RWMWD completed the Phalen Outlet capital improvement project. This regional flood control project included the installation of two new outlets and associated pipeline from Lake Phalen to the Beltline Interceptor. The project also included a new fixed-weir structure downstream of Keller Lake that controls the flows from the Upper Chain of Lakes (Kohlman, Gervais, and Keller Lakes). The entire system lowered the flood level of each of the four lakes, removing numerous homes and business from the 100-year flood plain delineated at the time of study (note that the District established new 100-year flood levels in 2015, described below).

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Lake Phalen subwatershed are the new 100-year flood elevations shown in Figure 2.8-9. The new inundation extents that have been modeled

throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.8.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Lake Phalen subwatershed are shown Figure 2.8-10, indicating areas where the water levels of waterbodies in the Lake Phalen subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.8.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The Phalen Chain of Lakes is a primary surface water feature in the RWMWD. Lake Phalen is the southernmost lake in the Chain and is often thought of as the centerpiece of the Phalen Regional Park System. Lake use is extremely high, with over one-half million visitors using the park grounds on an annual basis.

Shoreline erosion has had a significant impact on Lake Phalen. In 2001, the RWMWD partnered with the City of St. Paul, MDNR Fisheries, and others to undertake a five-year ecological restoration project along the Lake Phalen shoreline. This project included over 1.5 miles of shore restored. Thirteen schools and thousands of students have volunteered in the implementation and maintenance of the project. Numerous educational tours have taken place in the park. In 2005, the RWMWD began working with the MDNR and the University of Minnesota to assess the establishment of restored plant communities. The *Lake Phalen Walking Tour and Plant Guide* (Elvecrog and Bartodziej, 2005) is available from the RWMWD and educates residents and visitors regarding the restored plant communities. The RWMWD closely assesses all restoration areas to detect potential erosion problems and to determine appropriate management activities. The RWMWD supports long-term monitoring of this restoration, coordinating with the City of St. Paul to conduct prescribed burns and other routine management activities.

In 2013, the City of Maplewood and the District cooperated to enhance the natural habitat and reduce stormwater runoff at the Keller Golf Course, following the course's enrollment in the Audubon

International Golf Course Certification Program. The main objectives were to introduce natural buffer areas around the ponds in a way that adds beauty and visual interest for the golf patrons to enjoy. The District provided grant funding through its cost-share program and technical support. Maplewood and District staff partnered on the project management. The project resulted in the improvement of nearly 2,000 feet of shore. The introduction of a variety of native plants improve habitat, reduce shore erosion, and look good. Along with this, approximately 1 acre of no-play rough area (mainly turf grass) have been converted into native prairie. These efforts complement the ecological restoration work that is taking place in the Phalen Chain of Lakes corridor (Lake Phalen, Keller Lake, and Keller Golf Course). Over the next several years, the no-play areas will mature, and patrons will begin to experience the impressive synchronization of natural habitats and urban golf.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Lake Phalen subwatershed.

2.8.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Lake Phalen subwatershed (see Table 2.8-6). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Lake Phalen subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.8-6 Lake Phalen Subwatershed Implementation Activities

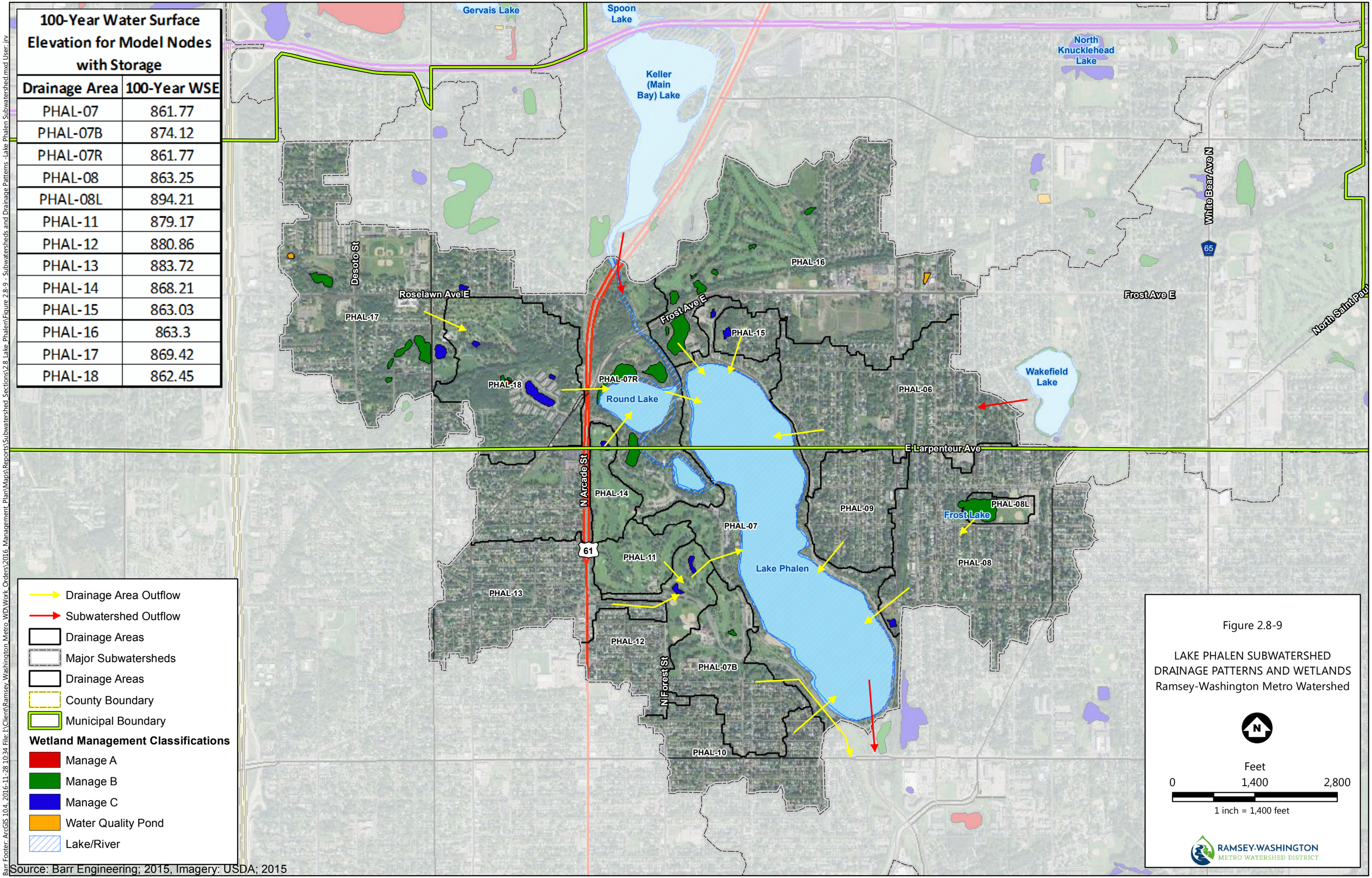
Activity ID No.	Lake Phalen Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LP-1	Coordinate with the City of St. Paul Parks Department, the Minnesota DNR and other agencies and citizen organizations, to address concerns about lake management and conditions.	**Continuous**	**$5,000 (average annual cost)**	**EC6**	**Tier 2**
LP-2*	Work with the City of St. Paul to improve the PHAL-08 pond	**2020**	**$150,000**	**WQ2, WQ17, WQ18, WQ19, FL8, IE7, IE17, MO6, MO21**	**Tier 1**
LP-3*	Implement a shoreline management study for Round Lake (Maplewood) to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC6**	**Tier 2**

Activity ID No.	Lake Phalen Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LP-4	Restore park areas in the Phalen Corridor	**2017-2020**	**$140,000**	**WQ18, EC3, EC6, IE7, IE17, MO6, MO21**	**Tier 3**
LP-5	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Lake Phalen and Round Lake (Maplewood).	**2017-2026**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
LP-6	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	**100-Year WSE**
PHAL-07	861.77
PHAL-07B	874.12
PHAL-07R	861.77
PHAL-08	863.25
PHAL-08L	894.21
PHAL-11	879.17
PHAL-12	880.86
PHAL-13	883.72
PHAL-14	868.21
PHAL-15	863.03
PHAL-16	863.3
PHAL-17	869.42
PHAL-18	862.45



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.8-9

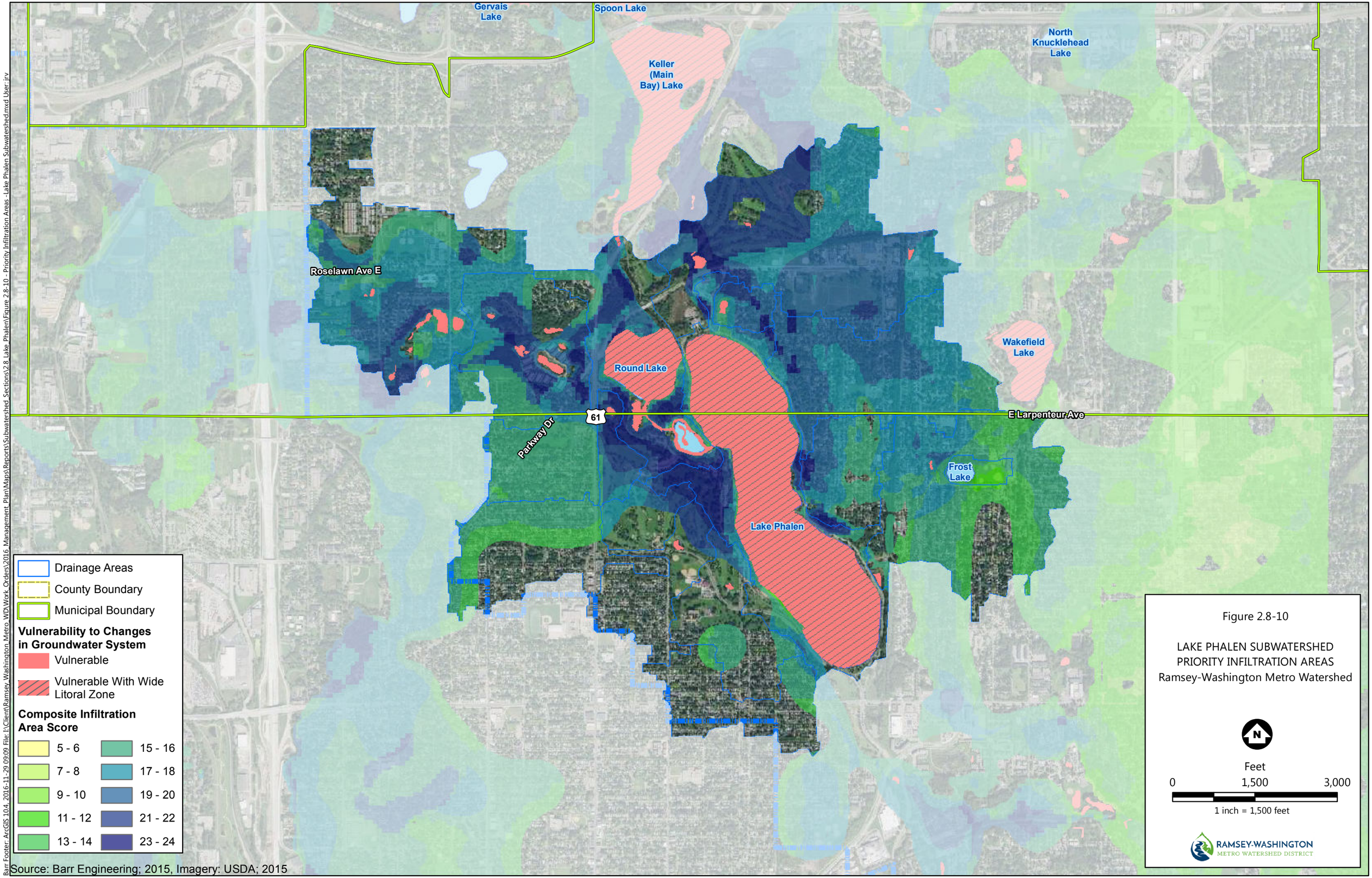
LAKE PHALEN SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

N

Feet
0 1,400 2,800
1 inch = 1,400 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4 2016-11-28 10:34 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.8_Lake_Phalen\Figure 2.8-9 - Subwatersheds and Drainage Patterns - Lake Phalen Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4 2016-11-29 09:09 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed Sections\2.8_Lake_Phalen\Figure 2.8-10 - Priority Infiltration Areas -Lake Phalen Subwatershed.mxd User: jrv

2.9 Wakefield Lake Subwatershed

2.9.1 General Description

Wakefield Lake (MDNR # 62-0011P) is located in Maplewood, just north of East Larpenteur Avenue and west of Prosperity Road (Figure 2.9-1) in Ramsey County.

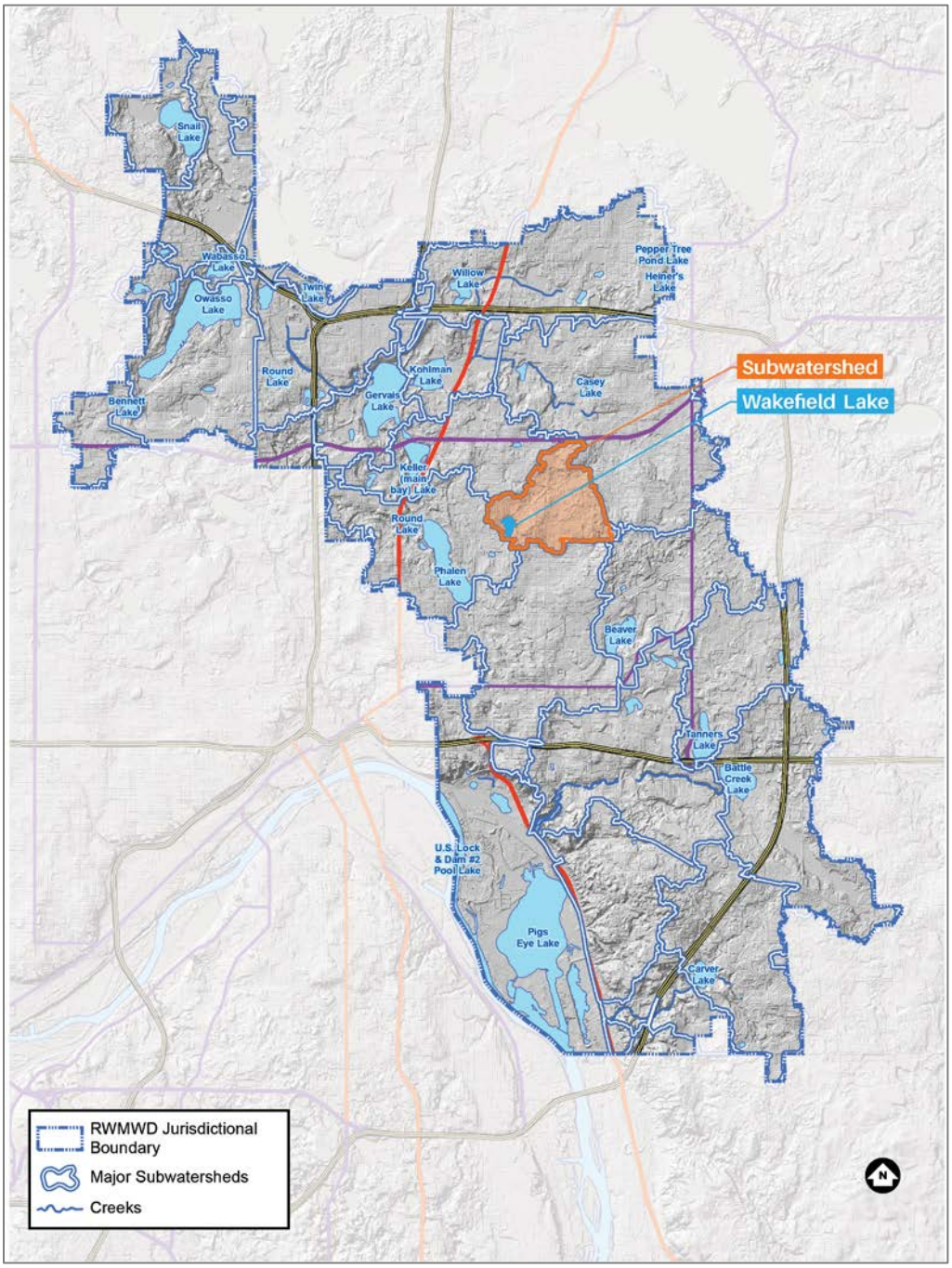


Figure 2.9-1 General location of Wakefield Lake and its Subwatershed

Primary public uses of Wakefield Lake include shoreline fishing, picnicking and aesthetic viewing. The Minnesota Department of Natural Resources (MDNR) FiN (Fishing in the Neighborhood) program cites Wakefield Lake as a good place for kids to fish in the east metropolitan area. Public access to the lake is available via Wakefield Park, although there is no official boat launch access on the lake. General facts about Wakefield Lake are shown in Table 2.9-1.

Table 2.9-1 Wakefield Lake Subwatershed Facts

Tributary Area (Direct)	948 acres
Tributary Area (Total)	948 acres
Downstream Watershed	Lake Phalen
MDNR Designation[1]	62-0011P
Lake Surface Area[1]	23 acres
Lake Mean Depth[1]	4.6 ft
Lake Maximum Depth[1]	9 ft
Lake Outlet Type[1]	Stoplog weir with gate
Lake Outlet Elevation[1]	884.9 ft
100-Year Flood Level[1]	889.5 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake; Impaired for Aquatic Recreation (excess nutrients), at risk of impairment for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Maplewood, North St. Paul, St. Paul, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Impaired

[1] Data for Wakefield Lake

2.9.1.1 Past Studies

The following list is a summary of past studies related to Wakefield Lake and/or its tributary subwatershed:

- *Report to RWMWD on the Water Quality of Beaver and Wakefield Lakes. Ramsey County Department of Public Works, March 1985.*
- *Wakefield Lake Strategic Lake Management Plan. Barr Engineering Company, 2008.*
- *Diatom Final Report for Kohlman, Wakefield and Battle Creek Lake. St. Croix Watershed Research Station, 2010.*

- *Wicklander's Pond to Wakefield Lake BMP Feasibility Study. Barr Engineering Company, 2014*
- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District*. Barr Engineering Co., Draft 2016.
- *Ramsey-Washington Metro Watershed District Total Maximum Daily Load Study*. Barr Engineering Co., Draft 2016.

2.9.1.2 Land Use

The Wakefield Lake watershed comprises a total of approximately 944 acres in portions of Maplewood and North St. Paul. The dominant land use in the watershed is low-density residential with a mixture of other land uses (Figure 2.9-2). Wakefield Lake is bordered by parkland owned by the City of Maplewood on the north and east sides of the lake. Future land use conditions are not expected to significantly differ from existing land use conditions, and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that controls the runoff rate and volume of the redeveloped site.

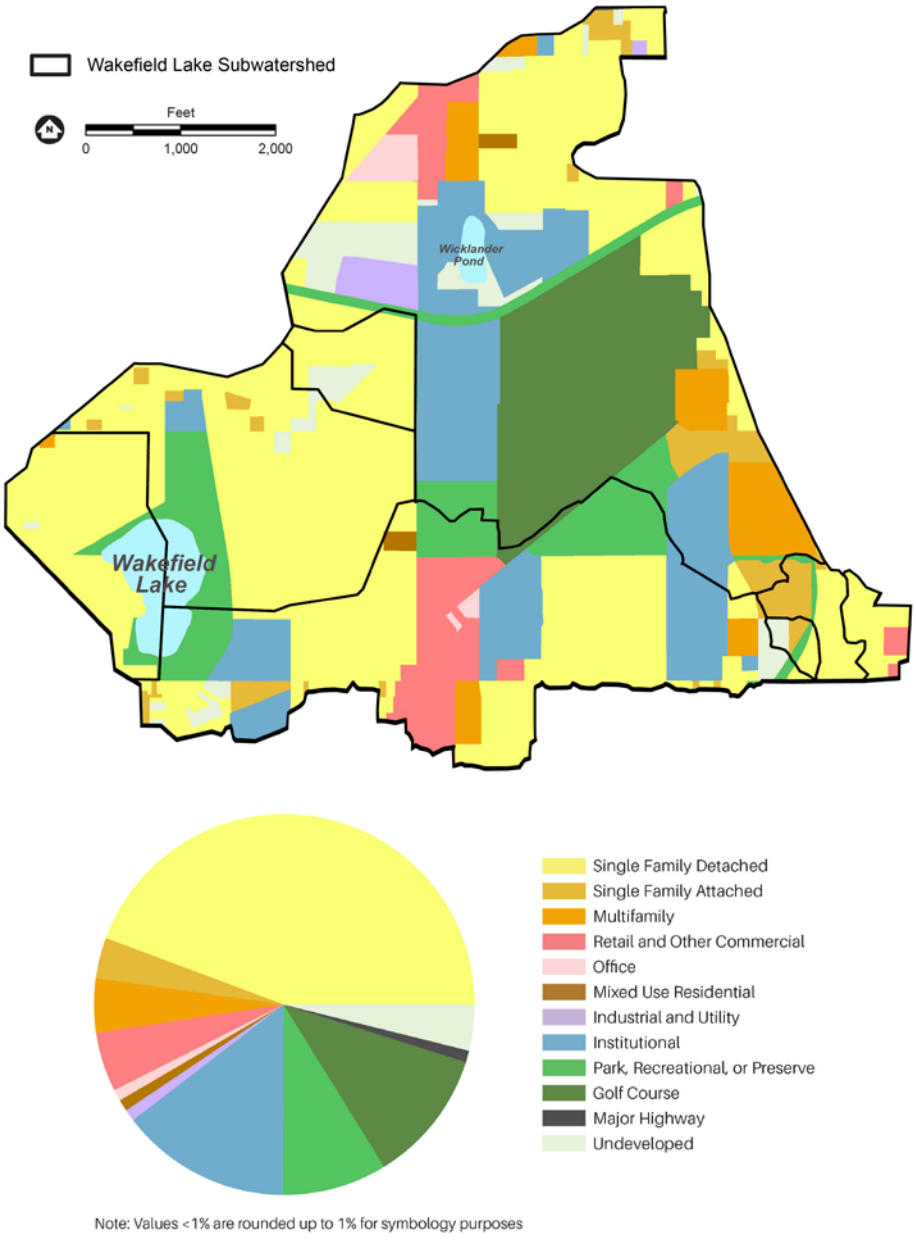


Figure 2.9-2 Breakdown of landuses throughout the Wakefield Lake Subwatershed (Met Council 2010 Landuse Information)

2.9.1.3 Drainage Patterns and Waterbodies

Discharge from Wakefield Lake flows over a stoplog weir into a 66 inch diameter pipe to Lake Phalen. Wakefield Lake receives runoff from three storm sewer outfalls (one from the Larpenteur Avenue storm sewer, one from a storm sewer that travels under Wakefield Park to drain the northeast tributary area, and one outfall on the northwest side of the lake), as well as sheet flow runoff from the lake's immediate drainage area.

For hydrologic modeling and management purposes, the Wakefield Lake subwatershed has been divided into numerous drainage areas, which are shown on Figure 2.9-10: arrows indicating the direction of flow from each area are included in the figure. Figure 2.9-10 also shows the estimated flood elevation in storage areas for the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts for the RWMWD (Section 1.12.3).

District-managed waterbodies within the Wakefield Lake subwatershed include only Wakefield Lake.

The wetlands within the Wakefield Lake subwatershed are also shown in Figure 2.9-10. The wetlands are color-coded based on the RWMWD wetland management classifications (Section 1.11.3).

2.9.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Wakefield Lake.

2.9.2.1 Historic Water Quality

The Ramsey County Department of Public Works staff samples the water quality of Wakefield Lake about 7 times per year on average, between the months of May and September. Figure 2.9-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.9-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Wakefield Lake relative to MPCA standards.

Table 2.9-2 Wakefield Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Wakefield Lake (2002-2011) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	106
Chlorophyll-a (µg/L)	≤ 20	29
Secchi disk transparency (m)	≥ 1.0	1.5

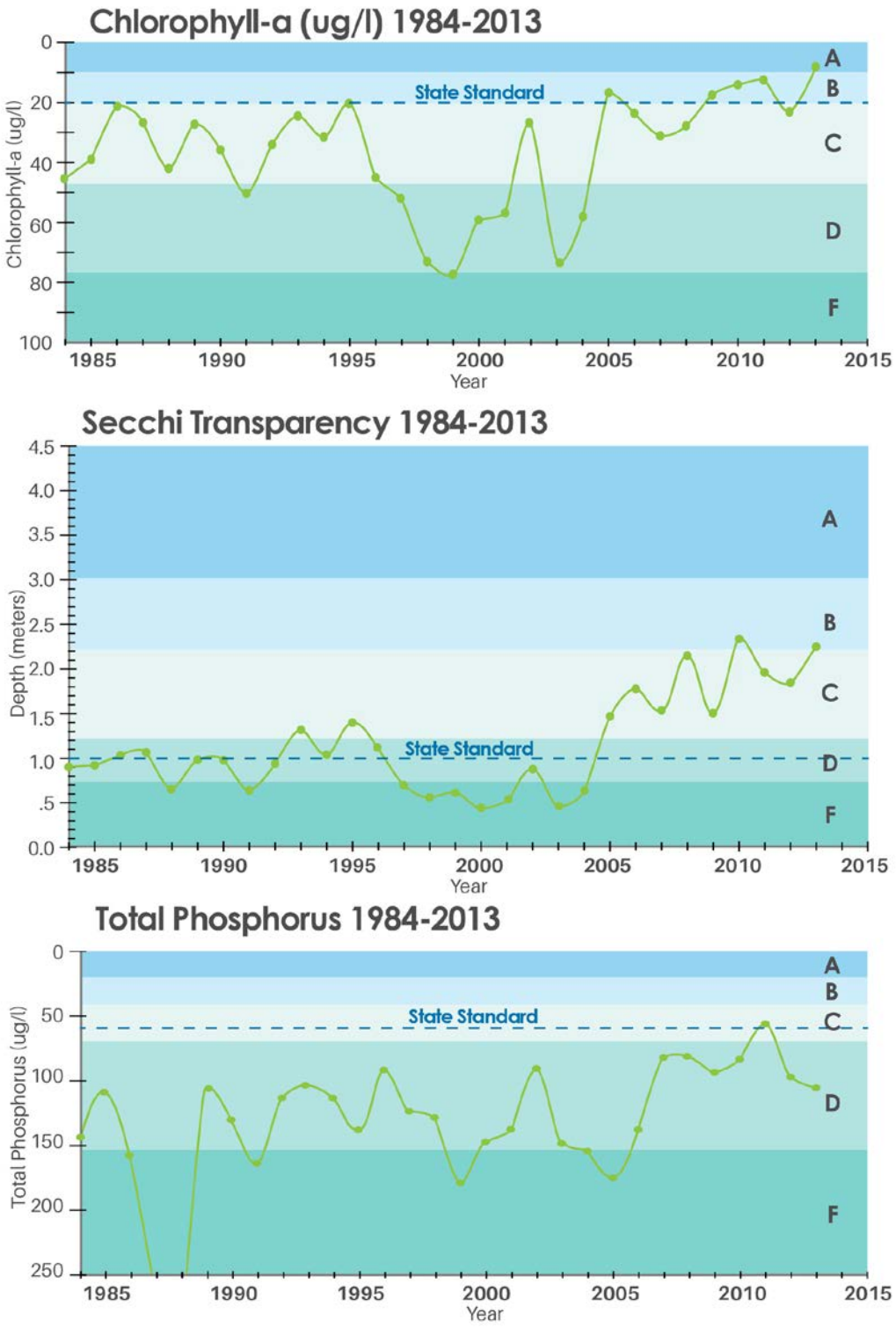


Figure 2.9-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Wakefield Lake (1984-2013)

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Wakefield Lake water quality data. The results of these analyses are shown in Table 2.9-3.

Table 2.9-3 Trend Analysis Results for Wakefield Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Wakefield Lake	1984 – 2012	Secchi Depth	Improving	Improving
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	Improving*	Improving

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

Sediment cores were taken from the lake in 2009 to assess the lake's internal phosphorus loading potential from sediment release. The sediment cores were also used to evaluate the water quality in the lake before European settlement. Fossilized algae in the lake were used to reconstruct the historical water quality of Wakefield Lake. By analyzing the types of diatom fossils in the core, scientists from the St. Croix Watershed Research Station were able to tell that, since the time of European settlement, Wakefield Lake has changed from having a moderate level of nutrients (mesotrophic) to having a high level of nutrients (eutrophic) that promote significant algal growth.

2.9.2.2 State of the Fishery

The MDNR assessed the Wakefield Lake fish population in 2011. According to the assessment, available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html), the lake's fishery is primarily comprised of black bullhead, black crappie, bluegill sunfish, golden shiner, hybrid sunfish, northern pile and yellow perch. Bluegill, black crappie, yellow perch and northern pike have been stocked in the lake since 2007. During an evaluation of the Phalen Chain of Lake's carp population in 2009 by the University of Minnesota's Sorensen Lab, no carp were found in Wakefield Lake.

2.9.2.3 State of the Macrophyte (Large Aquatic Plant) Community

The results of Wakefield Lake's June 29, 2012 macrophyte survey are summarized below in Figure 2.9-4. 91 sites were surveyed for macrophytes. Of these, 90 had vegetation, indicating that Wakefield Lake is a highly macrophyte-dominated lake.

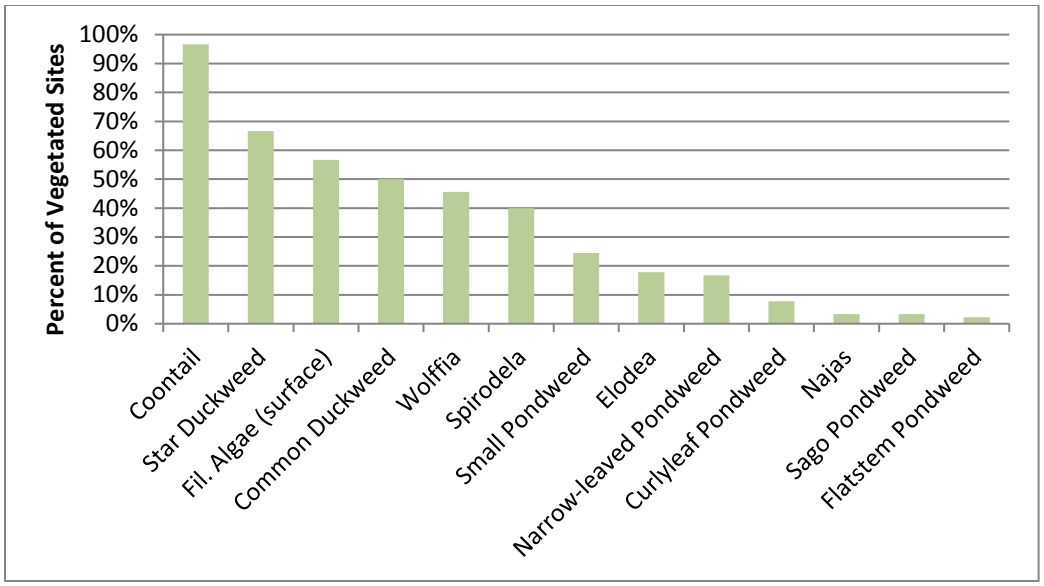


Figure 2.9-4 June, 2012 Wakefield Lake Macrophyte Survey Results

Where coontail, Flatstem Pondweed and filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Wakefield Lake. Filamentous green algae, while not actually a macrophyte, are notable because they can grow in abundance on other lake macrophytes, creating an aesthetic and recreational nuisance. Also, curlyleaf pondweed, an invasive species that can add phosphorus to the water column as it dies back in mid-summer, was found in the 2012 survey.

2.9.2.4 Water Quality Modeling

As part of the TMDL study process, water quality models were developed to estimate the sources of phosphorus to Wakefield Lake. A stormwater runoff model estimated the water and total phosphorus loads from the tributary watershed and an in-lake mass balance model was used to assess the impact of watershed loading on the lake and determine the amount of internal phosphorus loading in Wakefield Lake. The water quality models developed for Wakefield Lake are described in detail in the RWMWD TMDL Report (Draft, Barr Engineering, 2016).

The District also created a 2-dimensional model that shows how stormwater mixes within Wakefield Lake. Model results are shown in Figure 2.9-5 Wakefield Lake Mixing Patterns. This analysis revealed that stormwater entering from the northeast and northwest sides of the lake (shown in red) have the most influence on the lake's water quality, and the stormwater entering from the Larpenteur storm sewer (southeast, shown in blue) has the least. This is because the stormwater from the Larpenteur storm sewer mostly travels directly to the lake's outlet on the west side of the lake. The four images in Figure 2.9-5 show the modeled progression of stormwater mixing in the lake during a June, 2013 storm event.

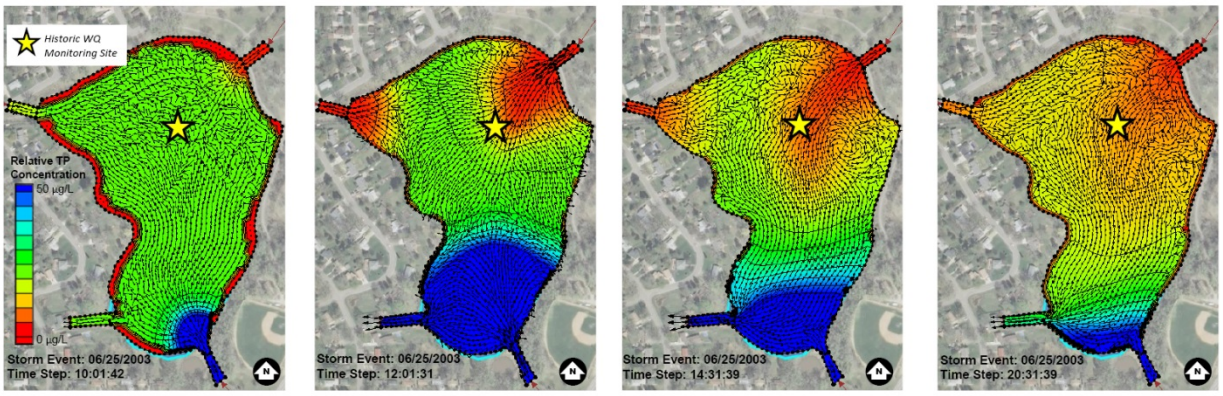


Figure 2.9-5 Wakefield Lake Mixing Patterns

Figure 2.9-6 shows the main drainage districts contributing flow and phosphorus loading to Wakefield Lake. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake.

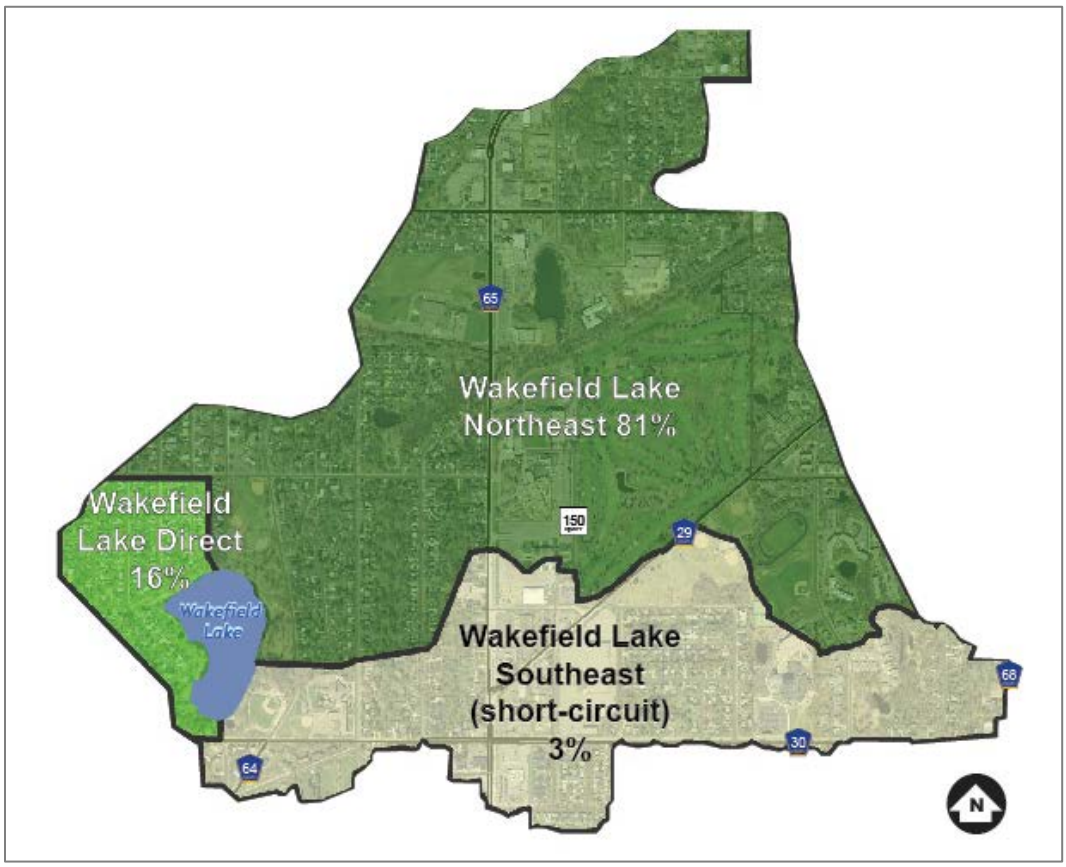


Figure 2.9-6 Drainage districts in the Wakefield Lake Subwatershed

The drainage districts to Wakefield Lake are summarized below:

- **Wakefield Lake Northeast Drainage District—**This 595-acre drainage district northeast of the Wakefield Lake represents approximately 63% of the total area tributary to Wakefield Lake, and delivers 81% of the total phosphorus load to the lake. Runoff from this drainage district flows through a series of ponds (such as Wicklander's Pond), ditches, and storm sewers before reaching Wakefield Lake through a storm sewer that runs below Wakefield Park.

- **Wakefield Lake Direct Drainage District—**This 65-acre drainage district northwest of the lake represents 7% of the area tributary to Wakefield Lake and 16% of the total phosphorus load to the lake. Runoff from this drainage district flows through residential areas and then through a storm sewer that outlets on the northwest side of the lake.

- **Wakefield Lake Southeast Drainage District—**This 284-acre drainage district southeast of the lake represents 30% of the area tributary to Wakefield Lake. Runoff from this drainage district is delivered through a large storm sewer that runs below Larpenteur Avenue, outletting into the southeast side of the lake, directly across from the lake's outlet. Runoff from this drainage district effectively short circuits the main body of Wakefield Lake, thereby contributing an effective total phosphorus load that is only estimate to be 3% of the total.

The pie chart shown in Figure 2.9-7 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads (June 1, 2004-September 30, 2004 growing season).

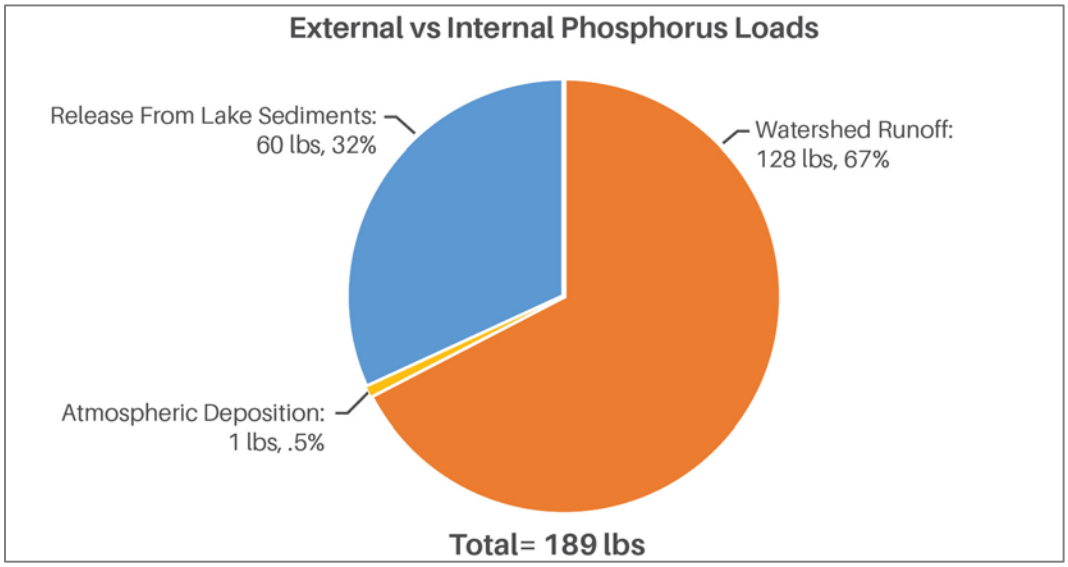


Figure 2.9-7 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Wakefield Lake

2.9.2.5 Water Quality Goals

The water quality goals for Wakefield Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.9-2.

Table 2.9-4 summarizes the beneficial use data for Wakefield Lake as well as the status of TMDLs for the various impairments (if applicable, see Section 1.10.2) and the RWMWD nutrient water quality classification of the lake. The data included in Table 2.9-4 are based on data available through the MPCA Environmental Data Access website.

Table 2.9-4 Assessment status of Wakefield Lake

Lake ID	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Water Quality Classification*
Wakefield Lake 62-0011	Imp (Excess Nutrients)	NA	IF (At Risk of Chloride Impairment)	Draft Nutrient TMDL to be completed in 2017.	Impaired

* RWMWD nutrient water quality classifications are described in Section 1.10.3.

Imp = Impaired
IF = the data collected was insufficient to make a finding
NA = not assessed

Wakefield Lake was originally listed on the MPCA 303(d) Impaired Waters List in 2002 due to excessive nutrients, with the pollutant of concern being identified as phosphorus. Wakefield Lake is a shallow lake in the North Central Hardwood Forest ecoregion of Minnesota. The RWMWD TMDL (Draft, Barr Engineering, 2016) summarizes the growing season total phosphorus budget for the critical conditions for Wakefield Lake, including the wasteload allocations by MS4s and load allocations developed in the RWMWD Total Maximum Daily Load Report (Draft, Barr Engineering Company, 2016) . The Wakefield Lake TMDL calls for a 41% reduction in total phosphorus from the tributary watershed (called a "wasteload" reduction), and a 60% reduction in the lake's internal load (called a "load" reduction). The baseline year by which this reduction will be measured is 2004.

2.9.2.6 Tracking TMDL Implementation Progress

The Wakefield TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016) calls for a 52 lbs per growing season reduction in phosphorus through projects implemented after 2004. Progress towards this goal has been achieved, and will continue, through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.9-8. The level shown on the "Phosphorus Reduction" bar in Figure 2.9-8 indicates the District's progress toward the Wakefield Lake phosphorus reduction goal as of December 31, 2015 as a result of District efforts.

2.9.2.7 District project example in the Wakefield Lake Subwatershed

In 2011, the District constructed an experimental stormwater filter made of "spent" lime from drinking water treatment processes, installed on the south side of Wakefield Lake (Figure 2.9-9). The lime removes high levels of phosphorus and other pollutants from the stormwater before it reaches the lake.

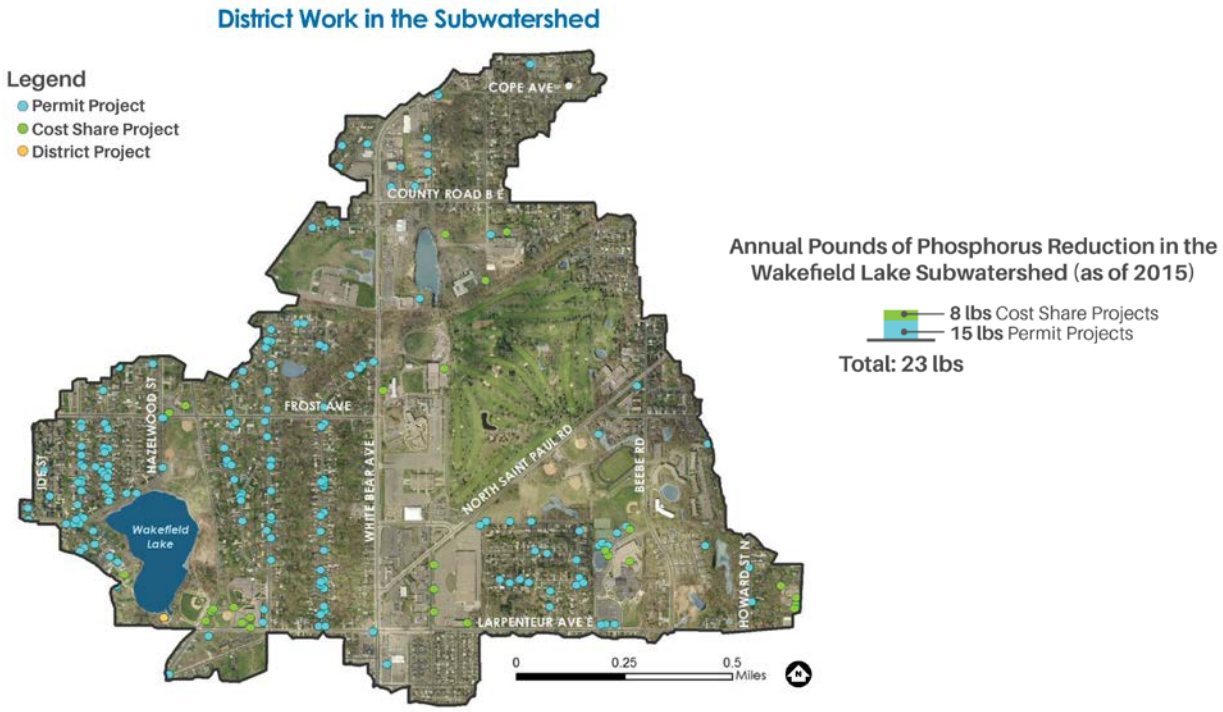


Figure 2.9-8 District work in the Wakefield Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015



Figure 2.9-9 District project example in the Wakefield Subwatershed: Spent Lime Filter

2.9.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. In 2015, the District supported this goal by updating their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Wakefield Lake subwatershed are the new 100-year flood elevations shown in Figure 2.9-10. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.9.4 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

2.9.5 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Wakefield Lake subwatershed are shown in Figure 2.9-11, indicating areas where the lake levels of waterbodies in the Wakefield Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.9.6 Future Implementation Activities

Based on the RWMWD TMDL report and several feasibility studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals for Wakefield Lake (Table 2.9-5). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

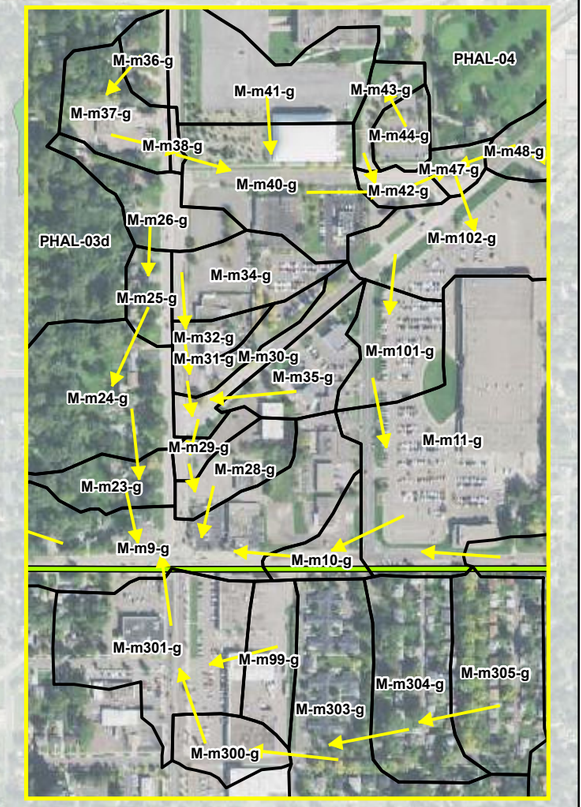
Table 2.9-5 Wakefield Lake Subwatershed Implementation Activities

Activity ID No.	Wakefield Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
WL-1*	Implement regional stormwater treatment BMPs in the subwatershed as prescribed in the Wakefield TMDL (Examples include: Enhanced treatment of flows through PHAL-05, Wakefield Park and expansion of spent lime treatment cell on the south end of Wakefield Lake)	**2017-2020**	**$1,000,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
WL-2*	Implement a shoreline management study and assist property owners/homeowners with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
WL-3*	Research future options for control of Wakefield Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
WL-4*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Wakefield Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
WL-5*	Evaluate water quality benefit of removing accumulated sediment from south end of Wakefield Lake to the improve Lake Phalen water quality.	**2018**	**$20,000**	**WQ2**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Drainage Area	100-Year WSE
POND3	1014
M-m56-g	1011.5
POND2	1010.5
POND1	1010.5
PHAL-04B	1002.2
M-m54-g	1001.8
M-m16-g	985.2
POND6	982.2
M-m55-g	978.7
M-m49-g	976.2
M-m48-g	975.2
M-m43-g	964
M-m41-g	964
M-m42-g	964
M-m40-g	963.9
M-m9-g	939.7
M-m301-g	938.2
m-M5-g	917.9
PHAL-05a	908.5
PHAL-04	908.5
PHAL-05b	904.1
PHAL-03d	903.4
PHAL-03	889.5



North Knucklehead Lake Lake

South Avenue

PHAL-05a

PHAL-04

PHAL-05b

White Bear Avenue

Goodrich Golf Course

PHAL-03e

Frost Avenue

N St Paul Road

PHAL-03d

POND6

PHAL-03

Wakefield Lake Lake

PHAL-04B

POND3

M-m6-g

POND2

m-M5-g

POND1

Larpenteur Avenue

Frost Lake Lake

Drainage Area Outflow
Subwatershed Outflow
Drainage Areas
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Figure 2.9-10

WAKEFIELD LAKE SUBWATERSHED DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

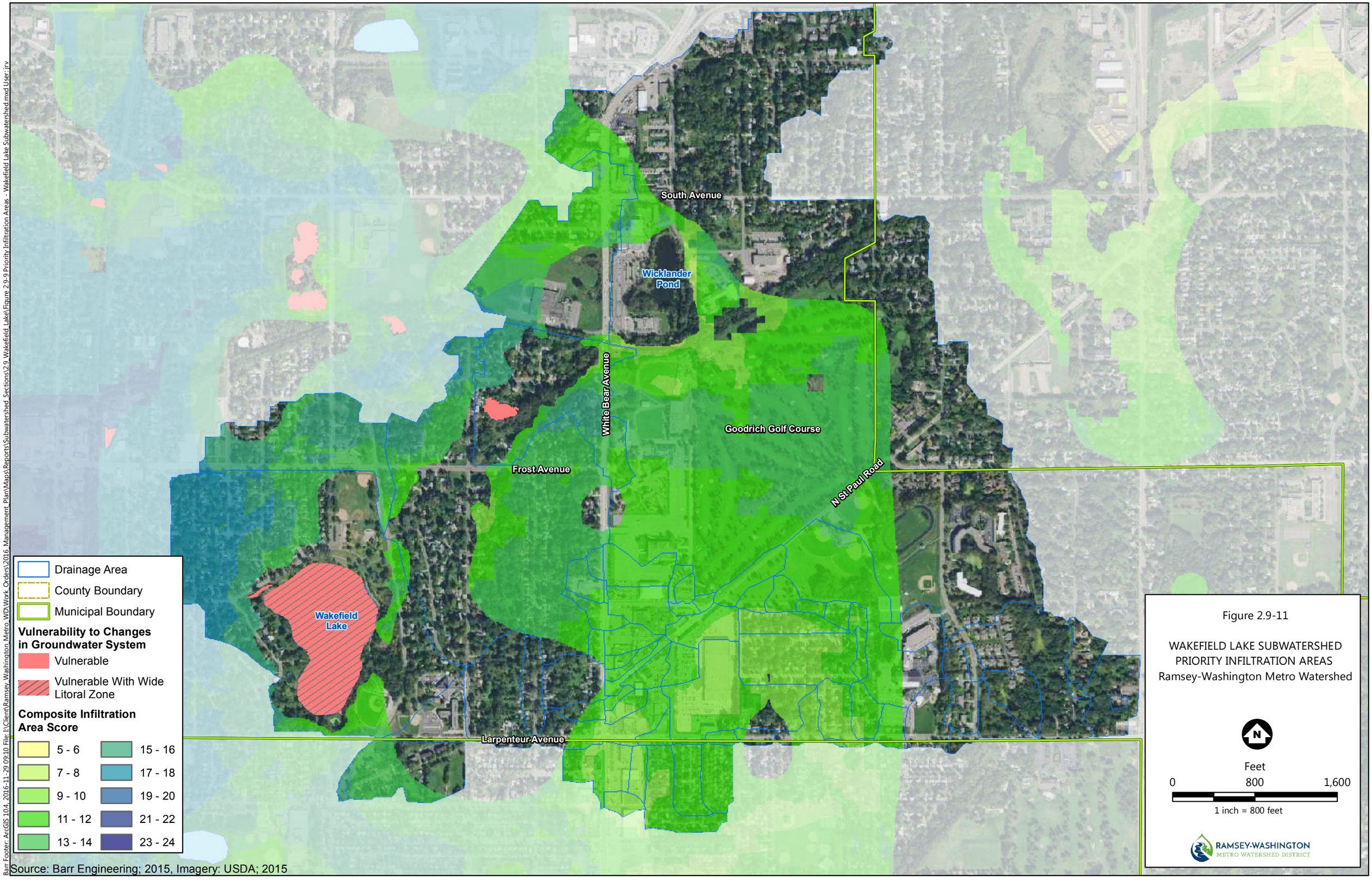
N

Feet
0 800 1,600
1 inch = 800 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Source: Barr Engineering, 2015; Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4, 2016-11-23 11:03 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.9_Wakefield_Lake\Figure 2.9-8 - Subwatershed Drainage Patterns - Wakefield Lake Subwatershed.mxd User: jrv



Barr Footer: ArcGIS 10.4, 2016-11-29 09:10 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.9_Wakefield_Lake\Figure 2.9-9 Priority Infiltration Areas - Wakefield Lake Subwatershed.mxd User: jrv

2.10 Beaver Lake Subwatershed

2.10.1 General Description

The Beaver Lake subwatershed covers 1,908 acres in the cities of St. Paul, Maplewood, and Oakdale (see Figure 2.10-1). Approximately three-quarters of the subwatershed is located in Ramsey County and approximately one-quarter in Washington County. The subwatershed drains to Beaver Lake, which is a District-managed lake located in Ramsey County, primarily in the city of Maplewood. Outflows from the Beaver Lake subwatershed discharge to the Beltline Interceptor storm sewer system (see Section 2.11).

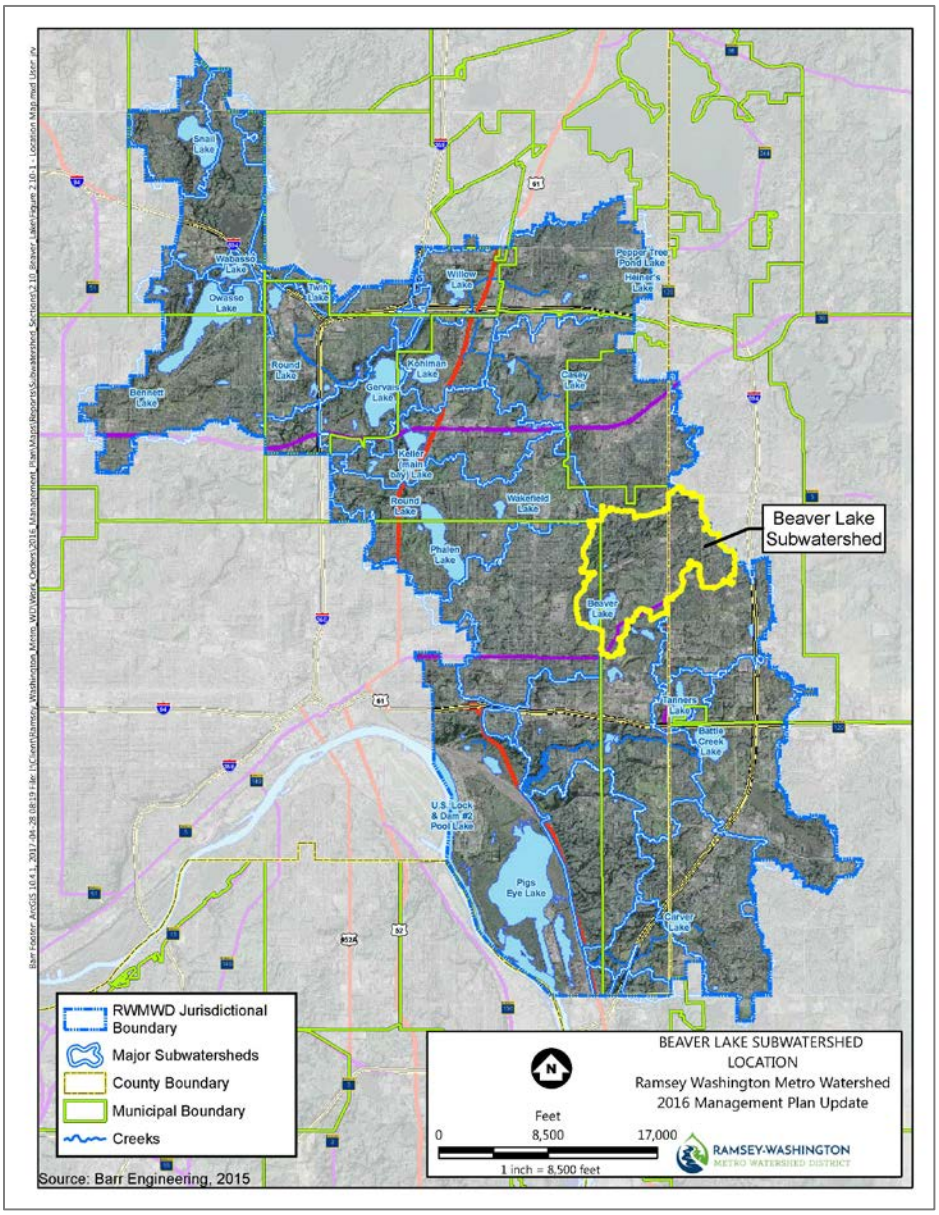


Figure 2.10-1 Beaver Lake Location Map

Beaver Lake is a MDNR public water (MDNR# 62-0016P) with a surface area of approximately 87 acres (including the wetlands that fringe the lake), a maximum depth of 11 feet, and a mean depth of 4 feet. Most of the lake is less than 8-feet deep, with the littoral area comprising 87 acres or 100% of the lake (MDNR Lakefinder Data). By MPCA definition, Beaver Lake is considered a shallow lake (a maximum depth of less than 15 feet and/or at least 80% of the lake less than 15-feet deep). Beaver Lake is a fishing lake used lake primarily for canoeing, fishing, picnicking, wildlife habitat, and aesthetic viewing. A Ramsey County park occupies most of the north and west shoreline. Additionally, there is no public boat access although there is a fishing pier on the west shoreline within the county park. Beaver Lake has an aerator that is operated to prevent winterkill.

Table 2.10-1 Beaver Lake Subwatershed Facts

Tributary Area (Direct)	1,935 acres
Tributary Area (Total)	1,935 acres
Downstream Watershed	St. Paul Beltline
MDNR Designation[1]	62-0016P
Lake Surface Area[1]	87 acres
Lake Mean Depth[1]	4 ft
Lake Maximum Depth[1]	11 ft
Lake Outlet Type[1]	36" Reinforced Concrete Pipe
Lake Outlet Elevation[1]	951.4 ft
100-Year Flood Level[1]	955.0 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake ; Impaired for Aquatic Consumption (mercury food consumption advisory), at risk of impairment for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Maplewood, St. Paul, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data for Beaver Lake

2.10.1.1 Past Studies

The following list is a summary of past studies related to Beaver Lake and/or its tributary subwatershed.

- *Report to RWMWD on the Water Quality of Beaver and Wakefield Lakes*. Ramsey County Department of Public Works, March 1985.
- *Report to RWMWD on the Water Quality of Beaver and Wakefield Lakes*. Ramsey County Department of Public Works, June 1986.

- *Beaver Lake Phase I Report: Summary of Current Conditions.* Prepared for RWMWD by Barr Engineering, August 2001.
- *Beaver Lake Strategic Lake Management Plan.* Prepared for RWMWD by Barr Engineering, March 2005.
- *DRAFT Feasibility Study for Replacement of Beaver Lake Outlet.* Prepared for RWMWD by Barr Engineering, June 2005.
- *DRAFT Beaver Lake Total Maximum Daily Load Report.* Prepared for RWMWD by Barr Engineering, September 2005.
- *Discussion of Water Quality Goals for Beaver Lake and Carver Lake.* Prepared for RWMWD by Barr Engineering, January 2006.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.10.1.2 Land Use

The Beaver Lake subwatershed is fully developed. Residential land uses of various densities are the predominant land uses (see Figure 2.10-2). Other land uses within the subwatershed include park, recreational, or preserve land uses and some industrial land uses in the northeast portion of the subwatershed. The Metropolitan Council's estimated 2030 land use anticipates very little land use change in the future, including the possible increase of industrial and commercial land use in the northeast (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

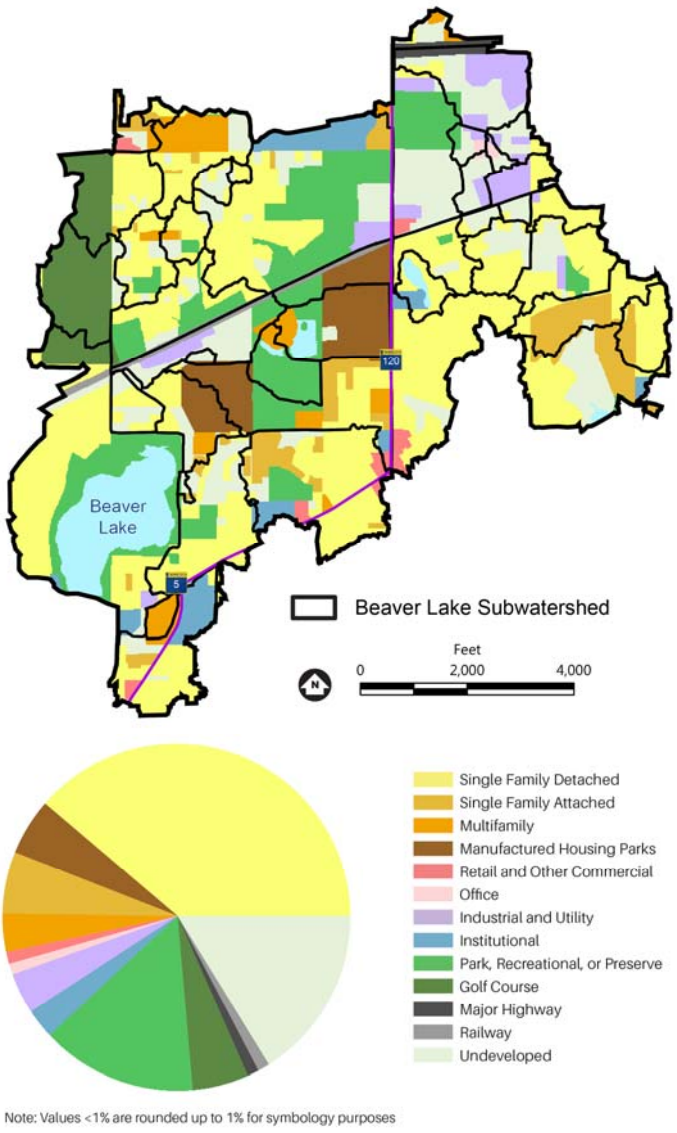


Figure 2.10-2 Breakdown of land uses throughout the Beaver Subwatershed (2010 Metropolitan Council)

2.10.1.3 Drainage Patterns and Waterbodies

The stormwater system within the Beaver Lake subwatershed is comprised of detention ponds, wetlands, storm sewers, drainage ditches, and overland flow paths, which all eventually drain to Beaver Lake (see Figure 2.10-8). Outflows from Beaver Lake flow directly into the Beltline Interceptor storm sewer system, which eventually discharges into the Mississippi River near the Metro Wastewater Treatment Plant.

The Beaver Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.10-8). Figure 2.10-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Beaver Lake subwatershed include only Beaver Lake.

Wetlands within the Beaver Lake subwatershed are shown in Figure 2.10-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.10.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Beaver Lake.

2.10.2.1 Historical Water Quality

The Ramsey County Department of Public Works staff samples the water quality of Beaver Lake about 7 times per year on average, between the months of May and September. Although the Ramsey County Department of Public Works has been collecting water quality monitoring data from Beaver Lake since 1974, only data from 1983 to present was analyzed to reflect more recent development conditions in the Beaver Lake subwatershed.

Figure 2.10-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.10-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Beaver Lake relative to MPCA standards. Beaver Lake was previously listed on the MPCA's Impaired Waters 303(d) List for excess nutrients (see Section 1.10.2). The RWMWD developed a draft TMDL report for the lake based on the Beaver Lake SLMP. Based on actions taken within the watershed to reduce nutrient load and improved water quality observed since its original listed, the MPCA removed Beaver Lake from the 2014 impaired waters list.

The RWMWD has assigned a water quality classification of "At Risk" to Beaver Lake based its recent removal from the impaired waters list and recent water quality data (see Table 2.10-2).

Table 2.10-2 Beaver Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Beaver Lake (2001-2010) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	70
Chlorophyll-a (µg/L)	≤ 20	11.9
Secchi disk transparency (m)	≥ 1.0	2.0

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Beaver Lake water quality data. The results of these analyses are shown in Table 2.10-3.

Table 2.10-3 Trend Analysis Results for Beaver Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Beaver Lake	1984 – 2012	Secchi Depth	Improving	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

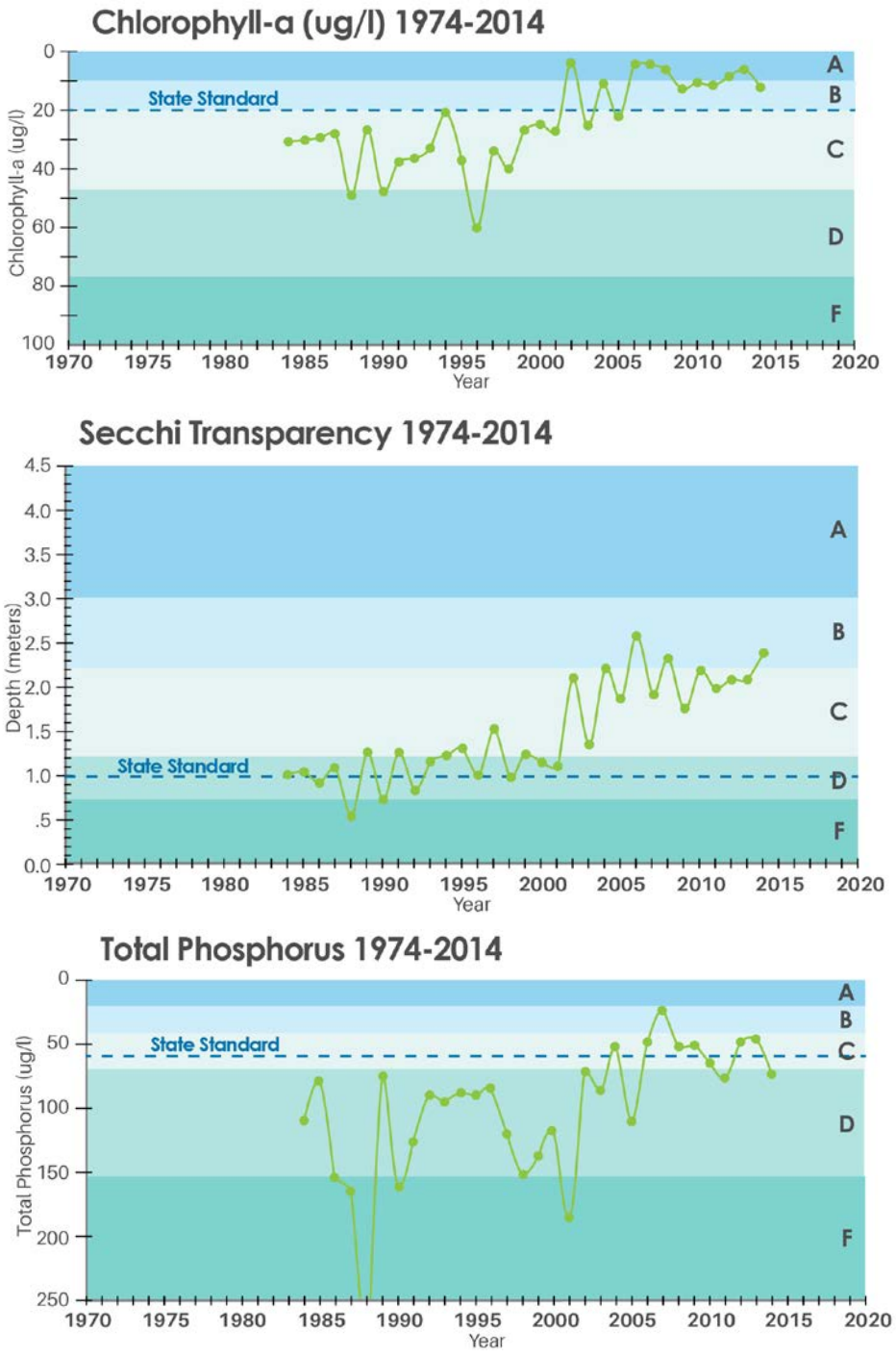


Figure 2.10-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Beaver Lake (1974-2014)

2.10.2.2 State of the Fishery

In 1992, the MDNR classified Beaver Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Beaver Lake is a Class 40 lake, which signifies a small, shallow lake that is subject to occasional winterkill (Schupp, 1992).

The Beaver Lake sport fish community consists of black crappie, bluegill, channel catfish, hybrid sunfish, largemouth bass, northern pike, pumpkinseed sunfish, and yellow perch. The MDNR actively manages the fishery in Beaver Lake by stocking a variety of fish. Fingerling and yearling channel catfish have been stocked every year from 1997 to 2009.

In addition to its stocking activities, the MDNR periodically assesses the Beaver Lake fish population. The last MDNR survey was performed in 2010. Data is available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html). Northern pike gill net catches have stayed consistent the last 3 fish surveys (2000, 2005, and 2010) ranging from 5 to 6 pike per gillnet. Gill netted pike averaged 17.6 inches and 1.9 lb. Beaver Lake has a history of providing a quality largemouth bass fishery. Two largemouth bass averaging 16 inches and 2.7 lb. were caught in trap nets. Two age-6 (2004 yearling stocking) channel catfish averaging 16.9 inches were sampled using both gill and trap nets in 2010. Anecdotal angler information has revealed anglers are catching adult channel catfish.

Panfish numbers varied during 2010 fish survey. Bluegill numbers were down from 2005. Of the 272 bluegills sampled using trap nets, approximately 63% were above 6.0 inches with no fish exceeding 7.5 inches. Black crappie and yellow perch numbers were low in 2010. Yellow perch relative abundance ranged from 22 to 186 perch per gillnet in the four fish surveys prior to 2005 (1980, 1990, 1995, and 2000) before dropping to less than 2 perch per gillnet in 2005 and 2010. The establishment of predator populations (largemouth bass and northern pike) may have led to decreases in perch numbers in 2005 and 2010.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Beaver Lake based on the presence of mercury. More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.10.2.3 State of the Macrophyte Community

On June 3, 2014, Ramsey Conservation District and Ramsey County Public Works Environmental Resources staff conducted a macrophyte survey of Beaver Lake. The results of this survey are summarized in Figure 2.10-4. 68 sites were surveyed for macrophytes. Of these, 66 had vegetation, indicating that Beaver Lake is a macrophyte dominated lake.

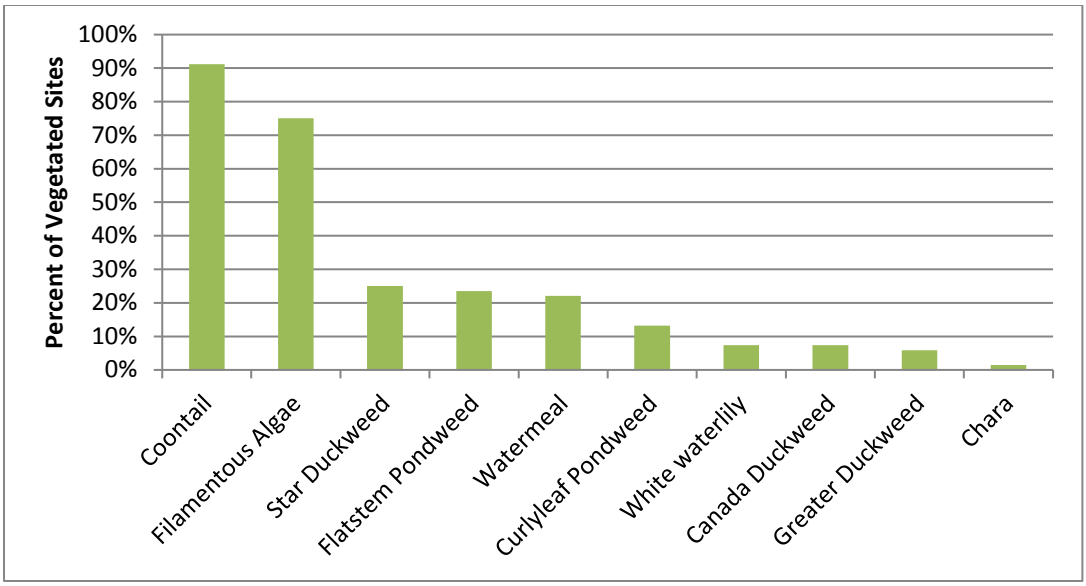


Figure 2.10-4 June, 2014 Beaver Lake Macrophyte Survey Results

Where coontail was found in the lake, it was present in high abundance relative to other macrophyte species in Beaver Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Although Eurasian watermilfoil was not detected in the 2014 survey, it is known to be present in the lake. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.10.2.4 Water Quality Modeling

The District performed water quality modeling of the Beaver Lake subwatershed as part of developing the *Beaver Lake Strategic Lake Management Plan* (SLMP) in 2004. A stormwater runoff model estimated the water and total phosphorus loads from the tributary watershed, and an in-lake mass balance model was used to assess the impact of watershed loading and determine the amount of internal phosphorus loading in Beaver Lake.

The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future best management practices (BMPs). The water quality models developed for Beaver Lake were used in the development of a draft total maximum daily load (TMDL) study for Beaver Lake in 2005. The water quality models developed for Kohlman Lake are described in detail in the *Draft Beaver Lake TMDL Report* (Barr, 2005). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the Beaver Lake subwatershed. The model was calibrated to water quality and stream flow monitoring data collected at the largest inflow to the lake during the summer of 1999. Modeled results were calculated for a range of climatic conditions to evaluate the variability of runoff and phosphorus loading under different hydrologic conditions.

The model results were used to estimate the amount of phosphorus reaching Beaver Lake from various drainage districts. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.10-5 shows the main drainage districts contributing flow and phosphorus loading to Beaver Lake.

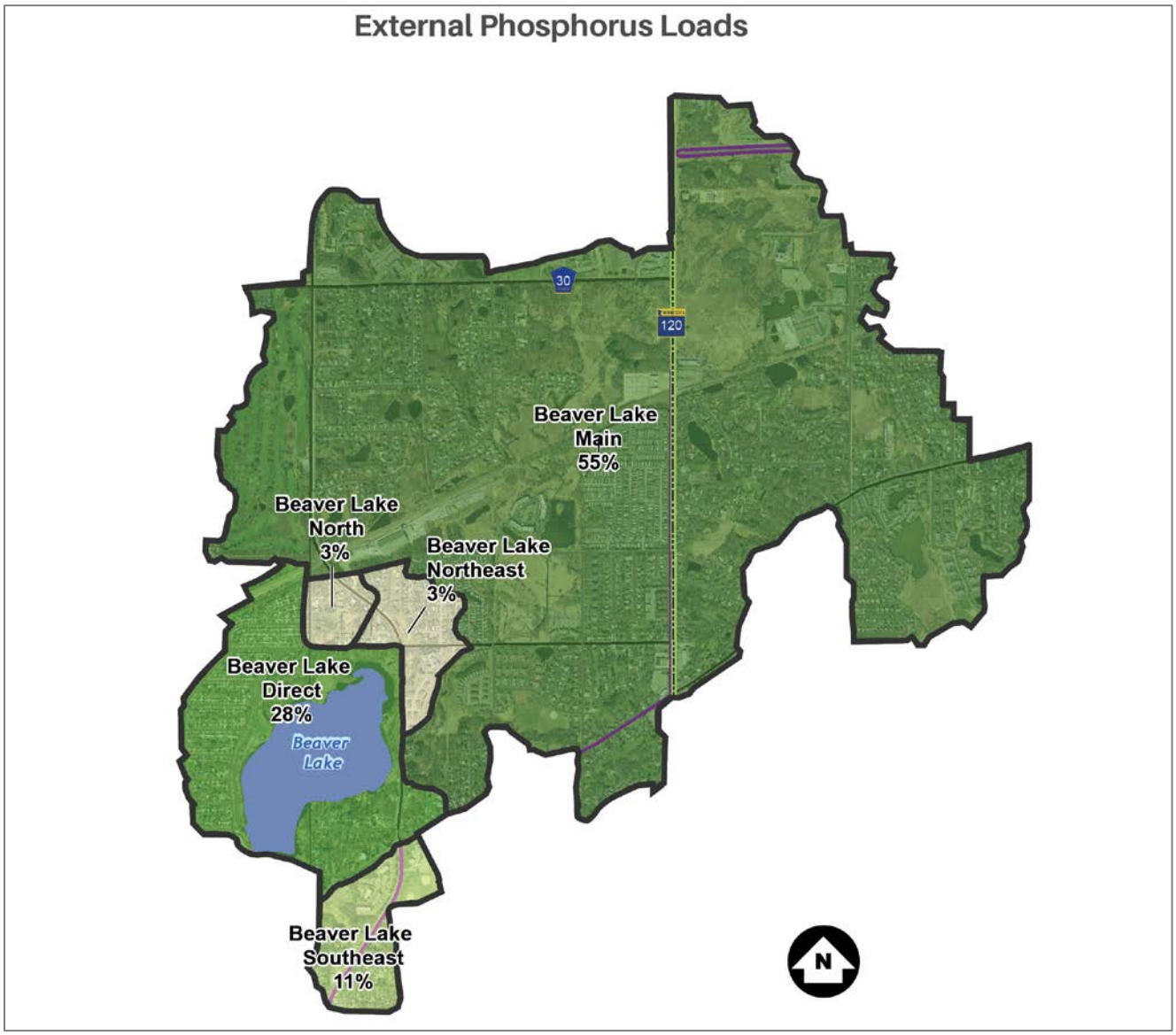


Figure 2.10-5 Drainage districts in the Beaver Lake subwatershed

An in-lake mass balance water quality model was also completed as a part of the SLMP to assess the impact of watershed loading and internal phosphorus loading on the water quality of Beaver Lake. Through this analysis, it was estimated that internal loading of total phosphorus could contribute up to 25% of the total average phosphorus loading to Beaver Lake. It was concluded that much of this internal loading is due to the release of phosphorus from the lake sediment, which typically occurs in late-July/early-August. Modeling results also indicate that further internal phosphorus loading from the

die-off of curlyleaf pondweed, typically in early-July, also impacts the lake water quality. These two processes, and thus the degree of internal loading to the lake, appear to be heavily dependent upon climatic conditions. The pie chart shown in Figure 2.10-6 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads.

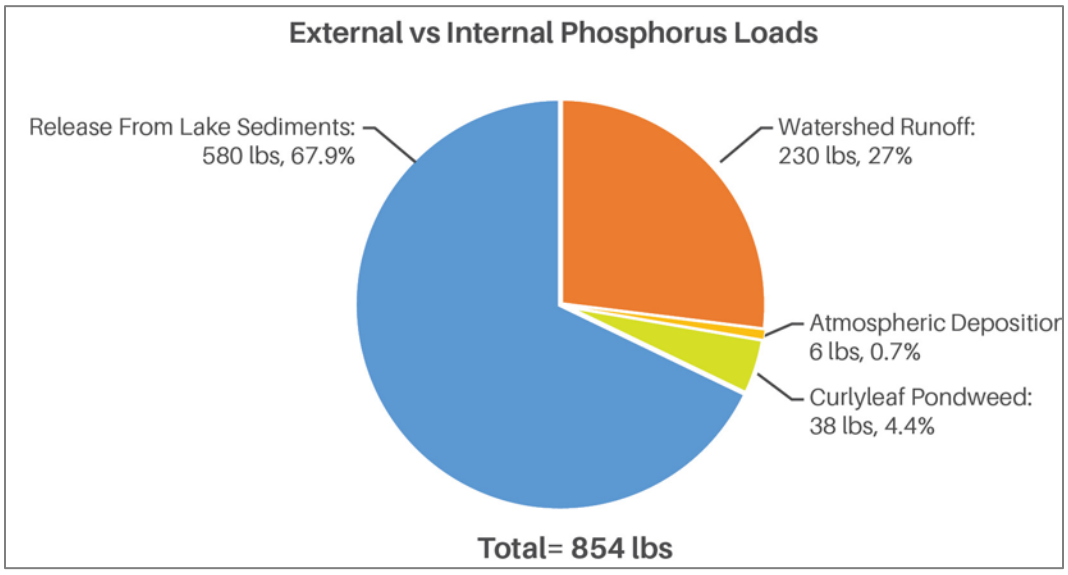


Figure 2.10-6 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Beaver Lake

2.10.2.5 Water Quality Goals

The water quality goals for Beaver Lake are consistent with the MPCA's shallow lake eutrophication standard for lakes in the North Central Hardwoods Forest Ecoregion shown in Table 2.10-2. The RWMWD will continue to evaluate water quality data in Beaver Lake for trends and adjust its water quality classification and management activities accordingly. Projects implemented in the Beaver Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.10-7.

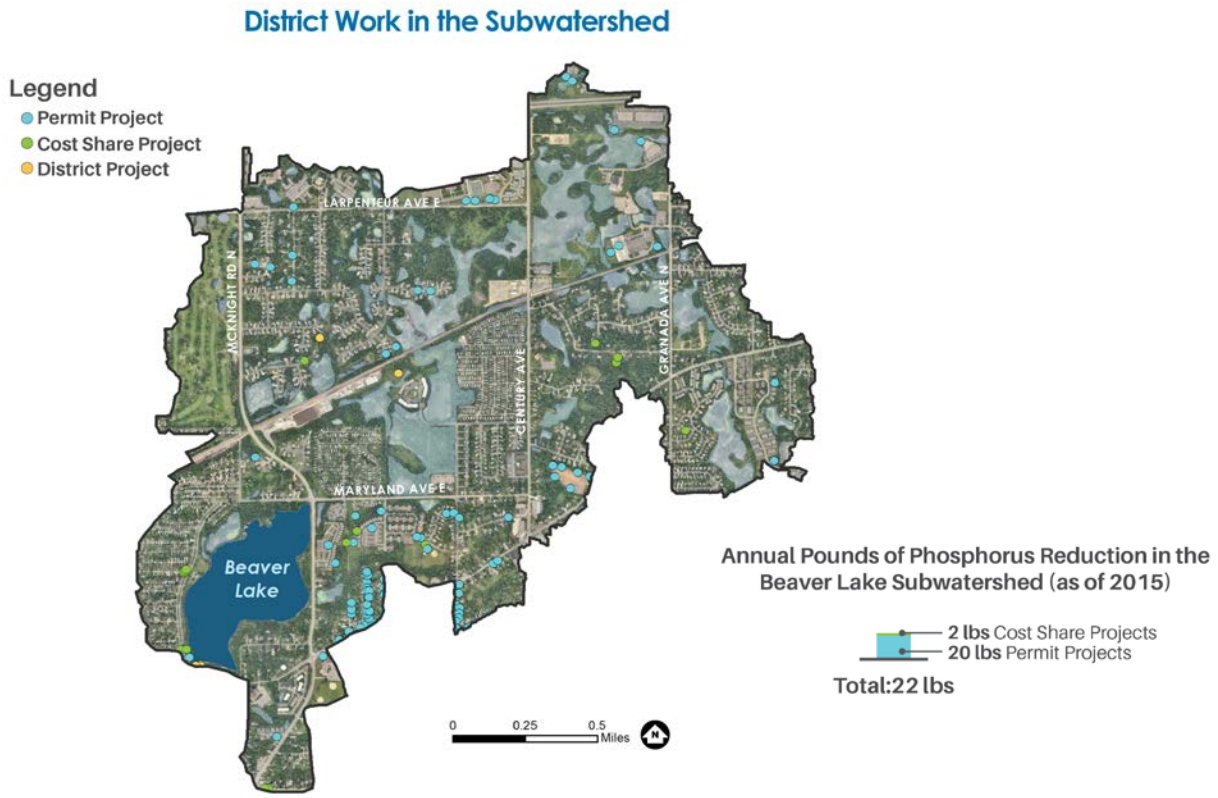


Figure 2.10-7 District work in the Beaver Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.10.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District performed hydrologic and hydraulic modeling for the Beaver Lake subwatershed as part of developing the 1997 RWMWD Plan. That analysis was used to estimate 100-year flood levels and identify potential flooding problems and recommend improvements. No significant flooding issues were identified in the Beaver Lake subwatershed as part of the 1997 study.

In 2005, RWMWD completed a study to assess the feasibility of modifying or replacing the outlet from Beaver Lake (Barr, 2005). The existing outlet included a horizontal tubular steel grate that served as a trash rack. The steel grate collected significant quantities of floating debris, which could result in significant flow restrictions through the steel grate. The study estimated that during high flow events, the capacity of the outlet was restricted to approximately one-third of its unobstructed capacity. As a result of the study, the District designed and installed a new trash rack that would to allow design flows to be conveyed out of Beaver Lake even if the trash rack was 80% plugged. The purpose of the project was to reduce flood levels in Beaver Lake and reduce outlet cleaning frequency. As a part of the project, the shoreline near the outlet was restored with native vegetation including forbs, grasses and shrubs

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Beaver Lake subwatershed are the new 100-year flood elevations shown in Figure 2.10-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.10.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Beaver Lake subwatershed are shown Figure 2.10-9, indicating areas where the water levels of waterbodies in the Beaver Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.10.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

RWMWD Natural Resources staff has been directly involved with the management of Maplewood Neighborhood Preserve properties. One of the high-profile sites, called the Priory Neighborhood Preserve, is located on the east side of the Beaver Lake subwatershed. In 2002, RWMWD staff, the MDNR, and the Maplewood Nature Center staff completed a Neighborhood Wilds Program, where residents living around and near the Priory were invited to partner on implementing numerous best management practices. The focus of this effort was to concentrate education and management efforts on this watershed, with the catalyst being the unique natural communities composing the Priory Preserve. This program resulted in a synchronized effort to remove buckthorn around the Preserve, install rain gardens, create natural buffers, and install native plant gardens. This program set the stage for an applied research project to control reed canary grass in a wetland in this neighborhood.

In 2002, the RWMWD partnered with the Maplewood Nature Center and homeowners in a Nebraska Avenue neighborhood for a wetland restoration project. The Nebraska Avenue Wetland is a small, shallow basin located at the convergence of four home lots. Prior to the project, the wetland was dominated by

reed canary grass (coverage of greater than 90%). The project's main objective was to restore a diverse native plant community in the wetland, using an approach recommended in a recent reed canary grass study (Reinhardt and Galatowitsch, 2004). District staff, along with local homeowners and other volunteers, removed the reed canary grass from the wetland and planted a native seed mix and seedlings. The District continues to monitor the site and provide maintenance and educational assistance to homeowners. Additional information on the Nebraska Avenue Test Wetland is available on the RWMWD website (www.rwmwd.org).

A large portion of the Beaver Lake shoreland is owned by Ramsey County. In 2004, the RWMWD, the MDNR, and Ramsey County Parks partnered on a project to reduce shore erosion and provide improved access to selected shoreland areas. Large limestone blocks were incorporated into the shore along several areas in the park. In addition, emergent patches of native vegetation were installed in areas that were isolated from these lake access points. In 2006, the District will improve the outlet structure on the south end of the Beaver Lake. Part of this project will include the installation of a native plant buffer around the outlet. This revegetation will stabilize the shore area and improve the aesthetic qualities and landscape view on the south end of the lake.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Beaver Lake subwatershed.

2.10.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Beaver Lake subwatershed (see Table 2.10-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Beaver Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

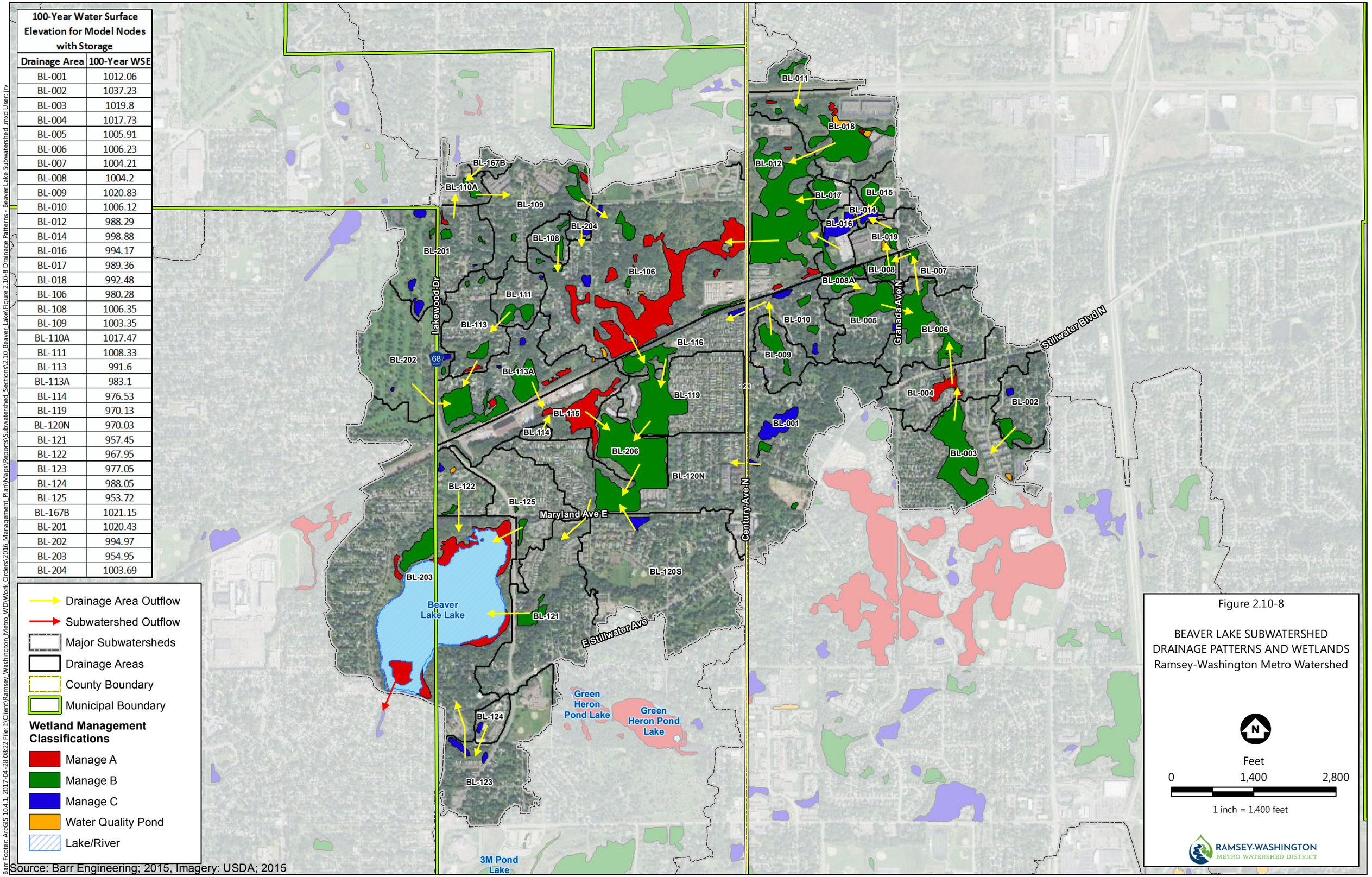
Table 2.10-4 Beaver Lake Subwatershed Implementation Activities

Activity ID No.	Beaver Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BL-1*	Implement improvements identified in the Beaver Lake SLMP, including implementation of BMPs in the lake's direct drainage area (BL-203)	**2018-2022**	**$400,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BL-2*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Beaver Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
BL-3*	Research future options for control of Beaver Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BL-4*	No other subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed, using past infiltration study work to help inform project decisions.	**Continuous**	**--**	**WQ17, MO13**	**--**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
BL-001	1012.06
BL-002	1037.23
BL-003	1019.8
BL-004	1017.73
BL-005	1005.91
BL-006	1006.23
BL-007	1004.21
BL-008	1004.2
BL-009	1020.83
BL-010	1006.12
BL-012	988.29
BL-014	998.88
BL-016	994.17
BL-017	989.36
BL-018	992.48
BL-106	980.28
BL-108	1006.35
BL-109	1003.35
BL-110A	1017.47
BL-111	1008.33
BL-113	991.6
BL-113A	983.1
BL-114	976.53
BL-119	970.13
BL-120N	970.03
BL-121	957.45
BL-122	967.95
BL-123	977.05
BL-124	988.05
BL-125	953.72
BL-167B	1021.15
BL-201	1020.43
BL-202	994.97
BL-203	954.95
BL-204	1003.69



Source: Barr Engineering; 2015, Imagery: USDA; 2015

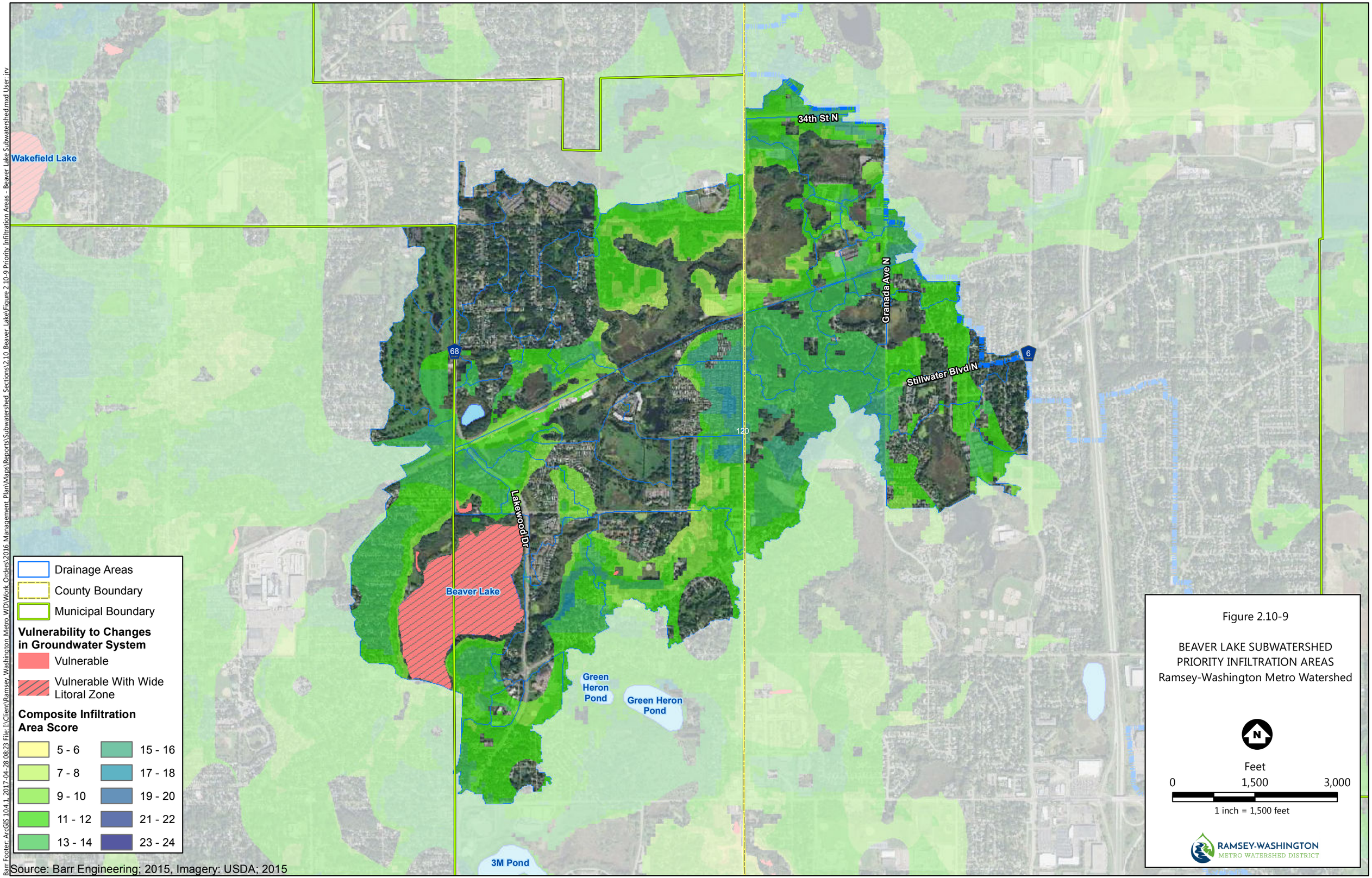
Figure 2.10-8

BEAVER LAKE SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,400 2,800
1 inch = 1,400 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:22 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.10_Beaver_Lake\Figure 2.10-8 Drainage Patterns - Beaver Lake Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:23 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.10_Beaver_Lake\Figure 2.10-9 Priority Infiltration Areas - Beaver Lake Subwatershed.mxd User: jrv

2.11 St. Paul Beltline Subwatershed

2.11.1 General Description

The St. Paul Beltline Storm Sewer (Beltline) subwatershed spans 2,913 acres in the cities of St. Paul and Maplewood (see Figure 2.11-1). The entire subwatershed is located in Ramsey County. The Beltline subwatershed is drained by a storm sewer pipe called the Beltline Interceptor. The Beltline Interceptor is an important part of the District's drainage infrastructure; it not only collects a large percentage of stormwater runoff from St. Paul's east side, but also conveys runoff from the entire Phalen Chain of Lakes subwatershed and the Beaver Lake subwatershed to the Mississippi River (see Figure 1-8). The total drainage area to the Beltline Interceptor is over 17,800 acres (27.8 square miles). There are no District-managed waterbodies with in the Beltline subwatershed.

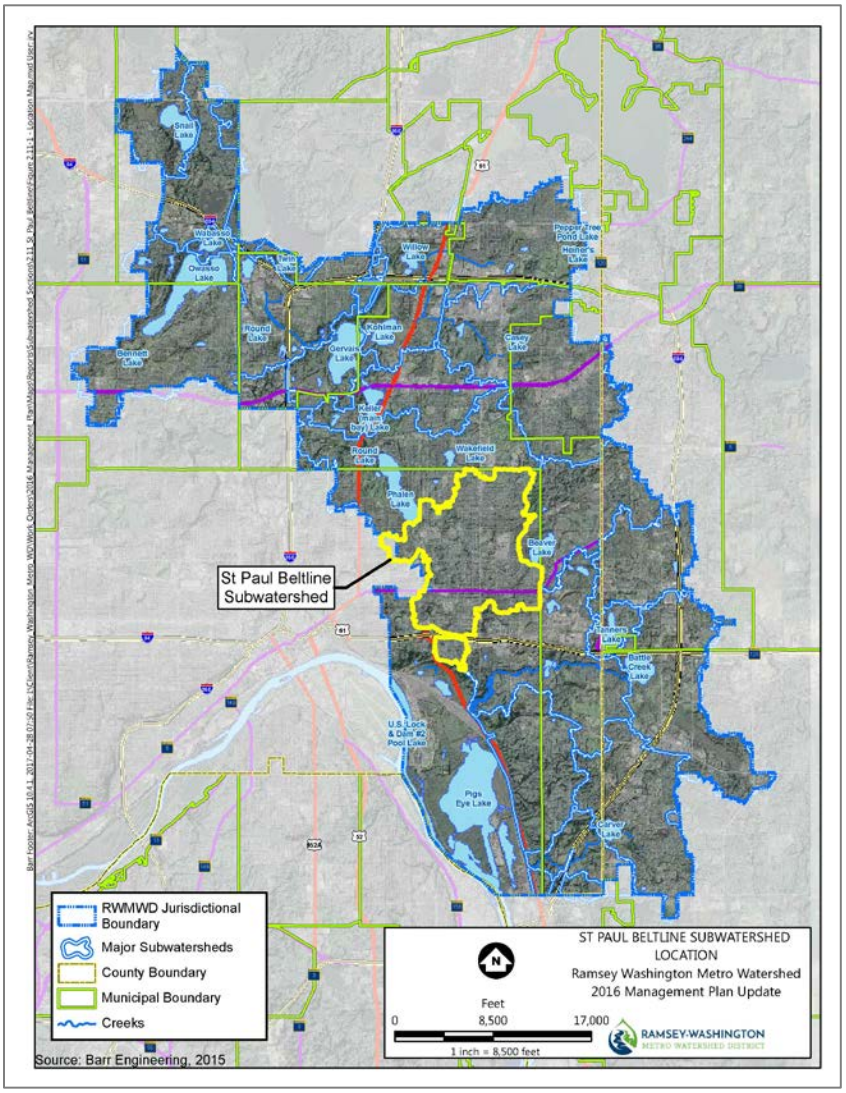


Figure 2.11-1 St. Paul Beltline Location Map

The Beltline Interceptor is approximately 5 miles long, extending from the outlets of Lake Phalen and Beaver Lake to the Mississippi River. Constructed in 1920, large sections of the Beltline Interceptor are cast-in-place concrete "horseshoe" pipe, with heights of 7, 8, 9, and 12 feet, and buried up to 30 feet underground. The Beltline Interceptor is a sensitive part of the District's network—past issues with pressurization in the Beltline Interceptor's downstream reaches have been the focus of several studies, modeling efforts, structural repairs, and capital improvement projects (CIPs).

In 1996, ownership and operation responsibility for the Beltline Outlet was officially transferred from the City of St. Paul to the RWMWD, and the Beltline Interceptor was transferred from the Metropolitan Council to the RWMWD. The District is responsible for the maintenance of the system.

Table 2.11-1 St. Paul Beltline Subwatershed Facts

Tributary Area (Direct)	**2,911 acres**
Tributary Area (Total)	**17,858 acres**
Downstream Watershed	**Mississippi River Bottomlands**
MS4s in the Direct Tributary Area	**Maplewood, St. Paul, Ramsey County**

2.11.1.1 Past Studies

The following list is a summary of past studies related to the Beltline Interceptor the St. Paul Beltline subwatershed.

- *Beltline Interceptor Hydraulics Study.* Prepared for RWMWD by Barr Engineering, 1997.
- *Hoyt Area Flood Analysis*. Prepared for the City of St. Paul, City of Maplewood, Ramsey County, and RWMWD by Barr Engineering, January 1998.
- *Beltline Interceptor Outfall Feasibility Study***.** Prepared for RWMWD by Barr Engineering, August 1998.
- *Phalen Village Wetland Restoration.* Prepared for RWMWD by Barr Engineering, 2002.
- *Beltline Interceptor XP-SWMM Modeling Update*. Prepared for RWMWD by Barr Engineering, September 2004.
- *Beltline Interceptor P8 Modeling*. Prepared for RWMWD by Barr Engineering, October, 2004.
- *Beltline Subwatershed CIP Feasibility Study (DRAFT)*. Prepared for RWMWD by Barr Engineering, July 2005.

2.11.1.2 Land Use

The St. Paul Beltline subwatershed is fully developed. Single-family residential and multifamily residential land use are the predominant land uses within the subwatershed (see Figure 2.11-2). Commercial, industrial, and institutional land uses are scattered throughout the watershed. The Metropolitan Council's estimated 2030 land use anticipates the conversion of single-family residential land use to higher density residential land use in the future (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

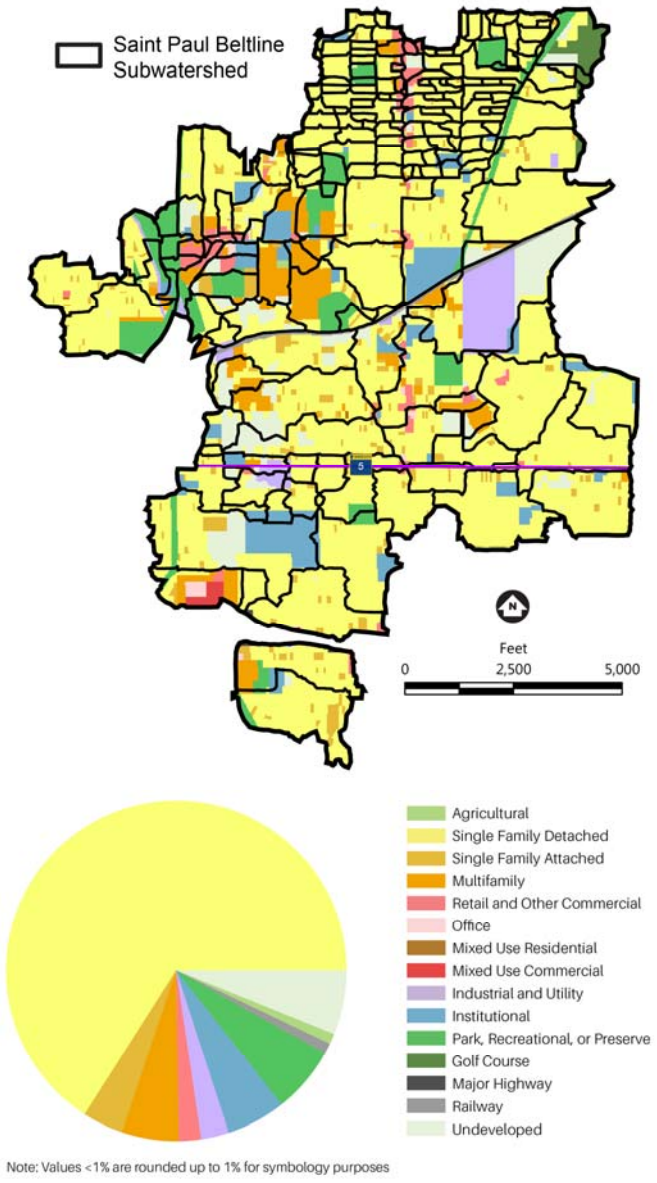


Figure 2.11-2 Breakdown of land uses throughout the St. Paul Beltline Subwatershed (2010 Metropolitan Council)

2.11.1.3 Drainage Patterns and Waterbodies

The stormwater system within the St. Paul Beltline subwatershed is comprised of a small number of detention ponds and wetlands, storm sewers, drainage ditches, and overland flow paths, which all eventually drain to the Beltline Interceptor (see Figure 2.11-5). The Beltline Interceptor receives runoff from the immediate Beltline subwatershed, as well as discharge from the entire Phalen Chain of Lakes watershed and the Beaver Lake subwatershed. The Beltline Interceptor discharges into the Mississippi Bottomlands subwatershed, which eventually drains to the Mississippi River.

The St. Paul Beltline subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.11-5 and Figure 2.11-6). Figure 2.11-5 and Figure 2.11-6 indicate the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

There are no District-managed waterbodies in the St. Paul Beltline subwatershed.

Wetlands within the St. Paul Beltline subwatershed are shown in Figure 2.11-5 according to the RWMWD wetland management classification (see Section 1.11.3).

2.11.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. Regionally, it is also important that the quality of stormwater discharged from the RWMWD to the Mississippi River be maintained and improved where practicable. The following Section discusses the water quality of the stormwater received and discharged by the Beltline Interceptor and goals for the St. Paul Beltline Interceptor subwatershed.

2.11.2.1 Historical Water Quality

Due to the amount of developed property (i.e., higher impervious areas) and low density of ponds and wetlands in the St. Paul Beltline subwatershed, the phosphorus loading from most of the major drainage areas is relatively high. Generally, the near fully-developed Beltline subwatershed has few detention ponds and wetlands. Therefore, stormwater runoff from these drainage areas receives little water quality treatment before entering the Beltline Interceptor.

Since 1995, the District has been monitoring the outlets of the Beltline Interceptor. The District currently cooperates with the Metropolitan Council to monitor the water quality of the Beltline Interceptor flows. The monitoring program is supported by grants from the Metropolitan Council and includes automatic sampling equipment at the Beltline Interceptor outlet to measure standard nutrients and metals. Additional program information and monitoring data may be found from the Met Council Stream Monitoring program website:
http://www.metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management/Stream-Monitoring-Assessment.aspx

No additional water quality data collected for any point along the Beltline Interceptor is available from the MPCA's Environmental Data Access website.

2.11.2.2 Water Quality Modeling

A water quality model was developed for the Beltline Interceptor system to estimate both stormwater flows and phosphorus loads from the St. Paul Beltline subwatershed (*Beltline Interceptor P8 Modeling*, Barr, 2004) using the P8 water quality modeling program (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP, Inc., 1990). The model was calibrated to water quality and stream flow monitoring data collected by the RWMWD in 1999. The District's monitoring equipment is located inside the Beltline Interceptor pipe near the intersection of the pipe and Warner Road. The model was developed to simulate several climatic conditions to evaluate the variability of runoff and phosphorus loading under three different hydrologic conditions: a wet year, a dry year, and a year with near average precipitation and temperatures.

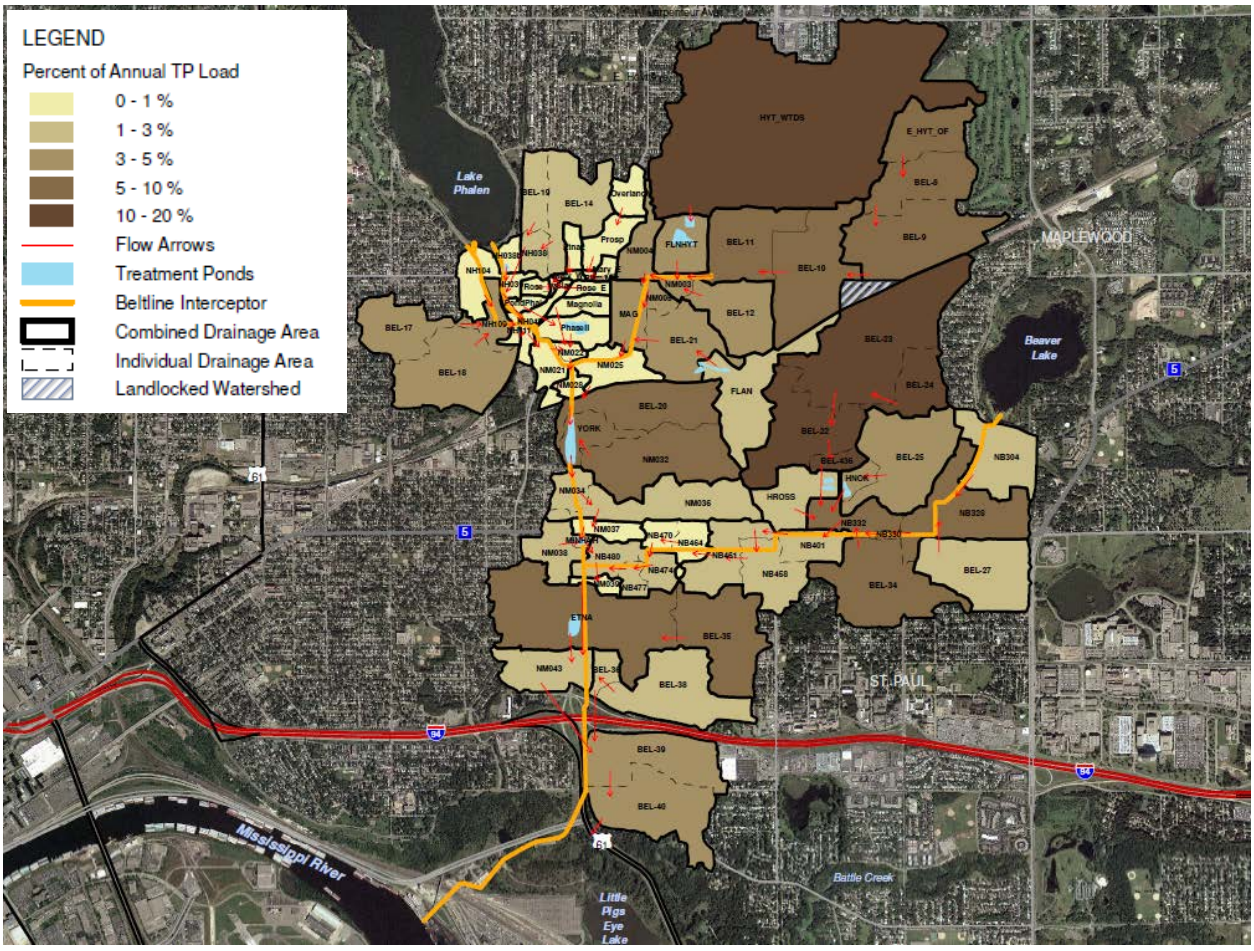


Figure 2.11-3 Drainage districts in the St. Paul Beltline subwatershed

Figure 2.11-3 shows the major drainage areas that contribute stormwater runoff to the Beltline Interceptor. As shown on the figure, a "combined drainage area" represents a group of individual drainage areas that drain to a common location modeled in P8. Figure 2.11-3 also shows the percent of annual

total phosphorus loading each major drainage area contributes to the Beltline Interceptor during an average year of precipitation. For example, the "Hyt_Wtds" major watershed contributes approximately 15% of the annual total phosphorus load, but only comprises 2.6% of the total watershed area.

Through the modeling, it was determined that a majority of the flow through the Beltline Interceptor is from the Phalen Chain of Lakes watershed (see Table 2.11-2). During the 1999 model calibration period, the flows from Lake Phalen contributed approximately 87% of the total flow going through the Beltline Interceptor sampler and the remaining 13% of the flow came from the Beltline subwatershed. Based on modeling results for an average precipitation year, 92% of the total flow going through the Beltline Interceptor is from Lake Phalen, and only 8% comes from the Beltline subwatershed (see Table 2.11-2). Analysis of lake level data for Beaver Lake and information about the Beaver Lake outlet indicate that the Beaver Lake subwatershed contributes less than 1% of the total flow to the Beltline Interceptor under each climatic condition. This led to the conclusion that flow and pollutant loading from Beaver Lake could be considered negligible for modeling purposes.

Table 2.11-2 Annual Flow Contributions to the Beltline Interceptor under Varying Climatic Conditions

Source	Average Year		Wet Year		Dry Year	
	Flow (ac-ft)	Flow (% of total)	Flow (ac-ft)	Flow (% of total)	Flow (ac-ft)	Flow (% of total)
St. Paul Beltline Subwatershed	2,947	7.6%	4,488	10.5%	2,377	8.5%
Lake Phalen	35,909	92.3%	37,822	88.9%	25,400	91.2%
Beaver Lake	64	0.2%	259	0.6%	86	0.3%

Based on results of P8 modeling

Although the majority of the flow through the Beltline Interceptor is from the Phalen Chain of Lakes watershed, the Beltline subwatershed contributed a larger portion of the overall phosphorus load. Based on modeling results for an average precipitation year, 27% of the total phosphorus load going through the Beltline Interceptor is from Lake Phalen, while 73% comes from the Beltline subwatershed (see Table 2.11-3). The large phosphorus loading from the Beltline Subwatershed is primarily due to the subwatershed being essentially fully developed with minimal water quality treatment of storm flows.

Table 2.11-3 Annual Total Phosphorus Contributions to the Beltline Interceptor under Varying Climatic Conditions

Source	Average Year		Wet Year		Dry Year	
	Total Phosphorus (lbs/yr)	Total Phosphorus (% of total)	Total Phosphorus (lbs/yr)	Total Phosphorus (% of total)	Total Phosphorus (lbs/yr)	Total Phosphorus (% of total)
St. Paul Beltline Subwatershed	6,016	72.8%	7,942	77.0%	4,851	75.3%
Lake Phalen	2,246	27.2%	2,366	23.0%	1,589	24.7%
Beaver Lake*	~0	~0%	~0	~0%	~0	~0%

* Phosphorus loading from Beaver Lake is assumed negligible, since the lake contributes less than 1% of the total annual flow

The term "cumulative removal" of phosphorus refers to the amount of total phosphorus removed from the surface water due to the ponds, wetlands, and other BMPs upstream of a given location. Based on the modeling results, the cumulative removal of total phosphorus in the entire Beltline subwatershed is low (6%). Modeling results indicate that 9% of the cumulative total phosphorus load from the Beltline subwatershed was in soluble form This low percentage indicates that much of the total phosphorus load from the Beltline subwatershed is in particulate form, which is much easier to remove with conventional treatment methods (such as detention ponds or other settling-type devices) than is soluble phosphorus.

2.11.2.3 Water Quality Goals

Generally, the nearly fully-developed Beltline subwatershed has few detention ponds or wetlands, and therefore, its runoff receives very little total phosphorus treatment before entering the Beltline Interceptor (*Beltline Interceptor P8 Modeling*, Barr, 2004). Also, since the majority of the flow in the Beltline Interceptor comes from Lake Phalen, water quality improvements in the Beltline subwatershed itself result in only slight improvement to the overall water quality at the outlet of the Beltline Interceptor.

Opportunities for water quality improvement projects within the St. Paul Beltline subwatershed are limited. However, the District will seek to incorporate water quality benefits where other project opportunities allow. This strategy is consistent with the Beltline Interceptor P8 Modeling study (Barr, 2004) and the Draft Beltline Subwatershed CIP Feasibility Study (CIP Feasibility Study, Barr, 2005). Projects implemented in the St. Paul Beltline subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program shown in Figure 2.11-4.

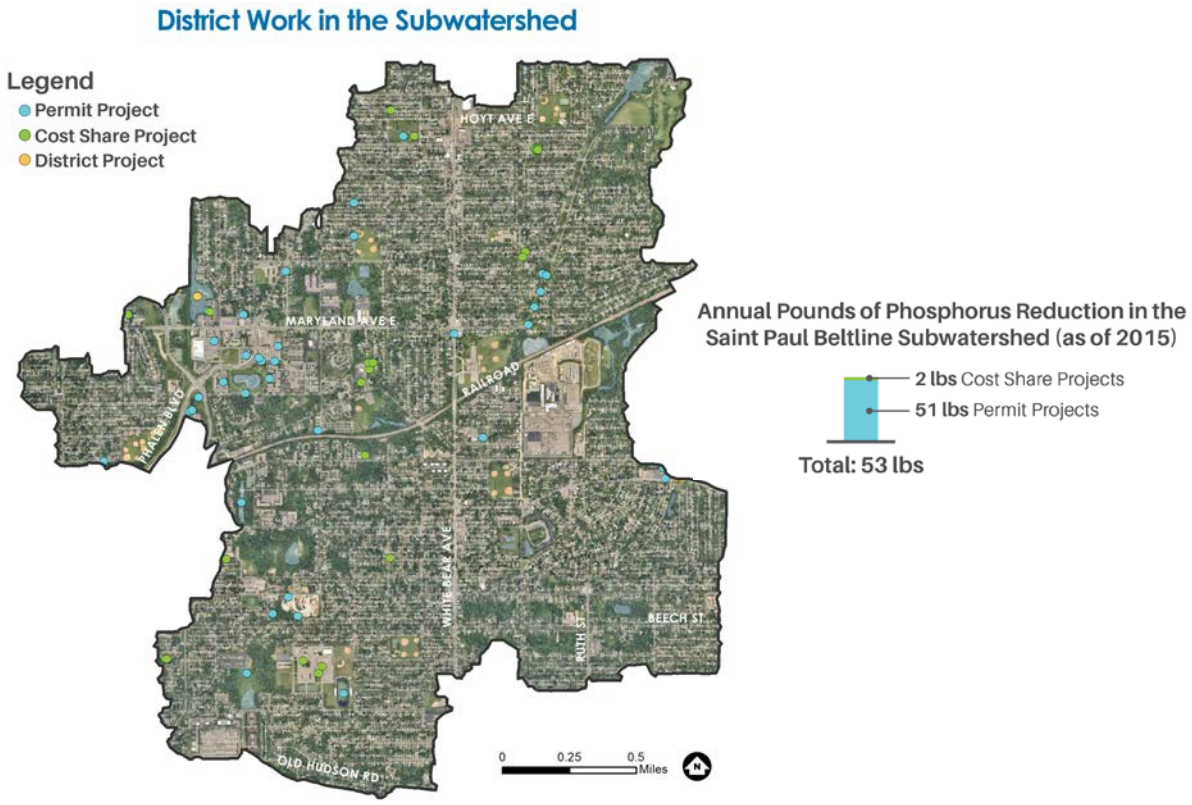


Figure 2.11-4 District work in the St. Paul Beltline Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.11.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. In 2001, the District completed improvements to the Beltline Interceptor outlet. This project primarily includes a transition/connection structure, 360 feet of storm sewer, and an energy dissipater. This project serves as an overflow for the Beltline Interceptor, to reduce hydraulic pressures and increase the capacity of portions of the Beltline.

In 2004, the RWMWD updated its existing hydrologic and hydraulic model the Beltline Interceptor and its tributary area (*Beltline Interceptor XP-SWMM Modeling Update*, Barr, 2004). The model results were used to establish flood levels and peak discharge rates. The model results identify where flooding problems may occur throughout the subwatershed during critical storm events. The model results also show the timing of the peak flow within the Beltline Interceptor and its lateral storm sewers during the critical storm events. This information can help set development limitations in critical areas, while lessening restrictions in other areas throughout the Beltline subwatershed. This information can also give developers options on how to limit the impact of their development on the Beltline Interceptor in cases where providing storage is not feasible.

The 2004 modeling indicated that the outlet improvements completed in 2001 greatly improved the conditions in the lower reach of the Beltline Interceptor, significantly reducing pressures in the pipe system at the downstream end of the structure. The lower pressures in the pipe increase the structural safety of the system. The 2004 modeling results estimate that except for some areas of localized flooding, stormwater in the Beltline Interceptor stays below ground during even the most critical 100-year frequency storm events.

The 2004 modeling helped to identify the location and extent of localized flooding, the structures affected by floodwaters, and future capital improvement projects (CIPs) that would protect them. In 2005, the District completed the *Draft Beltline Subwatershed CIP Feasibility Study* (CIP Feasibility Study, Barr, 2005) to analyze the recommendations resulting from the modeling update (documented in the *Beltline Interceptor XP-SWMM Modeling Update*). The CIP Feasibility Study assessed 8 sites of potential flooding during the 100-year event. Additional detail regarding the analytical methods and recommendations for District action are discussed in detail in the *Draft Beltline Subwatershed CIP Feasibility Study* (Barr, 2005).

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the St. Paul Beltline subwatershed are the new 100-year flood elevations shown in Figure 2.11-5. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.11.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the St. Paul Beltline subwatershed are shown in Figure 2.11-7, indicating areas where the water levels of waterbodies in the St. Paul Beltline subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.11.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

Prior to development, Ames Lake (in the Phase II drainage area, see Figure 2.11-5) was a natural wetland complex. As St. Paul developed, this wetland was filled with soil to make space for a shopping mall. In the 1990s, community redevelopment plans called for this mall to be razed and a wetland be created as a community amenity. In 2000, excavation and grading was completed and the upland, transitional, and aquatic zones were planted and seeded with native plant species. The RWMWD's 2003 biological monitoring results indicated that this wetland was of exceptional quality. This site received some of the highest index values recorded for a District wetland, resulting from its strong groundwater connection, and the diversion of a large majority of the stormwater runoff generated from the surrounding development. Additionally, the RWMWD and the City of St. Paul are actively managing the upland buffer areas. The District plans to continue to assist with the natural resources management of this system and incorporate the wetland into local environmental education efforts.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the St. Paul Beltline subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the St. Paul Beltline subwatershed.

2.11.6 Implementation Program

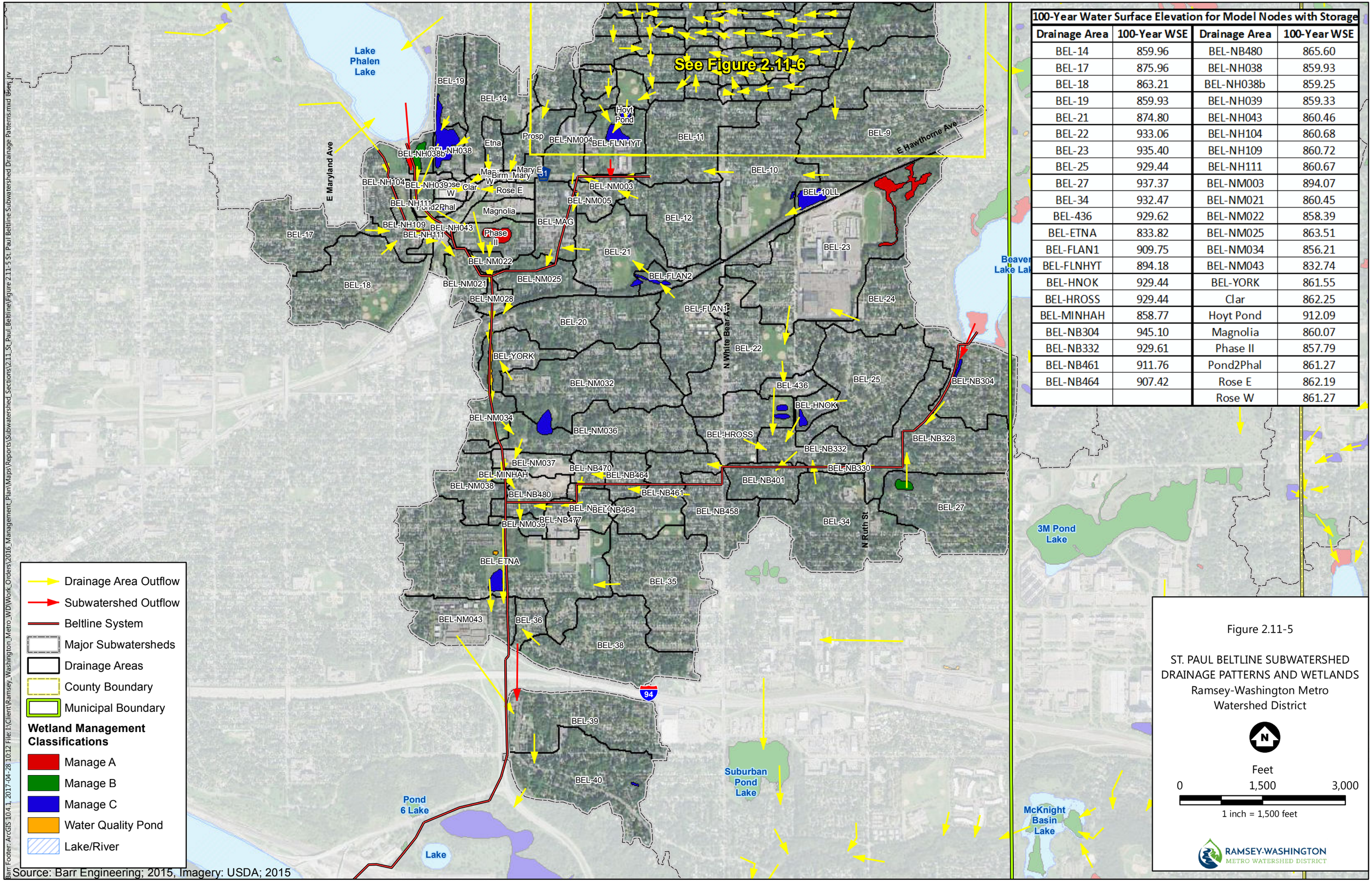
Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the St. Paul Beltline subwatershed (see Table 2.11-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the St. Paul Beltline subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.11-4 St. Paul Beltline Subwatershed Implementation Activities

Activity ID No.	St. Paul Beltline Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BELT-1	Implement water quality and flood control improvements listed in the Beltline CIP Feasibility Report, as identified in the Atlas 14 District remodeling effort, and as recommended by additional analyses.	**2017-2026**	**$500,000**	**WQ2, WQ17, WQ18, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
BELT-2	Complete Beltline tunnel repair projects as recommended in 2015 inspections, Re-inspect tunnel every 5 years.	**2017-2026**	**$5,000,000**	**FL1**	**Tier 1**
BELT-3	Prepare and implement a plan for increasing resiliency and controls for overflow from Lake Phalen	**2018-2026**	**$5,000,000**	**FL7, FL9, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

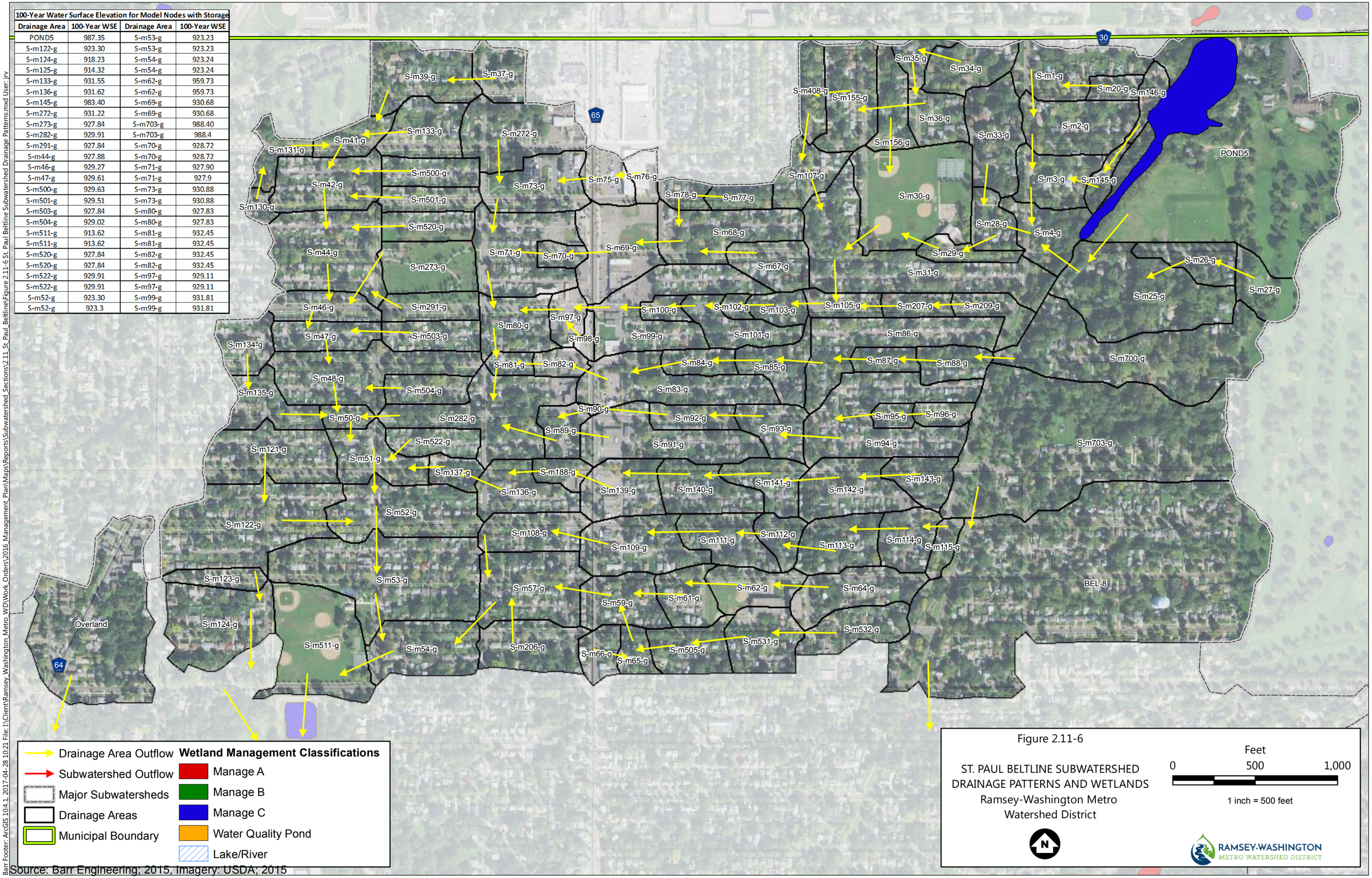
Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.



100-Year Water Surface Elevation for Model Nodes with Storage

Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
BEL-14	859.96	BEL-NB480	865.60
BEL-17	875.96	BEL-NH038	859.93
BEL-18	863.21	BEL-NH038b	859.25
BEL-19	859.93	BEL-NH039	859.33
BEL-21	874.80	BEL-NH043	860.46
BEL-22	933.06	BEL-NH104	860.68
BEL-23	935.40	BEL-NH109	860.72
BEL-25	929.44	BEL-NH111	860.67
BEL-27	937.37	BEL-NM003	894.07
BEL-34	932.47	BEL-NM021	860.45
BEL-436	929.62	BEL-NM022	858.39
BEL-ETNA	833.82	BEL-NM025	863.51
BEL-FLAN1	909.75	BEL-NM034	856.21
BEL-FLNHYT	894.18	BEL-NM043	832.74
BEL-HNOK	929.44	BEL-YORK	861.55
BEL-HROSS	929.44	Clar	862.25
BEL-MINHAH	858.77	Hoyt Pond	912.09
BEL-NB304	945.10	Magnolia	860.07
BEL-NB332	929.61	Phase II	857.79
BEL-NB461	911.76	Pond2Phal	861.27
BEL-NB464	907.42	Rose E	862.19
		Rose W	861.27

100-Year Water Surface Elevation for Model Nodes with Storage			
Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
POND5	987.35	S-m53-g	923.23
S-m122-g	923.30	S-m53-g	923.23
S-m124-g	918.23	S-m54-g	923.24
S-m125-g	914.32	S-m54-g	923.24
S-m133-g	931.55	S-m62-g	959.73
S-m136-g	931.62	S-m62-g	959.73
S-m145-g	983.40	S-m69-g	930.68
S-m272-g	931.22	S-m69-g	930.68
S-m273-g	927.84	S-m703-g	988.40
S-m282-g	929.91	S-m703-g	988.4
S-m291-g	927.84	S-m70-g	928.72
S-m44-g	927.88	S-m70-g	928.72
S-m46-g	929.27	S-m71-g	927.90
S-m47-g	929.61	S-m71-g	927.9
S-m500-g	929.63	S-m73-g	930.88
S-m501-g	929.51	S-m73-g	930.88
S-m503-g	927.84	S-m80-g	927.83
S-m504-g	929.02	S-m80-g	927.83
S-m511-g	913.62	S-m81-g	932.45
S-m511-g	913.62	S-m81-g	932.45
S-m520-g	927.84	S-m82-g	932.45
S-m520-g	927.84	S-m82-g	932.45
S-m522-g	929.91	S-m97-g	929.11
S-m522-g	929.91	S-m97-g	929.11
S-m52-g	923.30	S-m99-g	931.81
S-m52-g	923.3	S-m99-g	931.81



Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

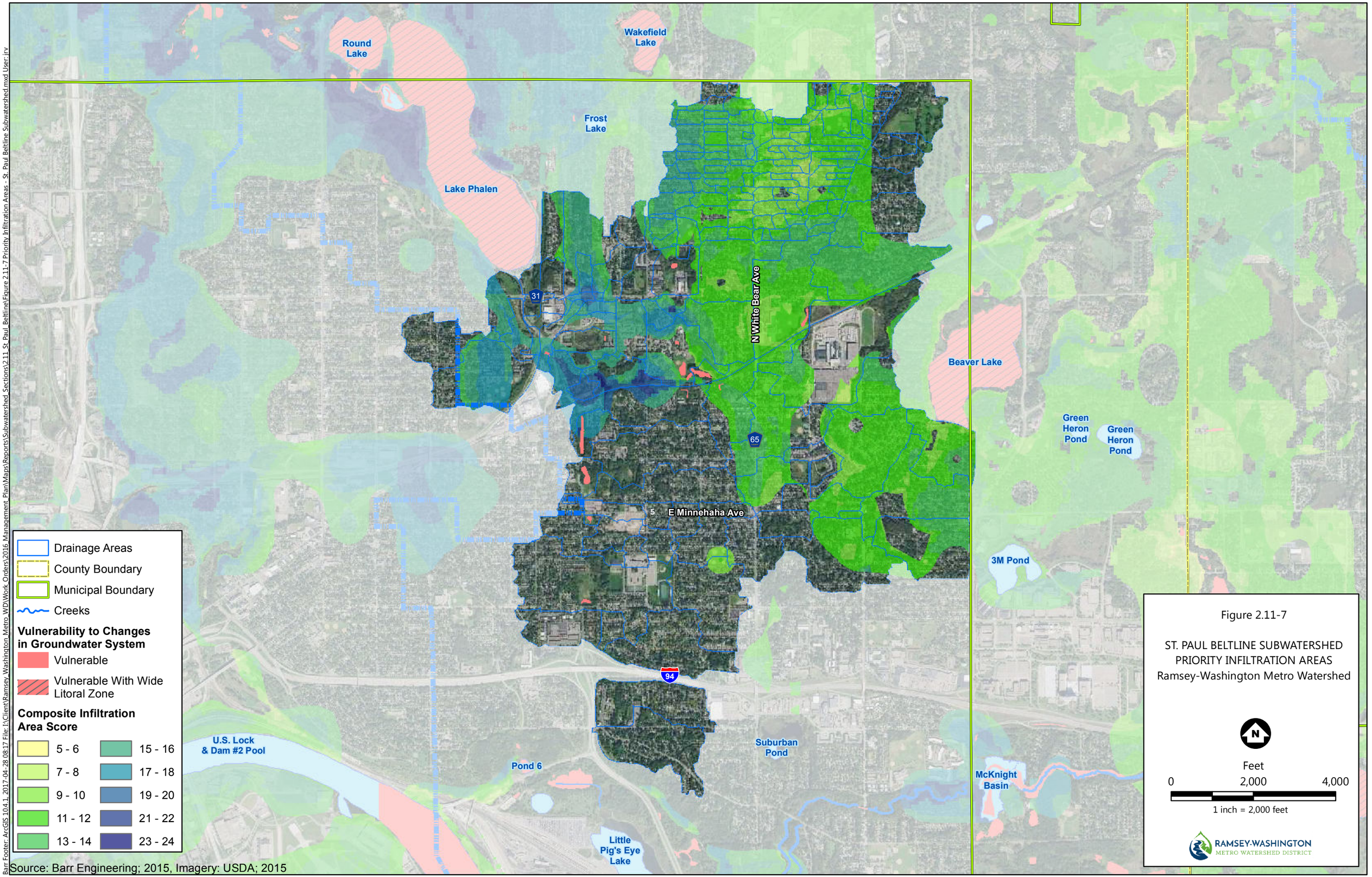
Figure 2.11-6

ST. PAUL BELTLINE SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro
Watershed District

Feet
0 500 1,000
1 inch = 500 feet

RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 10:21 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatersheds_Sections\2.11_St_Paul_Beltline\Figure 2.11-6 St. Paul Beltline Subwatershed Drainage Patterns.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:17 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.11_St_Paul_Beltline\Figure 2.11-7 Priority Infiltration Areas - St. Paul Beltline Subwatershed.mxd User: jrv

2.12 Mississippi River Bottomlands Subwatershed

2.12.1 General Description

The Mississippi River Bottomlands subwatershed, located in the southwest portion of the RWMWD, includes 3,724 acres in the city of St. Paul in Ramsey County (see Figure 2.12-1). The subwatershed lies within the floodplain of the Mississippi River and receives surface runoff from all other subwatersheds within the RWMWD not draining to the Grass Lake subwatershed. The total draining area tributary to the Mississippi River Bottomlands subwatershed is 33,832 acres (52.9 square miles). Eagle Lake, also known as North Star Lake, is the only District-managed lake within the Mississippi River Bottomlands subwatershed. Pig's Eye Lake is a major resource within the subwatershed, but is not classified as lacustrine under the Cowardin system, and therefore is not considered a District-managed lake (see Section 1.9.1). The District will manage Pig's Eye Lake as a wetland.

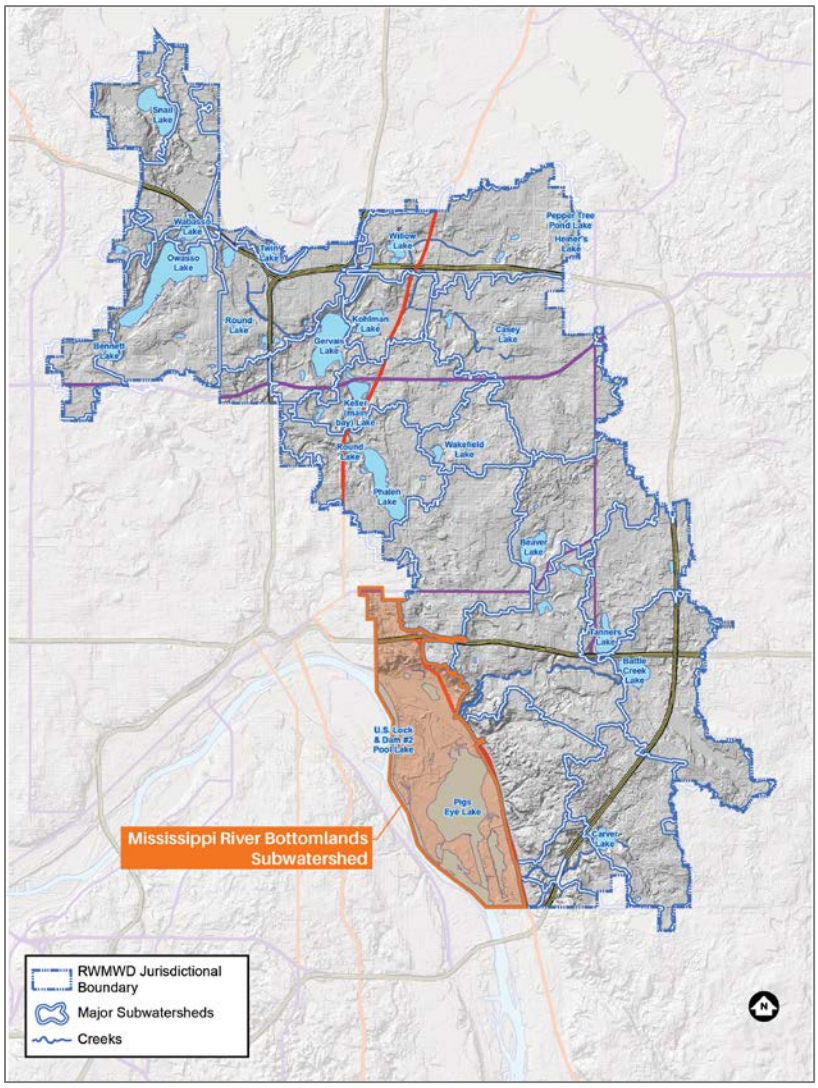


Figure 2.12-1 Mississippi River Bottomlands Location Map

Eagle Lake is a MDNR public water (MDNR# 62-0237P) with a surface area of 64 acres and a maximum depth of 5 feet. Eagle Lake has limited recreational use, as there is no public boat access and the lake is surrounded by industry. However, carry-on access to the lake is legal and bank fishing is possible off of the roadway on the west side of the lake. Eagle Lake receives discharge from the Fish Creek subwatershed (see Section 2.18) and the Blufflands subwatershed (see Section 2.16).

Pigs Eye Lake is a large riverine wetland and a significant regional waterbody. The lake is a MDNR public water (#62-0004P) with a surface area of 628 acres and a maximum depth of 4 feet. The shallow, unmeandered waterbody is in the floodplain of the Mississippi River and receives discharge from the Battle Creek subwatershed (see Section 2.15) and the Blufflands subwatershed (see Section 2.16). The location and land use surrounding Pigs Eye Lake preclude it from significant recreational use. The lake is a valuable wildlife habitat resource and is home to a considerable variety of birds and mammals. Since Pigs Eye Lake is hydraulically connected to the Mississippi River, the level of the lake is controlled by the stage of the river.

Table 2.12-1 Mississippi River Bottomlands Subwatershed Facts

Tributary Area (Direct)	3,724 acres
Tributary Area (Total)	33,832 acres
Downstream Watershed	Mississippi River (Outside of District)
MDNR Designation[1]	62-0237P
Lake Surface Area[1]	64 acres
Lake Maximum Depth[1]	5 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake; Impaired for Aquatic Consumption (mercury and PCB food consumption advisories)
MS4s in the Direct Tributary Area	St. Paul, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	NA

[1] Data for Eagle Lake (North Star Lake)

2.12.1.1 Past Studies

The following list is a summary of past studies related to the Mississippi River Bottomlands subwatershed.

- *Overall Plan: Ramsey-Washington Metro Watershed District.* Prepared for the RWMWD by Barr Engineering, February 1977.

2.12.1.2 Land Use

Since most of the Mississippi River Bottomlands subwatershed lies within the Mississippi River floodplain, the land is suitable only for open space or development not subject to significant flood damage. Land use

in the subwatershed is predominantly open space, wetlands, and industrial land use, as well as some low-density residential development in the northwest corner of the subwatershed (see Figure 2.12-2). The industry in the Mississippi River Bottomlands subwatershed includes the Metropolitan Wastewater Treatment Plant, a wood recycling facility, the old Pig's Eye Landfill, railroad, and various river industry. The Metropolitan Council's estimated 2030 land use anticipates the conversion of single-family residential land use to higher density residential land use in the north part of the subwatershed (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

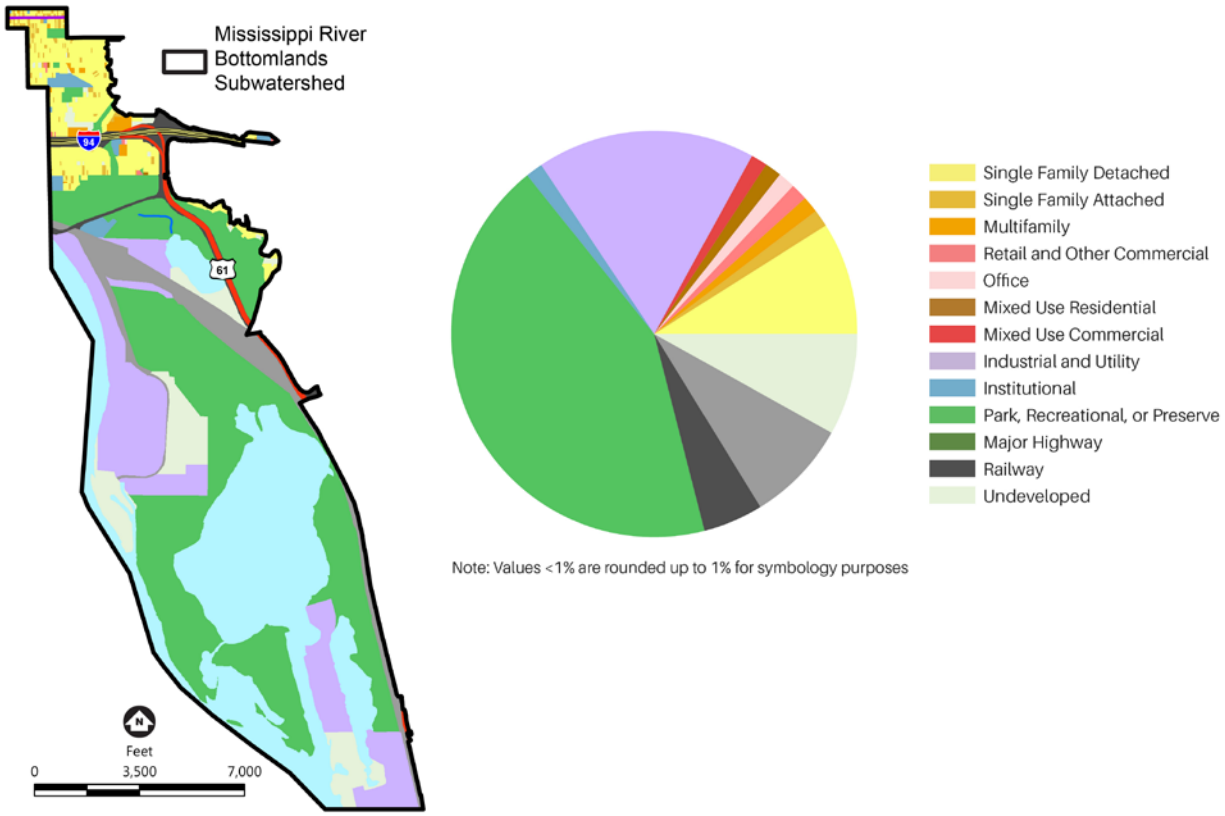


Figure 2.12-2 Breakdown of land uses throughout the Mississippi River Bottomlands Subwatershed (2010 Metropolitan Council)

2.12.1.3 Drainage Patterns and Waterbodies

The Mississippi River Bottomlands subwatershed lies within the floodplain of the Mississippi River and receives discharge from the St. Paul Beltline, Battle Creek, Blufflands, and Fish Creek subwatersheds (see Figure 1-8). The bottomlands area is considered backwaters of the Mississippi River and part of the Upper Mississippi River Pool 2.

The Mississippi River Bottomlands has not been subdivided into separate drainage areas for hydrologic modeling or management purposes (see Figure 2.12-4). This subwatershed was not included in the District's 2015 modeling update using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3), as the Mississippi River governs flood levels within this subwatershed.

District-managed waterbodies within the Lake Phalen subwatershed include only Eagle Lake (North Star Lake).

Wetlands within the Mississippi River Bottomlands subwatershed are shown in Figure 2.12-4 according to the RWMWD wetland management classification (see Section 1.11.3). The District will continue to manage Pig's Eye Lake as a Manage A wetland.

2.12.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. Regionally, it is important that the quality of stormwater discharged from the RWMWD to the Mississippi River be maintained and improved to the extent practicable. The following Section discusses the water quality conditions and goals for the District-managed lakes and other significant waterbodies within the Mississippi River Bottomlands subwatershed.

2.12.2.1 Historical Water Quality

Sedimentation has historically been a problem for the waterbodies in the Mississippi River Bottomlands subwatershed. Sedimentation occurs when the streams in the steep ravines east of the subwatershed enter the floodplain and lose their sediment-carrying capacity as the flow velocity decreases. The deposited sediment can plug the stream and further decrease the carrying capacity.

Eagle Lake (North Star Lake)

Eagle Lake (North Star Lake) has limited recreational use. Historical water quality data for Eagle Lake is limited, as the lake is not currently monitored by the RWMWD or Ramsey County. Satellite imagery acquired between 1999 and 2001 indicated that the lake's transparency depth is between 1.5 and 3.0 feet (MDNR LakeFinder: www.dnr.state.mn.us). The RWMWD has note assigned a nutrient water quality classification of due to limited knowledge of current water quality conditions.

Industrial land use adjacent to Eagle Lake may affect water quality. In 2012, Gerdau Ameristeel US, Inc. began a project to remove approximately 13,000 cubic yards of metal-contaminated sediment from about 3.5 acres of the lake. The MPCA published and Environmental Assessment Worksheet (EAW) for the project in 2012. A lake vegetation survey completed in August 2011 as part of the EAW concluded that the plant composition in Eagle Lake is low diversity and is dominated by common species that are often associated with silt substrates and turbid water (MPCA, 2012).

Pigs Eye Lake

Pigs Eye Lake is a large riverine wetland with limited recreational use. Historical water quality data for Pigs Eye Lake is limited, as the lake is not currently monitored by the RWMWD or Ramsey County. According to the MPCA's Environmental Data Access website, the mean concentration for total phosphorus in Pigs Eye Lake is 365 µg/L and the mean Secchi disc transparency for Pigs Eye Lake is 1.3 feet, giving the lake a hypereutrophic classification. However, the dataset used to calculate these averages is relatively old (collected between 1970 and 1988) and is limited to five total phosphorus measurements and 22 Secchi

depth measurements. Satellite imagery acquired between 1999 and 2000 indicated that the lake's transparency depth is less than 1.5 feet (MDNR LakeFinder: http://www.dnr.state.mn.us/lakefind/index.html).

Nutrient loading is also a significant problem in Pigs Eye Lake, since it receives phosphorus loading from all of the other subwatersheds in the RWMWD. The Metropolitan Wastewater Treatment Plant no longer discharges to the lake.

2.12.2.2 State of the Fishery

The MDNR performed a fisheries survey of Eagle Lake on July 10, 1991. The assessment is available on the MDNR Lake Finder website (http://www.dnr.state.mn.us/lakefind/index.html), under the lake name of North Star. Fish species identified in the survey include: black bullhead, black crappie, bluegill, brown bullhead, channel catfish, largemouth bass, northern pike, orange-spotted sunfish, white bass, yellow bullhead, yellow perch, bigmouth buffalo, bowfin (dogfish), common carp, freshwater drum, shorthead redhorse, white sucker, gizzard shad, and golden shiner.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Eagle Lake based on the presence of mercury. More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

The MDNR performed a fisheries survey of Pigs Eye Lake on August 14, 1984. The assessment is available on the MDNR Lake Finder website (http://www.dnr.state.mn.us/lakefind/index.html). Based on the survey results, the Pigs Eye Lake fishery is dominated by roughfish. Species identified in the survey include: black bullhead, black crappie, bluegill, brown bullhead, channel catfish, largemouth bass, northern pike, orange-spotted sunfish, pumpkinseed sunfish, white bass, white crappie, yellow perch, common carp, and freshwater drum.

2.12.2.3 Water Quality Goals

The water quality goals for Eagle Lake are consistent with the MPCA's shallow lake eutrophication standard for lakes in the North Central Hardwoods Forest Ecoregion shown in Table 1-3. While the District does not currently plan to monitor water quality in Eagle Lake, the RWMWD will evaluate water quality data in Eagle Lake for trends and adjust its water quality classification and management activities accordingly, should data become available. The District has not established water quality goals for Pigs Eye Lake based on the District's classification as a Manage A wetland. RWMWD will strive to maintain or improve the quality of the stormwater discharged from the RWMWD to the Mississippi River Bottomlands

Projects implemented in Mississippi River Bottomlands subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.12-3.

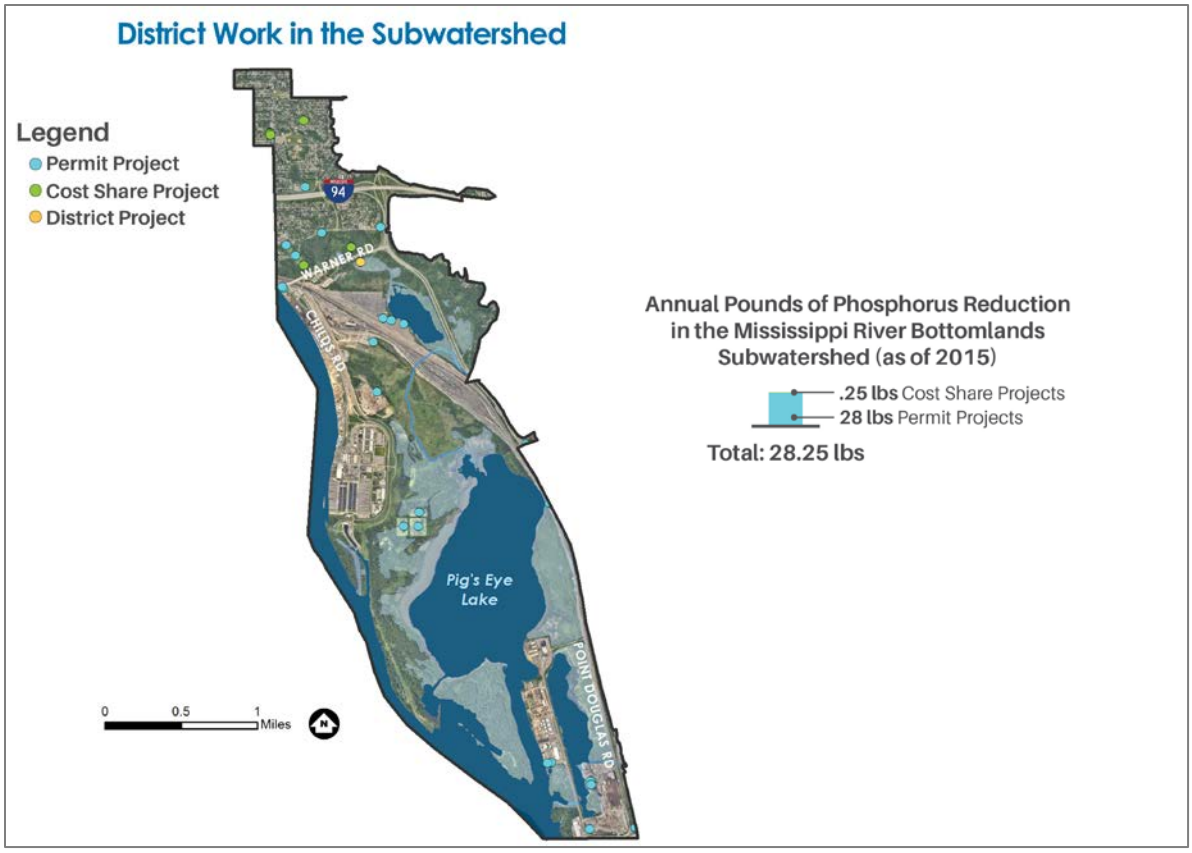


Figure 2.12-3 District work in the Mississippi River Bottomlands Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.12.3 Manage Risk of Flooding

The Mississippi River Bottomlands subwatershed lies within the floodplain of the Mississippi River. As such, development in this area is limited to land uses such as open space or industries not subject to significant flood damage. The District may cooperate with the City of St. Paul to address local flooding issues in the future, as such issues are identified by the city or District. No previous hydrologic modeling has been completed by the RWMWD for this subwatershed, and this area was not included in the District's 2015 modeling update using Atlas 14 data (see Section 1.12.3) due to flood levels in this subwatershed being governed by the Mississippi River. FEMA-established floodplains and 100-year flood levels for this area (see Section 1.12.2.1) were most recently published in 2010 and are available from FEMA at: https://msc.fema.gov/portal

2.12.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Mississippi River Bottomlands subwatershed are

shown in Figure 2.12-5, indicating areas where the water levels of waterbodies in the Mississippi River Bottomlands subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.12.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

In 2002, District Natural Resources program staff provided technical assistance on a prairie restoration project associated with the Metropolitan Wastewater Treatment (Metro) Plant facility. The District provided a restoration design and assisted with supervising the site preparation and plant installation. The project's main goal was to demonstrate to Metro Plant staff what could be done with open space areas around the plant, and to provide an interesting natural area for workers to walk around and use for lunch breaks. The RWMWD staff periodically monitors the site and makes management recommendations.

As of the writing of this Plan, the US Army Corps of Engineers is considering a project to use dredged sediment from Mississippi River Pool 2 to develop habitat improvements in Pig's Eye Lake. The project was identified in a feasibility study requested by Ramsey County Parks and Recreation in 2012. Potential alternatives may include the construction of islands of various sizes and locations within the lake, creating a range of habitat types for fish and wildlife. These islands would also reduce wind and wave action, improving vegetation in the lake, creating thermal shelter for waterfowl and protecting further shoreline erosion.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Mississippi River Bottomlands subwatershed.

The District will continue to seek opportunities to integrate natural resource benefits into its activities within the Mississippi River Bottomlands subwatershed.

2.12.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Mississippi River Bottomlands subwatershed (see Table 2.12-2). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Mississippi River Bottomlands subwatershed (e.g., implementation of the

RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.12-2 Mississippi River Bottomlands Subwatershed Implementation Activities

Activity ID No.	Mississippi River Bottomlands Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
MR-1	Collaborate with the City of St. Paul and Ramsey County on water management issues related to stormwater runoff from the Beltline Interceptor, Battle Creek, and Fish Creek Subwatersheds.	**Continuous**	**$5,000 (average annual cost)**	**WQ19, FL7, FL9**	**Tier 3**
MR-2	Coordinate with the Metropolitan Council and the MPCA on results and issues related to potential phosphorus discharge limits to the Mississippi River.	**Continuous**	**$5,000 (average annual cost)**	**WQ2**	**Tier 3**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Unnamed (Rd HW10) Lake

Pond 6

Little Pig's Eye Lake

U.S. Lock & Dam #2 Pool

Pigs Eye Lake

Unnamed (North Star) Lake

MISSISSIPPI RIVER BOTTOMLANDS SUBWATERSHED DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Figure 2.12-4

Source: Barr Engineering; 2015, Imagery: USDA; 2015

N

Feet
0 1,750 3,500
1 inch = 2,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Drainage Area Outflow
Subwatershed Only
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications
Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Barr Footer: ArcGIS 10.4, 2016-11-28 10:32 File: J:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.12_Mississippi_River_Bottomlands\Figure 2.12-4 - Drainage Patterns - Mississippi River Bottomlands Subwatershed .mxd User: jrv

E 3rd St

65

94

N White Bear Ave

Unnamed (Rd HW10) Lake

Pond 6

35

Little Pig's Eye Lake

Pigs Eye Lake

U.S. Lock & Dam #2 Pool

Unnamed (North Star) Lake

MISSISSIPPI RIVER BOTTOMLANDS SUBWATERSHED PRIORITY INFILTRATION AREAS Ramsey-Washington Metro Watershed

Figure 2.12-5

N

Feet

0 1,750 3,500

County Boundary

Municipal Boundary

Creeks

Vulnerability to Changes in Groundwater System

Vulnerable

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4, 2016-11-29 09:35 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.12_Mississippi_River_Bottomlands\Figure 2.12-5 Priority Infiltration Areas - Mississippi River Bottomlands Subwatershed.mxd User: jrv

2.13 Tanners Lake Subwatershed

2.13.1 General Description

The Tanners Lake subwatershed encompasses 1,707 acres in the east side of the District (see Figure 2.13-1). The Tanners Lake subwatershed is primarily located in the city of Oakdale in Washington County, with a small portion of the subwatershed within the cities of Landfall, Woodbury, and Maplewood in Ramsey County. Tanners Lake is the only District-managed lake within the subwatershed. Outflow from the Tanners Lake subwatershed flows underneath Interstate 94 into Battle Creek Lake.

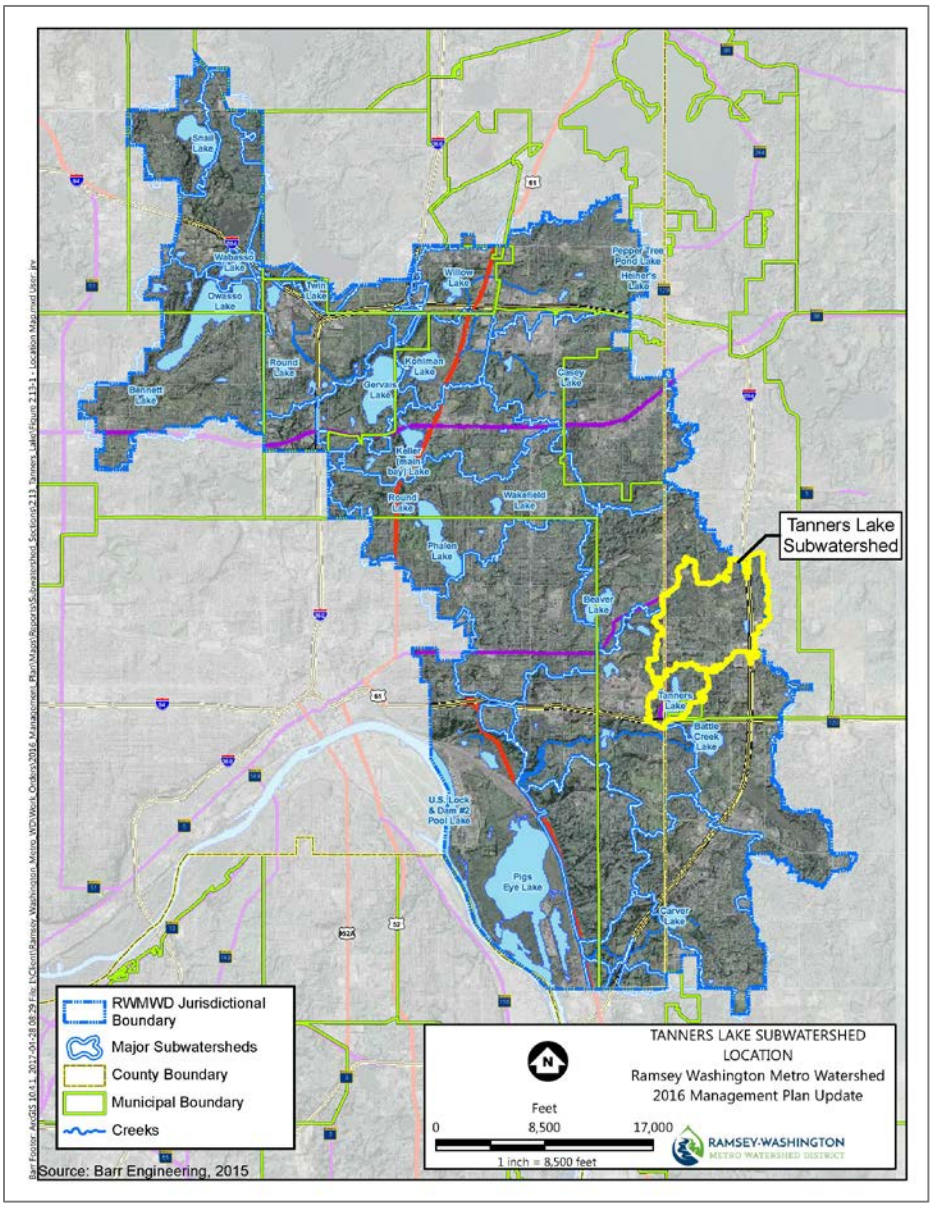


Figure 2.13-1 Tanners Lake Location Map

Tanners Lake is a District-managed lake located almost entirely in the cities of Oakdale and Landfall (the corporate limits of Woodbury and Maplewood encroach the shoreline of the lake along the northeast corner of the intersection of I-94 and Century Avenue). The lake is a MDNR public water (MDNR #82-0115P) with a surface area of 70 acres. The lake has a maximum depth of 46 feet and an average depth of approximately 20 feet. Tanners Lake discharges into Battle Creek Lake in Woodbury, which serves as the headwaters for Battle Creek, a tributary of the Mississippi River. Tanners Lake is used primarily for recreational uses such as swimming, skiing, and speed-boating, as well as fishing, canoeing, picnicking, viewing, and limited wildlife habitat.

Table 2.13-1 Tanners Lake Subwatershed Facts

Tributary Area (Direct)	1,707 acres
Tributary Area (Total)	1,707 acres
Downstream Watershed	Battle Creek Lake
MDNR Designation[1]	82-0115P
Lake Surface Area[1]	74 acres
Lake Mean Depth[1]	20 ft
Lake Maximum Depth[1]	46 ft
Lake Outlet Type[1]	48" Riser
Lake Outlet Elevation[1]	963.1 ft
100-Year Flood Level[1]	967.7 ft
Lake Littoral Area[1]	38%
MPCA Designations[1]	Deep Lake; Impaired for Aquatic Consumption (mercury food consumption advisory), Impaired for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Landfall, Maplewood, Oakdale, Woodbury, Ramsey County, Washington County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Data for Tanners Lake

Tanners Lake Park, a city park owned and operated by the City of Oakdale, is located on the east shore of the lake. The park includes a beach for swimming, as well as a boat access for fishing. Facilities are also present for sporting activities, including softball and volleyball.

The RWMWD currently operates an alum treatment facility on the north end of Tanners Lake that treats a significant portion of the watershed runoff to the lake. Alum is injected into the stormwater runoff which causes the phosphorus to precipitate out and settle into a sedimentation pond.

2.13.1.1 Past Studies

The following list is a summary of past studies related to Tanners Lake and the Tanners Lake subwatershed.

- *Grant Application to Conduct a Phase I Diagnostic/Feasibility Study of Water Quality Problems and Restorative Measures for Tanners Lake (Washington County, Minnesota)*. Prepared for RWMWD by Barr Engineering, April 1987.
- *Phase I Diagnostic/Feasibility Study of Water Quality Problems and Restorative Measures for Tanners Lake*. Prepared for RWMWD by Barr Engineering, May 1989.
- *Tanners Lake Outlet Hydrologic Study*. Prepared for RWMWD by Barr Engineering, September, 1993.
- *Clean Water Partnership Project Implementation Grant Application to Conduct a Phase II Lake Improvement/Protection Study of Tanners Lake (Washington County, Minnesota) (Draft)*. Prepared for RWMWD by Barr Engineering, October 1993.
- *Diagnostic/Feasibility Study of Water Quality Problems and Restorative Measures for Tanners Lake*. Prepared for RWMWD by Barr Engineering, October 1993.
- *Management Alternatives Report on the Diagnostic Feasibility Study of Tanners Lake (Summary)*. Prepared for RWMWD by Barr Engineering, August 1993.
- *Tanners Lake CIP Performance Evaluation*. Prepared for RWMWD by Barr Engineering, August 2003.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.13.1.2 Land Use

The Tanners Lake subwatershed is nearly fully developed. The primary land use within the watershed is single-family residential land use, although some areas of higher density residential land use are also present (see Figure 2.13-2). Parkland and wetlands make up about 20% of the subwatershed. Some commercial land use is present adjacent to Century Avenue and Interstate 694. Future estimated land use, based on the Metropolitan Council's 2030 (see Figure 1-5), is similar to existing conditions. Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

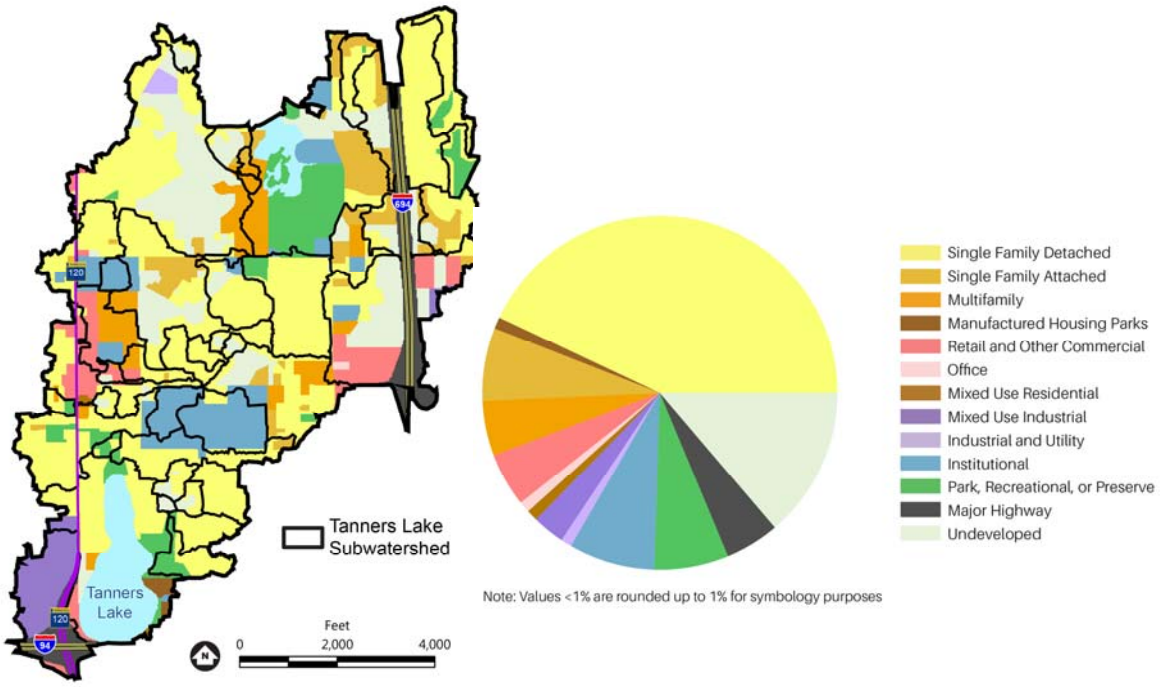


Figure 2.13-2 Breakdown of land uses throughout the Tanners Lake Subwatershed (2010 Metropolitan Council)

2.13.1.3 Drainage Patterns and Waterbodies

The subwatershed generally drains south towards Tanners Lake through a series of wetlands and detention ponds, connected primarily by storm sewers and drainage ditches. The northern two-thirds of the subwatershed discharge into a wetland directly north of Tanners Lake, which then flows into the lake. The lake discharges into Battle Creek Lake (and the Battle Creek Lake subwatershed) through an outlet structure under I-94.

The Tanners Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.13-6). Figure 2.13-6 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Tanners Lake subwatershed include only Tanners Lake.

Wetlands within the Tanners Lake subwatershed are shown in Figure 2.13-6 according to the RWMWD wetland management classification (see Section 1.11.3).

2.13.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following sections discuss the water quality goals and conditions for the District-managed water bodies in the Tanners Lake subwatershed.

2.13.2.1 Historical Water Quality

Tanners Lake is used primarily for recreational uses such as swimming, skiing, and speedboating, as well as fishing, canoeing, picnicking, viewing, and limited wildlife habitat. The lake receives runoff from its direct tributary subwatershed through storm sewer outfalls and culverts at various locations along the shoreline, and sheet flow runoff from the immediate drainage area.

The RWMWD samples the water quality of Tanners Lake every two weeks between the months of May and September. Figure 2.13-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.13-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Tanners Lake relative to MPCA standards. Tanners Lake was listed on the MPCA's Impaired Waters 303(d) List in 2002 due to excess nutrients (see Section 1.10.2). Tanners Lake was removed from the impaired waters list in 2004 based on additional monitoring data and water quality improvements within the Tanners Lake subwatershed (see Section 2.13.2.2).

The RWMWD has assigned a water quality classification of "Stable" to Tanners Lake based its removal from the impaired waters list and recent water quality data (see Table 2.13-2).

Table 2.13-2 Tanners Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Tanners Lake (2005-2014) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	27.3
Chlorophyll-a (µg/L)	≤ 14	7.0
Secchi disk transparency (m)	≥ 1.4	2.9

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on Tanners Lake water quality data. The results of these analyses are shown in Table 2.13-3.

Table 2.13-3 Trend Analysis Results for Tanners Lake Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Tanners Lake	1997 – 2012	Secchi Depth	Improving*	No Trend
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving*	Degrading*

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

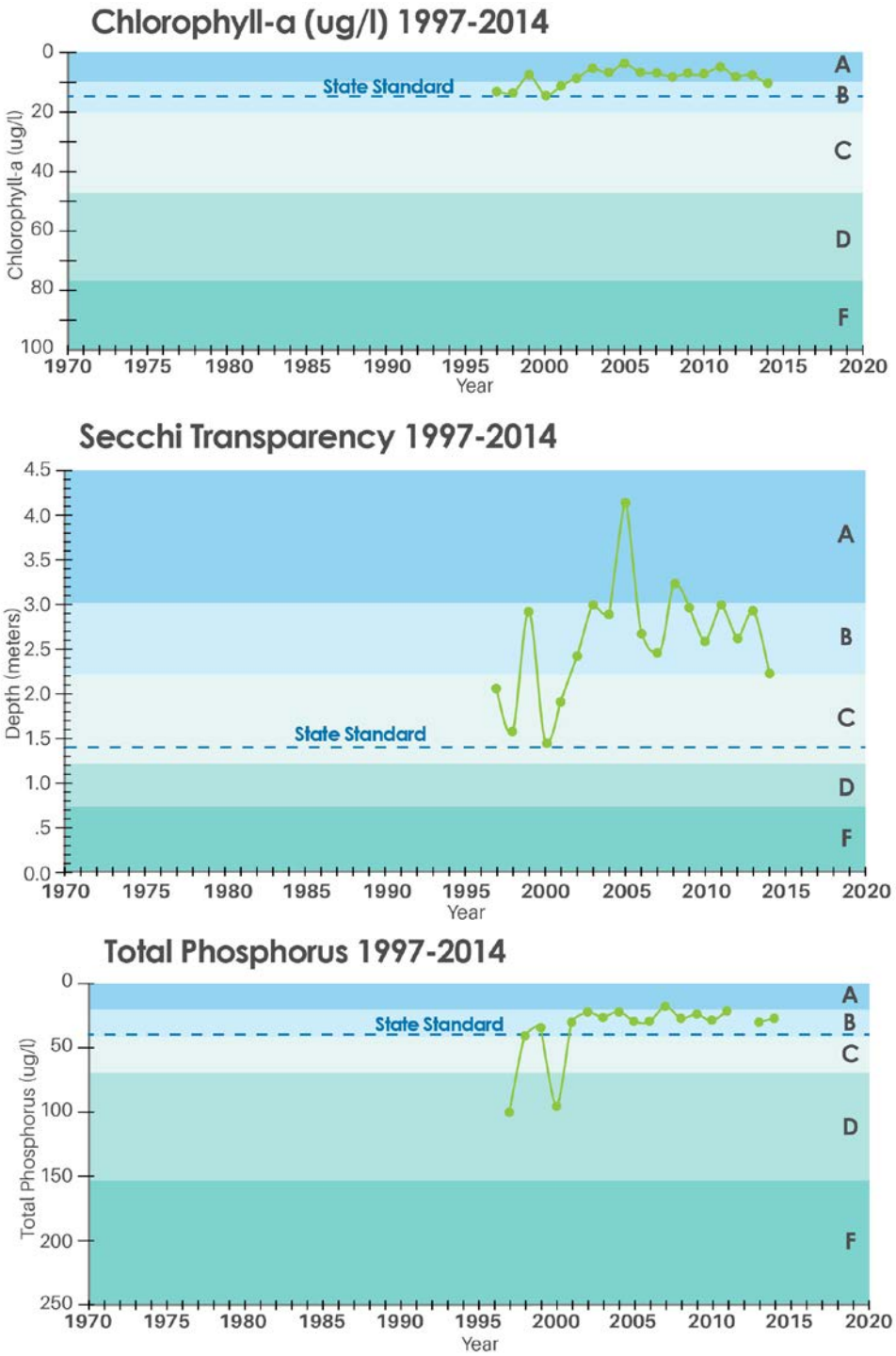


Figure 2.13-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Tanners Lake (1997-2014)

2.13.2.2 Water Quality Improvement Projects

Since establishing water quality goals for Tanners Lake in 1997, the RWMWD has completed several capital improvement projects (CIPs), which contributed to significant improvements in water quality. Several of these improvements have resulted in Tanners Lake being removed from the MPCA's Impaired Waters List for excess nutrients in 2004. Notable District water quality improvement projects in the watershed include:

- **Wetland improvements north of Tanners Lake** – In 1987, the District constructed two permeable weirs in a wetland north of the lake. The weirs disperse the flow across the wetland, creating a detention basin that allows sediment to settle. In 1994, the RWMWD implemented maintenance and improvements to this system.

- **Tanners Lake Water Quality Improvements Project** – In 1997, the District performed a series of projects to improve water quality in Tanners Lake, including:

    - Construction of improvements to an existing pond (Boat Ramp Pond) located on the southeast corner of Tanners Lake. Improvements included enlarging the pond, grading operations, and storm sewer construction intended to capture more of the stormwater runoff from the tributary watershed.

    - Construction of the 5th Street Basins, a multi-celled wetland treatment pond and an extended detention basin.

    - Construction of a weir and infiltration trench system near the southeast shore of Tanners Lake.

    - Construction of the Tanners Lake Alum Treatment Facility north of the lake. The alum treatment facility treats the majority of stormwater inflows coming from the Tanners Lake subwatershed. The RWMWD began operating the alum treatment facility in 1998. The facility injects alum into the stormwater, which causes phosphorus to precipitate and then flocculate and settle in a sedimentation pond. This highly successful project has resulted in removals of up to 88% of all phosphorus entering the facility in a typical hydrologic year (2001), according to the *Tanners Lake CIP Performance Evaluation* report (Barr, 2003).

Overall, the Tanners Lake Water Quality Improvements project and the Tanners Lake permeable weirs resulted in a 48% reduction in phosphorus loading to Tanners Lake during a typical hydrologic year (2001) (Barr, 2003).

2.13.2.3 State of the Fishery

In 1992, the MDNR classified Tanners Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Tanners Lake is a Class 30 lake, which signifies a good permanent fishery lake (Schupp, 1992).

The MDNR actively manages the fishery in Tanners Lake, stocking walleye and channel catfish on a nearly annual basis (and yellow perch in 2009). In addition to its stocking activities, the MDNR periodically assesses the Tanners Lake fish population. The last MDNR survey was performed in 2011. Survey results are available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html).

The most recent MDNR survey found bluegills to be the most abundant species in Tanners Lake. The bluegill population is average compared to similar lakes. The average bluegill measured in 2011 was 5.26 inches. Black crappies were also sampled in average abundance. Their average size was 6.17 inches. Only 2 walleye were sampled during the 2011 survey and were both stocked the previous year. Neither fish exceeded 12 inches in length. Northern pike were sampled in average abundance and size. Northern pike up to 27 inches were sampled during the survey. Pumpkinseed sunfish, green sunfish and hybrid sunfish were each sampled in average numbers. Channel catfish were not sampled during the 2011 survey, despite annual stocking.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Tanners Lake based on the presence of mercury and perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.13.2.4 State of the Macrophyte Community

On September 10, 2015, District staff conducted a macrophyte survey of Tanners Lake. The results of this survey are summarized below in Figure 2.13-4. In total, 62 sites were surveyed for macrophytes. Of these, 52 had vegetation, indicating that Tanners Lake is a macrophyte-dominated lake.

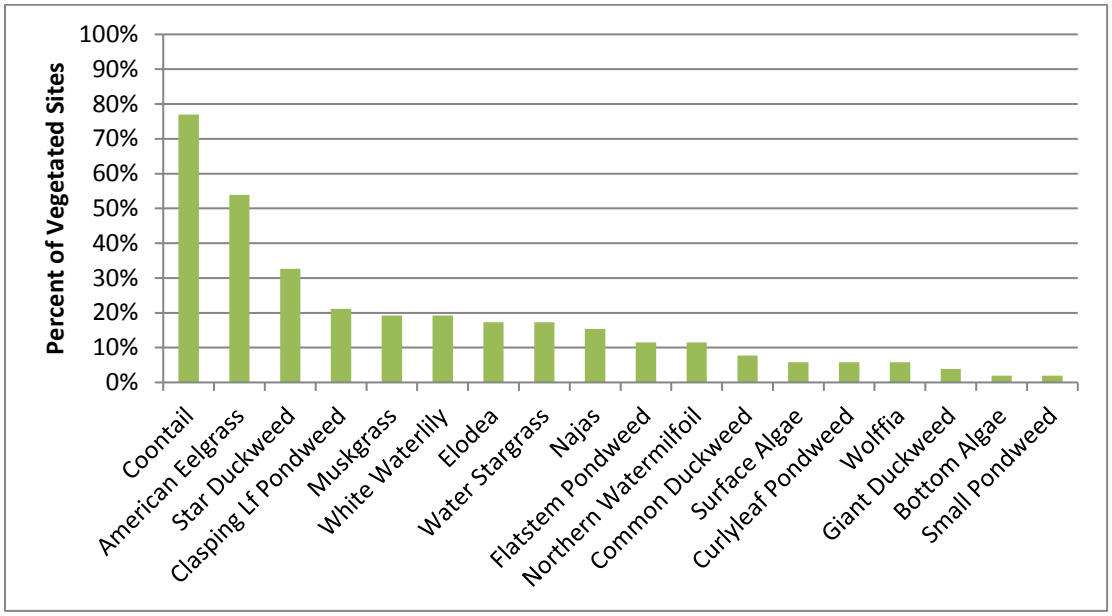


Figure 2.13-4 September, 2015 Tanners Lake Macrophyte Survey Results

Where filamentous algae and muskgrass were found in the lake, they were present in high abundance relative to other macrophyte species in Tanners Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.13.2.5 Water Quality Modeling

As part of the *Tanners Lake CIP Performance Evaluation* report (Barr, 2003), the District performed water quality modeling for Tanners Lake based on years 2001 and 2002. The stormwater and total phosphorus loads to Tanners Lake from its tributary watershed were estimated using the P8 computer model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990). The model was calibrated to water quality and stream flow monitoring data collected at the 7th Street monitoring station during the summer of 2002. The majority (79%) of the subwatershed discharges to the lake through this monitoring station, and most of that drainage area is treated by the Tanners Lake alum treatment facility.

The 2003 CIP evaluation determined that during a typical year (e.g., 2001), the combined CIPs reduced the phosphorus loading to Tanners Lake by 48%; the alum treatment facility was responsible for 97% of this reduction, based on modeling results.

2.13.2.6 Water Quality Goals

The water quality goals for Tanners Lake are consistent with the MPCA's deep lake eutrophication standard for lakes in the North Central Hardwoods Forest Ecoregion shown in Table 2.13-2. The RWMWD will continue to evaluate water quality data in Tanners Lake for trends and adjust its water quality classification and management activities accordingly. The District will continue to maintain the existing water quality improvement projects constructed by the District within the Tanners Lake subwatershed. Projects implemented in the Tanners Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.13-5.

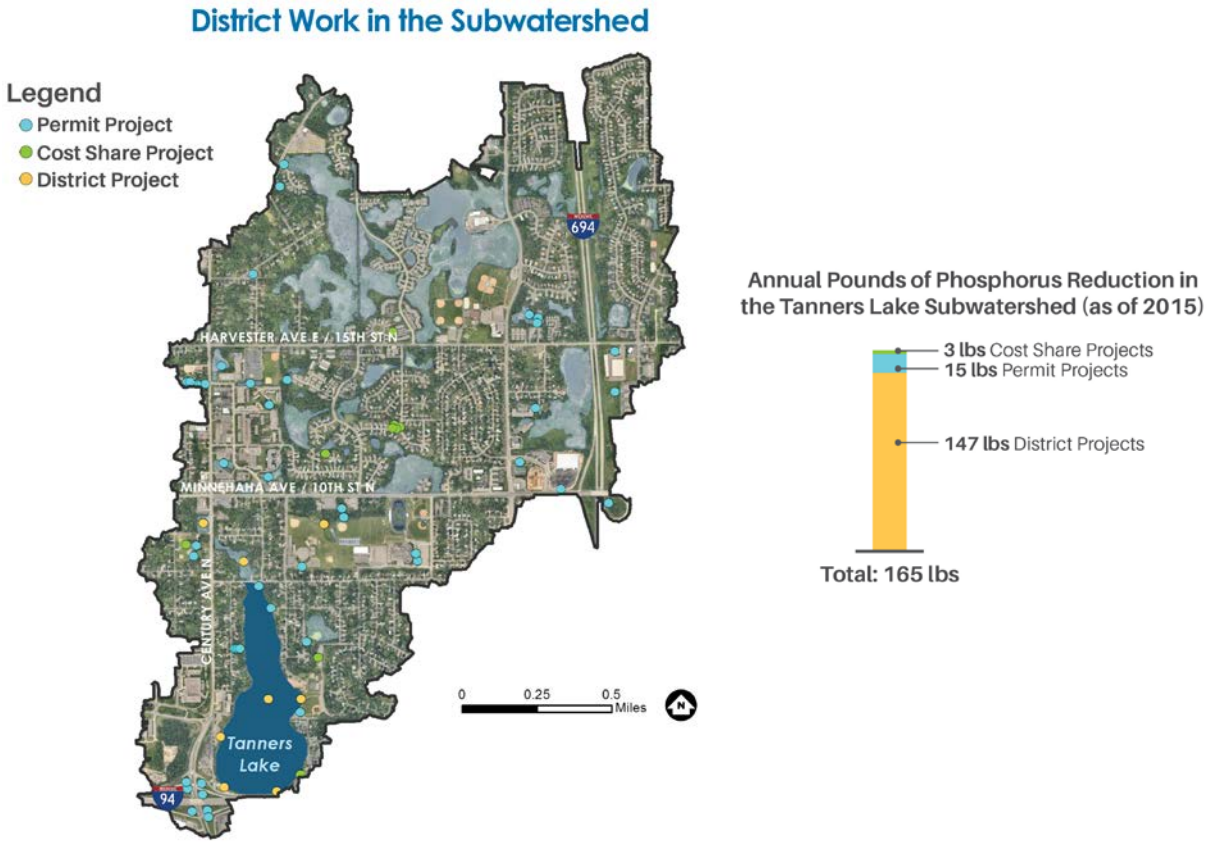


Figure 2.13-5 District work in the Tanners Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.13.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

In 1992, the RWMWD constructed a new outlet structure for Tanners Lake to replace an old and decaying pipe constructed by an individual 40 years earlier. The likely collapse of this outlet structure would have caused significant flooding on the lake. The new outlet was constructed in a different location along the south end of the lake.

Although the District has adopted rules to limit to the risk of flooding to new or redeveloped structures, there remain some low structures in the Tanners Lake subwatershed constructed before the formation of the District that remain at risk. The District has been working with the cities to prepare emergency response plans to protect these homes if needed. An important part of the emergency response plan is an early warning system that alerts emergency response teams to begin sandbagging operations. To provide this early warning, the District installed an automatic lake level monitoring station at Tanners Lake to allow the cities and the District to remotely monitor lake levels. Several of these stations throughout the District

were modified in 2010 to provide a call-out feature to automatically warn cities when the lake reaches a critical water level.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Tanners Lake subwatershed are the new 100-year flood elevations shown in Figure 2.13-6. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.13.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Tanners Lake subwatershed are shown in Figure 2.13-7, indicating areas where the lake levels of waterbodies in the Tanners Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.13.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD is involved in numerous habitat management areas throughout the District. After construction of the Tanners Lake alum treatment facility in 1997, the RWMWD revegetated the adjacent wetland with native plant species. The site was previously vegetated with several invasive, nonnative species, but now has zones of native prairie, shrubs, trees, and emergent plants, and an open water area within the pond. As a result, wildlife habitat has increased. The RWMWD actively manages the pond buffer; activities include reed canary grass and hybrid cattail control, as well as prescribed burns. A diversity of prairie wildflower species blooming at different times during the growing season offers a pleasant view from Century Avenue. The RWMWD staff will continue to manage this pond.

The Tartan High School/Oakdale Elementary Pond is another habitat management site within the Tanners Lake subwatershed. The pond, located between Oakdale Elementary School and Tartan High School, was designed to detain and treat stormwater runoff from the area (drainage area TL-28 in Figure 2.13-6). The

RWMWD, along with volunteers, replaced the turf grass vegetation around the pond perimeter with emergent, wet meadow, and prairie species vegetation. The restoration project resulted in over 60 native plant species becoming well established in and along the pond buffer, and provided additional wildlife habitat on the site. This area now provides an excellent opportunity for outdoor classroom activities in a high quality natural area. The RWMWD education staff will continue to work with school administration and teachers to incorporate watershed and natural resources curriculum into their science programs.

In cooperation with the MDNR and a private landowner, the RWMWD established an ecological shoreland restoration project on the west side of Tanner's Lake. This project was one of the first shoreland demonstration projects to take place in the District. Prior to restoration, the site consisted of a steep bank with considerable bare soil areas, rocked slopes, turf grass and invasive, non-native species suited to partially saturated soils, such as reed canary grass. Community volunteers, District staff, and MDNR staff seeded and planted native seedling plugs in spring 1999, and planted additional native seedling plugs in 2000 and 2001 to fill some dead areas. Currently, District staff monitors the site and conducts limited maintenance. The property is now up for sale. The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities on Tanners Lake and the surrounding watershed.

The RWMWD closely assesses all District restoration areas to detect potential erosion problems and to determine appropriate management activities. The District will also continue to seek opportunities to integrate natural resource benefits into its activities within the Tanners Lake subwatershed.

2.13.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Tanners Lake subwatershed (see Table 2.13-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Tanners Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

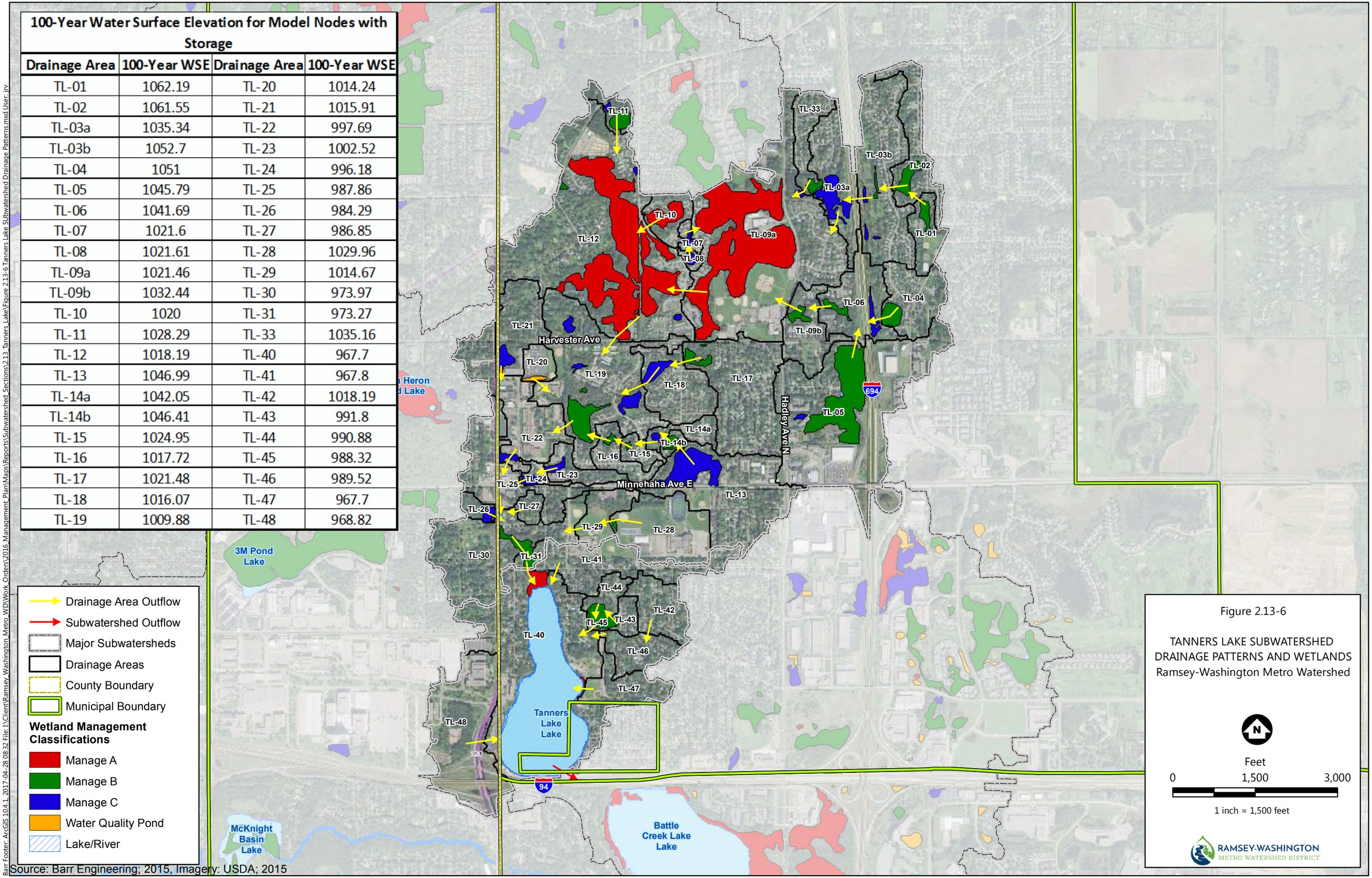
Table 2.13-4 Tanners Lake Subwatershed Implementation Activities

Activity ID No.	Tanners Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)		Relevant Strategic Overview Action Items**	Priority Tier
TaL-1	Implement the Tanners Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**		**WQ19, FL5, FL9**	**Tier 2**
TaL-2*	Continue alum treatment system operations and maintenance	**Continuous**	**Utilities (electric, water, comm.)**	**$3,000**	**WQ9**	**TaL-2***
			Chemical supply (alum)	**$60,000**		
			Pond floc removal	**$25,000**		
			$88,000 (average annual cost)			
TaL-3*	Continue alum system monitoring and reporting as required by current and future NPDES permit. Continue to monitor research of alum use for stormwater treatment, identifying best practices.	**Continuous**	**$40,000 (average annual cost)**		**WQ7**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage			
Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
TL-01	1062.19	TL-20	1014.24
TL-02	1061.55	TL-21	1015.91
TL-03a	1035.34	TL-22	997.69
TL-03b	1052.7	TL-23	1002.52
TL-04	1051	TL-24	996.18
TL-05	1045.79	TL-25	987.86
TL-06	1041.69	TL-26	984.29
TL-07	1021.6	TL-27	986.85
TL-08	1021.61	TL-28	1029.96
TL-09a	1021.46	TL-29	1014.67
TL-09b	1032.44	TL-30	973.97
TL-10	1020	TL-31	973.27
TL-11	1028.29	TL-33	1035.16
TL-12	1018.19	TL-40	967.7
TL-13	1046.99	TL-41	967.8
TL-14a	1042.05	TL-42	1018.19
TL-14b	1046.41	TL-43	991.8
TL-15	1024.95	TL-44	990.88
TL-16	1017.72	TL-45	988.32
TL-17	1021.48	TL-46	989.52
TL-18	1016.07	TL-47	967.7
TL-19	1009.88	TL-48	968.82



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.13-6

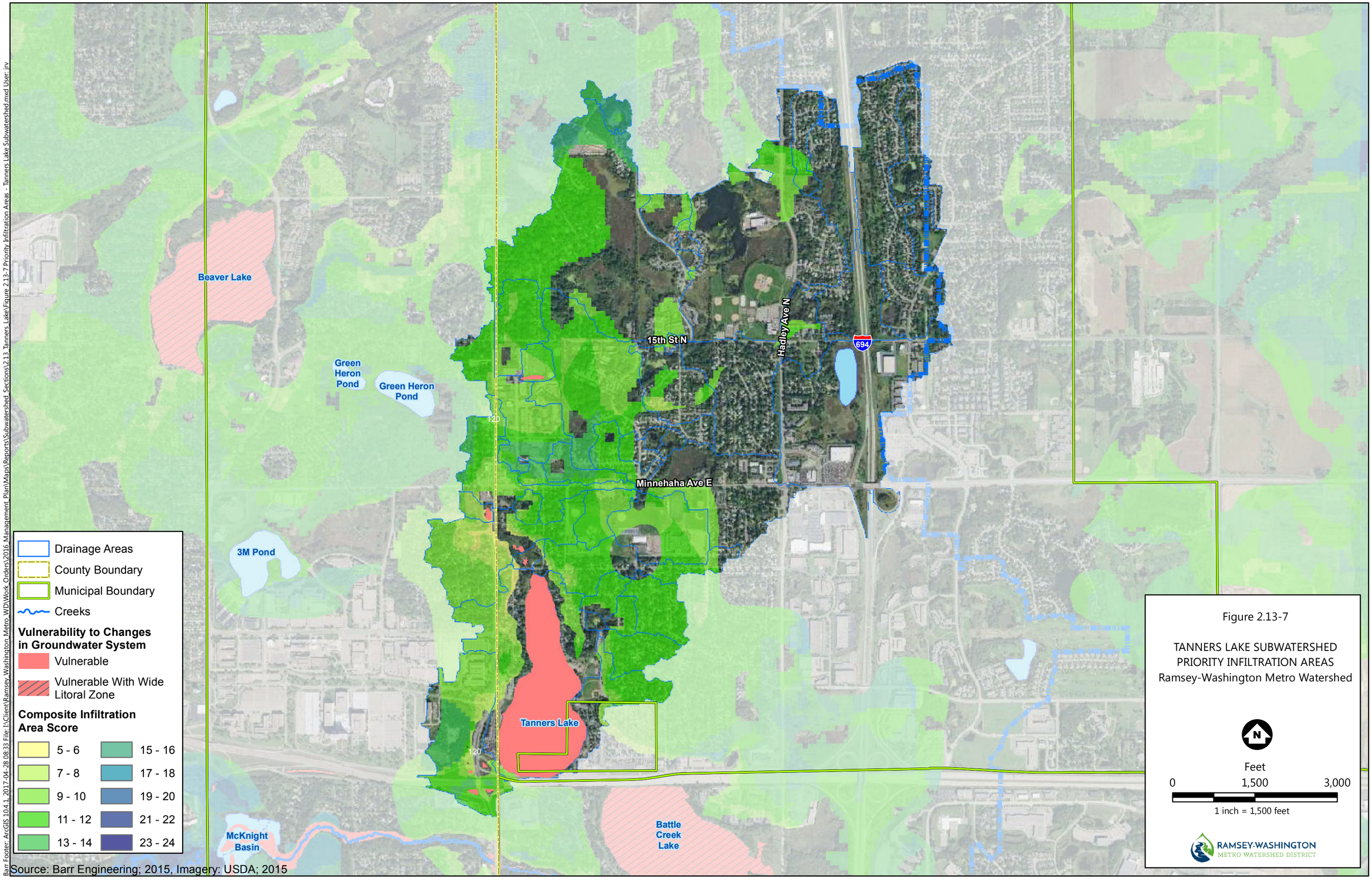
TANNERS LAKE SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,500 3,000

1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:32 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.13_Tanners_Lake\Figure 2.13-6 Tanners Lake SUbwatershed Drainage Patterns.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:33 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.13_Tanners_Lake\Figure 2.13-7 Priority Infiltration Areas - Tanners Lake Subwatershed.mxd User: jrv

2.14 Battle Creek Lake Subwatershed

2.14.1 General Description

The Battle Creek Lake subwatershed covers 2,635 acres and includes portions of the cities of Oakdale, Landfall, and Woodbury (see Figure 2.14-1). The Battle Creek Lake subwatershed receives flow from the Tanners Lake subwatershed, adding an additional 1,707 acres to the entire catchment for a total of 4,332 acres that ultimately drain into Battle Creek Lake. Battle Creek Lake is the only District-managed waterbody in the subwatershed.

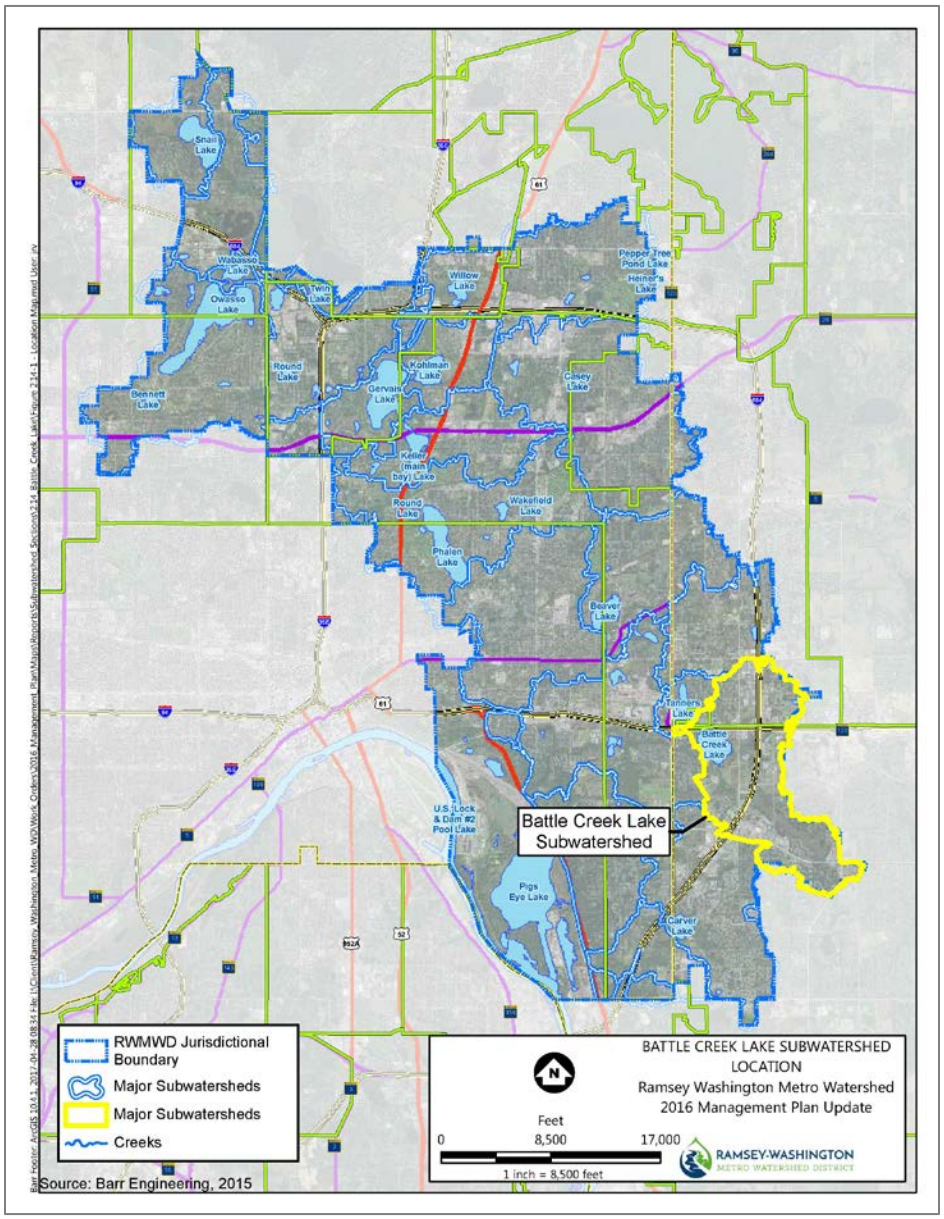


Figure 2.14-1 Battle Creek Lake Location Map

Battle Creek Lake is a MDNR public water (MDNR# 82-0091P) located entirely in the city of Woodbury (Washington County). Battle Creek Lake is located at the southwest corner of the I-94 and I-494/694 interchange (see Figure 2.14-1). The 103-acre lake has a maximum depth of 15 feet and an average depth of approximately 4 feet. The lake is bounded by the interstate highways, two residential developments, and two small city parks, Menomini Park and Shawnee Park. There is a public boat access at the southwest corner of the lake in Shawnee Park. The lake is used for a variety of recreational purposes, including motor boating, canoeing, fishing, picnicking, and viewing. The City of Woodbury operates an aeration system during the winter to prevent winterkill. Battle Creek Lake discharges to the west into Battle Creek, which eventually flows into the Mississippi River in St. Paul.

Table 2.14-1 Battle Creek Lake Subwatershed Facts

Tributary Area (Direct)	2,638 acres
Tributary Area (Total)	4,345 acres
Downstream Watershed	Battle Creek
MDNR Designation[1]	82-0091P
Lake Surface Area[1]	103 acres
Lake Mean Depth[1]	4 ft
Lake Maximum Depth[1]	15 ft
Lake Outlet Type[1]	72" Reinforced Concrete Pipe
Lake Outlet Elevation[1]	954.0 ft
100-Year Flood Level[1]	961.0 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake; Impaired for Aquatic Consumption (mercury food consumption advisory), Impaired for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Landfall, Oakdale, Woodbury, Washington County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data for Battle Creek Lake

2.14.1.1 Past Studies

The following list is a summary of past studies related to the Battle Creek Lake subwatershed.

- *DRAFT Battle Creek Lake Watershed Management Plan*. Prepared for RWMWD by Barr Engineering, July 1995.
- *Feasibility Report: Battle Creek Tunnel Repairs*. Prepared for RWMWD by Barr Engineering, 1995.
- *Discussion of Water Quality Goals for Battle Creek Lake*. Prepared for RWMWD by Barr Engineering, January 2006.
- *Battle Creek Lake Lake Status Report.* Prepared for RWMWD by Barr Engineering, 2009.

- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.14.1.2 Land Use

The Battle Creek Lake subwatershed has varied land use, including residential land use of varying densities, commercial land use, mixed use industrial, parks, and undeveloped areas occupied by wetlands (see Figure 2.14-2). There are significant undeveloped areas bordering the lake, and there are two large wetland areas, one in the southern portion, and the other in the northeastern portion of the subwatershed. Based on future land use projections, much of the remaining undeveloped areas not occupied by wetland will be converted to commercial/industrial development (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

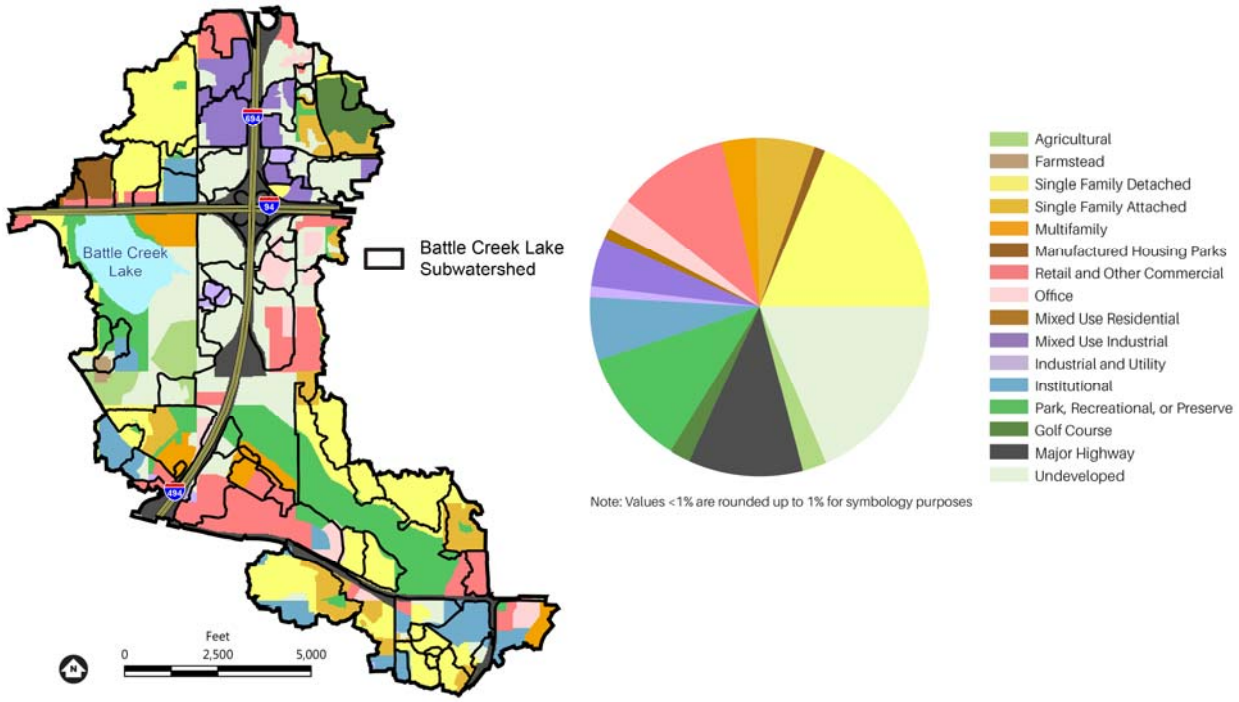


Figure 2.14-2 Breakdown of land uses throughout the Battle Creek Lake Subwatershed (2010 Metropolitan Council)

2.14.1.3 Drainage Patterns and Waterbodies

The Battle Creek Lake subwatershed drains into Battle Creek Lake through a series of wetlands and detention ponds, which are connected primarily by storm sewers and drainage ditches. The subwatershed also receives incoming flows from the Tanners Lake subwatershed. Battle Creek Lake discharges to the west to Battle Creek (and the Battle Creek subwatershed) via a 72 inch reinforced concrete pipe. Battle Creek eventually flows into the Mississippi River in St. Paul.

The Battle Creek Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.14-8). Figure 2.14-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Battle Creek Lake subwatershed include only Battle Creek Lake.

Wetlands within the Battle Creek Lake subwatershed are shown in Figure 2.14-8 according to the RWMWD wetland management classification (see Section 1.11.3). Tamarack Swamp, a wetland found in the southeast portion of the subwatershed, is the largest and most ecologically diverse wetland in the District. The wetland is named for the tamarack tree present in the wetland, a cold-climate conifer found in far northern latitudes, but generally quite rare in this part of the state.

2.14.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following sections discuss the water quality goals and conditions for the District-managed water bodies in the Battle Creek Lake subwatershed.

2.14.2.1 Historical Water Quality

Battle Creek Lake is used primarily for motorboating, canoeing, fishing, picnicking, and viewing. The lake receives flows from Tanners Lake, runoff from its direct tributary subwatershed through storm sewer outfalls and culverts at various locations along the shoreline, and sheet flow runoff from the immediate drainage area.

The RWMWD samples the water quality of Battle Creek Lake every two weeks between the months of May and September. Figure 2.14-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.14-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Battle Creek Lake relative to MPCA standards. Battle Creek Lake was listed on the MPCA's Impaired Waters 303(d) List in 2002 due to excess nutrients (see Section 1.10.2). Battle Creek Lake was removed from the impaired waters list in 2014 based on additional monitoring data and water quality improvements within the Battle Creek Lake subwatershed (see Section 2.14.2.5).

The RWMWD has assigned a water quality classification of "At Risk" to Battle Creek Lake based its removal from the impaired waters list and recent water quality data (see Table 2.14-2).

Table 2.14-2 Battle Creek Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Battle Creek Lake (2001-2010) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	71
Chlorophyll-a (µg/L)	≤ 20	10.7
Secchi disk transparency (m)	≥ 1.0	1.8

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on Battle Creek Lake water quality data. The results of these analyses are shown in Table 2.14-3.

Table 2.14-3 Trend Analysis Results for Battle Creek Lake Historical Water Quality Data

Waterbody	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

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

Sediment cores were taken from the lake in 2009 to assess the lake's internal phosphorus loading potential from sediment release. The sediment cores were also used to evaluate the water quality in the lake before European settlement. Fossilized algae in the lake were used to reconstruct the historical water quality of Battle Creek Lake. By analyzing the types of diatom fossils in the core, scientists from the St. Croix Watershed Research Station were able to tell that, since the time of European settlement, Battle Creek Lake has changed from having a moderate level of nutrients (mesotrophic) to having a high level of nutrients (eutrophic) that promote significant algal growth.

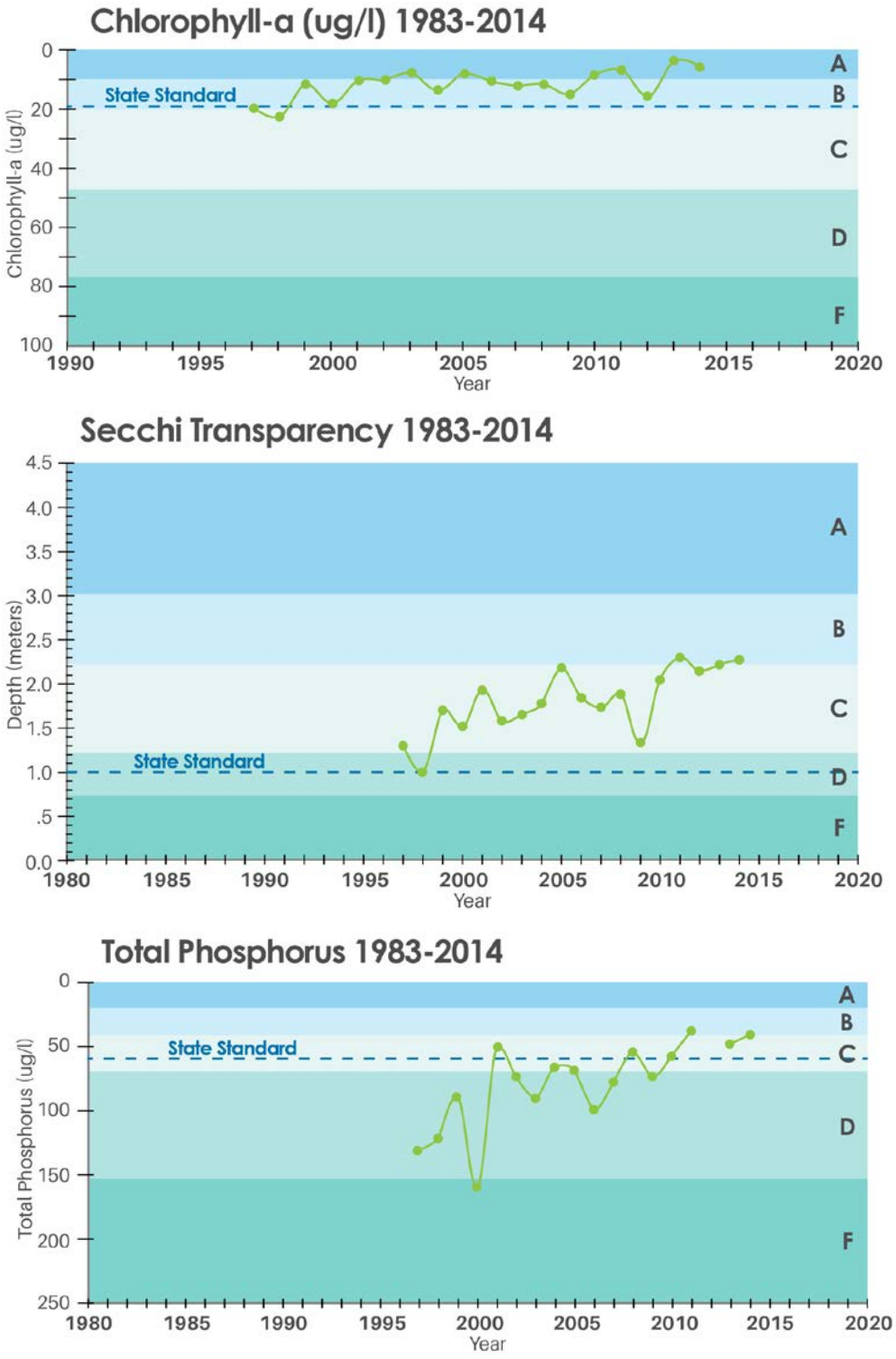


Figure 2.14-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Battle Creek Lake (1983-2014)

2.14.2.2 State of the Fishery

In 1992, the MDNR classified Battle Creek Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Battle Creek Lake is a Class 41 lake (Schupp, 1992).

The MDNR manages the fishery in Battle Creek Lake as part of its "Fishing in the Neighborhood" (FiN) program. The MDNR stocked the lake with bluegill adults in 2006, black crappie fingerlings (one to six months old) in 2007, and walleye fry (newly hatched fish) in 2013. In addition to its stocking activities, the MDNR periodically assesses the Battle Creek Lake fish population. The last MDNR survey was performed in 2014. Survey results are available on the MDNR Lake Finder website (www.dnr.state.mn.us/lakefind/index.html).

Consistent with past surveys, the 2014 survey found northern pike in above average numbers (9.0/gill net) but below average in size. Pike caught in the gill net averaged 17.5 inches and 1.42 lb., with only one northern pike exceeding 25 inches. Panfish were present in low to average numbers in 2014. Bluegill numbers were down considerably from previous surveys with only one fish being observed. Pumpkinseed sunfish were found in average abundance and size for lakes like Battle Creek. Hybrid sunfish were present in low to average numbers. No sampled pumpkinseeds or hybrid sunfish exceeded six inches. The overall low to average abundance of the various fish species found in Battle Creek Lake 2014 is likely due to severe winters in the two years prior to the survey; some winter kill likely occurred in spite of the lake being aerated.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Battle Creek Lake based on the presence of mercury and perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.14.2.3 State of the Macrophyte Community

The results of Battle Creek Lake's September 26, 2012 macrophyte survey are summarized below in Figure 2.14-4. In total, 110 sites were surveyed for macrophytes. Of these, 108 had vegetation, indicating that Battle Creek Lake is a highly macrophyte-dominated lake.

Where American water lotus, white water lily, and coontail were found in the lake, they were present in higher abundance relative to other macrophyte species in Battle Creek Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating an aesthetic and recreational nuisance. Also, curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer. Due to the timing of the 2012 survey (fall), the presence of curlyleaf pondweed in Battle Creek Lake may have been under-represented.

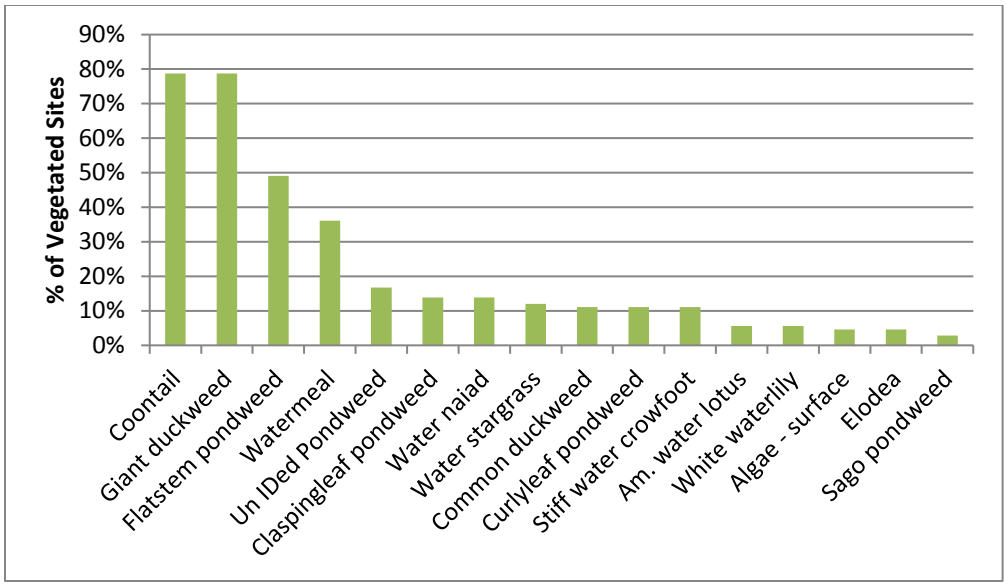


Figure 2.14-4 September, 2012 Battle Creek Lake Macrophyte Survey Results

2.14.2.4 Water Quality Modeling

The District performed water quality modeling of the Battle Creek Lake subwatershed as part of developing the *Battle Creek Lake Watershed Management Plan* in 1995. The District estimated the water and total phosphorus loads to the lake from the tributary watershed using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990). Although the model was not calibrated to monitoring data, it was calibrated to some degree by using published loading rates and urban water runoff volumes.

Figure 2.14-5 shows the main drainage districts contributing flow and phosphorus loading to Battle Creek Lake. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. The two areas of the subwatershed with the largest predicted phosphorus loading are the Tamarack Wetland and the Interchange drainage districts, which contribute 34.5% and 35.0% of the total phosphorus loading to Battle Creek Lake, respectively (not including the contribution from Tanners Lake). Under future development conditions, the Tamarack Wetland drainage district is estimated to achieve 50% cumulative phosphorus removal while the Interchange drainage district will achieve 41%. Figure 2.14-5 also shows the percent total phosphorus removal for each pond in the subwatershed.

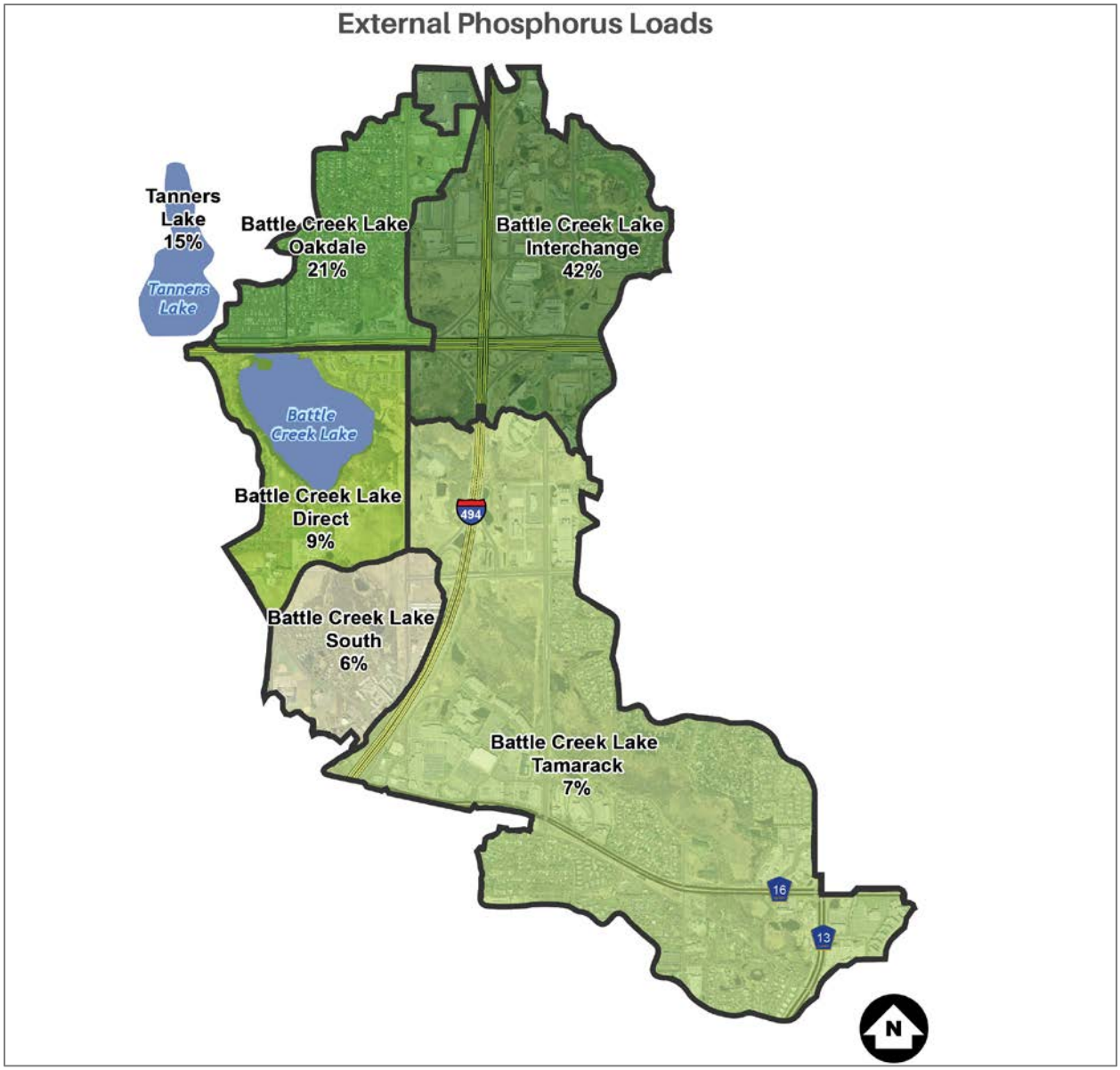


Figure 2.14-5 Drainage districts in the Battle Creek Lake subwatershed and upstream tributary watersheds

An in-lake mass balance model was used to simulate in-lake phosphorus concentrations resulting from watershed loading. The study did not include an investigation of the internal phosphorus load in the lake, and how it might be managed to improve the lake's water quality. The in-lake model was developed using Dillon and Rigler's empirical phosphorus model, which predicts in-lake summer phosphorus concentrations from lake basin morphometry, runoff volume, and inflow phosphorus mass (Barr, 1995). The model was calibrated using the spring and summer phosphorus monitoring data from 1993 and the inflow phosphorus loading predicted by the P8 model. Once calibrated, the model was used to simulate in-lake phosphorus concentrations for different scenarios to determine the impact of upstream

stormwater treatment activities. The pie chart shown in Figure 2.14-6 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads.

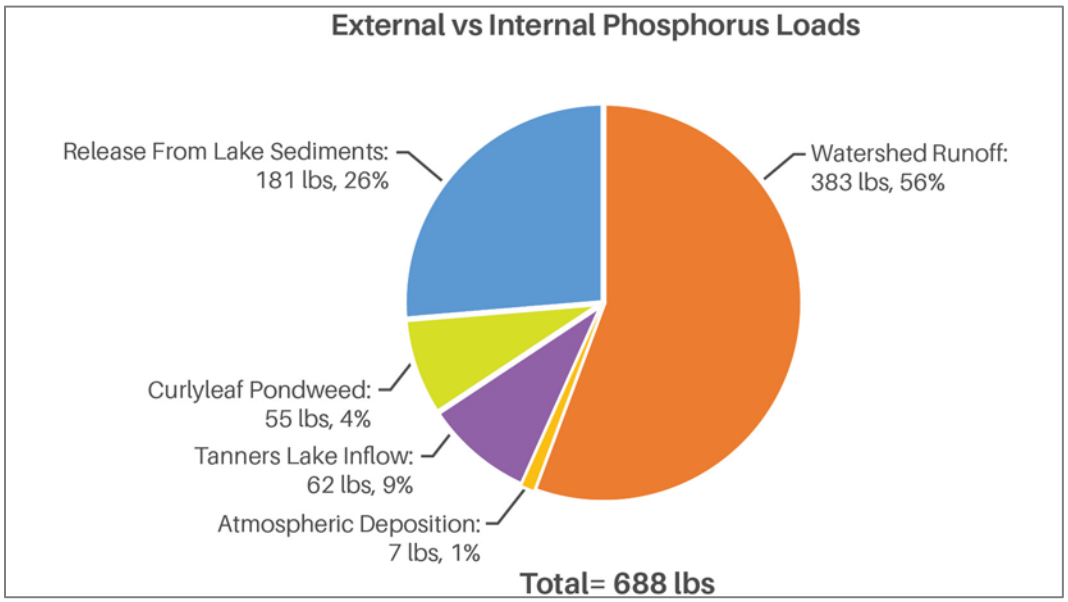


Figure 2.14-6 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Battle Creek Lake

2.14.2.5 Water Quality Improvement Projects

Since first establishing water quality goals for Battle Creek Lake in as part of the 1995 *Battle Creek Lake Watershed Management Plan*, the RWMWD has completed several capital improvement projects (CIPs), which contributed to significant improvements in water quality. Several of these improvements have resulted in Battle Creek Lake being removed from the MPCA's Impaired Waters List for excess nutrients in 2014. Notable District water quality improvement projects in the watershed include:

- **Apostolic Bible Institute Water Quality Pond** – Constructed from 2002 to 2004, this project involved the installation of approximately 660 feet of storm sewer and manhole/catch basin units, one diversion structure, a water quality treatment pond, and a pond outlet structure. The purpose of the project is to remove nutrients and sediments from stormwater runoff originating in a large residential area of Oakdale, prior to discharging to Battle Creek Lake. High flows bypass the pond to maximize the pond's water quality treatment effectiveness.

- **Fortis Pond Enhancements** – This project provides treatment of runoff from a commercial area prior to discharge into a high quality wetland immediately upstream of Battle Creek Lake. The Fortis Pond was originally constructed by the property developer for stormwater detention purposes as a part of the original development. The District modified the Fortis Pond in 2002-2003 by expanding the pond and adding a multi-stage outlet structure. The multi-stage outlet structure slows flow through the pond to allow silt and sediment to settle out in the pond. The outlet also reduces the amount of

floating debris being passed downstream. The project is inspected annually. Sediment removal is expected once every 10 years.

- **Valley Creek Road Stormwater Treatment System** – The purpose of this project was to treat stormwater runoff from a 128-acre residential are prior to discharging into Tamarack Swamp. The project is estimated to remove 60% of the total phosphorus load from this area, providing a positive long-term effect on Tamarack Swamp. A secondary purpose is to be a demonstration project for community officials, public works officials, development directors, city planners and engineers, as well as developers, consultants, and the general public. The project includes a series of infiltration basins with check dams, a flow splitter with an infiltration basin, and an extended detention pond and filtration system. In addition, this project included the stabilization of an eroded gully along the flow path to Tamarack Swamp.

- **East Tamarack Water Quality System (Polymer Filtration System)** – The Polymer Filtration System (PFS) treats stormwater runoff from two residential neighborhoods prior to entering the unique Tamarack Swamp wetland area. These neighborhoods had drained untreated runoff into the wetland causing visible degradation to the wetland habitat. The challenge was designing a treatment system with very little land available for a conventional pond treatment system. The system uses a safe polymer to make sediment particles heavier than normal and settle out of the runoff much faster than in conventional systems, allowing for a smaller pond size. The ponds were designed with porous pavers on the bottom of the pond to allow for convenient sweeping of the accumulated sediment as needed during the year.

- **Maplewood Living Streets Demonstration Project** – A first of its kind in Minnesota, the "Maplewood Living Streets" demonstration project was implemented as a part of Maplewood's Bartelmy-Meyers street reconstruction in 2011 and 2012. The "Living Streets" concept demonstrates how the cities can approach future street reconstruction projects that can be implemented with more efficiency and at a lower long-term cost than traditional roads, while also reducing impervious surfaces, treating runoff, improving aesthetics and pedestrian safety. The District worked closely with city staff to educate residents about the value of the street changes, resulting in half of the residents agreeing to have a rainwater garden on their property. The 7,000 feet of residential street included:



Maplewood Living Streets demonstration project.

  - narrowing the street from 32 feet to 24 feet, reducing pavement by 1 acre
  - adding 1.5 miles of sidewalk on one side of the street
  - installing 32 new rainwater gardens throughout the neighborhood
  - planting 120 drought-tolerant street trees throughout the neighborhood
  - creating a regional infiltration basin as an attractive feature in the local neighborhood park

The rainwater gardens, trees, and infiltration basin will sequester 40 tons of CO2 per year, as well as filter and infiltrate 50% of the stormwater runoff.

District water quality improvement projects in the Battle Creek Lake subwatershed have significantly reduced the amount of phosphorus loading to Battle Creek Lake. As a result, the MPCA removed Battle Creek Lake from the Impaired Waters 303(d) List in 2014. Projects implemented in the Battle Creek Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.14-7.

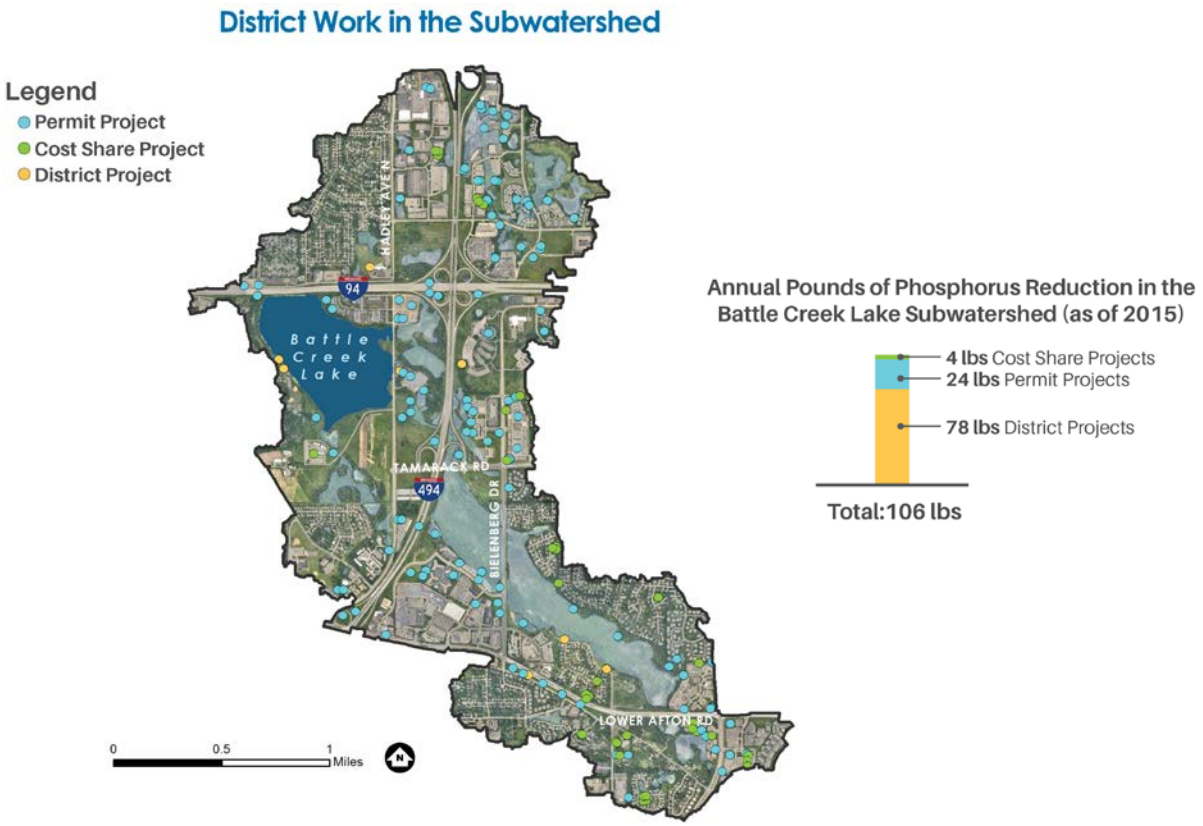


Figure 2.14-7 District work in the Battle Creek Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.14.2.6 Water Quality Goals

The water quality goals for Battle Creek Lake are consistent with the MPCA's shallow lake eutrophication standards in the North Central Hardwoods Forest Ecoregion, shown in Table 2.14-2. The RWMWD will continue to evaluate water quality data in Battle Creek Lake for trends and adjust its water quality classification and management activities accordingly.

2.14.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. The District performed hydrologic and hydraulic modeling for the Battle Creek Lake subwatershed in 1995 as part of the *Battle Creek Lake Watershed Management Plan* to identify potential flooding problems and recommend improvements.

A 1998 District feasibility study recommended constructing a berm in West Tamarack Swamp, and using the storage available in the swamp to reduce the rate of stormwater discharge to Battle Creek Lake. The District abandoned the berm construction plan, based on the results of a vegetation assessment that determined the hydrology of West Tamarack Swamp should not be changed in order to protect the sensitive wetland species within the swamp. Around the time the vegetation assessment was completed, MnDOT informed the District of their plans to construct a new freeway interchange with I-494 at Tamarack Road. The District used this opportunity to work with MNDOT to construct a stormwater management system within the interchange to reduce flow rates at the I-494 crossing, eliminating the need for the berm in West Tamarack Swamp.

In 2003, the RWMWD completed a flood control berm on the southwest side of Battle Creek Lake. The primary goal of the berm is to protect the homes in the area around Shawnee and Menomini Parks from flooding. The berm also provides additional recreational use for the neighborhood residents with a walking trail constructed on the top of the berm.

During moderate and heavy storm events, flooding occurs on and along Weir Drive, which is located immediately east of Battle Creek Lake. Hydrologic and hydraulic modeling shows that flood water will overtop Weir Drive as a result of major rainfall events. Intense short duration (i.e., 1-hour) rainfall events are expected to cause Weir Drive to flood by waters overtopping the roadway from its east side. Heavy, long duration (i.e., 4-day) rainfall events are expected to cause Weir Drive to flood by Battle Creek Lake rising and flowing over the roadway from the west.

In cooperation with the City of Woodbury's emergency services department, the RWMWD developed an emergency response plan in 2005 to guide actions during extreme (100-year) rainfall events in the area of Weir Drive and Battle Creek Lake. The emergency response plan is an interim measure until Weir Drive is raised and the culvert capacity is increased in conjunction with the future bridge over I-94 connecting Weir Drive to Hadley Avenue North. An important part of the emergency response plan is an early warning system that alerts emergency response teams to begin sandbagging operations. To provide this early warning, the District installed an automatic lake level monitoring station at Battle Creek Lake to allow the city and the District to remotely monitor lake levels. Several of these stations throughout the District were modified in 2010 to provide a call-out feature to automatically warn cities when the lake reaches a critical water level.

Vogel Manufacturing Co., located east of Weir Drive, had experienced flooding of their parking lot and loading dock facility. The RWMWD completed a flood control project in 2005 that corrected the flooding problem by routing stormwater flows around the facility.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Battle Creek Lake subwatershed are the new 100-year flood elevations shown in Figure 2.14-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.14.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Battle Creek Lake subwatershed are shown in Figure 2.14-9, indicating areas where the water levels of waterbodies in the Battle Creek Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.14.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The Tamarack Swamp located in the southeast of the Battle Creek Lake subwatershed is a unique, high-quality wetland within the RWMWD. The District has performed several water quality improvement projects to reduce the nutrient load in stormwater runoff that was draining to the wetland without adequate treatment (see Section 2.14.2.5).

The District has also included ecosystem restoration elements to other projects within the subwatershed. Battle Creek Lake Berm was designed as a flood water protection project for homes near Battle Creek Lake in Woodbury. As part of this project, the RWMWD developed a revegetation plan consisting of a mix of native seed and plants appropriate for the aquatic, transitional, and upland zones of the site. Volunteers from a local school planted prairie seedlings in June of 2003, while District staff planted wet meadow and emergent plants. This restoration demonstrates ecologically-based shoreland management in a highly visible area (the site is close to the boat launch and the fishing pier). RWMWD staff actively manage the berm and the shoreland area, controlling invasive weed species and conducting limited supplemental plantings.

The RWMWD Valley Creek Road Infiltration Project (see Section 2.14.2.5), the RWMWD Natural Resources staff developed a revegetation plan, which included a diverse mix of 25 native tree and shrub species. Plant installation was conducted by a Ramsey County Sentence-to-Serve Work Crew and supervised by the RWMWD. The City of Woodbury, Ramsey County Corrections, and the RWMWD partner to monitor and maintain this site. This stormwater infiltration site is an excellent demonstration of the effective use of native trees and shrubs in an aesthetically pleasing way, with the added benefit of providing high quality songbird habitat.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas in the subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Battle Creek Lake subwatershed.

2.14.6 Implementation Program

Based on studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Battle Creek Lake subwatershed (see Table 2.14-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Battle Creek Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.14-4 Battle Creek Lake Subwatershed Implementation Activities

Activity ID No.	Battle Creek Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BCL-1	Implement the Battle Creek Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**FL5**	**Tier 2**
BCL-2*	Research future options for control of Battle Creek Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BCL-3*	Perform a feasibility study of retrofit opportunities throughout the Battle Creek Lake Subwatershed to improve water quality	**2018**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BCL-4*	Implement projects deemed feasible in the Battle Creek Lake Subwatershed Feasibility Study	**2019-2026**	**$500,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**

Activity ID No.	Battle Creek Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BCL-5*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Battle Creek Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
BC-04	1028.87
BC-07	1030.12
BC-08	1049.34
BC-09	1026.34
BC-10	999.79
BC-11	1038.28
BC-22	1027.81
BC-22A	1023.59
BC-23	1032.83
BC-24	994.36
BC-25	987.61
BC-26	987.69
BC-28	987.04
BC-28A	1000.16
BC-30	991.99
BC-32	1040.99
BC-33	1043.72
BC-34	995.27
BC-35	977.74
BC-36	974.72
BC-38	962.46
BC-39	961.02
BC-40	961.94
BC-41	969.91
BC-43	985.8
BC-44	988.89
BC-45	996.13
BC-46	997.18
BC-47	991.05
BC-48	991.09
BC-55	1033.82
BC-56X	1028.52
BC-57A	1035.49
BC-59	1031.68
BC-60	1039.44
BC-61	1041.71
BC-63X	1028.01
BC-64X	1043.13
BC-66X	1048.95
BC-67	1022.29
BC-69	1059.36
BC-70	1067
BC-72	959.25
BC-75A	971.98

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

BATTLE CREEK LAKE SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

Figure 2.14-8

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:53 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.14_Battle_Creek_Lake\Figure 2.14-8 Drainage Patterns - Battle Creek Lake Subwatershed .mxd User: jrv

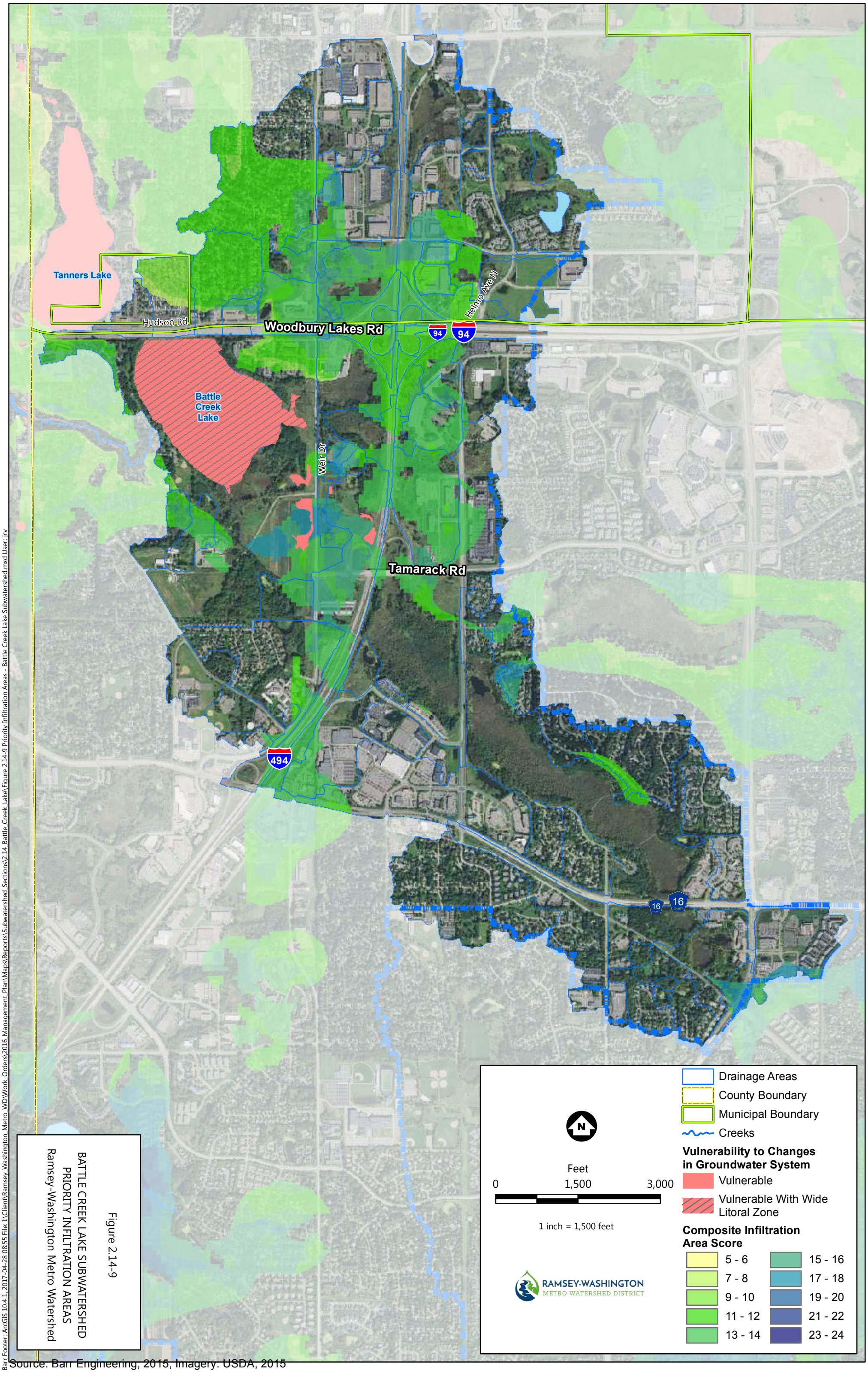


Figure 2.14-9

BATTLE CREEK LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

Source: Barr Engineering, 2015; Imagery: USDA, 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:55 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.14_Battle_Creek_Lake\Figure 2.14-9 Priority Infiltration Areas - Battle Creek Lake Subwatershed.mxd User: irv

2.15 Battle Creek Subwatershed

2.15.1 General Description

The Battle Creek subwatershed spans 2,900 acres, including portions of the cities of Maplewood, St. Paul, and Woodbury (see Figure 2.15-1). The majority of the subwatershed is located in Ramsey County, with a small portion on the eastern side in Washington County. The Battle Creek subwatershed receives flows from the Battle Creek Lake. The only District-managed waterbody within the Battle Creek subwatershed is Battle Creek.

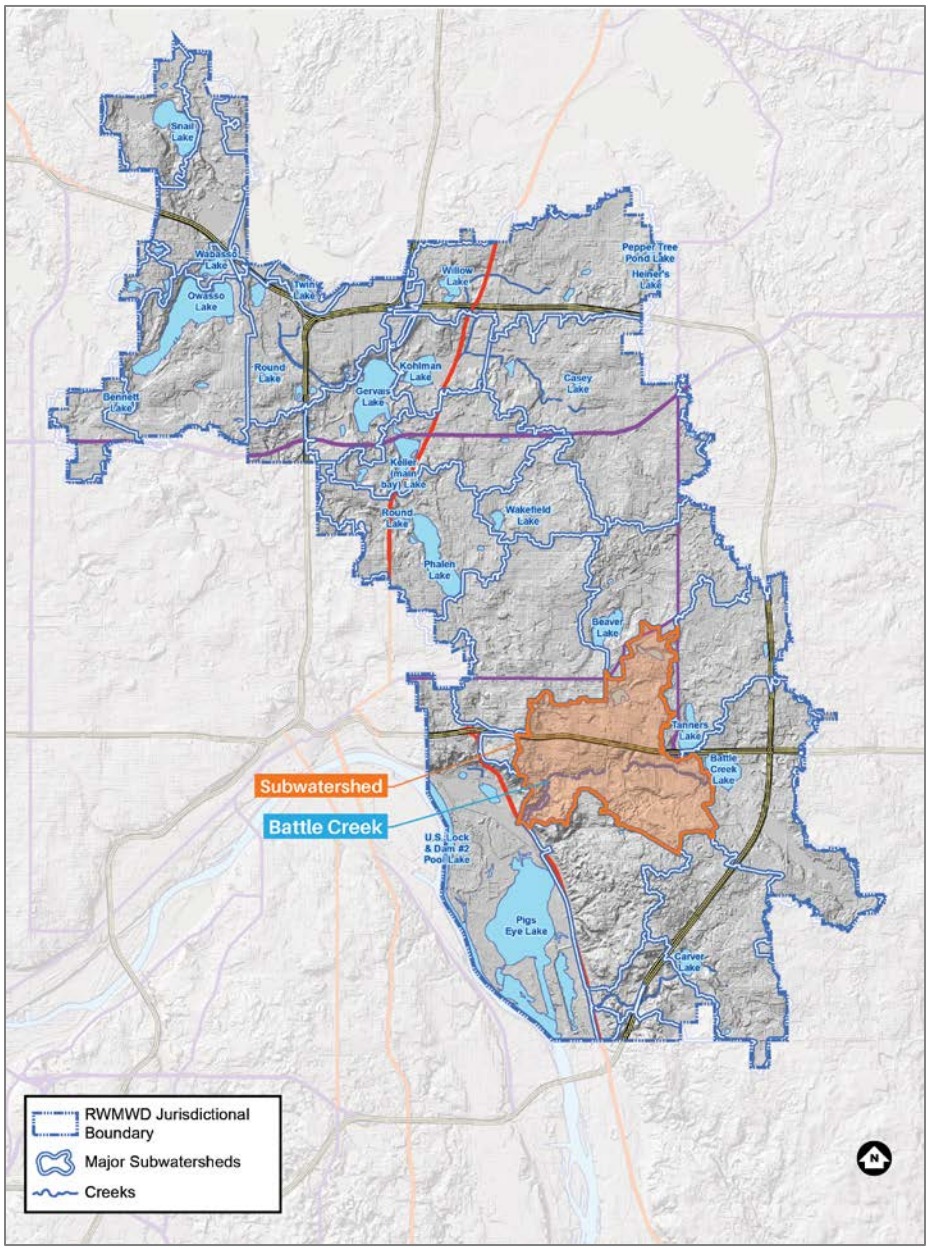


Figure 2.15-1 Battle Creek Location Map

Battle Creek is a perennial, urban stream that originates at the outlet from Battle Creek Lake in Woodbury. The creek then flows west and discharges into Pigs Eye Lake and the Mississippi River in the Mississippi River Bottomlands subwatershed. Along Battle Creek in St. Paul, there is a well-maintained regional park with facilities for hiking and bicycling. Historically, Battle Creek was plagued by frequent and devastating floods that caused loss of life, substantial property damage, and heavy stream erosion. The RWMWD completed a significant restoration project in 1982. The District continues to conduct maintenance on the creek to sustain that project.

Table 2.15-1 Battle Creek Subwatershed Facts

Tributary Area (Direct)	**2,972 acres**
Tributary Area (Total)	**7,314 acres**
Downstream Watershed	**Mississippi River Bottomlands**
MPCA Designations[1]	**Impaired for Aquatic Life (chloride, fish bioassessments, macroinvertebrate bioassessments)**
MS4s in the Direct Tributary Area	**Maplewood, St. Paul, Woodbury, Ramsey County, Washington County**
RWMWD Nutrient Water Quality Classification[1]	**Impaired**

[1] Data for Battle Creek

2.15.1.1 Past Studies

The following list is a summary of past studies related to the Battle Creek subwatershed.

- *Battle Creek Watershed Management Plan*. Prepared for RWMWD by Barr Engineering, November 1977.
- *Battle Creek Erosion Control Project Report*. Prepared for RWMWD by Barr Engineering, 1983.
- *An Evaluation of District Water Quality Data Collected from 1977 through 1989.* Prepared for RWMWD by Barr Engineering, 1990.
- *Feasibility Report: Battle Creek Tunnel Repairs*. Prepared for RWMWD by Barr Engineering, January 1995.
- *Battle Creek Sediment Study*. Prepared for RWMWD by Barr Engineering, November 2002.
- *Battle Creek Stressor Identification Study.* Prepared by the MPCA, 2015.
- *Ramsey-Washington Metro Watershed District Total Maximum Daily Load Study.* Barr Engineering Co., Draft 2016.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.15.1.2 Land Use

The majority of the land use within the watershed is low-density residential with areas of industrial land use (see Figure 2.15-2). Approximately 30% of the watershed is undeveloped or parkland, most of which is associated with the Battle Creek Regional Park. Approximately 10% of the subwatershed consists of the 3M industrial complex. Based on future land use projections, much of the residential area within St. Paul is expected to increase in density (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

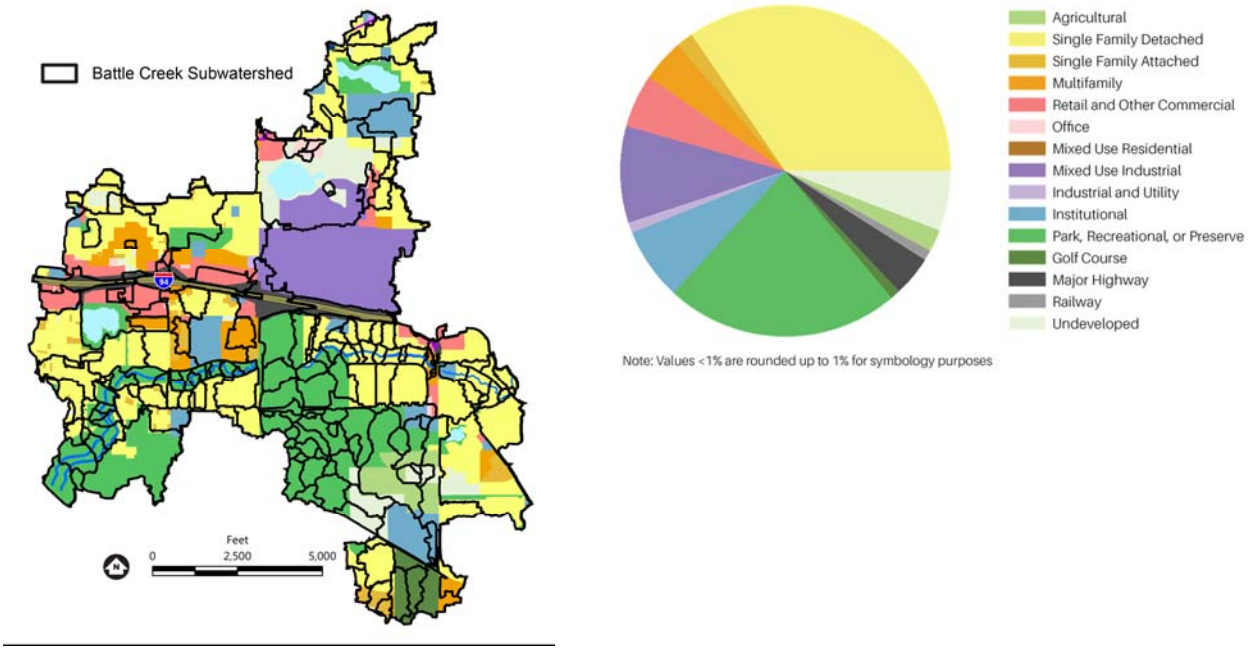


Figure 2.15-2 Breakdown of land uses throughout the Battle Creek Subwatershed (2010 Metropolitan Council)

2.15.1.3 Drainage Patterns and Waterbodies

Battle Creek receives discharges from Battle Creek Lake, as well as from the area directly tributary to the creek. Some of the runoff in the Battle Creek subwatershed flows directly into the creek; however, most of the area drains through a network of storm sewers, detention ponds, and wetlands. The runoff from the St. Paul residential neighborhoods in the northwestern portion of the subwatershed are directed first into a large detention pond on the south side of I-94 before the water then flows into the creek. The southeastern portion, consisting primarily of Battle Creek Regional Park, has several wetlands that filter the runoff before the flows eventually reach the creek. Battle Creek discharges into Pigs Eye Lake, in the Mississippi River Bottomlands subwatershed.

The Battle Creek subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.15-6). Figure 2.15-6 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year

storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Battle Creek subwatershed include only Battle Creek.

Wetlands within the Battle Creek subwatershed are shown in Figure 2.15-6 according to the RWMWD wetland management classification (see Section 1.11.3).

2.15.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following sections discuss the water quality goals and conditions for the District-managed water bodies in the Battle Creek subwatershed.

2.15.2.1 Historical Water Quality

Battle Creek is a perennial stream that originates at the outlet from Battle Creek Lake in Woodbury. The creek then flows west and discharges into Pigs Eye Lake (Mississippi River Bottomlands subwatershed).

Since 1996, the District has cooperated with the Metropolitan Council to monitor the flow and water quality of Battle Creek. The Metropolitan Council monitors the water quality of Battle Creek as part of its Stream Monitoring Program. The monitoring station is located in St. Paul, near U.S. Highway 61, 2.2 miles upstream from the creek's confluence with the Mississippi River. The program samples a number of dissolved and suspended solids, and performs a macroinvertebrate count on the creek. The most recent data available is from 2012, and is summarized in the 2014 report published by the Metropolitan Council. The Metropolitan Council's 2014 report includes 2003-2012 water quality averages for total suspended solids, total phosphorus, nitrates, and chloride; this information is summarized in Table 2.15-2.

Based on available water quality data, Battle Creek is listed as impaired for aquatic life with a primary stressor of total suspended solids (TSS). The stressor identification study identified as 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.

Table 2.15-2 Battle Creek historic water quality parameters (Metropolitan Council)

Water Quality Parameter	MPCA Stream Standard (Central River Nutrient Region)	Battle Creek (2003-2012) Flow-weighted Median Concentration
Total Phosphorus (µg/L)	≤ 100	197
Total Suspended Solids (mg/L)	≤ 30	83
Nitrates (µg/L)	--	320
Chloride (mg/L)	≤ 230	134

Data from Met Council 2014 Mississippi River Tributary Streams Assessment; chloride data may reflect a different data set than used by the MPCA to determine Battle Creek chloride impairment.

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on Battle Creek water quality data. The results of these analyses are shown in Table 2.15-3.

Table 2.15-3 Trend Analysis Results for Battle Creek Historical Water Quality Data

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%

Green values indicate an improving trend in water quality for that parameter
Red values indicate a degrading trend in water quality for that parameter

The Metropolitan Council's 2014 water quality report also calculates a Macroinvertebrate Index of Biological Integrity (M-IBI) to assess overall water quality. M-IBI considers macroinvertebrate community richness and composition, pollution tolerance, life histories, trophic interactions, and physical and other parameters that all are components of the biological integrity of the stream. Higher scores indicate better conditions. Battle Creek M-IBI scores from 2004 to 2011 are shown in Figure 2.15-3. All of the M-IBI scores were below the impairment threshold, which suggests that this stream reach habitat and water quality were typically unable to sustain all of the needs for aquatic life.

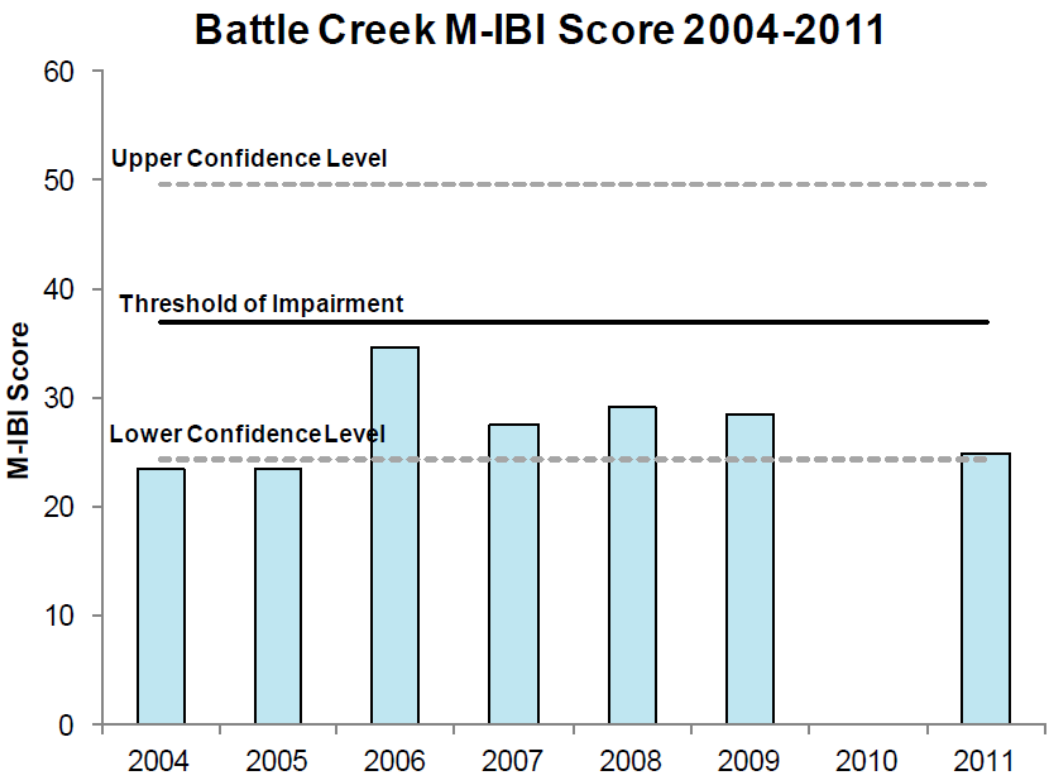


Figure 2.15-3 Battle Creek Annual Macroinvertebrate Index of Biological Integrity (M-IBI) Scores, 2004-2011(from Met Council Report)

Additional program information and monitoring data may be found from the Met Council Stream Monitoring program website:
http://www.metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management/Stream-Monitoring-Assessment.aspx

2.15.2.2 Water Quality Modeling and Analysis

The District performed modeling and analysis of Battle Creek water quality data as part of the TMDL study. This included evaluation of the primary stressors contributing to the impairment of Battle Creek. The analysis of stressors was completed using the EPA's Causal Analysis/ Diagnoses Decision Information System (CADDIS) (USEPA, 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 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. Excess sediment (TSS), chloride, low dissolved oxygen, total phosphorus (TP), altered habitat, habitat fragmentation, and four heavy metals (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. As a result of the stressor identification 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 in Table 2.15-4; more detailed information can be found in the Battle Creek Stressor Identification Report.

Table 2.15-4 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)

Following the identification of TSS as the primary stressor for the Battle Creek impairment, the District developed a TMDL using the load-duration approach. The load-duration approach considers TSS load in combination with streamflow to calculate expected concentrations of TSS in the stream. The Battle Creek hydrograph was divided into five flow regimes:

- High flows (flows above the 90th percentile of average daily flow)
- Moist conditions (flows between the 60th and 90th percentiles of daily average flow)
- Mid-range flows (flows between the 40th and 60th percentile of daily average flow)
- Dry conditions (flows between the 10th and 40th percentiles of daily average flow)
- Low flows (flows below the 10th percentile of average daily flow)

Similarly, a load duration curve was developed for Battle Creek. The load duration curve relates TSS loading at a given flow to how often that flow value is exceeded in the stream. The final TSS load duration curve is presented in Figure 2.15-4. Figure 2.15-4 demonstrates that exceedances of the TSS standard in Battle Creek (i.e., points above the orange line) are common, particularly during high flows, moist conditions, and mid-range flows. Because the TSS water quality standard states that the TSS concentration of 30 mg/L may be exceeded no more than 10% of the time, the allowable total daily loading capacity (orange circles) are compared to the 90th percentile value of existing loading (blue circles) within each flow regime to determine required loading reductions. The resulting waste load allocation is the difference between the two points, and varies by flow regime.

Determination of the allowable TSS load and required reductions in TSS loading to Battle Creek are described in greater detail in the Battle Creek TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016).

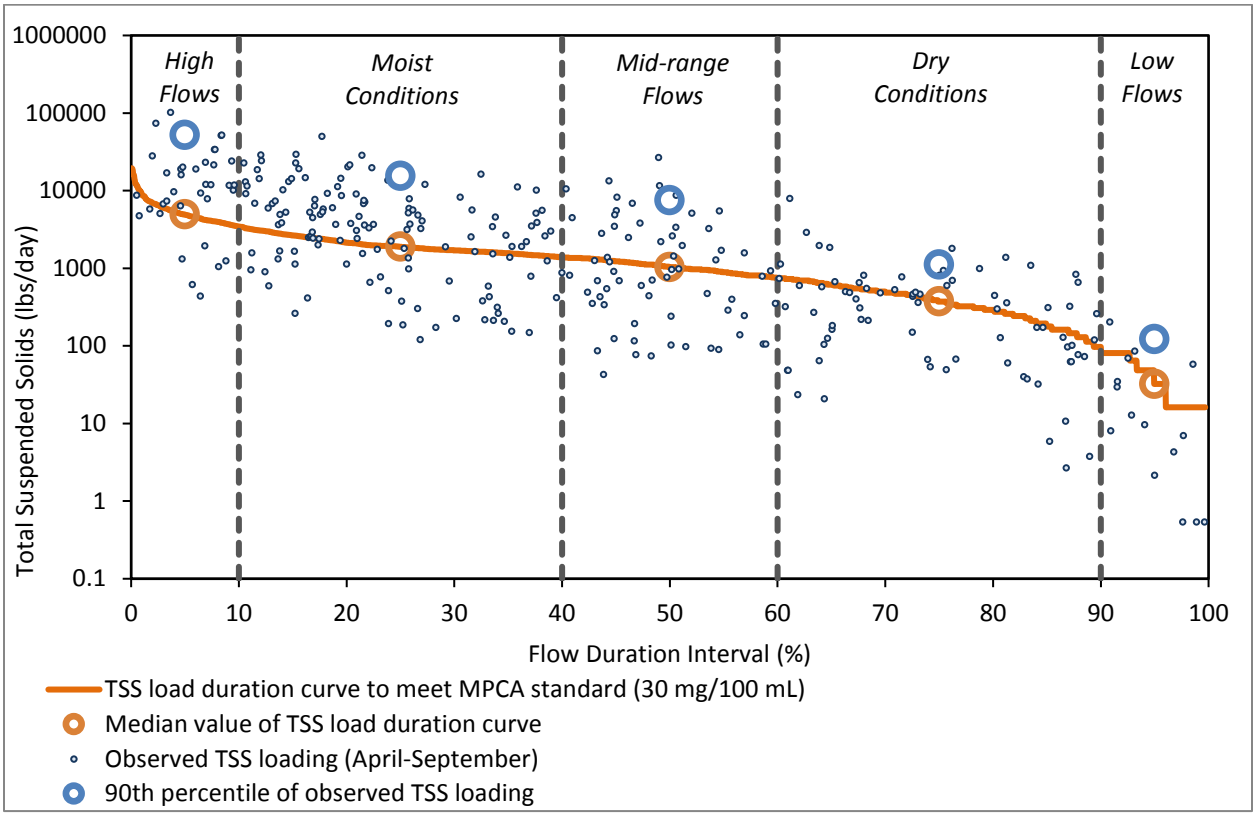


Figure 2.15-4 Battle Creek TSS load duration curve

2.15.2.3 Water Quality Goals

The water quality goals for Battle Creek are consistent with the MPCA's nutrient standard for streams in the Central River Nutrient Region shown in Table 1-3 and Table 2.15-2. The RWMWD strives to ensure that the watercourse and banks of Battle Creek are stable so as to minimize erosion and sediment problems. The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion and other stream degradation problems.

Battle Creek is listed on the MPCA's Impaired Waters 303(s) List with an impaired use of aquatic life based on three stressors: chloride, fish bioassessments, and macroinvertebrate bioassessments. A TMDL has been developed to address total suspended solids in Battle Creek (Barr Engineering Co., Draft 2016). Chloride impairments in Twin Cities Metropolitan Area are being handled through the MPCA's Metro Area Chloride Project. To address this issue, the MPCA has developed Twin Cities Metropolitan Area (TCMA)

Chloride Management Plan and *Chloride Total Maximuma Daily Load (TMDL)*. Battle Creek is included in the *TCMA Chloride TMDL*. For more information on this project, see the MPCA's website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/metro-area-chloride-project/road-salt-and-water-quality.html#tcma-chloride-project.

2.15.2.1 Tracking TMDL Implementation Progress

The Battle Creek TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016) calls for reductions in total suspended solids loading. The load reductions vary according to five different flow regimes. Under the "mid" flow regime, a reduction of 395 lbs/day of total suspended solids is required. Progress towards this goal will be achieved through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.15-5.

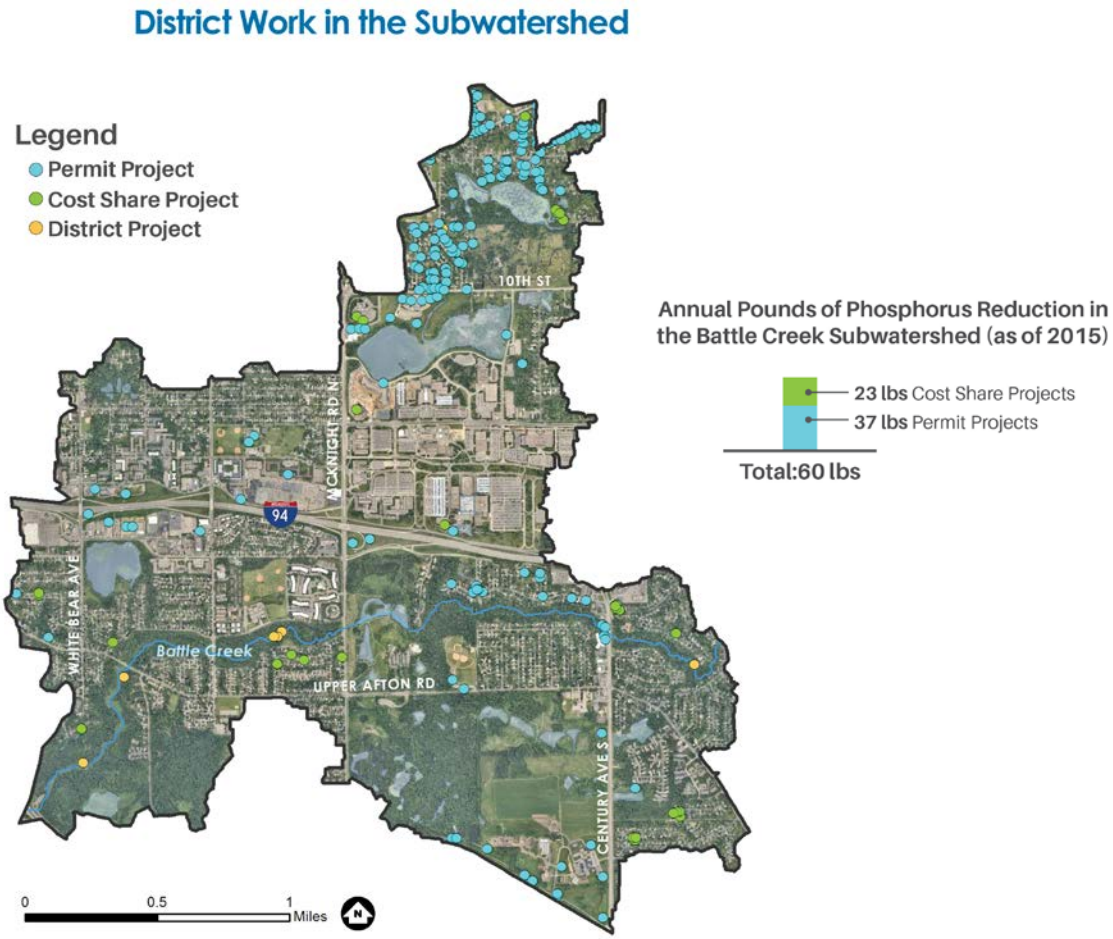


Figure 2.15-5 District work in the Battle Creek Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.15.2.2 Water Quality Improvement Projects

The District has made the water quality of Battle Creek a priority, with the completion of multiple improvement projects in the entire catchment area of the creek, which includes the Tanners Lake subwatershed (see Section 2.13) and Battle Creek Lake subwatershed (see Section 2.14). Those specific water quality improvement projects are discussed in their respective sections of this document. Specifically in the Battle Creek subwatershed, the erosion control projects discussed below not only provide flood control benefits, they have also improved the quality of the creek by reducing the sediment loading through erosion mitigation measures, and reducing the velocity of the creek flows.

2.15.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

For many years Battle Creek was plagued by frequent and devastating floods that caused loss of life, substantial property damage, and heavy stream erosion. To remedy this situation, the RWMWD initiated a large erosion control project to stabilize Battle Creek. The project was completed in 1983. The project entailed the construction of several sheet pile drop structures which helped to prevent erosion along the creek and added aesthetic value along the bicycling/walking trail. The project also involved the creation of a 200 acre-foot detention basin to contain major flood events. A large pipe installed on the downstream portion of the project diverts floodwaters underground to prevent erosion in the park. The project enjoyed great success, which led to the redevelopment of the parkland along the creek. The area has since become a popular recreational area.

The project has required minor routine maintenance of trash racks and excavation of accumulated sediment in the upstream ponds. In 1989 the District had to open a Section of the pipe to repair joint separations. A larger pipe repair project was completed in 1996, which involved replacing a 150-foot Section of the pipe with a hydraulically superior alignment.

Due to the success of the project in reducing the stream velocities and preventing large-scale erosion, the creek deposits sediment where the velocities decrease. This buildup of sediment allows for vegetation growth, which further blocks the channel and reduces the flow capacity of the creek. The first cleanup was performed during the winter of 1991-1992, and the sediment and vegetation were removed. In 2002, the RWMWD prepared the *Battle Creek Sediment Study* to evaluate the need for another cleanout of the channel. Sediment and vegetation had again blocked portions of the creek, and in some cases were causing the creek to overflow during low flows. In addition, a substantial portion of the flow was being diverted into the flood diversion pipe so that the creek was running nearly dry. The study concluded that Battle Creek should be cleaned out every 5 years as part of a regular maintenance plan.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Battle Creek subwatershed are the new 100-year flood elevations shown in Figure 2.15-6. The new inundation extents that have been

modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.15.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Battle Creek subwatershed are shown Figure 2.15-7, indicating areas where the water levels of waterbodies in the Battle Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.15.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The Ramsey County Correctional Facility is located in the southeast portion of this subwatershed. Starting in the late 1990s, the RWMWD Natural Resources staff developed a strong partnership with the correctional facility's staff that oversees their greenhouse operation. This facility has provided a majority of the native plant stock used in District restoration projects. Ramsey County work crews have also assisted with the installation and maintenance of many ecological restorations. This partnership has resulted in major cost savings to the RWMWD. In addition, the RWMWD Natural Resources staff has had the opportunity to consult on the management of Corrections grounds. Wetlands have been created as well as large prairie patches. Some of these areas are adjacent to Battle Creek Regional Park. This partnership has been quite valuable to the District, and the RWMWD will continue to support this partnership.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas in the subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Battle Creek subwatershed.

2.15.6 Implementation Program

Based on the RWMWD TMDL report and studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Battle Creek subwatershed

(see Table 2.15-5). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Battle Creek subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.15-5 Battle Creek Subwatershed Implementation Activities

Activity ID No.	Battle Creek Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BC-1	Implement the McKnight Basin Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**FL5, FL9**	**Tier 2**
BC-2*	Perform a feasibility study of retrofit opportunities throughout the Battle Creek Subwatershed to reduce watershed TSS load	**2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BC-3*	Implement water quality projects deemed feasible in the Battle Creek Subwatershed Feasibility Study	**2018-2026**	**$1,000,000**	**WQ2, WQ17, WQ18, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
BC-4	Study the effect of increasing flood storage in McKnight Basin and upstream of Weir Drive on improving flood resiliency in Battle Creek and implement recommended projects	**2018-2022**	**$500,000**	**WQ2, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage									
Drainage Area	100-Year WSE	Drainage Area	100-Year WSE	Drainage Area	100-Year WSE	Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
C-18	982.93	C-33H	928.63	C-49B	917.03	C-59H	940.85	C-66B	892.39
C-19A	948.57	C-33I	932.13	C-50	915.95	C-59K	888.96	C-67B	847.55
C-19B	948.95	C-33J	937.70	C-50C	919.28	C-60A	868.31	C-68A	840.60
C-19C	952.12	C-33K	938.25	C-51	916.87	C-60B	880.76	C-68B	855.72
C-19D	955.57	C-33L	941.59	C-52A	908.55	C-60C	874.34	C-69	868.41
C-19F	959.05	C-33M	929.40	C-52B	908.55	C-61A	850.83	C-70A	845.71
C-19H	984.02	C-34B	968.01	C-52C	973.58	C-61C	870.76	C-70B	841.53
C-19J	963.48	C-34C	970.71	C-52D	908.55	C-61D	895.65	C-70C	842.14
C-20A	956.18	C-36	966.11	C-52E	908.55	C-61G	904.32	C-71A	841.56
C-20B	956.18	C-37	970.30	C-53	932.32	C-61K	900.86	C-71B	850.91
C-20C	961.89	C-38	960.59	C-54A	917.05	C-61L	908.47	C-71C	858.63
C-20M	954.68	C-39A	939.06	C-54B	963.72	C-61M	917.34	C-71D	868.72
C-20N	955.39	C-39B	963.06	C-54C	975.09	C-61N	957.54	C-71E	870.61
C-20O	963.41	C-39C	963.60	C-54E	982.25	C-61O	884.82	C-71F	872.84
C-21	963.19	C-39D	933.84	C-55A	980.74	C-62A	893.03	C-72A	724.35
C-22A	1008.54	C-39E	958.75	C-55B	986.44	C-62B	913.39	C-72C	734.16
C-22B	1007.78	C-40A	953.35	C-55C	987.98	C-62C	952.79	C-72D	764.66
C-23A	1035.93	C-40B	966.59	C-55D	993.07	C-63	900.53	C-72E	774.61
C-23B	1035.71	C-40C	995.44	C-55E	987.76	C-64	918.75	C-72F	784.79
C-29	989.26	C-41	941.87	C-55F	992.84	C-65A1	875.48	C-72G	794.89
C-30A	959.13	C-42A	933.84	C-55G	982.32	C-65A2	875.48	C-72H	805.73
C-30B	965.52	C-42B	933.84	C-55H	982.41	C-65B	875.60	C-72J	815.64
C-30C	976.64	C-42C	933.84	C-55J	988.38	C-65C	876.80	C-72K	842.66
C-30D	983.11	C-43	928.78	C-56A	1000.30	C-65D	881.77	LA-20	996.78
C-30E	982.35	C-44	935.08	C-56B	1013.49	C-65E	882.50	LA-20A	999.44
C-30G	1001.61	C-45A	924.77	C-56C	1015.29	C-65F	882.66	LA-24A	996.68
C-31A	944.31	C-45B	924.77	C-58A	952.44	C-65G	887.33	LA-24B	1024.41
C-31B	949.61	C-45C	929.31	C-58B	944.27	C-65H	891.53	LA-24C	1025.12
C-33A	914.01	C-46	911.29	C-59A	875.78	C-65J	892.26	LA-25A	1037.04
C-33B	914.48	C-48A	921.93	C-59B	879.90	C-65K	895.16	LA-26A	1034.24
C-33C	918.64	C-48B	937.54	C-59C	886.15	C-65L	896.16	LA-26B	1034.24
C-33D	920.91	C-48C	924.69	C-59D	906.90	C-65O	897.17	LA-27A	1032.52
C-33F	925.31	C-48D	932.09	C-59E	911.42	C-65Q	896.59	LA-27B	1031.40
C-33G	926.86	C-49A	917.04	C-59F	938.06	C-66A	839.29		

Green Heron Pond

Green Heron Pond

3M Pond

Suburban Pond

McKnight Basin

Tanners Lake

Battle Creek Lake

Unnamed (North Battle Lake)

Conway Ave E

Century Ave

Drainage Area Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Feet
0 1,500 3,000

1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Figure 2.15-6

BATTLE CREEK SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:54 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.15_Battle_Creek\Figure 2.15-6 Subwatershed and Drainage Patterns - Battle Creek Subwatershed.mxd User: jrv

Beaver Lake
Green Heron Pond
Green Heron Pond
34
3M Pond
Conway Ave E
65
Tanners Lake
94
Suburban Pond
McKnight Basin
68
Battle Creek Lake
25
Century Ave
Pigs Eye Lake
Unnamed (North Star) Lake

Figure 2.15-7

BATTLE CREEK SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

Drainage Areas
County Boundary
Municipal Boundary
Creeks

Vulnerability to Changes in Groundwater System
Vulnerable
Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score
5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24

N

Feet
0 1,500 3,000

1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 12:40 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.15_Battle_Creek\Figure 2.15-7 Priority Infiltration Areas- Battle Creek Subwatershed.mxd User: jrv

2.16 Blufflands Subwatershed

2.16.1 General Description

The Blufflands subwatershed, located in the southern part of the RWMWD, includes 1,941 acres within the cities of St. Paul and Maplewood (Figure 2.16-1). The subwatershed is located almost entirely within Ramsey County. The topography of the subwatershed varies from moderately rolling to steep, with numerous rock outcroppings in the steep bluff region along Highway 61. The Blufflands subwatershed consists of several drainage districts that contribute runoff to separate ravines that outlet into the Pigs Eye Lake area in the Mississippi River Bottomlands subwatershed (see Section 2.12). There are no District-managed waterbodies within the Blufflands subwatershed.

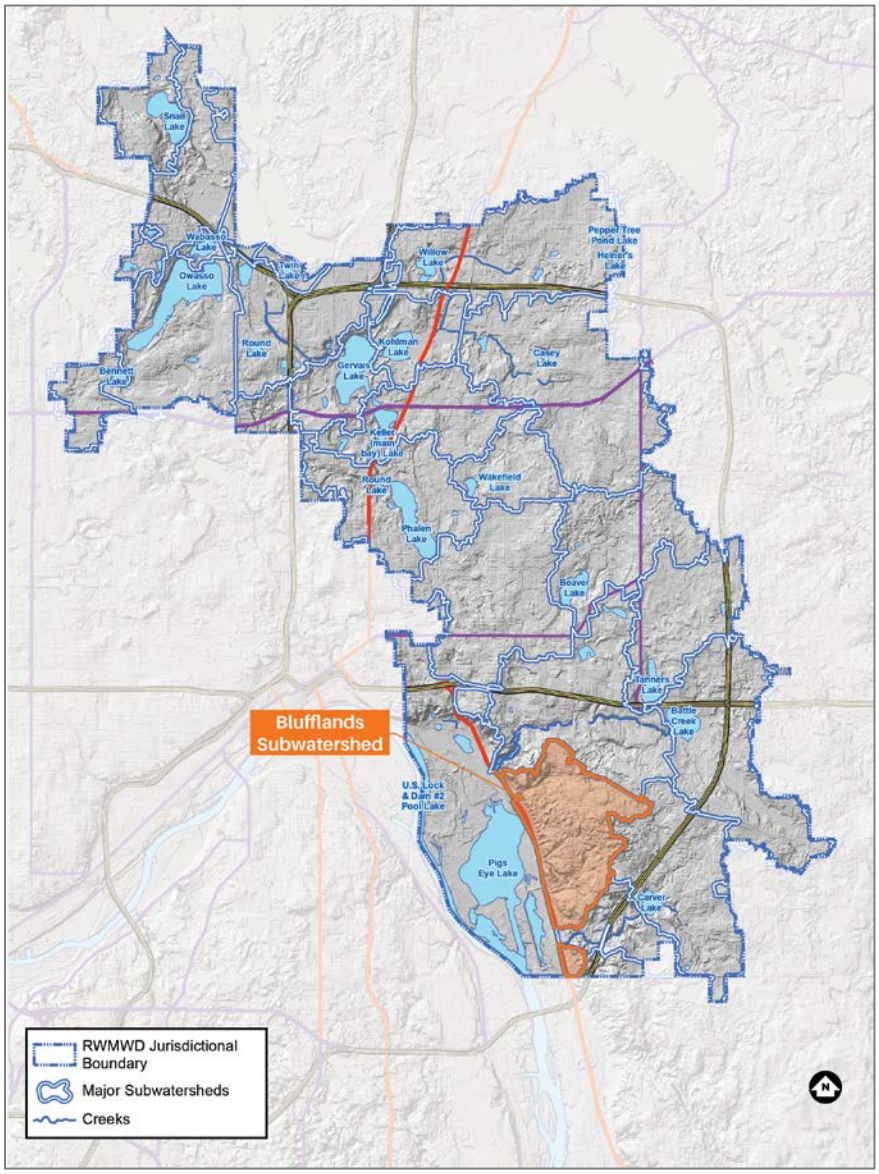


Figure 2.16-1 Blufflands Location Map

Table 2.16-1 Blufflands Subwatershed Facts

Tributary Area (Direct)	1,844 acres
Tributary Area (Total)	1,844 acres
Downstream Watershed	Mississippi River Bottomlands
MS4s in the Direct Tributary Area	Maplewood, St. Paul, Woodbury, Ramsey County

2.16.1.1 Past Studies

The following list is a summary of past studies related to the Blufflands subwatershed.

- *Overall Plan: Ramsey-Washington Metro Watershed District.* Prepared for the RWMWD by Barr Engineering, February 1977.
- *Lower Afton Road Drainageway Feasibility Study.* Prepared for RWMWD by Barr Engineering, January 1995.

2.16.1.2 Land Use

Based on the Metropolitan Council 2010 land use data, the Blufflands subwatershed is essentially fully developed (see Figure 2.16-2). The land use is primarily single-family residential, with park, recreational, or preserve land uses along the steep bluffs and rolling hills, and small amounts of higher-density residential, and institutional land use throughout the subwatershed. The Metropolitan Council's estimated 2030 land use anticipates the conversion of single-family residential land use to higher density residential land use in the north part of the subwatershed (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

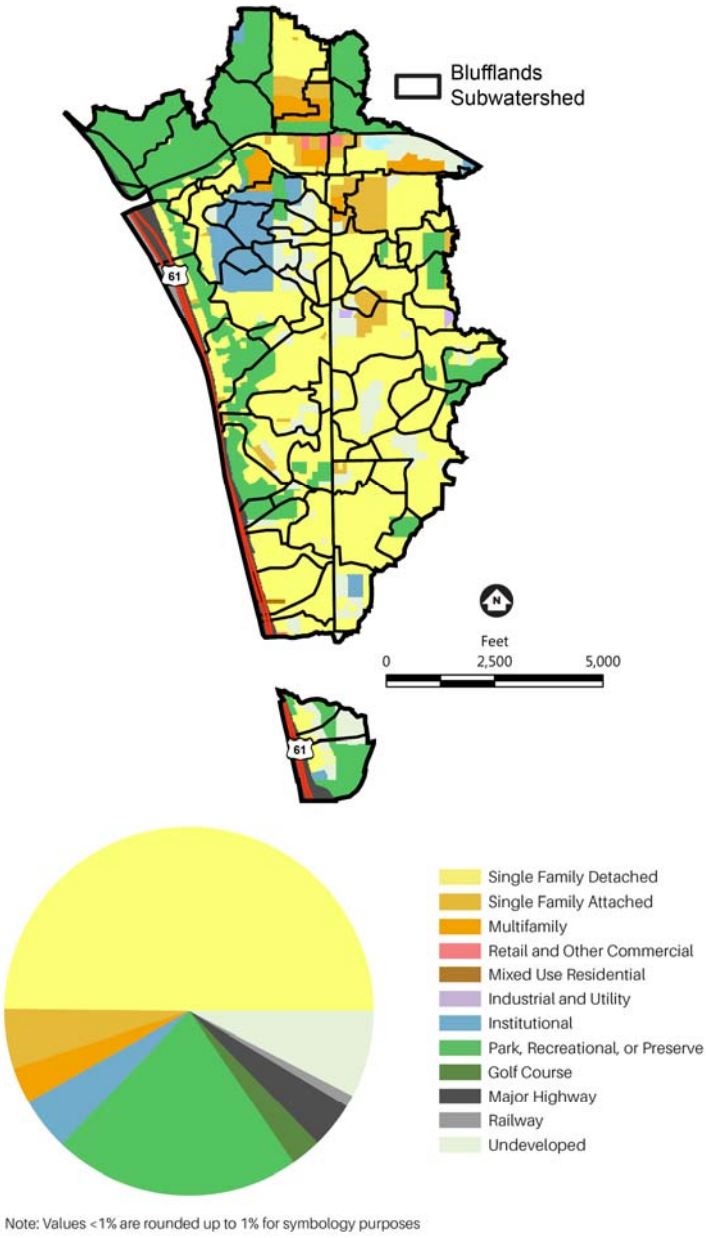


Figure 2.16-2 Breakdown of land uses throughout the Blufflands Subwatershed (2010 Metropolitan Council)

2.16.1.3 Drainage Patterns and Waterbodies

The Blufflands subwatershed consists of several smaller drainage districts that contribute runoff to separate ravines that outlet into the Pigs Eye Lake area (Mississippi River Bottomlands subwatershed). A drainage district is described as a network of drainage areas that all drain to the same point. These drainage districts are identified in Figure 2.16-4 according to their prefix and are described below:

- **Lower Afton drainage district** – this area spans approximately 672 acres and includes Johnson Pond. The drainage areas within this region are labeled with the prefix "LA-".

- **Blufflands drainage districts 2, 3, 4, and 5** – these areas span 451 acres. The drainage areas within each of these regions are labeled with the prefixes "BL2-", "BL3-", "BL4-", and "BL5-".

- **Totem drainage district** – this area spans approximately 204 acres. The drainage areas within this region are labeled with the prefix "TO-".

- **Springside Drive drainage district** – this area spans approximately 179 acres. The drainage areas within this region are labeled with the prefix "SP-".

- **Highwood drainage district** – this area spans 438 acres. The drainage areas within this region are labeled with the prefix "HW-".

The drainage districts of the Blufflands subwatershed described above has been further divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.16-4). Figure 2.16-4 indicates the direction of flow from each drainage area. The Lower Afton drainage district is the only district within the subwatershed where hydrologic modeling has been completed. For the Lower Afton drainage district, Figure 2.16-4 includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

There are no District-managed waterbodies within the Blufflands subwatershed.

Wetlands within the Blufflands subwatershed are shown in Figure 2.16-4 according to the RWMWD wetland management classification (see Section 1.11.3).

2.16.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. Regionally, it is important that the quality of stormwater discharged from the RWMWD to the Mississippi River be maintained and improved to the extent practicable. The following Section discusses the water quality conditions and goals Blufflands subwatershed.

2.16.2.1 Historical Water Quality

Limited information is available regarding the water quality of the stormwater runoff generated in the Blufflands subwatershed and discharged to the Mississippi River Bottomlands subwatershed. The Lower Afton drainage district is the only portion of the subwatershed that has been studied for water quality purposes. For the remaining areas/regions within the Blufflands subwatershed, it is recommended that hydrologic and water quality studies be developed on an as-needed basis. No additional water quality data within the Blufflands subwatershed is available from the MPCA's Environmental Data Access website.

2.16.2.2 Water Quality Modeling

As part of the *Lower Afton Road Drainageway Feasibility Study* (1995), water quality modeling was done for the Lower Afton area/region. The primary objective of the study was to address flooding and erosion problems along Lower Afton Road, between Highway 61 and Johnson Pond (east of McKnight Road), and to address sedimentation problems in Johnson Pond. Water quality modeling was performed using P8 to determine the relative water quality benefits of Johnson Pond on the downstream waterbodies, based on the improvement options that were studied. The model was also used to evaluate pond improvement options upstream of Johnson Pond to reduce the phosphorus loading to the pond. Modeling results indicated that the phosphorus removal efficiency of Johnson Pond was approximately 49%, or nearly half of the phosphorus entering the pond. The phosphorus removal efficiency of all ponds and wetlands in the Lower Afton study area was estimated to be 57%.

2.16.2.3 Water Quality Goals

Stormwater runoff from the Blufflands subwatershed discharges to the Pigs Eye Lake area in a number of locations. Because of the sediment loading problems in the Mississippi River Bottomlands area and the downstream Mississippi River, it is important that the quality of the stormwater discharged from the RWMWD to this area be maintained and improved where practicable.

Due to the steep topography in this area, erosion can be a problem. The RWMWD will strive to maintain these drainage channels were possible and prevent excessive erosion and sediment loading to the downstream waterbodies. One way to minimize erosion in the subwatershed is to provide upstream storage, therefore limiting the peak flows in the ravines. The RWMWD will seek opportunities to provide upstream storage as development and/or redevelopment occurs in this subwatershed.

The District will continue to consider opportunities to improve water quality in the Blufflands subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.16-3.

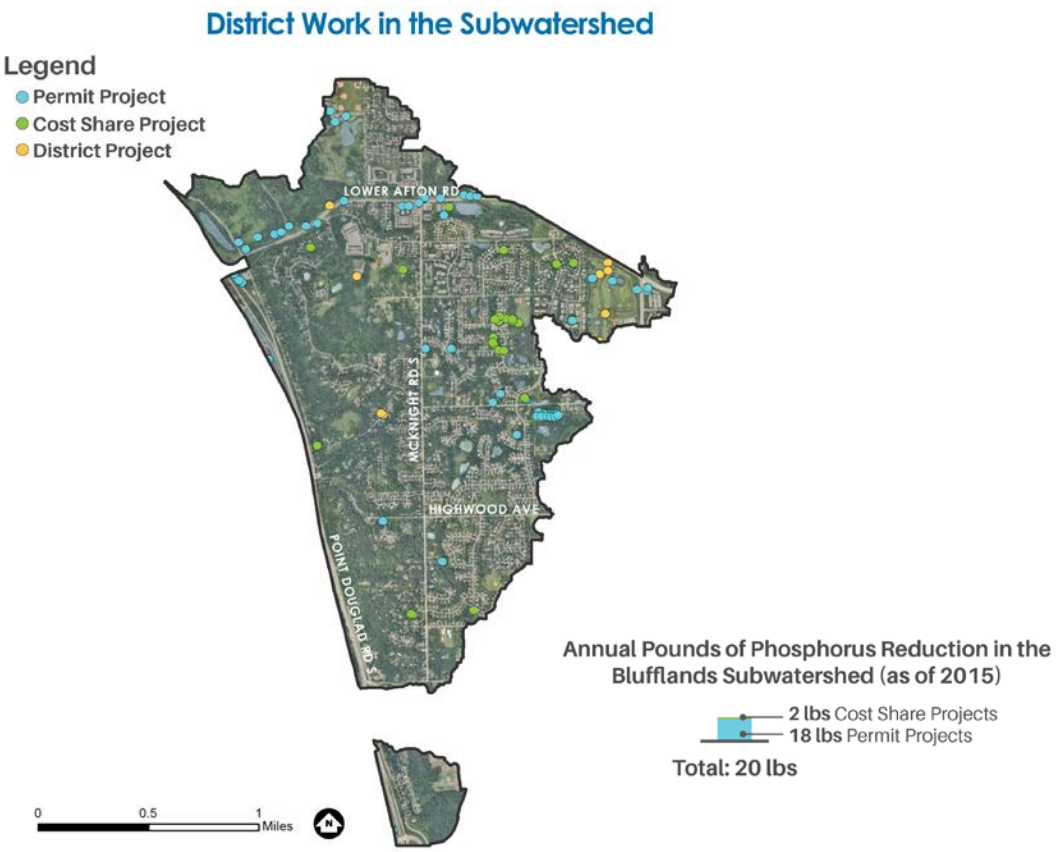


Figure 2.16-3 District work in the Blufflands Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.16.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

In 1995, the *Lower Afton Road Drainageway Feasibility Study* and the associated capital improvement project were completed to address flooding and erosion problems along Lower Afton Road, between Highway 61 and Johnson Pond. The project involved replacing an old outlet structure at Johnson Pond, and stabilizing erosion along the drainage channel next to Upper Afton Road. The channel and drop structures were originally constructed in the 1950s, but flows bypassed the concrete drop structures, which caused severe channel erosion. The project restored the integrity of the drop structures and repaired the erosion sites. A downstream concrete flume was still functional, but was repaired where needed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Blufflands subwatershed are the new

100-year flood elevations shown in Figure 2.16-4 for the Lower Afton drainage area. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.16.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Blufflands subwatershed are shown in Figure 2.16-5, indicating areas where the water levels of waterbodies in the Blufflands subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.16.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The central and eastern portions of this subwatershed contain a majority of the smaller (1- to 5-acre), high-quality wetlands in the District. District Natural Resources staff have been working with the City of Maplewood and Ramsey County Parks to intensively manage the buffers around these wetlands to preserve their ecological integrity. The RWMWD, the City of Maplewood, and Ramsey County Parks have identified this effort as a long-term priority.

The Ponds at Battle Creek Golf Course, directly to the south of the Ramsey County Correctional Facility, was constructed in 2002-03. Through the biological monitoring program, RWMWD staff located two high-quality wetlands on the golf course. RWMWD staff shared the data with Ramsey County staff and the golf course superintendent, and discussed preliminary buffer management plans for these ecologically important wetlands. The District's goal is to formalize a management plan and provide ongoing technical assistance to golf course staff, similar to the RWMWD's arrangement with Keller Golf Course.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas in the subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Blufflands subwatershed.

2.16.6 Implementation Program

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Blufflands subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Blufflands subwatershed are identified (see Table 2.16-2). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.16-2 Blufflands Subwatershed Implementation Activities

Activity ID No.	Blufflands Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
BLUFF-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
LA-01	715
LA-07	920.48
LA-08S	871.63
LA-11B	911.69
LA-17B	929.44
LA-18	967.89
LA-19P	1027.07
LA-20	996.56
LA-22	1020.12
LA-23	1022.21
LA-25A	1036.43
LA-27	1030.62

McKnight Basin Lake

LA-07 LA-08 C-40LL C-51b LA-06 LA-11B LA-08S LA-02 LA-05 LA-13 LA-17A LA-17B LA-01 LA-12 LA-01a LA-03 LA-15 LA-16 LA-18 TO-02 TO-04 TO-08 TO-08A TO-09 LA-23 TO-10 TO-03 TO-06 TO-10 LA-21 TO-14 LA-22 TO-07 TO-11 TO-13B LA-19P TO-15 SP-06 HW-20 TO-12 BL2-03 BL2-04 TO-16 SP-05 HW-19 BL2-06 BL2-05 SP-04 HW-16 BL2-07 SP-01 HW-17 HW-05 HW-15 HW-22 HW-06 SP-02 HW-10 HW-21 HW-07 BL3-08 HW-11 HW-14 HW-04 BL3-09 HW-08 HW-12 HW-02 HW-01 BL4-10 HW-09 HW-13 HW-03 BL4-11 BL4-12 BL4-15 BL4-13 BL4-14 BL5-15 BL5-16 BL5-17

Pigs Eye Lake Lake

Pigs Eye Lake Lake

Unnamed (North Star) Lake Lake

Carver Lake Lake

U.S. Lock & Dam #2 Pool Lake

494

BLUFFLANDS SUBWATERSHED DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Figure 2.16-4

N

Feet
0 1,500 3,000

1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications
Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 09:12 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatersheds_Sections\2.16_Blufflands\Figure 2.16-4 Drainage Patterns - Blufflands Subwatershed .mxd User: jrv

Suburban Pond
Upper Afton Rd
McKnight Basin
Tanners Lake
Battle Creek Lake
Pigs Eye Lake
Unnamed (North Star) Lake
U.S. Lock & am #2 Pool
Carver Lake
94
68
35
25

Drainage Areas
County Boundary
Municipal Boundary
Creeks

Composite Infiltration Area Score
5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24

Vulnerability to Changes in Groundwater System
Vulnerable
Vulnerable With Wide Litoral Zone

N
Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Figure 2.16-5
BLUFFLANDS SUBWATERSHED PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 09:13 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.16_Blufflands\Figure 2.16-5 Priority Infiltration Areas - Blufflands Subwatershed.mxd User: jrv

2.17 Carver Lake Subwatershed

2.17.1 General Description

The Carver Lake watershed includes 2,272 acres. Most of the watershed lies within the city of Woodbury (Washington County) (see Figure 2.17-1). However, a small portion of the watershed, west of Century Avenue, is located within the city of Maplewood (Ramsey County).

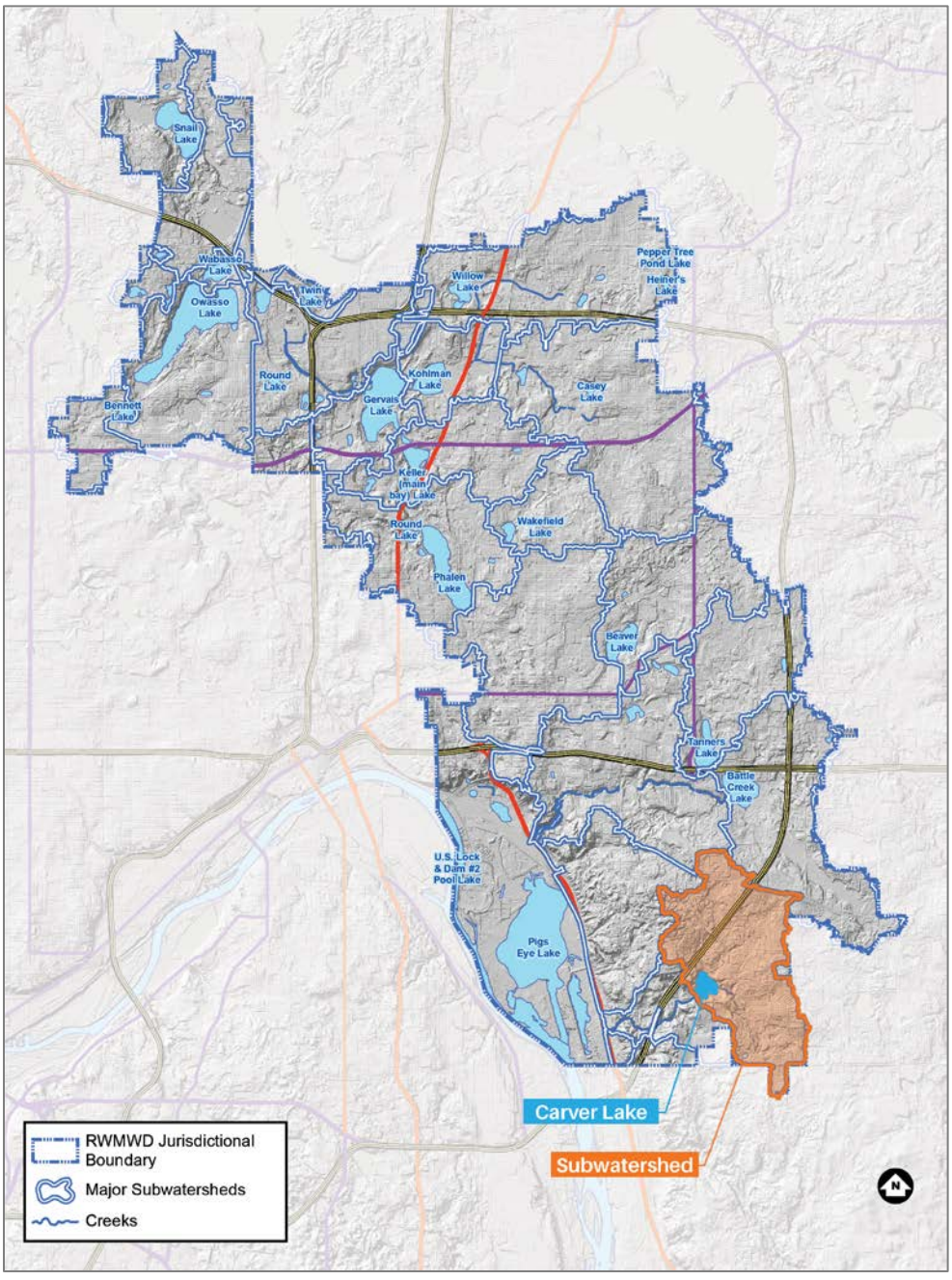


Figure 2.17-1 Carver Lake Location Map

Carver Lake is located entirely within the city of Woodbury and is the only District-managed waterbody in the Carver Lake subwatershed. The lake is a MDNR public water (MDNR#82-0166P) and is approximately 49 acres in size. Carver Lake is a deep basin, with an average depth of 16 feet and a maximum depth of 36 feet. Because of its depth, the lake stratifies strongly during the summer months, and tends to mix only in the spring and fall. Carver Lake is used primarily for swimming and canoeing. There is a public beach located on the southeast side of the lake, along with a canoe access point. The lake serves as an important regional amenity, with the City of Woodbury's Carver Lake Park that is heavily used for picnicking and hiking.

Table 2.17-1 Carver Lake Subwatershed Facts

Tributary Area (Direct)	2,274 acres
Tributary Area (Total)	2,274 acres
Downstream Watershed	Fish Creek
MDNR Designation[1]	82-0166P
Lake Surface Area[1]	49 acres
Lake Mean Depth[1]	16 ft
Lake Maximum Depth[1]	36 ft
Lake Outlet Type[1]	48" Reinforced Concrete Pipe
Lake Outlet Elevation[1]	906.2 ft
100-Year Flood Level[1]	913.4 ft
Lake Littoral Area[1]	50%
MPCA Designations[1]	Deep Lake; Impaired for Aquatic Consumption (mercury food consumption advisory), Impaired for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Maplewood, Woodbury, Ramsey County, Washington County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data for Carver Lake

2.17.1.1 Past Studies

The following list is a summary of past studies related to Carver Lake and the Carver Lake subwatershed.

- *Discussion of Water Quality Goals for Beaver Lake and Carver Lake*. Prepared for RWMWD by Barr Engineering, January 2006.
- *Subwatershed Infiltration – Carver Lake Subwatershed; Woodbury MN*. Memorandum report prepared by Barr Engineering, March 2003 Draft.
- *Evaluation of Water Quality Effects from Implementation of Infiltration Practices in Carver Lake Watershed* – Memorandum prepared by Barr Engineering, October 2000.

- *Carver Lake Strategic Lake Management Plan*. Prepared for RWMWD by Barr Engineering, October 2000.
- *Greenways and Natural Areas Report & Vegetative Cover Inventory*. RWMWD, June 1999.
- *1991 Water Quality Monitoring of Carver Lake*. Prepared for RWMWD by Barr Engineering, June 1992.
- *Carver Ravine Hydrologic Study*. Prepared for RWMWD by Barr Engineering, 1991.
- *Carver Lake Watershed Management Plan*. Prepared for RWMWD by Barr Engineering, February 1979.
- *Carver Lake Infiltration Study. 2008*.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District*. Barr Engineering Co., Draft 2016.

2.17.1.2 Land Use

The Carver Lake subwatershed is generally urbanized and includes low-, medium-, and high-density residential land use. Although there are some limited open spaces and a few agricultural tracts of land in the southern portion of the watershed, much of the watershed is fully developed (see Figure 2.17-2). Metropolitan Council future land use projections indicate that most undeveloped areas in the watershed will be converted to commercial/industrial development with some additional high-density residential units (see Figure 1-5). New development and redevelopment areas that exceed 1 acre fall subject to the RWMWD's volume reduction rule that controls the runoff rate and volume of developed and redeveloped sites.

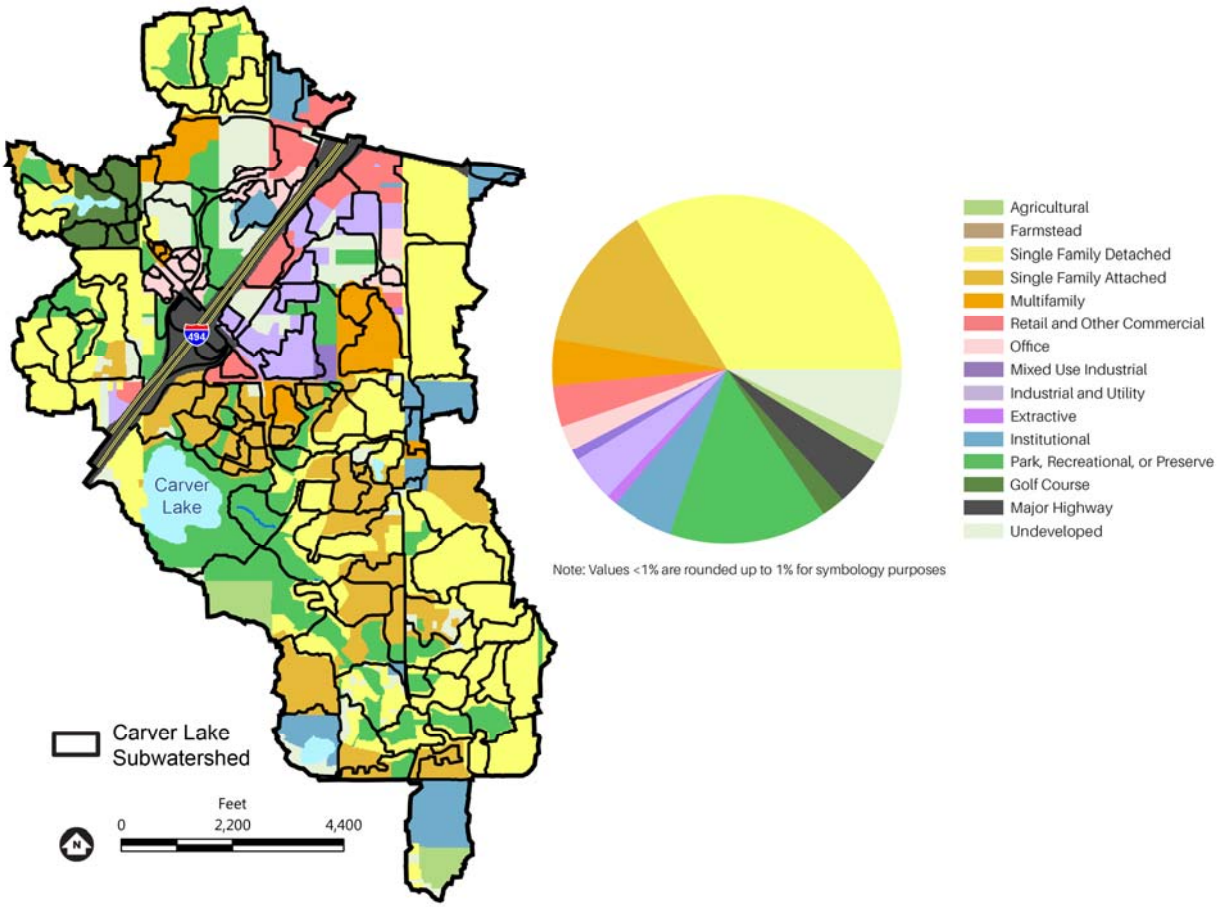


Figure 2.17-2 Breakdown of land uses throughout the Carver Lake Subwatershed (2010 Metropolitan Council)

2.17.1.3 Drainage Patterns and Waterbodies

Stormwater drainage within the Carver Lake subwatershed flows overland, or is channeled through storm sewers and drainage ditches, and routed through detention ponds and wetlands. The entire subwatershed drains to Carver Lake. Runoff from the watershed enters the lake in three different locations—two via pond outlets on the north and northeast sides of the lake and one via Carver Ravine on the southeast side of the lake. Discharge from the Carver Lake subwatershed flows into the Fish Creek subwatershed, which discharges to Eagle Lake, a backwater of the Mississippi River southeast of Pig's Eye Lake.

The Carver Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.17-8). Figure 2.17-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Carver Lake subwatershed include only Carver Lake.

Wetlands within the Carver Lake subwatershed are shown in Figure 2.17-8 according to the RWMWD wetland management classification (see Section 1.11.3). The many wetlands within the Carver Lake subwatershed function as a part of the subwatershed's stormwater drainage system.

2.17.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following sections discuss the water quality goals and conditions for the District-managed water bodies in the Carver Lake subwatershed.

2.17.2.1 Historical Water Quality

The water quality of Carver Lake has been cataloged over many years, with summer average total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparencies available dating back to 1977. There are some gaps in the water quality data record – no data exists for the period 1979-1982, or for 1989-1992.

Figure 2.17-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. Table 2.17-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Carver Lake relative to MPCA standards. The RWMWD has assigned a water quality classification of "At Risk" to Carver Lake recent water quality data as compared to applicable standards (see Table 2.17-2).

Table 2.17-2 Carver Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Carver Lake (2001-2010) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	40
Chlorophyll-a (µg/L)	≤ 14	13.9
Secchi disk transparency (m)	≥ 1.4	1.9

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on Carver Lake water quality data. The results of these analyses are shown in Table 2.17-3.

Table 2.17-3 Trend Analysis Results for Carver Lake Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Carver Lake	1997 – 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving*	No Trend
		Chlorophyll-*a*	No Trend	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

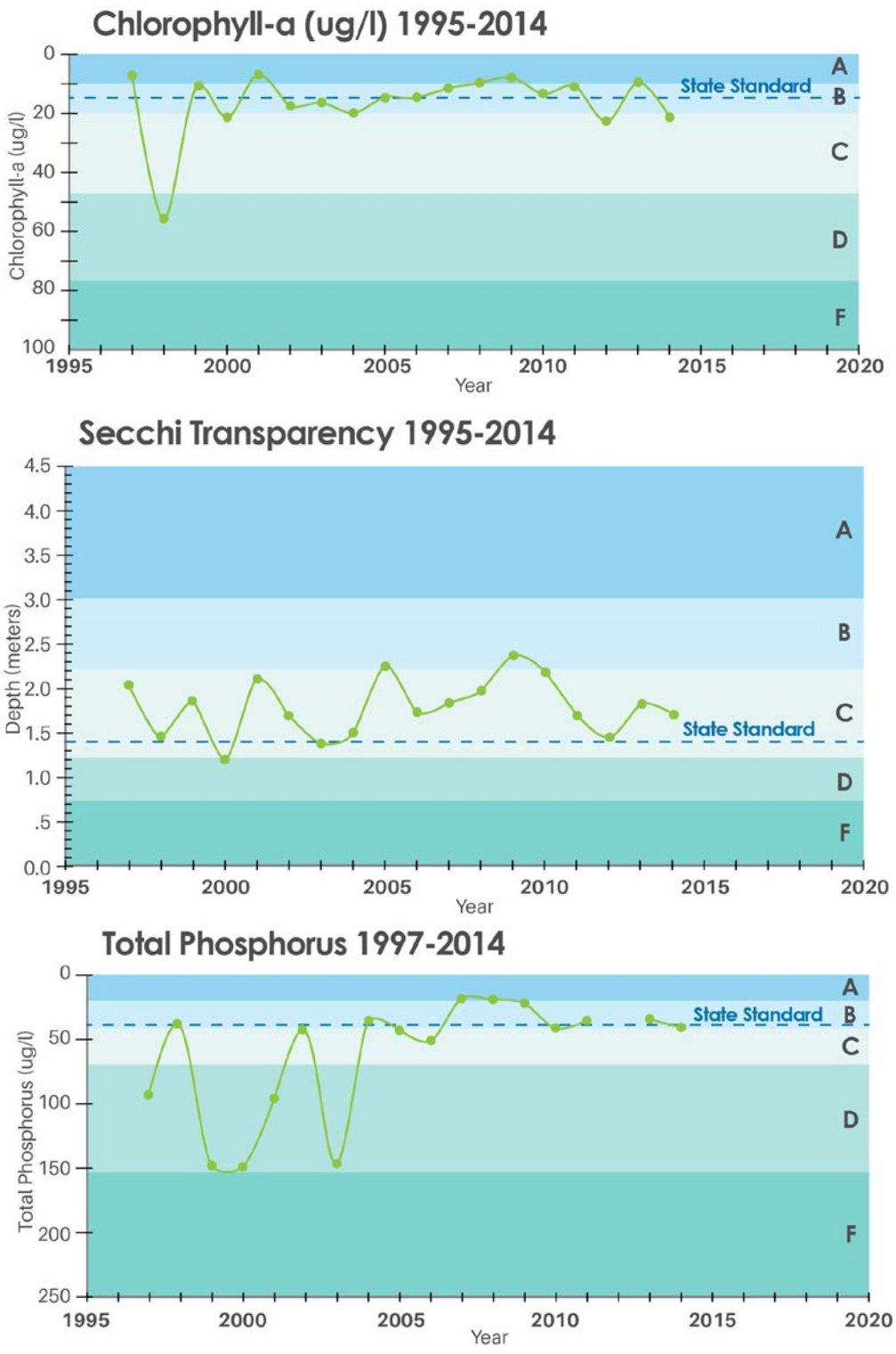


Figure 2.17-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Carver Lake (1997-2012)

2.17.2.2 State of the Fishery

In 1992, the Minnesota Department of Natural Resources (MDNR) classified Carver Lake and other Minnesota lakes relative to fisheries. According to its ecological classification, Carver Lake is a Class 30 lake, which signifies a good permanent fishery lake (Schupp, 1992). According to its classification, Carver Lake's primary fish species are northern pike, bluegill, and carp.

The MDNR surveyed the lake's fisheries in 1960, 1983, 1993, and 1998, and completed population assessments during 1977, 1988, and 1998. The MDNR manages the lake for bluegill and largemouth bass, but has not stocked Carver Lake in the past 10 years.

A MDNR recreational use survey of Carver Lake, completed in 1980, and a creel survey, completed in 1994, indicated fishing and other recreational use dropped drastically during that time interval. The drop is believed to be caused by reduced accessibility. Three access opportunities disappeared during the 1980 through 1994 period: (1) users could no longer launch boats off of Century Avenue on the southwest side of the lake; (2) there was no longer a boat livery on the north end which used to rent boats and allow launching for a fee; and (3) the private camp on the east shore became city park land. Consequently, fishing pressure dropped from 179 hours per acre in 1980 to 56 hours per acre in 1994, with a shift from mostly boat angling (81.3 percent) to mostly bank angling (95.8 percent). Other recreational boating dropped from 63 hours per acre in 1980 to 8 hours per acre in 1994. Shorefishing is still possible from a wharf in the city park, and several informal spots off a paved walking path that runs along a good portion of the shoreline.

A MDNR 2014 fish assessment found an average Bluegill population dominated by small to mid-sized fish. Average length was less than five inches. Black crappie abundance was low, with most fish less than 6 inches (range of 4 to 9 inches). Northern pike abundance was average for lakes similar to Carver Lake. Largemouth bass abundance was low in 2014, but some large fish were found. Low numbers of black bullhead, yellow bullhead, pumpkinseed sunfish, hybrid sunfish and yellow perch were also sampled.

2.17.2.3 State of the Macrophyte Community

On September 25, 2014, District staff conducted a macrophyte survey of Carver Lake. The results of this survey are summarized below in Figure 2.17-4. In total, 97 sites were surveyed for macrophytes. Of these, 50 had vegetation, indicating that Carver Lake has some areas of open water outside of its littoral zone.

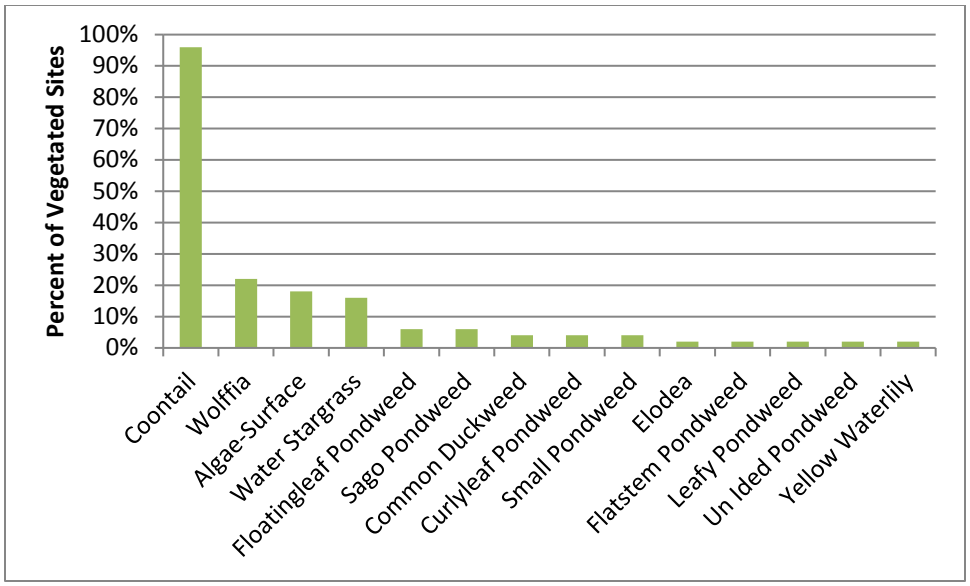


Figure 2.17-4 September, 2014 Carver Lake Macrophyte Survey Results

Where filamentous algae and coontail were found in the lake, they were present in high abundance relative to other macrophyte species in Carver Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.17.2.4 Water Quality Modeling

The District performed water quality modeling in the development of the *Carver Lake Strategic Lake Management Plan*. The water quality models were developed to estimate the sources of phosphorus to Carver Lake. The water quality models were also used to evaluate the impacts of already-completed capital improvement projects and potential future best management practices (BMPs). Watershed modeling using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) estimated the runoff volumes and phosphorus loads from different areas within the Carver Lake subwatershed. The model was calibrated to water quality and stream flow monitoring data collected at the largest inflow to the lake during the summer of 1999.

For modeling purposes, the 2,272 acres comprising the Carver Lake subwatershed were divided into three smaller drainage districts: northwest, northeast, and south. Figure 2.17-5 shows the major drainage areas that contribute stormwater runoff to Carver Lake and the estimated percentage of annual watershed phosphorus loading that each drainage area contributes during an average climatic year. Under average climatic conditions, each contributes approximately one third of the surface water runoff, and one third of the annual phosphorus load to Carver Lake. In each of the drainage districts, ponds and wetlands provide water treatment for the runoff, significantly reducing the amount of sediments and other contaminants before the runoff reaches Carver Lake.

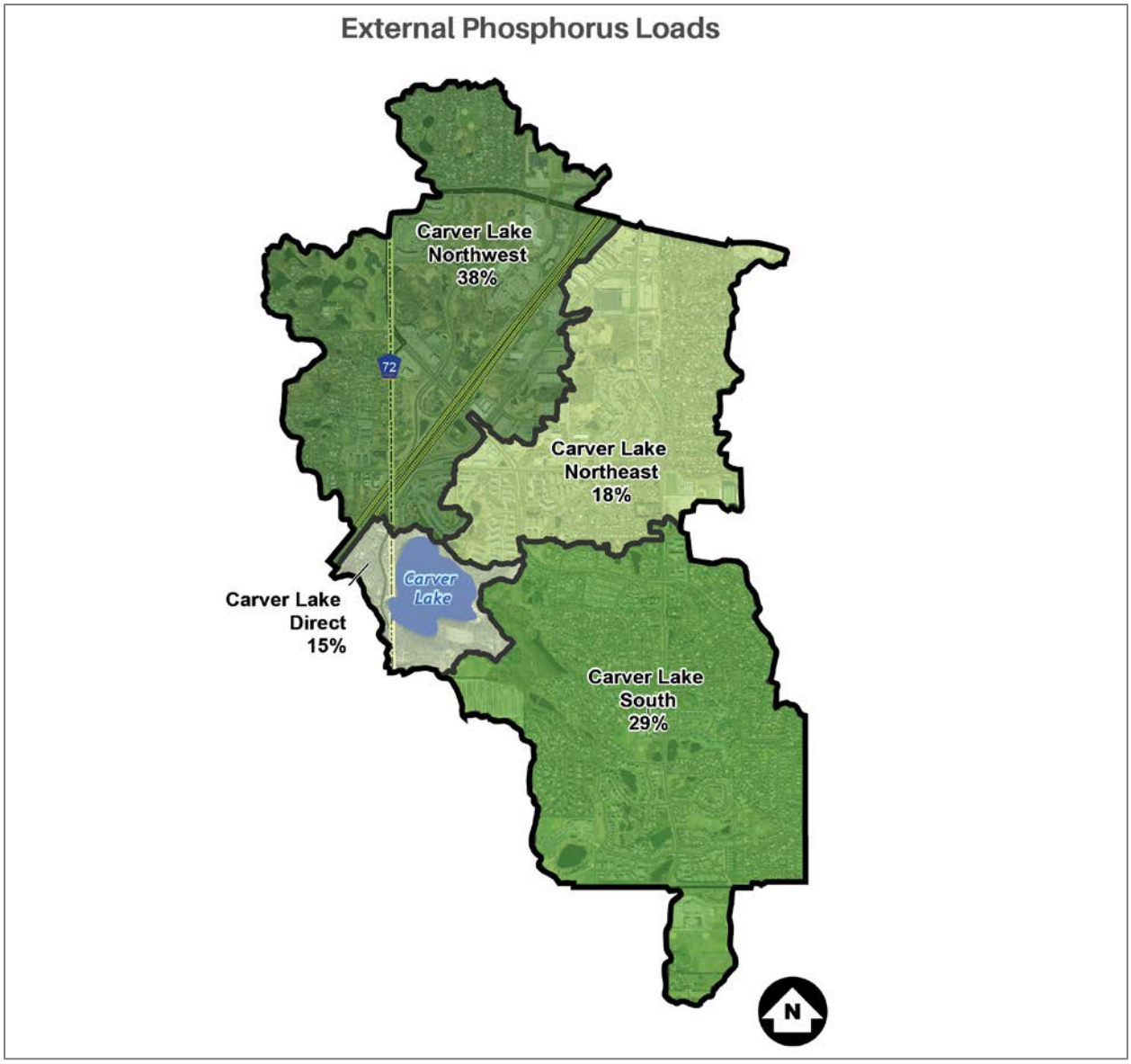


Figure 2.17-5 Drainage districts in the Carver Lake subwatershed

An in-lake mass balance water quality model was also completed as a part of the SLMP to assess the impact of watershed loading and internal phosphorus loading on the water quality of Carver Lake. Through this analysis, it was determined that internal phosphorus loading for Carver Lake was relatively insignificant. The amount of atmospheric phosphorus loading to the lake was found to be higher, but relatively insignificant in comparison to the loading from surface water runoff. The pie chart shown in Figure 2.17-6 shows the relative contribution of the lake's internal and external (subwatershed) phosphorus loads.

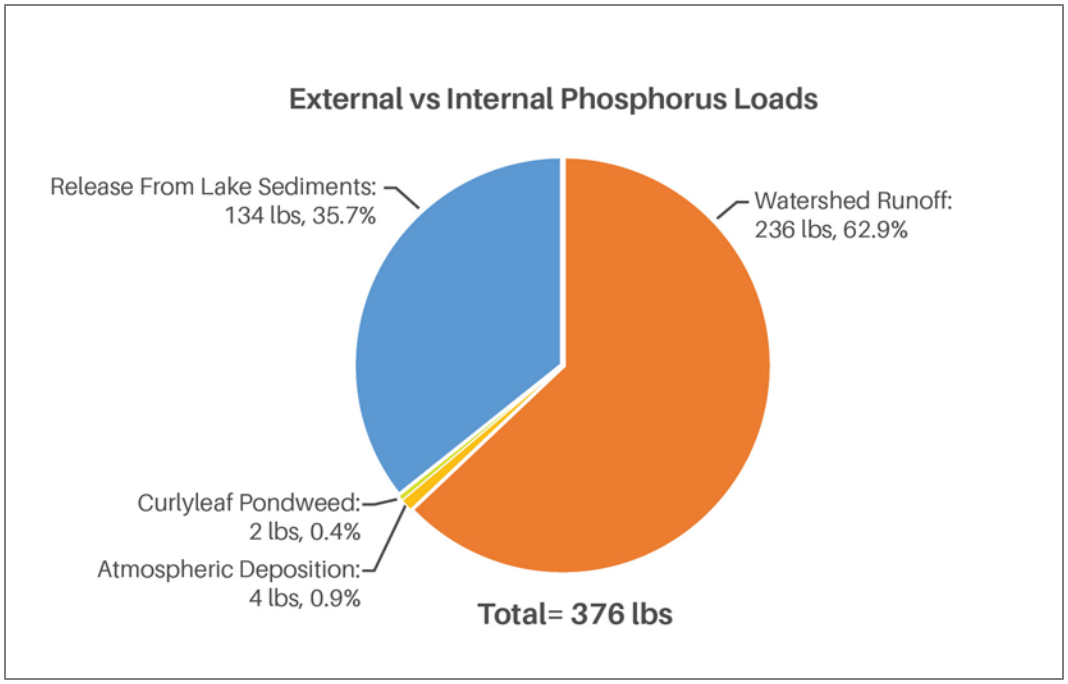


Figure 2.17-6 External (Watershed) vs Internal (Release from Lake Sediments) Phosphorus Loads to Carver Lake

The models were used as a predictive tool to evaluate the impact of various water quality improvement options on the water quality of Carver Lake. The modeling conducted as part of the Carver Lake SLMP (Barr, 2000) revealed that the ponding/wetland systems present throughout the Carver Lake subwatershed remove about 60% of the total watershed phosphorus load prior to it entering the lake. However, the system of open water ponds and wetlands remove primarily particulate phosphorus. Modeling indicated that about two-thirds of the residual phosphorus load entering the lake, after being treated by the existing pond/wetland system, is soluble reactive phosphorus (i.e., the form of phosphorus that dissolves in water and is readily useable by algae). Modeling results indicated that, without additional treatment, the soluble phosphorus load could lead to further water quality degradation.

The Carver Lake SLMP looked at one option – alum treatment – for adequately removing the soluble phosphorus from the runoff waters draining to Carver Lake. A subsequent follow-up study evaluated stormwater infiltration as another option for removing soluble phosphorus. Alum treatment involves injecting liquid alum into the water to remove the phosphorus. The second option involves infiltrating a portion of the stormwater runoff. The follow-up modeling showed that infiltration of the first quarter-inch to half-inch of runoff from directly-connected impervious (hard surface) areas would achieve the 1997 RWMWD water quality goals (i.e., total phosphorus goal of 30 µg/L). Infiltration and percolation remove additional particulate phosphorus through filtering of the water through the soils. Based on the results of these studies, the RWMWD deemed infiltration (and not alum treatment) to be the preferred treatment option.

2.17.2.5 Water Quality Improvement Projects

This District has implemented several water quality improvement projects in the Carver Lake subwatershed. In 1992, the District completed the Carver Ravine project following completion of the Carver Ravine Hydrologic Study (Barr, 1991) to stabilize ravine erosion and prevent siltation of the lake. Carver Ravine is an intermittent stream leading from a residential development to Carver Lake. The Ravine is entirely on city park land. The City of Woodbury brought this problem to the attention of the District and asked for District help in stabilizing ravine erosion and siltation of the lake.

The project design called for backfilling several severe erosion scarps, relocating the channel where necessary, installing two boulder drop structures to control flow velocity, and constructing three ponds for stormwater treatment. One pond was constructed by a private developer to treat runoff from his development. Another pond was created from a low emergent wetland area with little or no standing water. This wetland was a gravel pit prior to the construction of the subdivision. The third pond was constructed at the downstream end of the ravine as a final sediment pool prior to discharging to Carver Lake. The City of Woodbury and the District cooperate to perform periodic maintenance of the ponds.

In 2006, the District completed the Carver Lake Porous Paver Project. The project involved replacing the existing asphalt with porous pavement within the turn-around portions of cul-de-sacs on Macbeth Court and Juliet Drive in Woodbury. Both locations receive significant drainage from upstream areas, including lawns, buildings, driveways, and streets. Prior to project implementation, all of this runoff entered storm sewers and flowed into Carver Lake without treatment. The project infiltrates runoff into the ground, where phosphorous and other nutrients are filtered out naturally. This infiltrated stormwater reduces the volume of stormwater runoff and nutrient loads reaching Carver Lake. This project was completed as a test to monitor the benefits achieved by porous pavement as a method of infiltration and volume reduction. District staff monitored the project from 2005 through 2007.

The District will continue to consider opportunities to improve water quality in the Carver Lake subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.17-7.

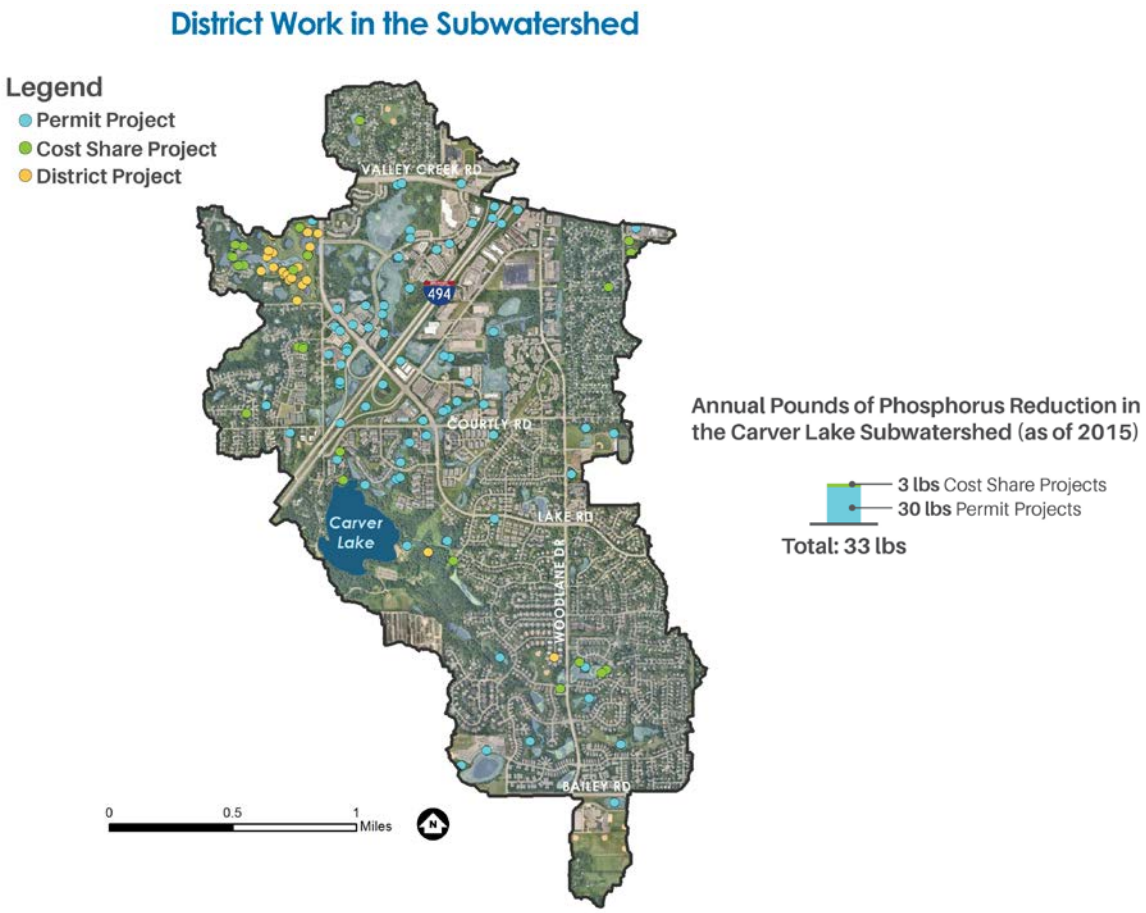


Figure 2.17-7 District work in the Carver Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.17.2.6 Water Quality Goals

The water quality goals for Carver Lake are consistent with the MPCA's deep lake eutrophication standard for lakes in the North Central Hardwoods Forest Ecoregion shown in Table 2.17-2. The RWMWD will continue to evaluate water quality data in Carver Lake for trends and adjust its water quality classification and management activities accordingly. The District will continue to maintain the existing water quality improvement projects constructed by the District within the Carver Lake subwatershed.

2.17.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

The District performed hydrologic and hydraulic modeling for the Carver Lake subwatershed as part of its 1997 Watershed Management Plan to determine peak discharges and flood levels from a 100-year frequency rainfall event and identify locations where improvements should be considered. At that time, no significant flooding problems were identified in the Carver Lake subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Carver Lake subwatershed are the new 100-year flood elevations shown in Figure 2.17-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.17.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Carver Lake subwatershed are shown in Figure 2.17-9, indicating areas where the water levels of waterbodies in the Carver Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.17.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The District is involved with several natural resource management projects within the Carver Lake subwatershed. In 2000 and 2001, the District's Natural Resources staff provided planning, design, and maintenance assistance to the architect for the Ponds at Battle Creek golf course, part of which drains to the Carver Lake subwatershed. This assistance included providing guidance for the selection, planting, and maintenance of native plants.

The Carver Lake SLMP (Barr, 2000) recognizes that the Carver Lake subwatershed is an urbanized area with limited undeveloped land. To facilitate the establishment of a natural resources system, the RWMWD inventoried the area's natural communities and formulated a plan of action for cities to consider for implementation. This plan of action is outlined in the *Greenways and Natural Areas Report & Vegetative Cover Inventory* (Greenways Report) completed by the District in June 1999. Greenways and natural areas provide numerous environmental benefits, including stormwater runoff volume reduction.

According to the SLMP, the dominant upland natural resource areas in the Carver Lake subwatershed are urban forest areas, followed by areas of old field, agriculture, oak forest, mixed lowland hardwood, and

smaller pockets of conifer plantation, box elder forest, cottonwood forest, and aspen forest. Much of the remaining undeveloped land is undeveloped because it has previously been considered "marginal," or undevelopable. These "marginal" areas now contain a large amount of the District's remaining natural resources. With the increasing demand for land to develop, there is increasing pressure to use these remaining marginal parcels. Restricting development of marginal lands would preserve natural resources and protect adjacent and downstream areas.

The Carver Lake SLMP also shows the greenway corridors in the Carver Lake subwatershed area, as taken from the Greenways Report. Greenways provide important transit corridors for wildlife moving between isolated habitats. Greenways also preserve biodiversity and wildlife habitat by protecting environmentally sensitive land along streams and wetlands. These environmentally sensitive lands also help maintain water quality, providing a protective buffer for streams, wetlands, ponds, and lakes. Wildlife and ecological communities are also served by greenways in other ways. The vegetative cover, having a variety of plant communities, root depths, and canopy layers, provides a valuable diversity of ecological niches for wildlife. These vegetated areas, requiring little or no maintenance or chemical treatment, also enhance water uptake and evapotranspiration, thereby reducing stormwater runoff volumes that would otherwise require detention and water quality treatment. In developing best management practices (BMPs) for the protection of Carver Lake, the District incorporated and considered data from the June Greenways Report to integrate natural resources into their overall planning effort for Carver Lake and its subwatershed.

In 2005, RWMWD Natural Resources staff consulted with City of Woodbury staff on a shoreland restoration project on Carver Lake. Several shore segments in a city park (Carver Lake Park) on the east side of the lake are experiencing increased levels of erosion. The City was interested in ecological restoration using soft armoring techniques. The District provided technical assistance by developing a comprehensive ecological restoration plan. The RWMWD staff supervised the site preparation and native plant installation, and provided routine monitoring.

In 2011, the District entered a partnership with the Ponds at Battle Creek golf course to improve the ecological diversity of the no-play and buffer areas. The ecological restoration approach applied variety of natural resources management practices that have value to the course and to its natural systems. Three wetlands on the course property are ecologically diverse, and rank very high compared to others in the watershed. The management plan focused on these wetland buffers, which has included gully repair, invasive species management, and the introduction of a variety of native wetland and upland plant species. Over a five year period, this partnership will result in the restoration of over 5 acres of wetland buffer. This management will help in preserving the high quality wetlands, and at the same time, improve the golf experience through breathtaking views of native prairie, and the possibility of some spectacular wildlife sightings.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas in the subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities within the Carver Creek subwatershed.

2.17.6 Implementation Program

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Carver Lake subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Carver Lake subwatershed are identified (see Table 2.17-4). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.17-4 Carver Lake Subwatershed Implementation Activities

Activity ID No.	Carver Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
CL-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

100-Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	100-Year WSE
CARV	913.39
CARV-1	1042
CARV-3	1050.58
CARV-5a	1040.96
CARV-6	1028.43
CARV-7a	1014.32
CARV-7b	1033.79
CARV-7c	1016.86
CARV-7d	1029.78
CARV-9	989.19
CARV-9a	1057.22
CARV-9b	999.97
CARV-9c	1007.25
CARV-10	1006.42
CARV-11a	997.23
CARV-11b	1000.67
CARV-11c	998.83
CARV-11d	1011.52
CARV-11e	1008.17
CARV-12a	989.19
CARV-12b	995.92
CARV-12c	995.25
CARV-13a	989.19
CARV-13b	981.12
CARV-15	1028.43
CARV-16	1033.04
CARV-17a	1034.08
CARV-17b	1028.43
CARV-18	1039.47
CARV-20	1035.2
CARV-21a	1038.82
CARV-21b	1033.33
CARV-22	942.06
CARV-23b	964.02
CARV-23d	997.13
CARV-24	967.5
CARV-25	956.01
CARV-26	1006.19
CARV-27a	1006.32
CARV-27b	1009.91
CARV-28	1003.4
CARV-29	952.66
CARV-33a	952.71
CARV-33c	971.31
CARV-34a	989.22
CARV-34b	992
CARV-38a	993.27
CARV-38b	989.22
CARV-39	1013.37
CARV-41	1016.12
CARV-43	1061.74
CARV-45	1018.99
CARV-48	977.69
CARV-48a	973.95
CARV-49a	997.92
CARV-49b	995.53
CARV-49c	997.96
CARV-51	973.99
CARV-53	976.55
CARV-56	916.32
CARV-57	951.77
CARV-58	941.67
CARV-59	933.1
CARV-60	919.19
CARV-64	997.31
CARV-66	962.45
CARV-68	1001.27
CARV-70a	1033.18
CARV-73	1025.03
CARV-74a	1048.52
CARV-78	916.14
CARV-79	958.6
CARV-80	955.06
CARV-85	1002.59
CARV-90	971.58
CARV-90a	975.09
CARV-93a	959.32
CARV-93b	982.75
CARV-94	971.23
CARV-95c	970.77
CARV-99b	989.76
CARV-100	1001.13
CARV-101	995.07
CARV-102	978.42
CARV-103	996.87
CARV-106	1027.12
CARV-108	1043.01

CARV-2
CARV-1
CARV-3
CARV-4a
CARV-4b
CARV-4c
CARV-5a
CARV-7b
CARV-5b
16
25
CARV-7a
CARV-8
CARV-9a
CARV-18
CARV-15
CARV-16
CARV-6
CARV-7d
CARV-41
CARV-43
CARV-17a
CARV-10
CARV-9c
CARV-42
CARV-17b
CARV-9b
CARV-37
CARV-20
CARV-11a
CARV-40
CARV-21b
CARV-21a
CARV-36
CARV-14
CARV-12a
CARV-9
CARV-11e
CARV-11c
CARV-31a
CARV-39
CARV-12b
CARV-35
CARV-23a
CARV-36a
CARV-45
CARV-12c
CARV-23c
CARV-13a
CARV-44
CARV-13b
CARV-38a
CARV-26
CARV-34a
CARV-47
CARV-46
CARV-23b
CARV-34b
Lake Rd
CARV-24
CARV-22
CARV-38b
CARV-28
CARV-49a
CARV-27
CARV-25
CARV-33b
CARV-27a
CARV-29
CARV-31b
CARV-33c
CARV-50
CARV-51
CARV-33a
CARV-53
CARV-70a
Highwood Ave
CARV-32
CARV-52
CARV-49b
CARV-57
CARV-49c
CARV-108
CARV-27b
CARV-30
CARV-63
CARV-110
CARV-70b
CARV-54
CARV-58
CARV-64
CARV-69
CARV-56
CARV-55
CARV-61
CARV-67
Woodlane Dr
CARV-62
CARV-72
CARV-74a
CARV-59
CARV-68
CARV-60
CARV-56a
CARV-109
CARV-73
CARV-106
CARV-65
CARV-107
CARV-74b
CARV-66
CARV-76
Carver
Lake Lake
CARV-77
CARV-75
CARV-86
CARV-78
CARV
CARV-91
CARV-84
CARV-85
494
CARV-87
CARV-79
CARV-83
CARV-81
CARV-80
CARV-82
CARV-88
CARV-90a
CARV-94
CARV-89
CARV-92
CARV-90
CARV-95a-dummy
CARV-97
CARV-95a
CARV-104
CARV-95c
CARV-93a
CARV-96
CARV-95b
CARV-48
CARV-48a
CARV-102
CARV-103
CARV-93b
CARV-99a
CARV-98
CARV-101
CARV-99b
Bailey Rd
18
CARV-100

Figure 2.17-8

CARVER LAKE SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

N
Feet
0 1,300 2,600
1 inch = 1,300 feet

RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications
Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4.1, 2017-04-28 08:57 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.17_Carver_Lake\Figure 2.17-8 Subwatershed Drainage Patterns - Carver Lake.mxd User: jrv

Valley Creek Rd
Century Ave
Lake Rd
494
Highwood Ave
Woodlane Dr
Carver Lake
Bailey Rd

Barr Footer: ArcGIS 10.4, 2016-11-29 10:01 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.17_Carver_Lake\Figure 2.17-9 Priority Infiltration Areas - Carver Lake Subwatershed.mxd User: jrv

CARVER LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

Figure 2.17-9

N

Feet
0 1,300 2,600
1 inch = 1,300 feet

Drainage Areas
County Boundary
Municipal Boundary
Creeks

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

Source: Barr Engineering; 2015, Imagery: USDA; 2015

2.18 Fish Creek Subwatershed

2.18.1 General Description

The Fish Creek subwatershed covers 783 acres, in the cities of Maplewood, St. Paul, Woodbury, and Newport (see Figure 2.18-1). The majority of the Fish Creek subwatershed is located in Ramsey County, with the southeastern portion in Washington County. The subwatershed receives flow from Carver Lake, which is the headwaters of Fish Creek. The total area tributary to Fish Creek, including Caver Lake, is 3,055 acres. Fish Creek is a perennial, urban stream that originates at Carver Lake and ultimately discharges to Eagle Lake and the Mississippi River. Fish Creek is the only District-managed waterbody within the Fish Creek subwatershed.

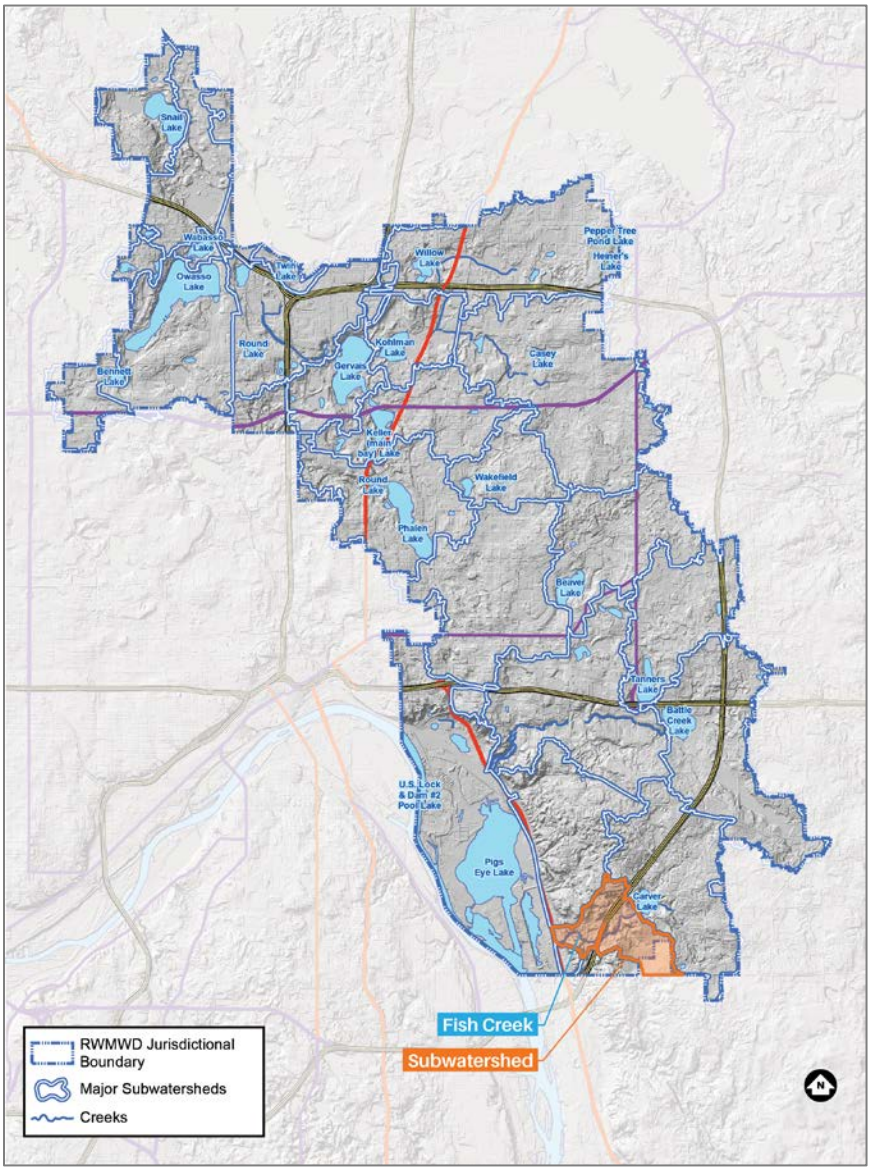


Figure 2.18-1 Fish Creek Location Map

Table 2.18-1 Fish Creek Subwatershed Facts

Tributary Area (Direct)	783 acres
Tributary Area (Total)	3,055 acres
Downstream Watershed	Mississippi River Bottomlands
MPCA Designations[1]	Impaired for Aquatic Recreation (E. coli), at risk for impairment for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Maplewood, St. Paul, Woodbury, Ramsey County, Washington County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data for Fish Creek

2.18.1.1 Past Studies

The following list is a summary of past studies related to the Fish Creek subwatershed.

- *Fish Creek Hydrologic Study.* Prepared for RWMWD by Barr Engineering, 1988.
- *Sediment Source Loading to Fish Creek and Ponds.* Prepared for RWMWD by Barr Engineering 2007.
- *Ramsey-Washington Metro Watershed District Total Maximum Daily Load Study.* Barr Engineering Co., Draft 2016.
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.

2.18.1.2 Land Use

Land use within the Fish Creek subwatershed includes significant areas of park and open space owned by Ramsey County or the City of Maplewood, as well as some areas classified as agricultural (see Figure 2.18-2). The remainder of the subwatershed is single-family residential land use, with some highway (I-494) and commercial areas in the southeast portion of the subwatershed. Based on the Metropolitan Council future land use projections for 2030, much of the currently undeveloped land in this subwatershed will be converted into low-density residential development, as well as an increased area of commercial land use in the southeast portion of the subwatershed (see Figure 1-5). Development and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the developed or redeveloped site.

The RWMWD has identified several homes within the direct watershed to Fish Creek that still utilize septic systems and are not served by the sanitary sewer system.

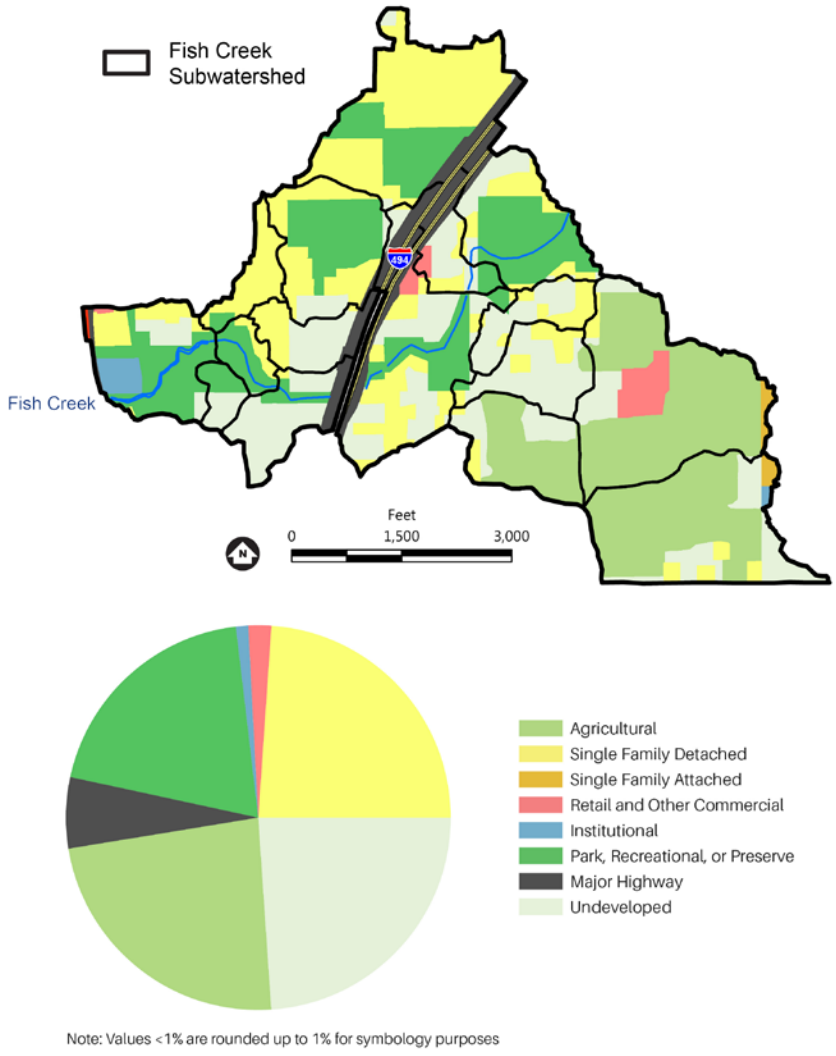


Figure 2.18-2 Breakdown of land uses throughout the Fish Creek Subwatershed (2010 Metropolitan Council)

2.18.1.3 Drainage Patterns and Waterbodies

The subwatershed receives flows from Carver Lake (Carver Lake subwatershed), which is the headwaters of Fish Creek. Fish Creek (and the Fish Creek subwatershed) drains to Eagle Lake (Mississippi River Bottomlands subwatershed), between the Blufflands 4 and Blufflands 5 drainage districts (Blufflands subwatershed, see Section 2.16).

The Fish Creek subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.18-7). Figure 2.18-7 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Fish Creek subwatershed include only Fish Creek.

Wetlands within the Fish Creek subwatershed are shown in Figure 2.18-7 according to the RWMWD wetland management classification (see Section 1.11.3).

2.18.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following sections discuss the water quality goals and conditions for the District-managed water bodies in the Fish Creek subwatershed.

Historically, Fish Creek experienced significant streambed erosion caused by increased stormwater flows. In the late 1980s, the RWMWD undertook a significant restoration project that included the construction of drop structures along the length of the creek as well as the construction of an underground pipe to handle the flood flows in the steeper Section of the creek. The RWMWD continues to conduct maintenance on the creek to sustain that project.

2.18.2.1 Historical Water Quality

Fish Creek is a perennial stream that originates at the outlet from Carver Lake in Woodbury. The creek then flows west and discharges into Eagle Lake (Mississippi River Bottomlands subwatershed).

Since 1996, the District has cooperated with the Metropolitan Council to monitor the flow and water quality of Fish Creek. The Metropolitan Council monitors the water quality of Fish Creek as part of its Stream Monitoring Program. The monitoring station is located in St. Paul, 0.2 miles upstream from the creek's confluence with the Mississippi River. The program samples a number of dissolved and suspended solids, and performs a macroinvertebrate count on the creek. The most recent data available is from 2012, and is summarized in the 2014 report published by the Metropolitan Council. The Metropolitan Council's 2014 report includes 2003-2012 water quality averages for total suspended solids, total phosphorus, nitrates, and chloride; this information is summarized in Table 2.18-2. Based on an average phosphorus concentration exceeding MPCA stream eutrophication standards, the District has assigned a RWMWD nutrient water quality classification of At Risk to Fish Creek.

Table 2.18-2 Fish Creek historic water quality parameters (Metropolitan Council)

Water Quality Parameter	MPCA Stream Standard (Central River Nutrient Region)	Fish Creek (2003-2012) Flow-weighted Median Concentration
Total Phosphorus (µg/L)	≤ 100	198
Total Suspended Solids (mg/L)	≤ 30	55
Nitrates (µg/L)	--	710
Chloride (mg/L)	≤ 230	111

Data from Met Council 2014 Mississippi River Tributary Streams Assessment

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on Fish Creek water quality data. The results of these analyses are shown in Table 2.15-3.

Table 2.18-3 Trend Analysis Results for Fish Creek Historical Water Quality Data

Stream	Water Quality Criteria	Water Quality Trend	Percent Change
Fish Creek	Total Suspended Solids	Improving Trend	-37%
	Total Phosphorus	Improving Trend	-47%
	Nitrate	Improving Trend	-21%

Green values indicate an improving trend in water quality for that parameter
Red values indicate a degrading trend in water quality for that parameter

The Metropolitan Council's 2014 water quality report also calculates a Macroinvertebrate Index of Biological Integrity (M-IBI) to assess overall water quality. M-IBI considers macroinvertebrate community richness and composition, pollution tolerance, life histories, trophic interactions, and physical and other parameters that all are components of the biological integrity of the stream. Higher scores indicate better conditions. Fish Creek M-IBI scores from 2004 to 2011 are shown in Figure 2.18-3. All of the M-IBI scores were below the impairment threshold, which suggests that the habitat and water quality of this stream reach were typically unable to sustain all of the needs for aquatic life.

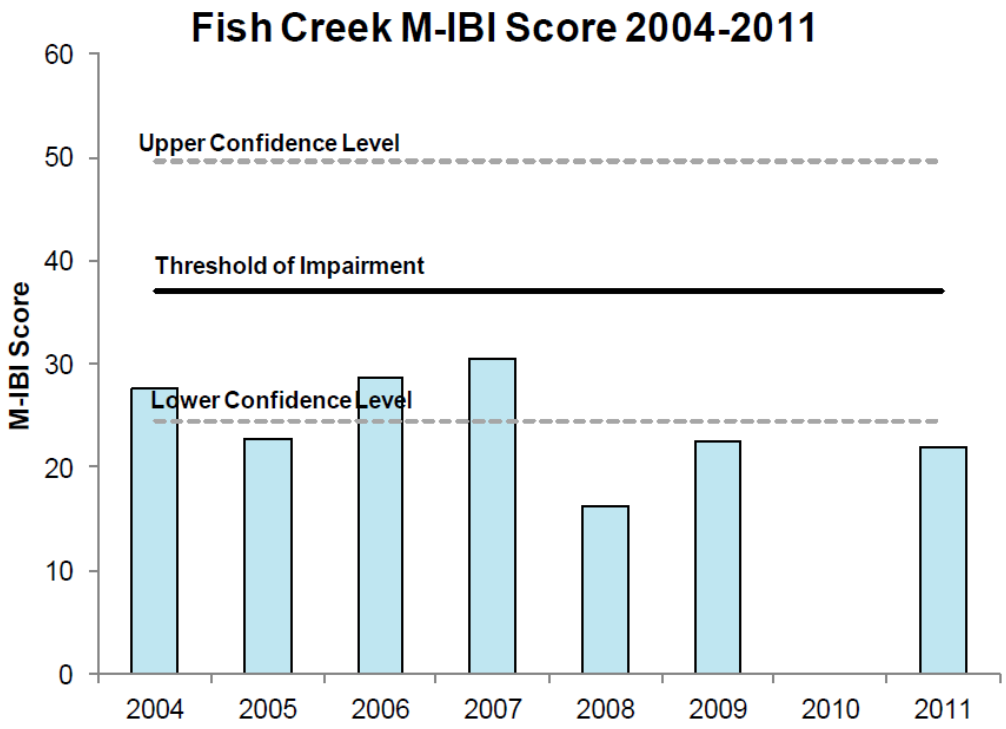


Figure 2.18-3 Fish Creek Annual Macroinvertebrate Index of Biological Integrity (M-IBI) Scores, 2004-2011 (from Met Council Report)

Additional program information and monitoring data may be found from the Met Council Stream Monitoring program website:
http://www.metrocouncil.org/Wastewater-Water/Services/Water-Quality-Management/Stream-Monitoring-Assessment.aspx

The Metropolitan Council also measured *Escherichia coli* (*E. coli*) in water quality samples taken from the Fish Creek monitoring location from 2008 through 2013. *E. coli* was also collected in 2012 and 2013 at the three additional sampling locations along Fish Creek. These sites were selected to evaluate changes in *E. coli* concentrations from upstream to downstream. Samples were compared to the MPCA's water quality standard for E. coli of 126 organisms per 100 mL (calculated as a geometric mean of not less than five samples within any month, and no more than 10% of all samples within a month exceed 1,260 organisms per 100 mL, see Table 1-3).

2.18.2.2 Water Quality Modeling and Analysis

The District performed analysis of Fish Creek water quality data as part of the TMDL study. This included a source assessment to identify the primary sources of *E. coli* to Fish Creek. The 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). This study provides an inventory of the sources of bacteria within the Fish Creek watershed, including:

- Septic systems and human waste
- Stormwater runoff and pets
- Sanitary sewer exfiltration
- Fecal matter from wildlife

The TMDL source assessment also assessed the potential for the bacteria from each source to reach surface waters under wet and dry conditions. This was performed using the methodology originally applied in the Southeast Minnesota Regional Fecal Coliform TMDL (MPCA, 2002). This analysis concluded that bacteria loading to Fish Creek is dominated by loading from humans. 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.

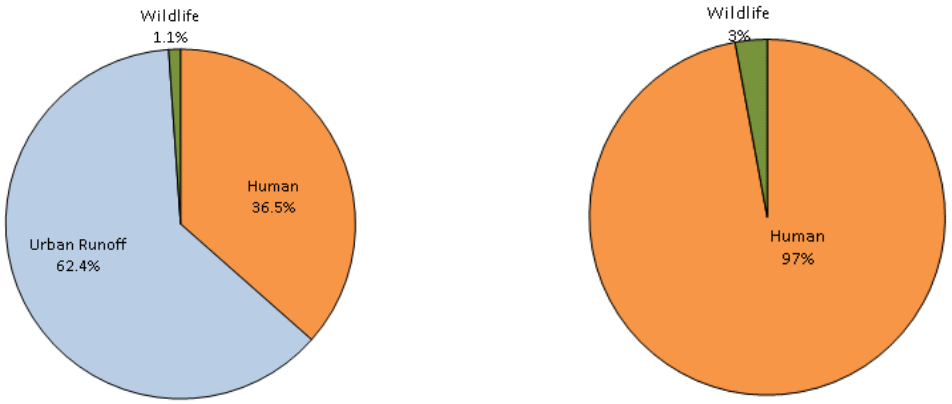


Figure 2.18-4 Estimated bacteria loading to Fish Creek by source under wet weather conditions (left) and dry weather conditions (right)

Following the identification of the primary bacteria sources, the District developed a TMDL and wasteload allocation using the load-duration approach. The load-duration approach considers bacteria load in combination with streamflow to calculate expected concentrations of bacteria in the stream. The Fish hydrograph was divided into five flow regimes:

- High flows (flows above the 90th percentile of average daily flow)
- Moist conditions (flows between the 60th and 90th percentiles of daily average flow)
- Mid-range flows (flows between the 40th and 60th percentile of daily average flow)
- Dry conditions (flows between the 10th and 40th percentiles of daily average flow)
- Low flows (flows below the 10th percentile of average daily flow)

Similarly, a load duration curve was developed for Fish Creek. The load duration curve relates bacteria loading at a given flow to how often that flow value is exceeded in the stream. The final bacteria load duration curve is presented in Figure 2.18-5. Figure 2.18-5 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. At the mid-points of the flow regimes, the geometric mean of the observed conditions (green circles) are compared to the load duration curve (i.e., the allowable load represented by the red circles) to determine required load reductions. The resulting waste load allocation is the difference between the two points, and varies by flow regime.

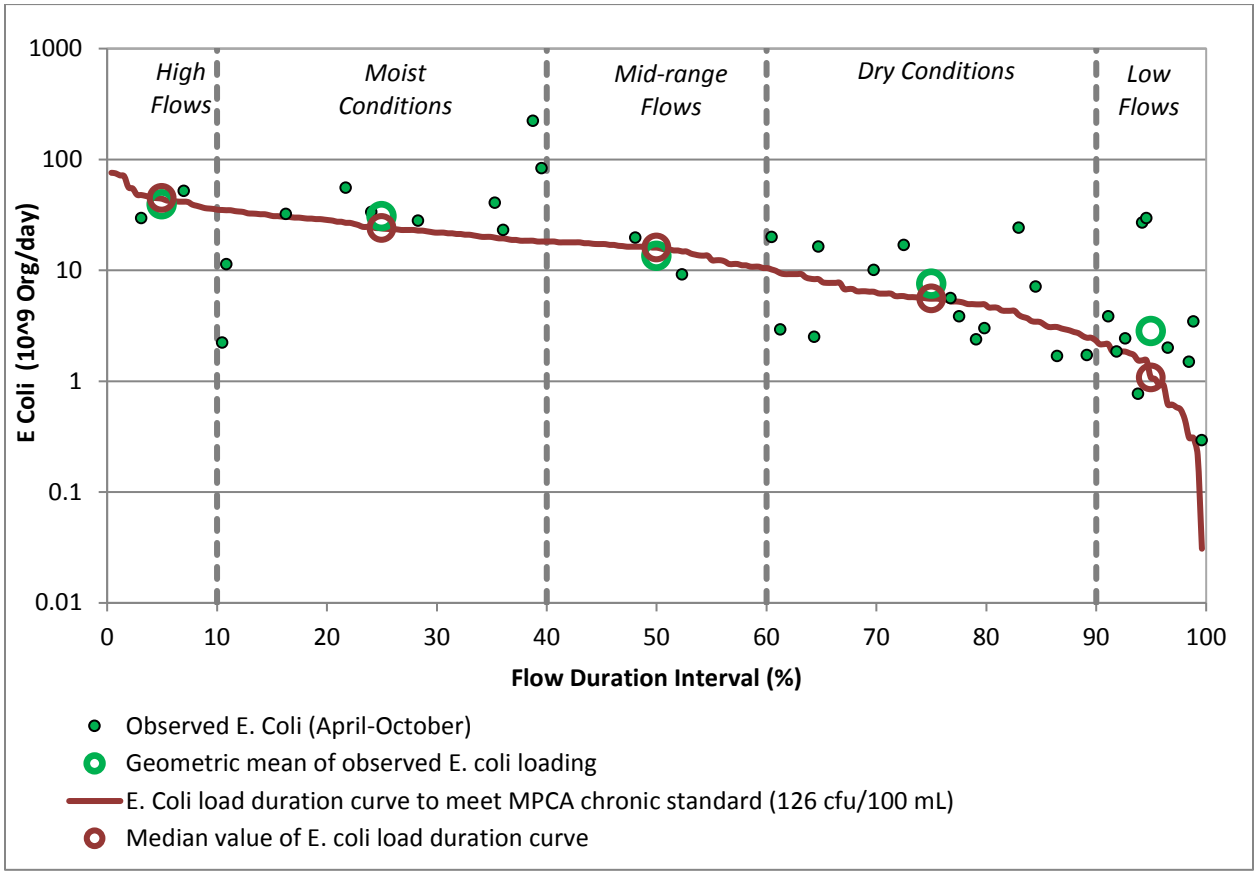


Figure 2.18-5 Fish Creek *E. coli* load duration data

Determination of the allowable bacteria load and required reductions in bacteria loading to Fish Creek are described in greater detail in the Fish Creek TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016).

2.18.2.3 Water Quality Goals

The water quality goals for Fish Creek are consistent with the MPCA's nutrient standards for streams in the Central River Nutrient Region and *E. coli* standards shown in Table 1-3 and Table 2.18-2. The RWMWD strives to ensure that the watercourse and banks of Fish Creek are stable so as to minimize erosion and sediment problems. The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion and other stream degradation problems.

Fish Creek was added to the 2014 MPCA Impaired Waters 303(d) List with an impaired use of aquatic recreation due for *Escherichia 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. The District analyzed flow and bacteria data as part of the RWMWD WRAPS study following the protocol outlined for Minnesota Bacteria TMDLs (see Section 2.18.2.2) and completed a bacteria source assessment identifying the major sources contributing *E. coli* to Fish Creek.

Following the source assessment, a TMDL was developed for Fish Creek addressing the sources of *E. coli*. This study was conducted in accordance with the MPCA and EPA guidance. The resulting wasteload allocations by MS4s and load allocations are included in the *RWMWD Total Maximum Daily Load Report* (MPCA, 2016).

2.18.2.4 Tracking TMDL Implementation

The Fish Creek TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016) calls for reductions in E. coli loading to Fish Creek. The load reductions vary according to five different flow regimes. Under the "mid" flow regime, a reduction of 6.5 billion organisms per day is required. The wasteload allocation described in the TMDL is "categorical", meaning that the total load allocations to several permitted sources are grouped into a single wasteload allocation (with the exception of the reduction assigned to the MnDOT Metro District). The categorical approach is being taken as the RWMWD is initially taking the lead role in implementing projects to achieve the reduction defined in the Fish Creek bacteria TMDL. The city of Newport, while hydrologically tributary to Fish Creek, is not included among the MS4s implicated in the categorical wasteload allocation, as Newport is not currently within the legal limits of RWMWD. As such, RWMWD plans to help its official member cities achieve this wasteload allocation without the involvement of the City of Newport.

Progress towards this goal will be achieved through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.18-6.

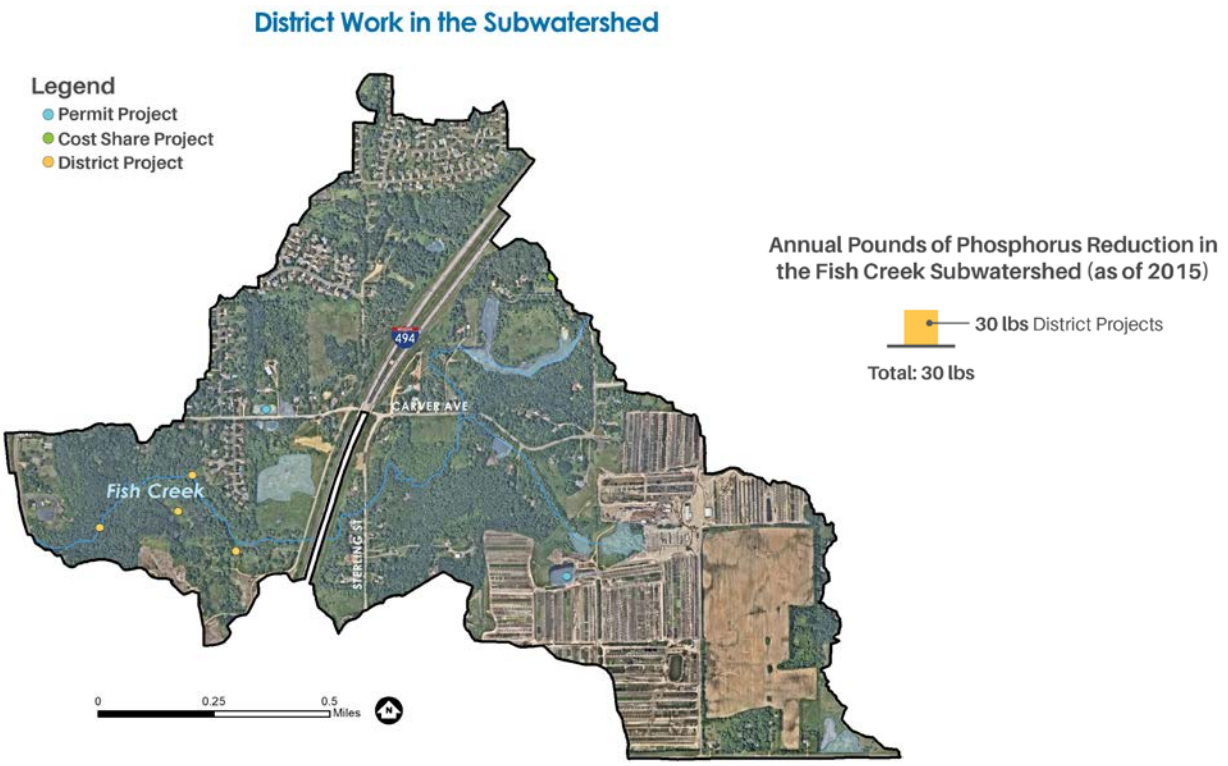


Figure 2.18-6 District work in the Fish Creek Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.18.2.5 Water Quality Improvement Projects

The District has performed several projects within the Fish Creek watershed to improve water quality and achieve other benefits. Some of these projects are identified in Figure 2.18-6.

In 1988-1989, the District completed a capital improvement project to stabilize the creek bed and minimize bank erosion caused by increased stormwater flows. The project included installation of an underground pipe for flood flows in the steep Section of the creek (about one-half mile long). A surface channel was reconstructed to carry low flows. The project also included development of three upstream control structures to delay storm flows.

In 2005, an extreme storm event caused considerable damage to Fish Creek. Each of the three embankments within the lower ravine (downstream of I-494) and the three embankments upstream of I-494 overtopped, and four of the six embankments required significant repair. The creek had to be temporarily rerouted to allow District Staff to fully assess the damage for permanent repair and restoration. Approximately 900 feet of channel and seven waterfall drop structures were reinforced and/or reconstructed. Also three earth dams were removed to restore an open creek from I-494 to Highway 61. The flood flow pipeline was extended approximately 600 feet and a new diversion structure was installed near I-494. The flood flow pipeline extension contains potentially-damaging flows within in the pipe until

they discharge on bedrock 400 feet upstream of Highway 61. The diversion structure routes low-flows above ground, into the creek, to sustain the creek.

The RWMWD will continue to conduct physical monitoring of the stream to identify streambank and other erosion problems. The RWMWD will implement stream management and stream restoration projects and actions to address identified streambank erosion, gully erosion and other stream degradation problems.

2.18.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being.

The RWMWD has performed significant restoration projects to combat the effects of urbanization and repair damage from extreme storm events. Although the primary objective of the projects was to minimize erosion and stabilize the stream channel, alterations to the stormwater system were made to decrease peak flows through the stream, including three upstream control structures to delay storm flows, and construction of an underground pipe to handle flood flows in the steeper Section of the creek.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Fish Creek subwatershed are the new 100-year flood elevations shown in Figure 2.18-7. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.18.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Fish Creek subwatershed are shown in Figure 2.18-8, indicating areas where the water levels of waterbodies in the Fish Creek subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.18.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy

ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities along shoreland areas in the subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Fish Creek subwatershed.

2.18.6 Implementation Program

Based on the RWMWD TMDL report and studies conducted between 2007 and 2016, several implementation activities are recommended to meet the District goals in the Fish Creek subwatershed (see Table 2.18-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Fish Creek subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

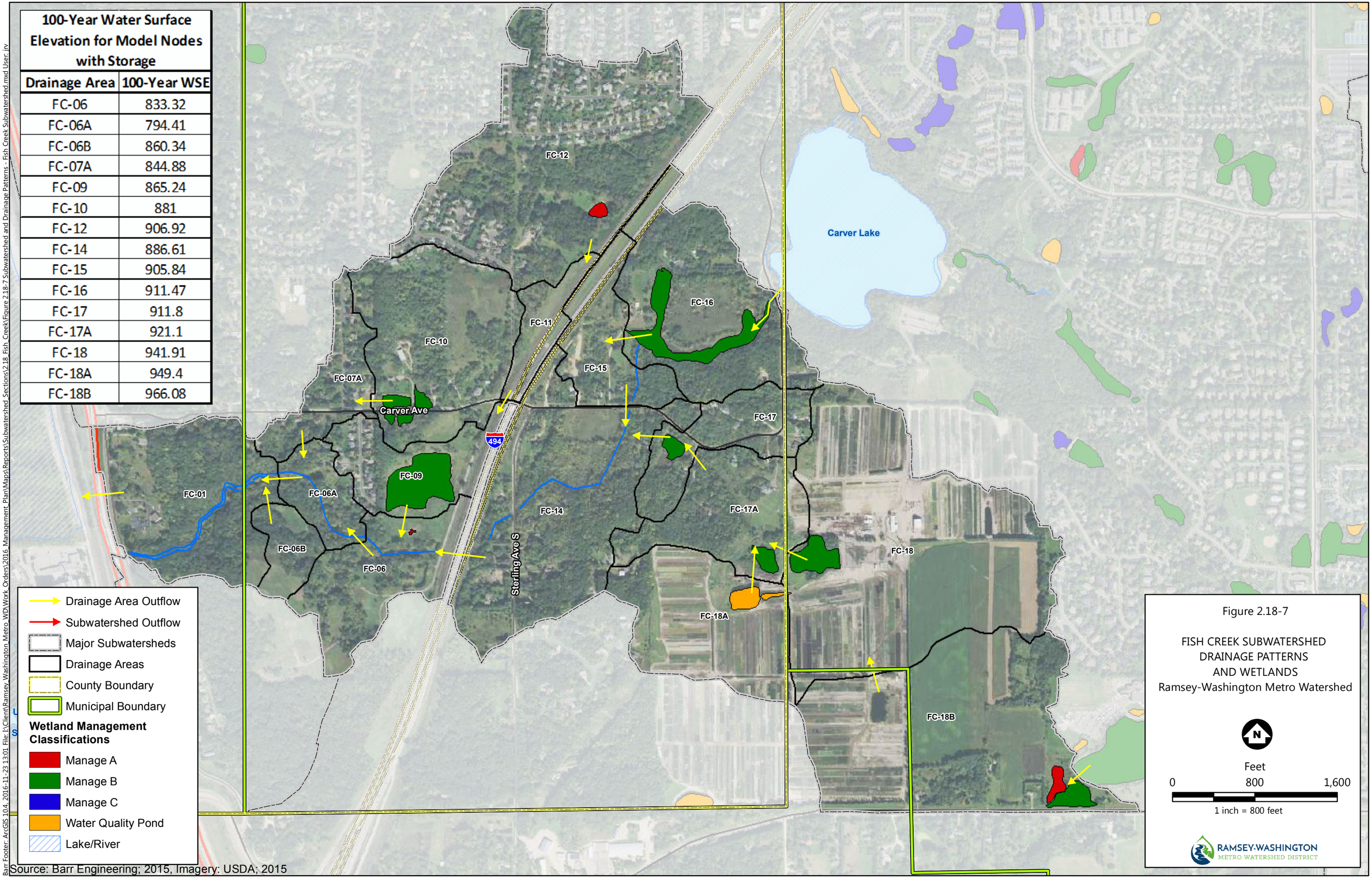
Table 2.18-4 Fish Creek Subwatershed Implementation Activities

Activity ID No.	Fish Creek Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
FC-1*	Assist MS4s in implementing the Fish Creek TMDL, such as educating citizens about proper management of pet waste.	**2017-2026**	**$5,000**	**IE3, IE5, IE6**	**Tier 2**
FC-2	Study the effect of increasing flood storage upstream of I-494, in Bailey Nursery and other upstream areas on improving flood resiliency in Fish Creek and implement recommended projects.	**2018-2022**	**$500,000**	**WQ2, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	100-Year WSE
FC-06	833.32
FC-06A	794.41
FC-06B	860.34
FC-07A	844.88
FC-09	865.24
FC-10	881
FC-12	906.92
FC-14	886.61
FC-15	905.84
FC-16	911.47
FC-17	911.8
FC-17A	921.1
FC-18	941.91
FC-18A	949.4
FC-18B	966.08



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.18-7

FISH CREEK SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 800 1,600
1 inch = 800 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 13:01 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.18_Fish_Creek\Figure 2.18-7 Subwatershed and Drainage Patterns - Fish Creek Subwatershed.mxd User: jrv

Carver Lake

Carver Ave

494

Sterling Ave S

Unnamed (North Star) Lake

Drainage Areas

County Boundary

Municipal Boundary

Creeks

Vulnerability to Changes in Groundwater System

Vulnerable

Composite Infiltration Area Score

5 - 6	15 - 16
7 - 8	17 - 18
9 - 10	19 - 20
11 - 12	21 - 22
13 - 14	23 - 24

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.18-8

FISH CREEK SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

N

Feet

0 800 1,600

1 inch = 800 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-29 10:03 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.18_Fish_Creek\Figure 2.18-8 Priority Infiltration Areas - Fish Creek Subwatershed.mxd User: jrv

2.19 Grass Lake Subwatershed

2.19.1 General Description

The Grass Lake subwatershed covers 1,412 acres and includes portions of the city of Shoreview (see Figure 2.19-1). The Grass Lake watershed receives inflow from the Snail Lake subwatershed (see Section 2.22), Shoreview Lake subwatershed (see Section 2.21), and Lake Wabasso subwatershed (see Section 2.25); the total area draining to the Grass Lake subwatershed is 5,688 acres (8.9 miles). The Grass Lake watershed was formerly part of the Grass Lake Watershed Management Organization (GLWMO) and was added to the RWMWD as part of a 2013 major plan amendment. The Grass Lake subwatershed drains outside of the District to West Vadnais Lake.

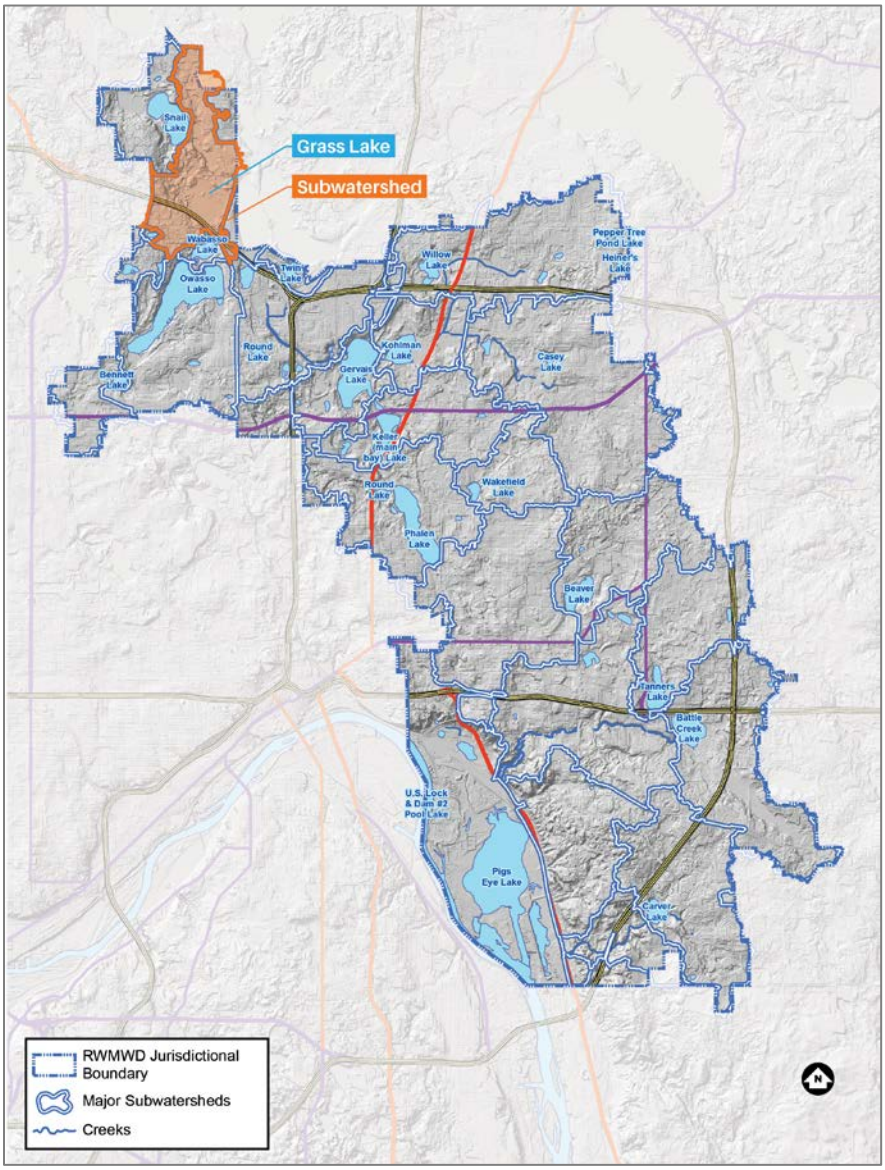


Figure 2.19-1 Grass Lake Location Map

There are no District-managed waterbodies in the Grass Lake subwatershed. Grass Lake is a 16 acre MDNR public water wetland (MDNR# 62-0074W) located in the city of Shoreview. Grass Lake is entirely surrounded by the Grass Lake Nature Preserve and Snail Lake Regional Park, which are owned and operated by the Ramsey County Parks and Recreation Department. The parks include parking areas and trails, although there is no direct access to Grass Lake. While commonly referred to as a lake, Grass Lake is not categorized as lacustrine (see Section 1.9.1). The District will manage Grass Lake as a wetland.

Table 2.19-1 Grass Lake Subwatershed Facts

Tributary Area (Direct)	1,412 acres
Tributary Area (Total)	5,688 acres
Downstream Watershed	West Vadnais Lake (Out of District)
MDNR Designation[1]	62-0074W
Lake Surface Area[1]	16 acres
Lake Outlet Type[1]	18" Corrugated Polyethylene Pipe
Lake Outlet Elevation[1]	881.6 ft
100-Year Flood Level[2]	-- (land-locked, restricted outlet)
MPCA Designations[1]	Wetland
MS4s in the Direct Tributary Area	Shoreview, Vadnais Heights, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Not Applicable (wetland)

[1] Data based on Grass Lake

[2] 100-year flood level for land-locked basins not established (see Section 1.12.3)

2.19.1.1 Past Studies

The following list is a summary of past studies related to Grass Lake and the Grass Lake subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.

2.19.1.2 Land Use

Existing land use in the Grass Lake subwatershed includes single-family residential land use in the north part of the subwatershed (see Figure 2.19-2). Some commercial land use is also present near the intersection of Highway 96 and Hodgson Road. The south part of the subwatershed includes mostly office, industrial, and higher-density residential land use. Snail Lake Regional Park and the Grass Lake

Nature Preserve occupy a significant area of park, recreational, or preserve land use adjacent to and north of Grass Lake. No significant land use changes are projected in the Grass Lake subwatershed based on the Metropolitan Council 2030 land use data (see Figure 1-5). New development and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the developed or redeveloped site.

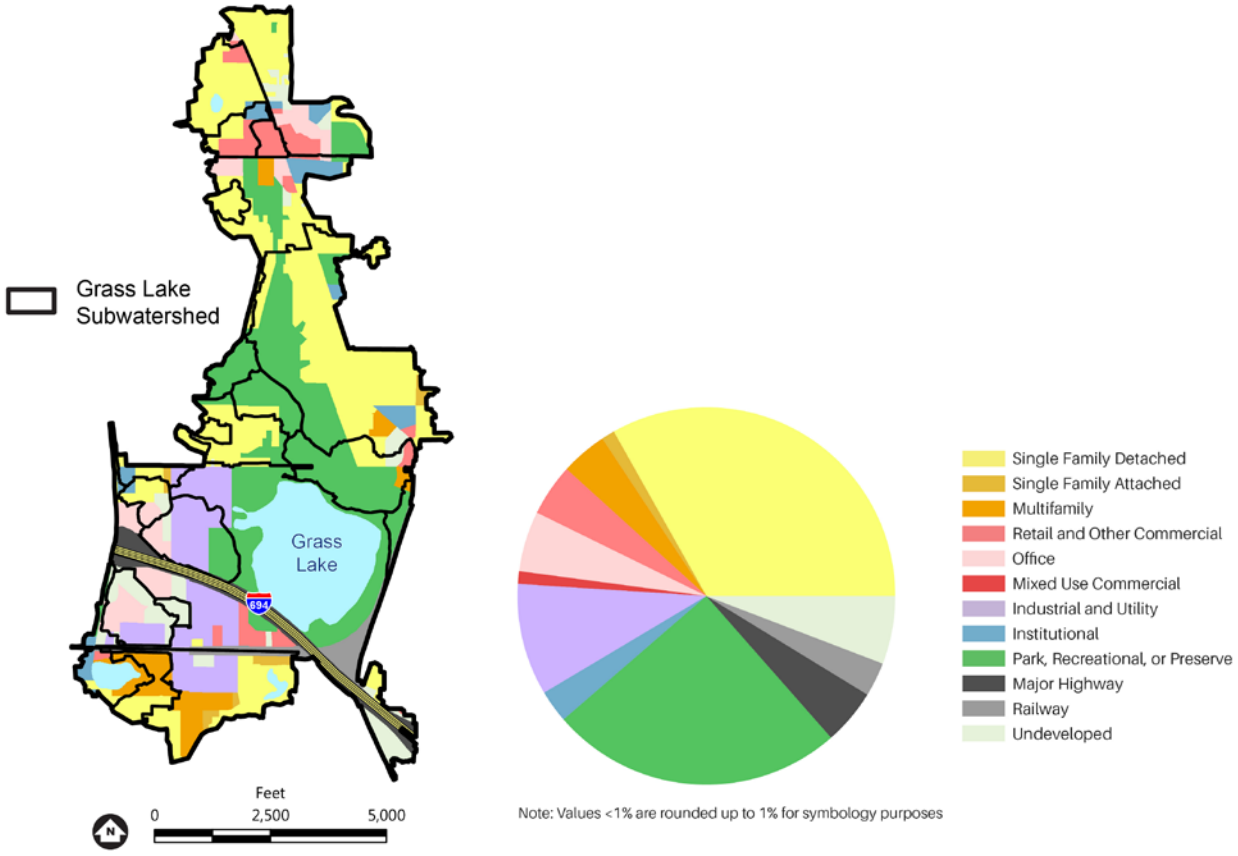


Figure 2.19-2 Breakdown of land uses throughout the Grass Lake Subwatershed (2010 Metropolitan Council)

2.19.1.3 Drainage Patterns and Waterbodies

The Grass Lake subwatershed receives inflow from the Shoreview Lake subwatershed and Lake Wabasso subwatershed. Flows from Lake Wabasso enter the Grass Lake subwatershed from the south through culverts underneath Interstate 694. Flow is possible from the Snail Lake subwatershed, but only when water levels in Snail Lake are very high (above 887.9 feet). Grass Lake outlets towards West Vadnais Lake (outside of the District) via an 18 inch corrugated polyethylene pipe, then a 48 inch reinforced concrete pipe under the railroad tracks east of Grass Lake and a 42 inch reinforced concrete pipe under Rice Street. The downstream drainage network significantly restricts outflow from Grass Lake, resulting in water level fluctuations in Grass Lake similar to a landlocked basin.

The Grass Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.19-4). Figure 2.19-4 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

There are no District-managed waterbodies within the Grass Lake subwatershed.

Wetlands within the Grass Lake subwatershed are shown in Figure 2.19-4 according to the RWMWD wetland management classification (see Section 1.11.3).

2.19.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for the Grass Lake subwatershed. Because Grass Lake discharges outside of the RWMWD boundary, it is important to achieve high water quality of drainage originating in, and draining through, the Grass Lake subwatershed.

2.19.2.1 Historical Water Quality

Grass Lake is a wetland, and is not regularly monitored by Ramsey County or the RWMWD. Limited water quality data for Grass Lake was collected in 1984 and is available from the MPCA's Environmental Data Access website. There is insufficient data to assess current water quality conditions or trends. Based on its classification as a wetland by the MPCA, Grass Lake was not evaluated by the District as part of the RMWMD WRAPS study.

2.19.2.2 Water Quality Goals

The RWMWD has not established numerical water quality goals for Grass Lake. As a wetland, Grass Lake is not subject to the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion (see Section 1.10.1 and Table 1-3).

The District will continue to consider opportunities to improve water quality in the Grass Lake subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.19-3.

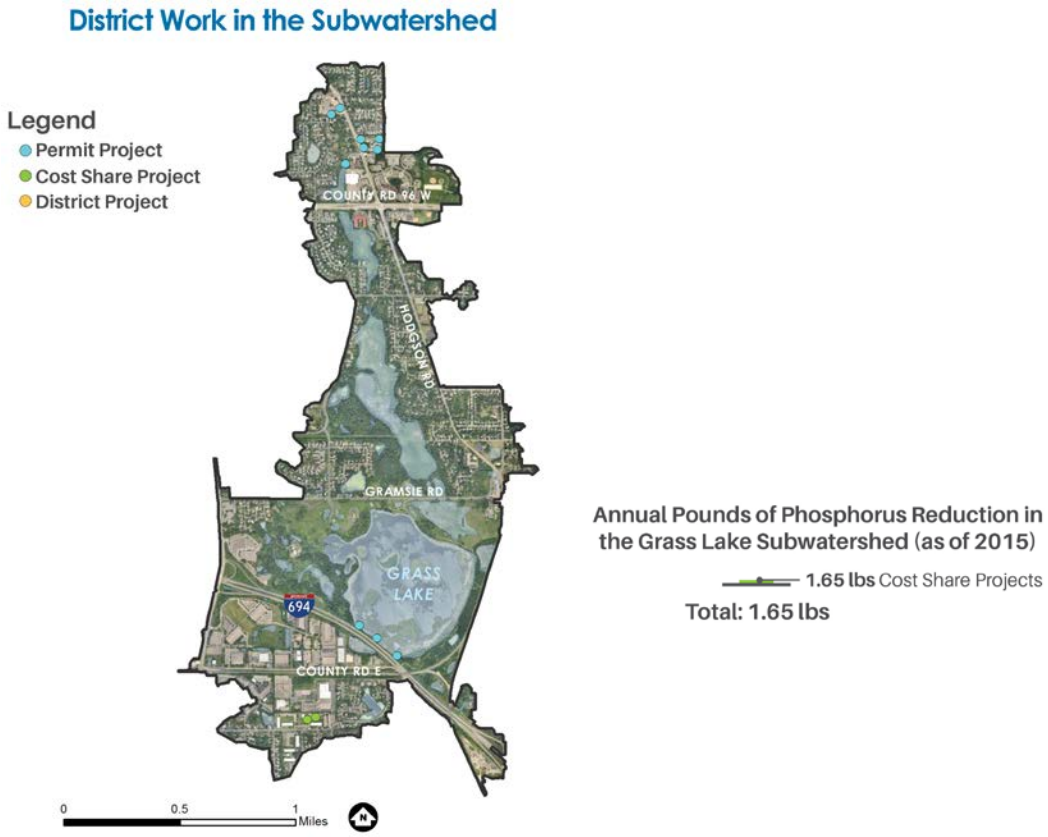


Figure 2.19-3 District work in the Grass Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.19.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Grass Lake subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Grass Lake subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Grass Lake subwatershed are the new 100-year flood elevations shown in Figure 2.19-4. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.19.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Grass Lake subwatershed are shown in Figure 2.19-5, indicating areas where the water levels of waterbodies in the Grass Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.19.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

Grass Lake is a significant wetland resources within the Grass Lake subwatershed. The wetland is entirely surrounded by Ramsey County parkland. The District will cooperate with Ramsey County and the City of Shoreview to ensure the ecological integrity of Grass Lake and other natural areas within the Grass Lake subwatershed.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Grass lake subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Grass Lake subwatershed.

2.19.6 Future Implementation Activities

The District has identified implementation activities specific to the Grass Lake subwatershed recommended to meet the District goals (see Table 2.19-2). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Grass Lake subwatershed (e.g., implementation of the RWMWD permit program). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.19-2 Grass Lake Subwatershed Implementation Activities

Activity ID No.	Grass Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
GrL-1	Survey the connection between Grass Lake and Vadnais Lake, assess conditions and implement any needed improvements.	**2017**	**$20,000**	**FL1, FL7, FL9**	**Tier 1**

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	**100-Year WSE**
GL-01	Land-Locked* (Restricted Outlet)
GL-01a	883.05
GL-02	887.67
GL-03	931.3
GL-05	881.99
GL-06a	882.5
GL-06b	883.24
GL-07	901.5
GL-08	915.54
GL-09	902.76
GL-10	908.05
GL-11	912.17
GL-12	922.42
GL-13	883.24
GL-13a	904.04
GL-14	883.22
GL-15	890.93
GL-16	925.13
GL-16a	941.77
GL-17	902.49
GL-18	937.86
GL-19	946.9
GL-20	950.96
GL-21	900.64
SL-08a	892.46

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

*100-Year WSE not determined for land-locked (restricted outlet) waterbodies; see Section 1.12.3

Source: Barr Engineering; 2015, Imagery: USDA; 2015

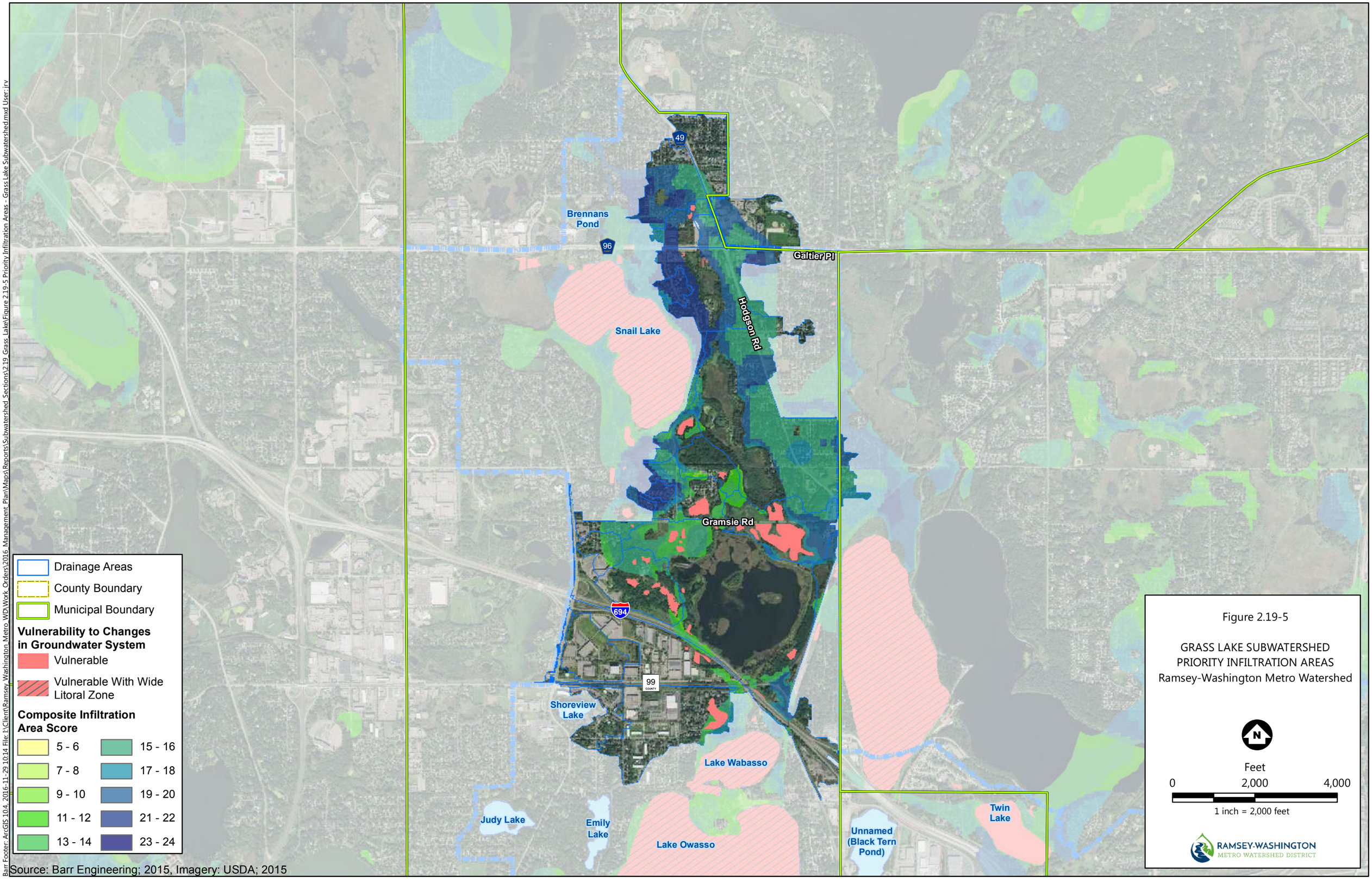
Figure 2.19-4

GRASS LAKE SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 2,000 4,000
1 inch = 2,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-09-06 15:42 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.19_Grass_Lake\Figure 2.19-4 Subwatersheds and Drainage Patterns - Grass Lake Subwatershed.mxd User: jrv


Brennans Pond
Snail Lake
Hodgson Rd
Galtier Pl
Gramsie Rd
Shoreview Lake
Lake Wabasso
Judy Lake
Emily Lake
Lake Owasso
Unnamed (Black Tern Pond)
Twin Lake
49
96
694
99
Drainage Areas
County Boundary
Municipal Boundary
Vulnerability to Changes in Groundwater System
Vulnerable
Vulnerable With Wide Litoral Zone
Composite Infiltration Area Score
5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24
Figure 2.19-5
GRASS LAKE SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed
Feet
0
2,000
4,000
1 inch = 2,000 feet
RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT
Source: Barr Engineering; 2015, Imagery: USDA; 2015
Barr Footer: ArcGIS 10.4 2016-11-29 10:14 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.19_Grass_Lake\Figure 2.19-5 Priority Infiltration Areas - Grass Lake Subwatershed.mxd User: jrv

2.20 Bennett Lake Subwatershed

2.20.1 General Description

The Bennett Lake subwatershed includes 721 acres within the city of Roseville, entirely within Ramsey County (see Figure 2.20-1). The Bennett Lake subwatershed is part of the larger Grass Lake watershed, as water passes from Bennett Lake to Lake Owasso, then Lake Wabasso, and ultimately into Grass Lake (see Figure 1-8). The Bennett Lake subwatershed was formerly part of the Grass Lake Watershed Management Organization (GLWMO) and was added to the RWMWD as part of a 2013 major plan amendment.

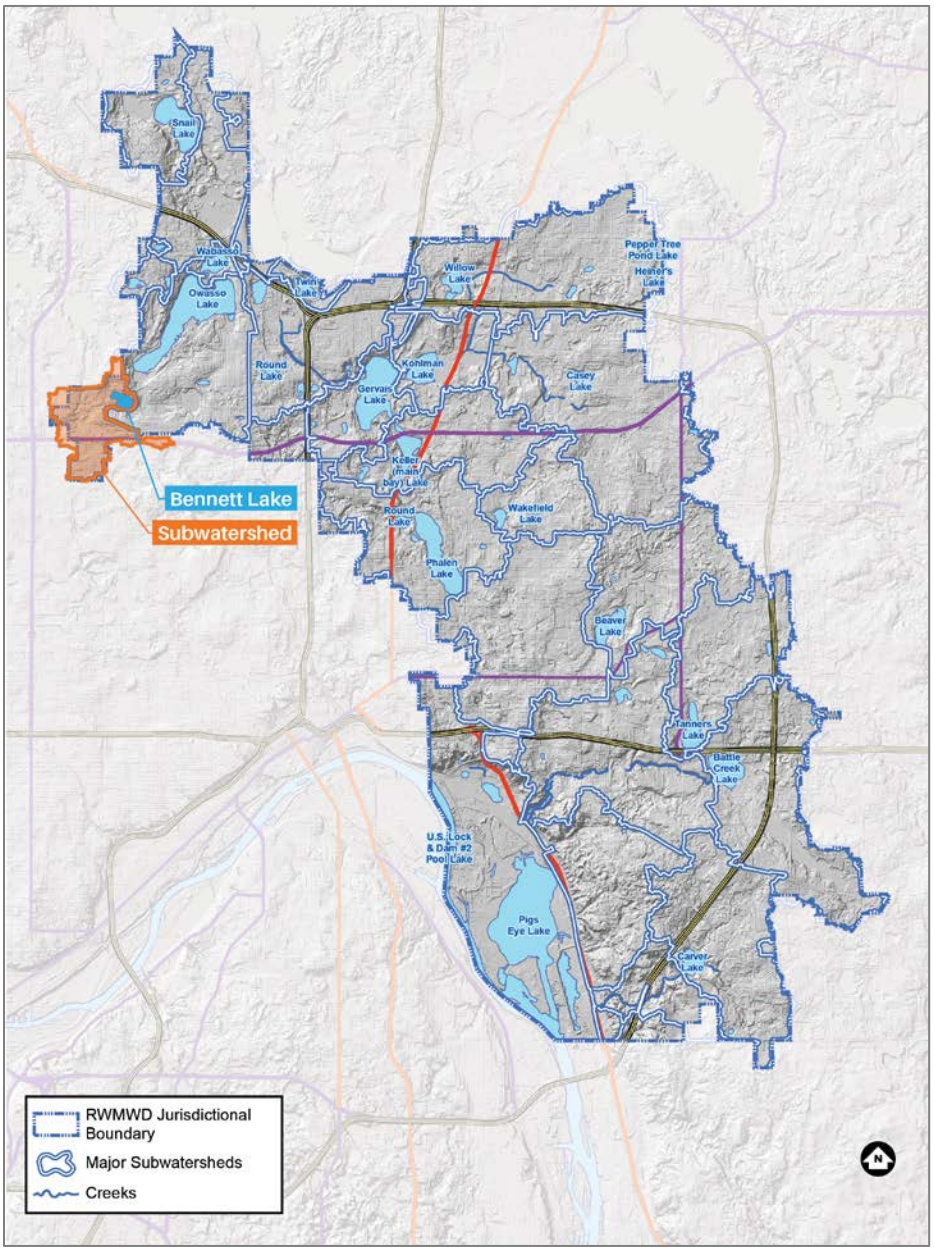


Figure 2.20-1 Bennett Lake Location Map

Bennett Lake is a MDNR public water (MDNR# 62-0048P) located in the city of Roseville and is the only District-managed waterbody in the Bennett Lake subwatershed. The lake is approximately 25 acres and has a maximum depth of 9 feet. The City of Roseville's Central Park surrounds Bennett Lake. It has a fishing pier and provides canoeing opportunities. Additionally, the MDNR uses Bennett Lake as a fish rearing pond. The lake has experienced frequent winterkills, and as a result, the City of Roseville operates a winter aeration system. An aeration system is also operated in the summer.

Table 2.20-1 Bennett Lake Subwatershed Facts

Tributary Area (Direct)	721 acres
Tributary Area (Total)	721 acres
Downstream Watershed	Lake Owasso
MDNR Designation[1]	62-0048P
Lake Surface Area[1]	25 acres
Lake Maximum Depth[1]	9 ft
Lake Outlet Type[1]	2 ft-wide Weir
Lake Outlet Elevation[1]	887.0 ft
100-Year Flood Level[1]	892.2 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake; Impaired for Aquatic Recreation (Excess Nutrients), Impaired for Aquatic Consumption (mercury food consumption advisory), At Risk for impairment for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Roseville, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Impaired

[1] Data based on Bennett Lake

2.20.1.1 Past Studies

The following list is a summary of past studies related to Bennett Lake and the Bennett Lake subwatershed:

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Ramsey-Washington Metro Watershed District Watershed Restoration and Protection Strategies (WRAPS) Report.* Barr Engineering Company, Draft 2016.
- *Ramsey-Washington Metro Watershed District Total Maximum Daily Load Study.* Barr Engineering Company, Draft 2016.
- *Lake Owasso Use Attainability Analysis.* Prepared for GLWMO by Barr Engineering, April 2009.

- *GLWMO Watershed Management Plan*. Grass Lake Watershed Management Organization, June 2011.

2.20.1.2 Land Use

The Bennett Lake subwatershed is nearly fully developed. Land use in the subwatershed includes mostly single-family residential land use (see Figure 2.20-2). Roseville Area High School (institutional land use) is located in the central portion of the watershed. Smaller areas of multi-family residential, commercial, and institutional use are scattered throughout the subwatershed. No significant land use changes are projected in the Bennett Lake subwatershed based on the Metropolitan Council 2030 land use data (see Figure 1-5). New development and redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the developed or redeveloped site.

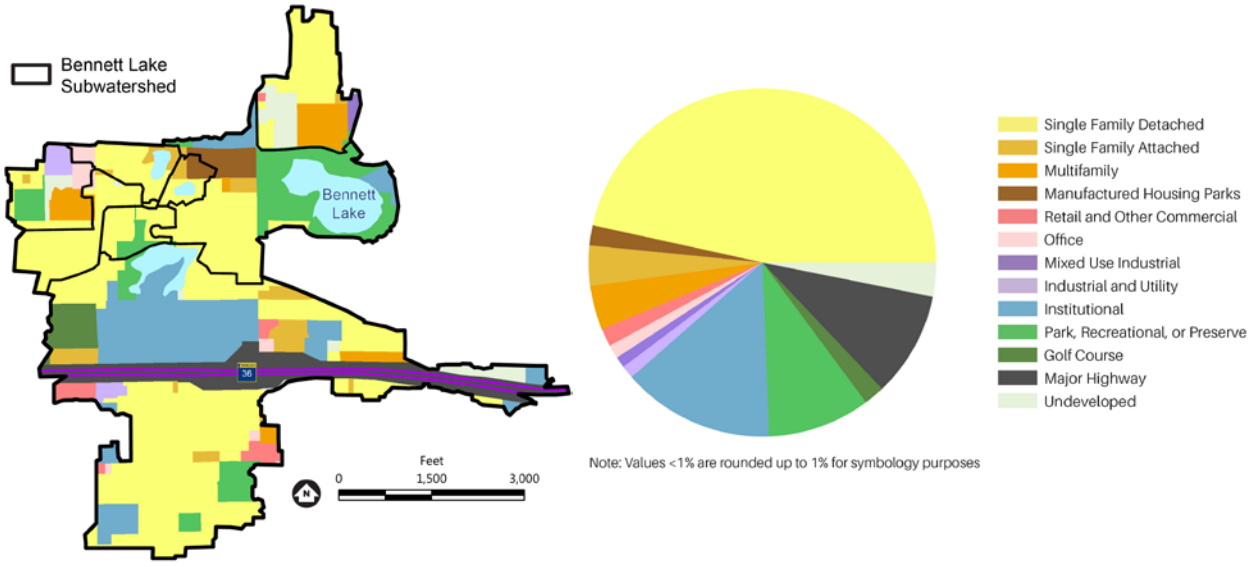


Figure 2.20-2 Breakdown of land uses throughout the Bennett Lake Subwatershed (2010 Metropolitan Council)

2.20.1.3 Drainage Patterns

The Bennett Lake subwatershed generally drains from southwest to northeast towards Bennett Lake. Bennett Lake discharges over a two foot wide weir on the southeast side of the lake into a wetland in the Lake Owasso subwatershed. Stormwater runoff from the Bennett Lake subwatershed is ultimately tributary to Grass Lake, via Lake Owasso and Lake Wabasso (see Figure 1-8).

The Bennett Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.20-8). Figure 2.20-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Bennett Lake subwatershed include only Bennett Lake.

Wetlands within the Bennett Lake subwatershed are shown in Figure 2.20-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.20.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Bennett Lake.

2.20.2.1 Historical Water Quality

Bennett Lake is classified by the MPCA as a shallow lake due to a maximum depth of less than 15 feet and a littoral area exceeding 80% of the lake. The Ramsey County Department of Public Works staff samples the water quality of Bennett Lake about 7 times per year on average, between the months of May and September. Figure 2.20-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.20-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Bennett Lake relative to MPCA standards. Bennett Lake was listed on the MPCA 303(d) Impaired Waters List in 20006 with a use of aquatic recreation impaired due to excessive nutrients, specifically phosphorus (see Section 1.10.2). The RWMWD has assigned a water quality classification of "Impaired" to Bennett Lake based on its inclusion on the impaired waters list (see Section 1.10.3).

Table 2.20-2 Bennett Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Bennett Lake (2003-2012) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	138.4
Chlorophyll-a (µg/L)	≤ 20	37.5
Secchi disk transparency (m)	≥ 1.0	0.9

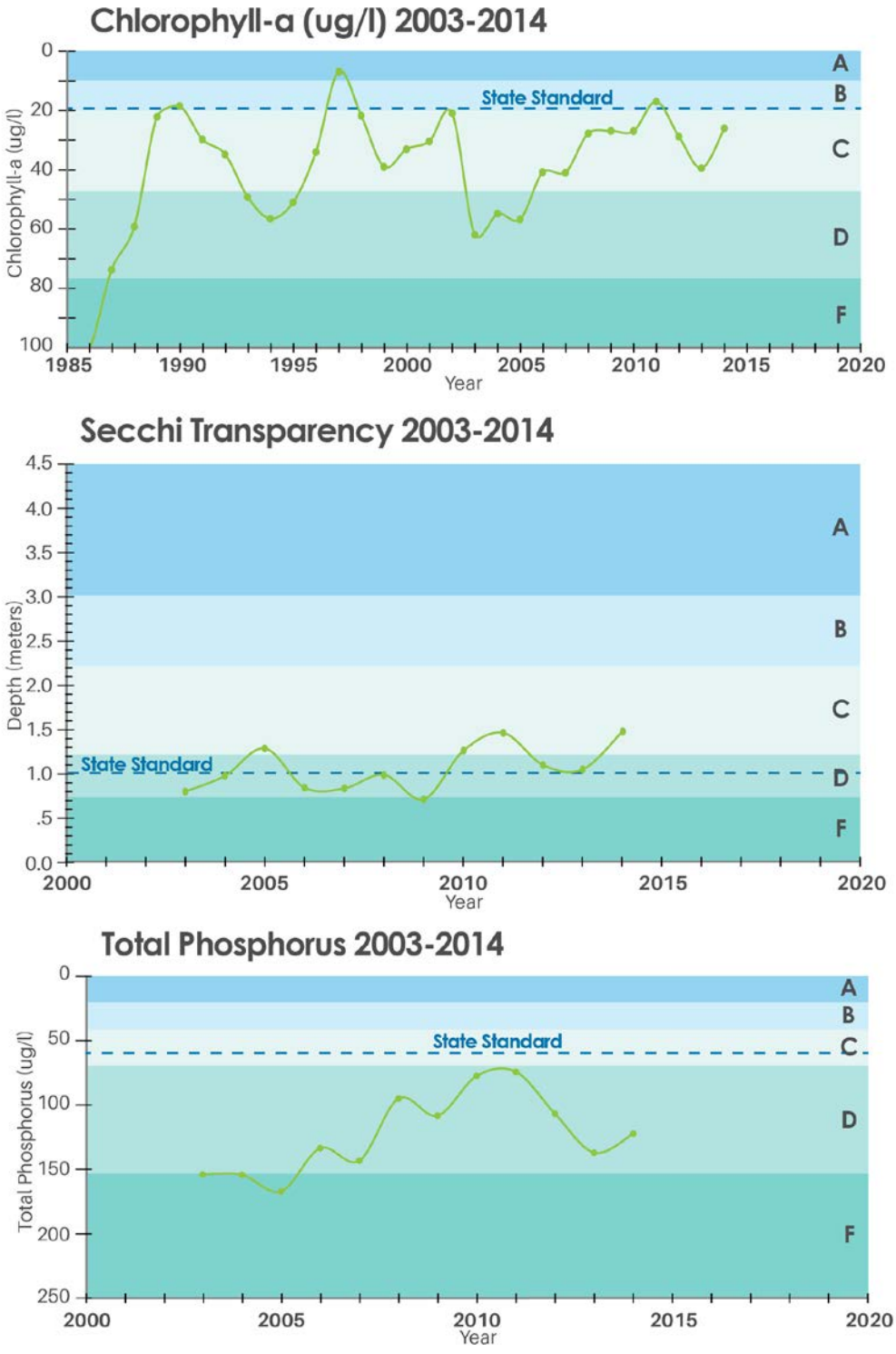


Figure 2.20-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Bennett Lake (1984-2012)

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Bennett Lake water quality data. The results of these analyses are shown in Table 2.20-3.

Table 2.20-3 Trend Analysis Results for Bennett Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Bennett Lake	1984 – 2012	Secchi Depth	Improving	Improving
		Total Phosphorus	Improving	Improving
		Chlorophyll-*a*	Improving	Improving

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

Sediment cores were collected from Bennett Lake in November of 2012 to assess the lake's internal phosphorus loading potential from sediment release. The amount of mobile phosphorus present in lake sediments can impact water quality, as phosphorus bound to iron in the sediment becomes soluble under anoxic conditions 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. The estimated mobile phosphorus release rate from the sediments ranged from 0.2 - 0.4 mg/m^2/day in Bennett Lake, which is enough to impact lake water quality given the small volume of the lake (RWMWD TMDL Report, 2016 draft).

2.20.2.2 Status of the Fishery

Bennett Lake is a popular local fishing resource. The lake is 23 acres in size and has a maximum depth of 9 feet. An aeration system located on the east shore prevents winterkill and a fishing pier is located on the west shore. There are additional locations for shoreline fishing around the lake. The MDNR manages the Bennett Lake fishery for bluegill, channel catfish, black crappie, northern pike, and walleye. Fish management consists primarily of stocking panfish and catfish in the spring.

The MDNR performed a fishery survey in June, 2011 (http://www.dnr.state.mn.us/lakefind/index.html). The 2011 survey found that bluegill were very abundant and could be readily caught from the fishing pier. The average length of fish sampled in 2011 (4.8 inches) was smaller than the previous survey (5.6 inches) though abundance was similar. A few small black crappie were sampled in 2011; the average length was 5.5 inches. Historically the black crappie catch and size structure has varied greatly from survey to survey. Northern pike were the most abundant predator species in the 2011 survey with twelve caught (ranging from 18.9 inches to 31.3 inches in length). Northern pike are not stocked in Bennett Lake and are sustained through natural reproduction. Walleye have been stocked into Bennett most recently in 2010. Three walleyes sampled were all from the 2010 stocking (age one fish, under 10 inches long). Channel catfish, which have been stocked almost every year since 1996, were found in low numbers. No largemouth bass were seen during the 2011 survey. Other species sampled included black bullhead, golden shiner, yellow perch, green sunfish, pumpkinseed sunfish and hybrid sunfish. Common carp were observed in Bennett Lake in 2012.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Bennett Lake based on the presence of mercury and perfluorooctane sulfanate (PFOS). More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.20.2.3 Status of Macrophyte Community

On September 9, 2013, District staff conducted a macrophyte survey of Bennett Lake. The results of this survey are summarized below in Figure 2.20-4. In total, 96 sites were surveyed for macrophytes. Of these, 89 had vegetation, indicating that Bennett Lake is a macrophyte dominated lake. 2013 survey results show a limited aquatic plant community indicative of disturbed, high-nutrient conditions.

Where coontail and filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Bennett Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Although not detected in the fall, 2013 survey, curlyleaf pondweed was present at 64% of surveyed sites in 2009. Curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

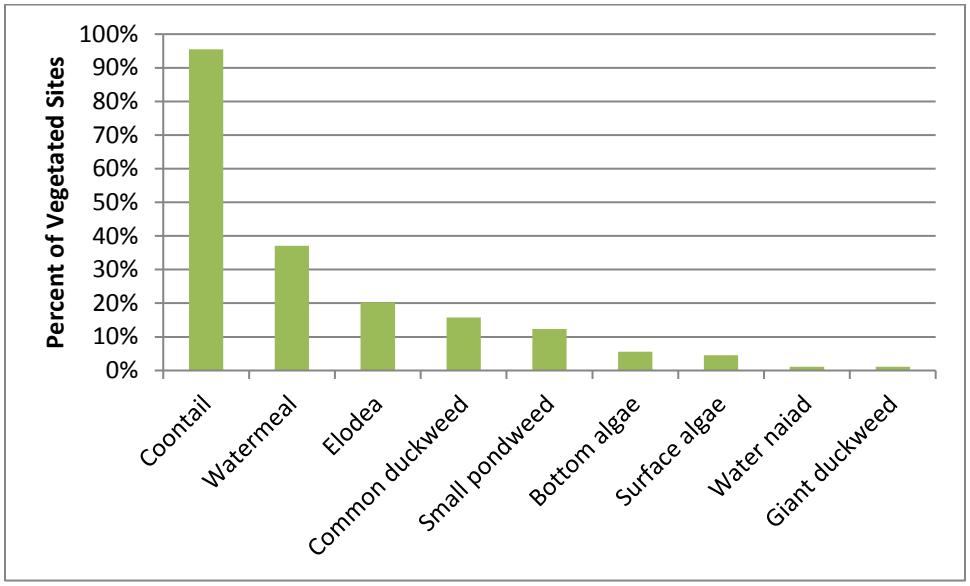


Figure 2.20-4 September, 2013 Bennett Lake Macrophyte Survey Results

2.20.2.4 Water Quality Modeling and Analysis

As part of the TMDL study process, water quality models were developed to estimate the sources of phosphorus to Bennett Lake. A stormwater runoff model estimated the water and total phosphorus loads from the tributary watershed using the P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990). The P8 model used in this study was originally developed as part of the Lake Owasso Use Attainability Analysis (Barr, 2009), and was calibrated as part of the larger Lake Owasso P8 model.

For modeling purposes, Bennett Lake subwatershed was divided into three drainage districts. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake. Figure 2.20-5 shows the major drainage areas that contribute stormwater runoff to Bennett Lake and the estimated percentage of annual watershed phosphorus loading that each drainage area contributes during an average climatic year.

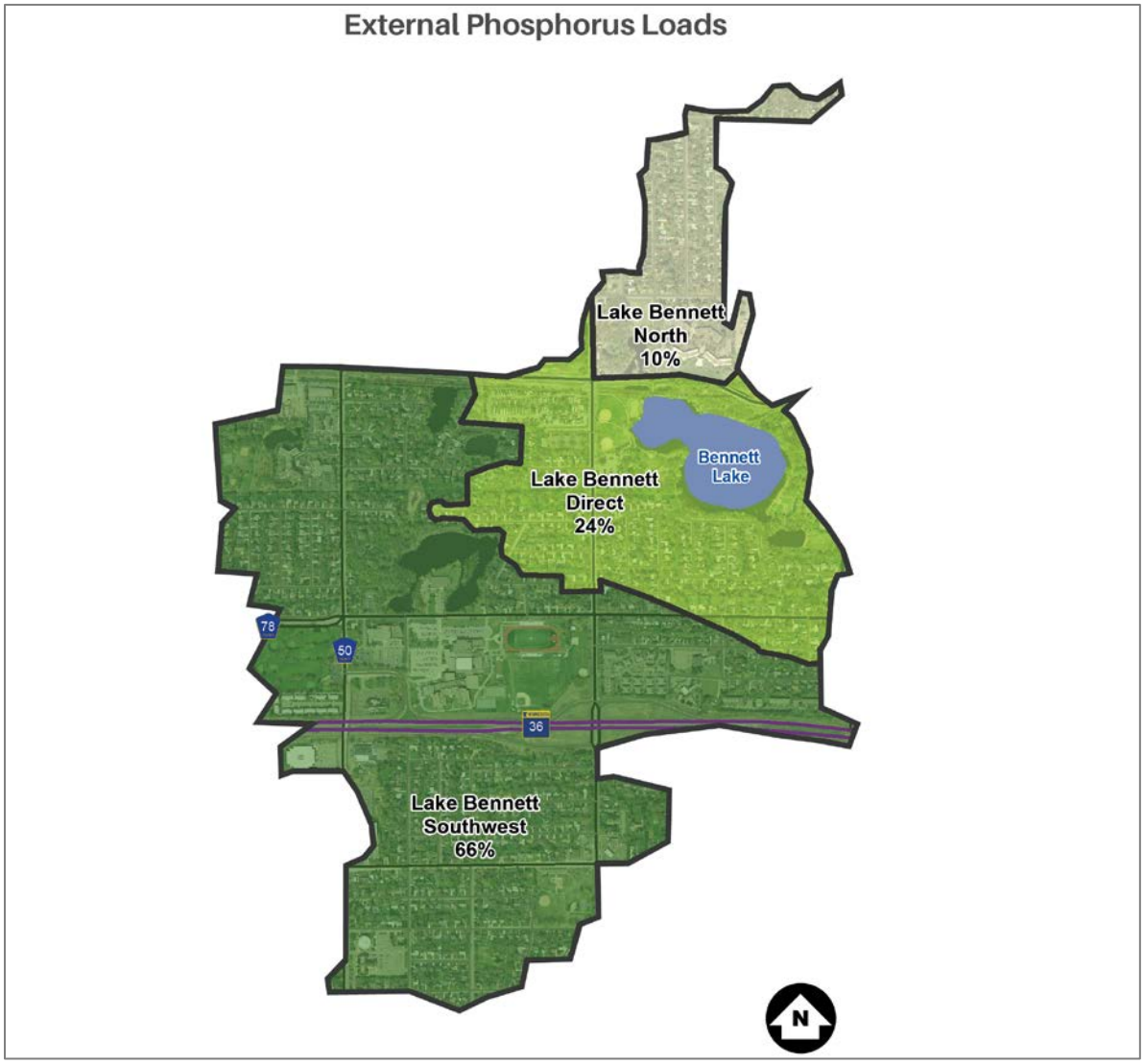


Figure 2.20-5 Drainage districts in the Bennett Lake subwatershed

An in-lake mass balance model was used to assess the impact of watershed loading on the lake and determine the amount of internal phosphorus loading in Bennett Lake. The water quality modeling methodology and results for Bennett Lake are described in detail in the RWMWD TMDL Report (Draft, Barr Engineering, 2016).

The watershed loading and in-lake water quality models of Bennett Lake were used to estimate the relative contribution of the lakes internal and external (watershed) phosphorus loads for the 2005 growing season (see Figure 2.20-6).

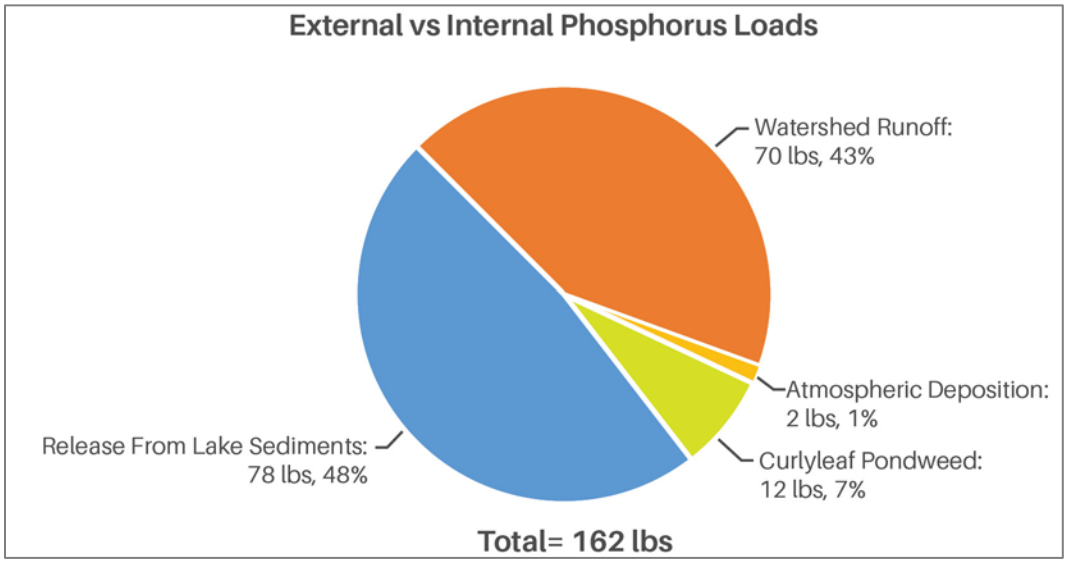


Figure 2.20-6 Bennett Lake 2005 growing season total phosphorus budget

2.20.2.5 Water Quality Goals

The water quality goals for Bennett Lake are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.20-2. The RWMWD will continue to evaluate Bennett Lake water quality data for trends and adjust its water quality classification and management activities accordingly.

Table 2.20-4 summarizes the beneficial use data for Bennett Lake as well as the status of total maximum daily load studies (TMDLs) for the various impairments (if applicable, see Section 1.10.2) and the RWMWD nutrient water quality classification of the lake. The data included in Table 2.20-4 is based on data available through the MPCA Environmental Data Access website.

Table 2.20-4 Assessment status of Bennett Lake

Lake ID	Aquatic Recreation	Aquatic Consumption	Aquatic Life	Comments	RWMWD Nutrient Water Quality Classification*
Bennett Lake 62-0048	Imp (Excess Nutrients)	Imp (Mercury FCA)	IF (At Risk of Chloride Impairment)	Statewide Mercury TMDL completed in 2007; Nutrient TMDL to be completed in 2017.	Impaired

* RWMWD nutrient water quality classifications are described in Section 1.10.3
Imp = Impaired
IF = the data collected was insufficient to make a finding
NA = not assessed

Bennett Lake was listed on the MPCA 303(d) Impaired Waters List in 2006 due to excessive nutrients, with the pollutant of concern being identified as phosphorus. Bennett Lake is also listed as impaired for mercury; the mercury impairment is addressed by the statewide mercury TMDL (MPCA, 2008). The RWMWD TMDL (Draft, Barr Engineering, 2016) summarizes the growing season total phosphorus budget for the critical conditions for Bennett Lake, including the wasteload allocations by MS4s and load allocations developed in the RWMWD TMDL (Draft, Barr Engineering Company, 2016) . The Bennett Lake TMDL calls for a 61% reduction in total phosphorus from the tributary watershed (called a "wasteload" reduction), and a 80% reduction in the lake's internal load (called a "load" reduction). The baseline year by which this reduction will be measured is 2005.

2.20.2.6 Tracking TMDL Implementation Progress

The Bennett TMDL Section of the RWMWD TMDL Report (Draft, Barr Engineering, 2016) calls for a 115 lbs per growing season reduction in phosphorus through projects implemented after 2005. Progress towards this goal will be achieved through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.20-7. The level shown on the "Phosphorus Reduction" bar in Figure 2.20-7 indicates the District's progress toward the Bennett Lake phosphorus reduction goal as of December 31, 2015 as a result of District efforts.

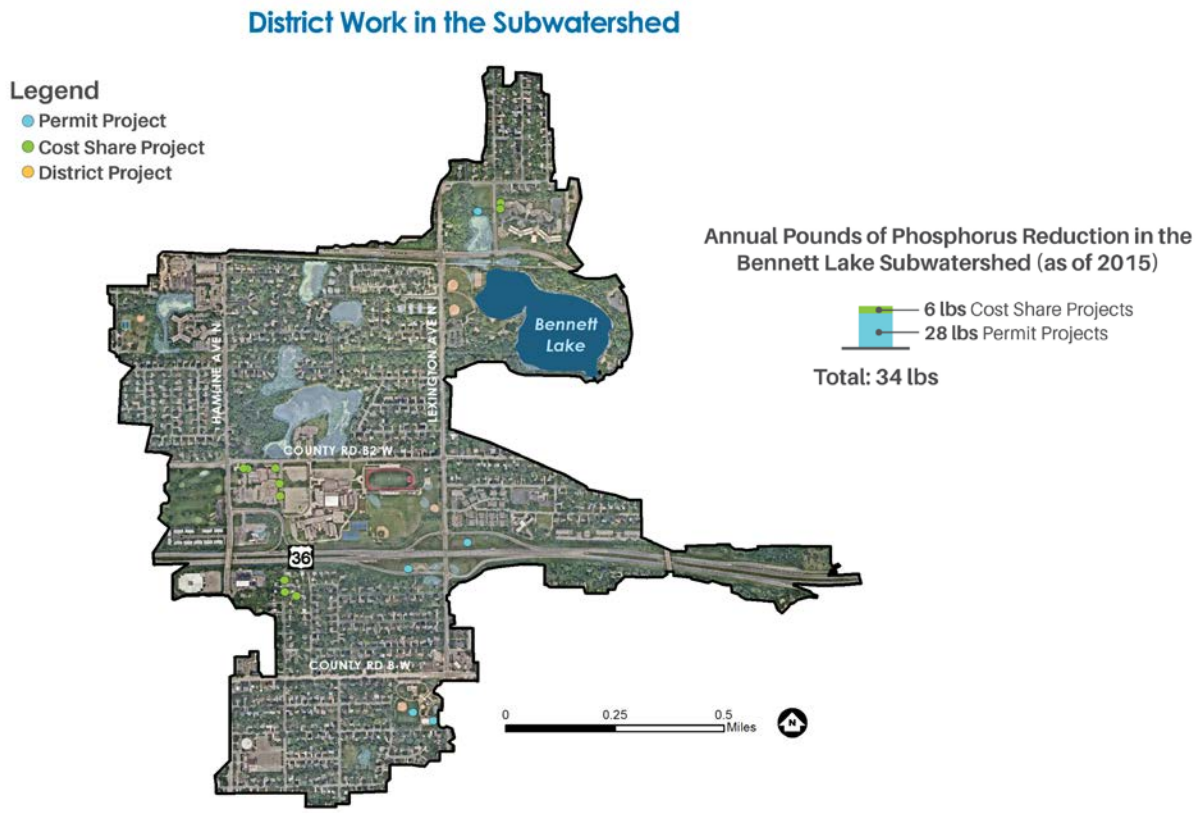


Figure 2.20-7 District work in the Bennett Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.20.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Bennett Lake subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Bennett Lake subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Bennett Lake subwatershed are the new 100-year flood elevations shown in Figure 2.20-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.20.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Bennett Lake subwatershed are shown in Figure 2.20-9, indicating areas where the water levels of waterbodies in the Bennett Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.20.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Bennett Lake subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Bennett Lake subwatershed.

2.20.6 Implementation Program

Based on the RWMWD TMDL report, several implementation activities are recommended to meet the District goals for Bennett Lake (see Table 2.20-5). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

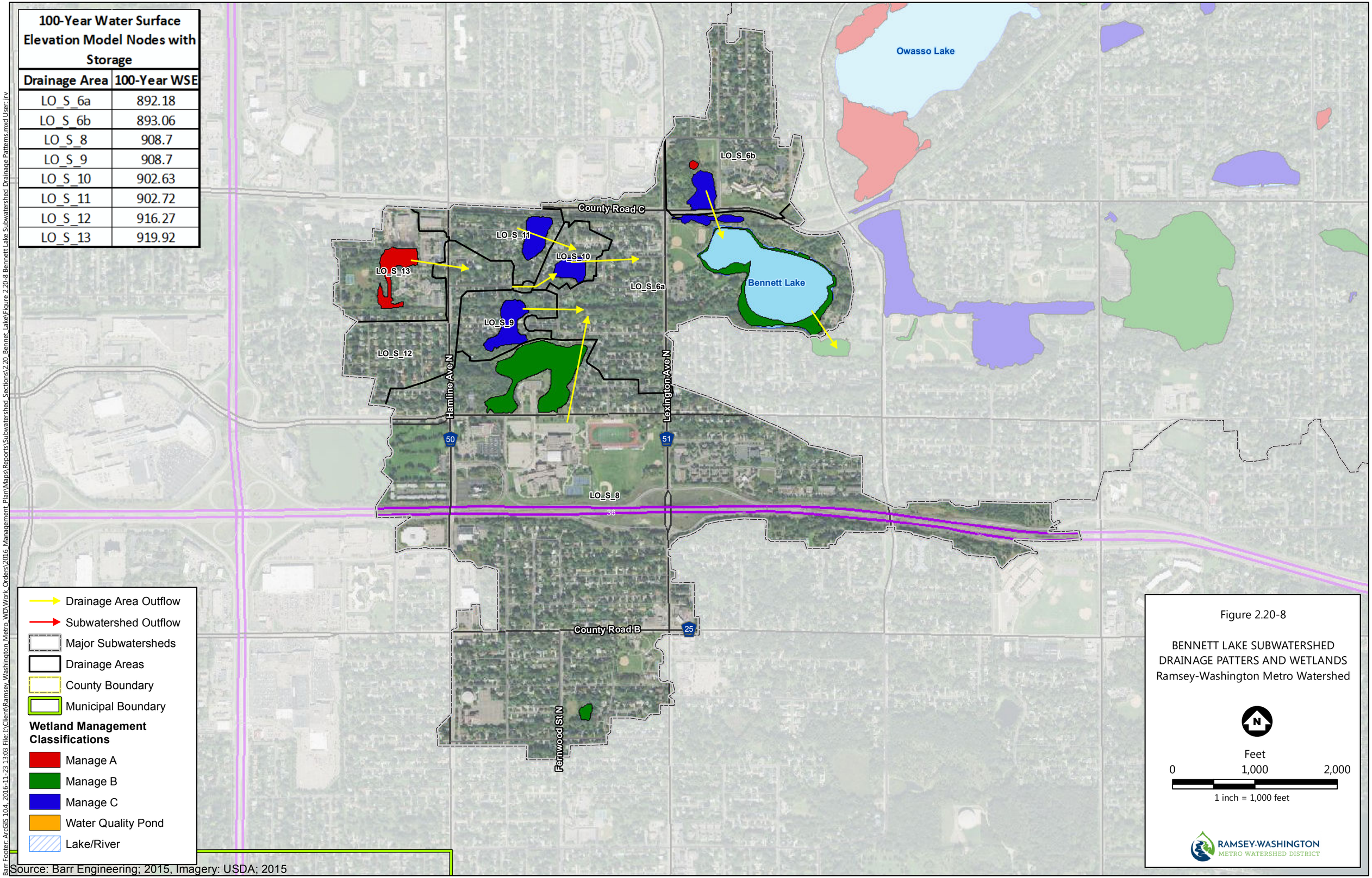
Table 2.20-5 Bennett Lake Subwatershed Implementation Activities

Activity ID No.	Bennett Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BeL-1*	Implement a shoreline management study and assist with lakeshore restoration to enhance lakeshore native habitat and stabilization (partner with existing efforts)	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
BeL-2*	Perform a feasibility study of retrofit opportunities throughout the Bennett Lake Subwatershed to improve water quality, including enhanced treatment of Willow Pond outflows, regional stormwater treatment within Central Park and other options identified in previous studies, including the Bennett Lake TMDL.	**2016-2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BeL-3*	Research future options for control of Bennett Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BeL-4*	Implement projects deemed feasible in the Bennett Lake Subwatershed Feasibility Study	**2018-2026**	**$750,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BeL-5*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Bennett Lake.	**2020**	**$100,000**	**WQ2, EC3**	**Tier 2**
BeL-6*	Evaluate the carp population in the Lake Owasso-Central Park Wetlands- Bennett Lake chain	**2017-2018**	**See LO-6**	**EC3, EC5**	**Tier 2**
BeL-7*	Manage the carp population in the Lake Owasso-Central Park Wetlands-Bennett Lake chain if deemed necessary.	**2019-2026**	**See LO-7**	**WQ2, EC3, EC5**	**Tier 2**

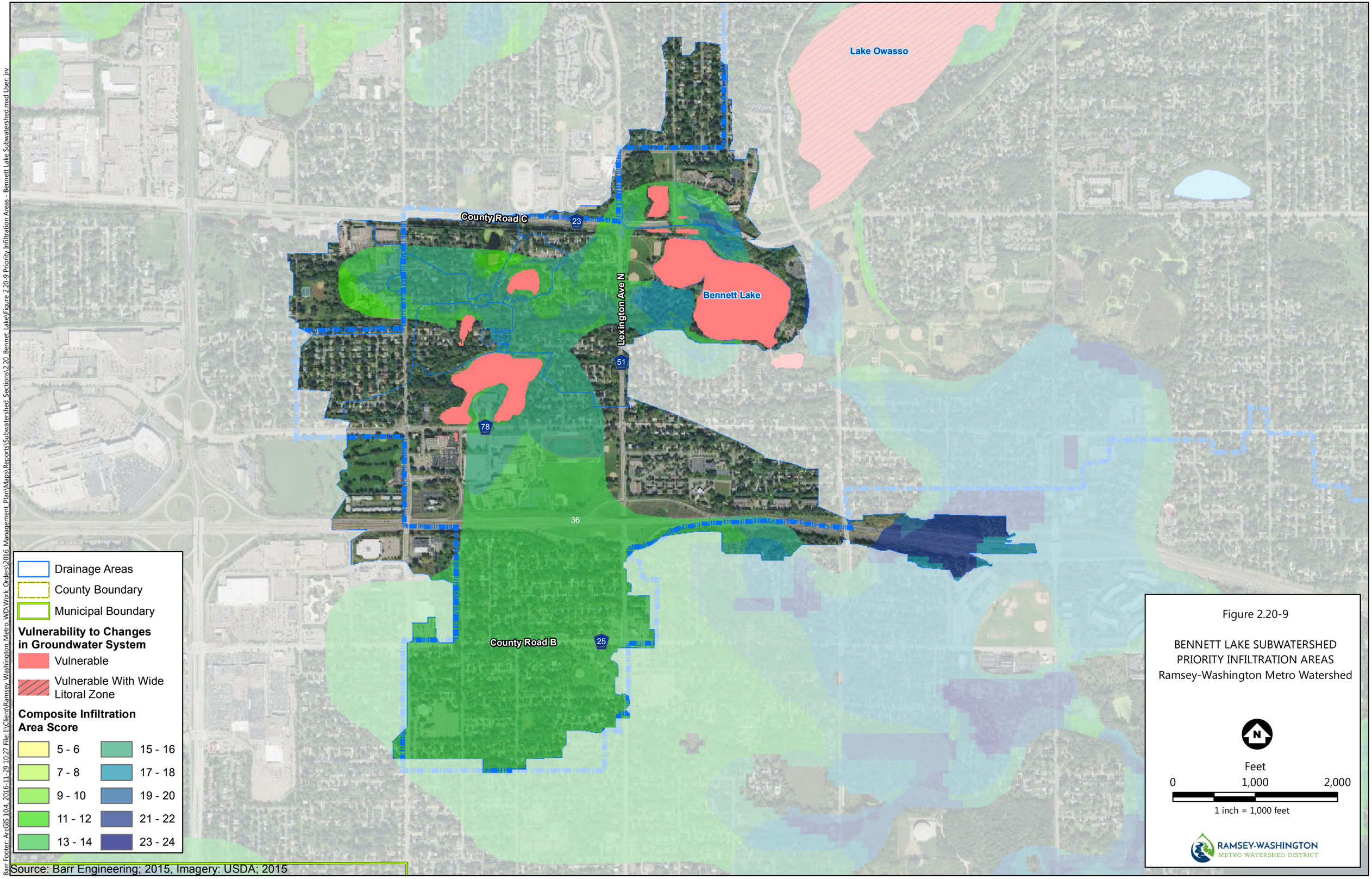
*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	**100-Year WSE**
LO_S_6a	892.18
LO_S_6b	893.06
LO_S_8	908.7
LO_S_9	908.7
LO_S_10	902.63
LO_S_11	902.72
LO_S_12	916.27
LO_S_13	919.92



Barr Footer: ArcGIS 10.4, 2016-11-23 13:03 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.20_Bennet_Lake\Figure 2.20-8 Bennett Lake Subwatershed Drainage Patterns.mxd User: jrv



Barr Footer: ArcGIS 10.4, 2016-11-29 10:27 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2_20_Bennet_Lake\Figure 2.20-9 Priority Infiltration Areas - Bennett Lake Subwatershed.mxd User: jrv

2.21 Shoreview Lake Subwatershed

2.21.1 General Description

The Shoreview Lake subwatershed is a small subwatershed of 28 acres located within the city of Shoreview in Ramsey County, southeast of the intersection of Lake Johana Boulevard and Victoria Street North. The subwatershed contains only the area directly tributary to Shoreview Lake. The Shoreview Lake subwatershed is landlocked under normal hydrologic conditions. Under extreme rainfall events, water leaves Shoreview Lake and discharges to the Kroiss Pond under extreme rainfall events vie the storm sewer system.

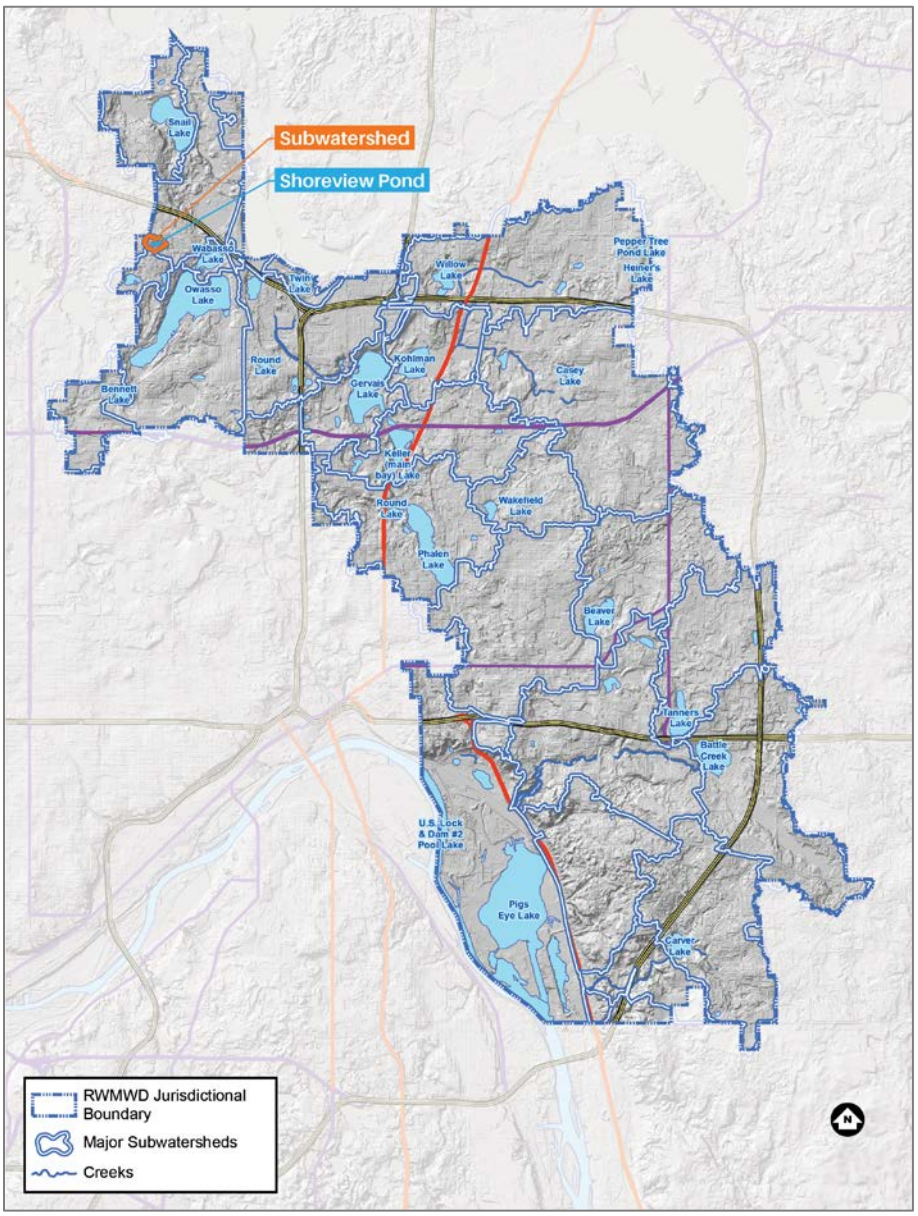


Figure 2.21-1 Shoreview Lake Location Map

Shoreview Lake is a MDNR public water wetland (MDNR# 62-0079W). The 11-acre lake is a District-managed lake. Shoreview Lake is generally not used for recreational activities. There are no public boat accesses, beaches, or piers. Private residential docks are present and the lake may be used for fishing and boating by residents.

Table 2.21-1 Shoreview Lake Subwatershed Facts

Tributary Area (Direct)	28 acres
Tributary Area (Total)	28 acres
Downstream Watershed	Grass Lake
MDNR Designation[1]	62-0079W
Lake Surface Area[1]	11 acres
Lake Outlet Type[1]	18" Reinforced Concrete Pipe
Lake Outlet Elevation[1]	945.46 ft
100-Year Flood Level[1]	946.9 ft
MPCA Designations[1]	Shallow Lake
MS4s in the Direct Tributary Area	Shoreview, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data based on Shoreview Lake

2.21.1.1 Past Studies

The following list is a summary of past studies related to Shoreview Lake and its tributary subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Ramsey-Washington Metro Watershed District Watershed Restoration and Protection Strategies (WRAPS) Report.* Barr Engineering Company, Draft 2016.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.

2.21.1.2 Land Use

The Shoreview Lake subwatershed is fully developed and includes single family residential, multi-family residential, institutional, and commercial land use (see Figure 2.21-2). A significant portion (40%) of the subwatershed is occupied by the lake itself. Projected future land used in the subwatershed includes additional higher-density residential land use (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

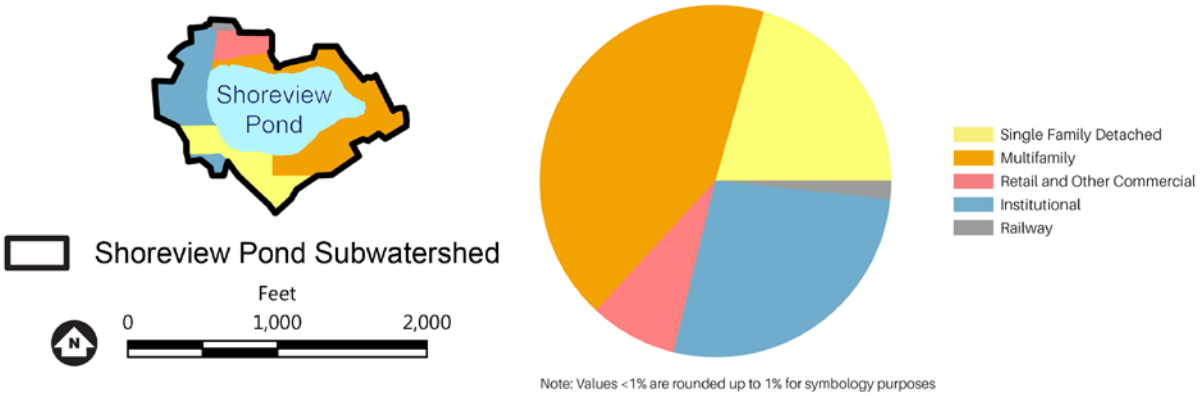


Figure 2.21-2 Breakdown of land uses throughout the Shoreview Lake Subwatershed (2010 Metropolitan Council)

2.21.1.3 Drainage Patterns and Waterbodies

The Shoreview Lake subwatershed overflows towards Grass Lake only during significant hydrologic events. Figure 2.21-5 indicates the direction of flow from Shoreview Lake area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Shoreview Lake subwatershed include Shoreview Lake.

There are no wetlands within the Shoreview Lake subwatershed based on the RWMWD wetland inventory (see Section 1.11.2 and Figure 1-12).

2.21.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Shoreview Lake.

2.21.2.1 Historical Water Quality

Shoreview Lake has not been regularly monitored by Ramsey County or the RWMWD in the past. The MPCA's Environmental Data Access website does not include any water quality data for Shoreview Lake. There is insufficient data to assess current water quality conditions or trends. Water quality data was collected from Shoreview Lake as part of the District's WRAPS study.

Figure 2.21-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record. The amount of data is insufficient to calculate 10-year water quality averages or trends with confidence. Based on the limited amount of water quality data available, the District has assigned a water quality management classification of "At Risk" to Shoreview Lake.

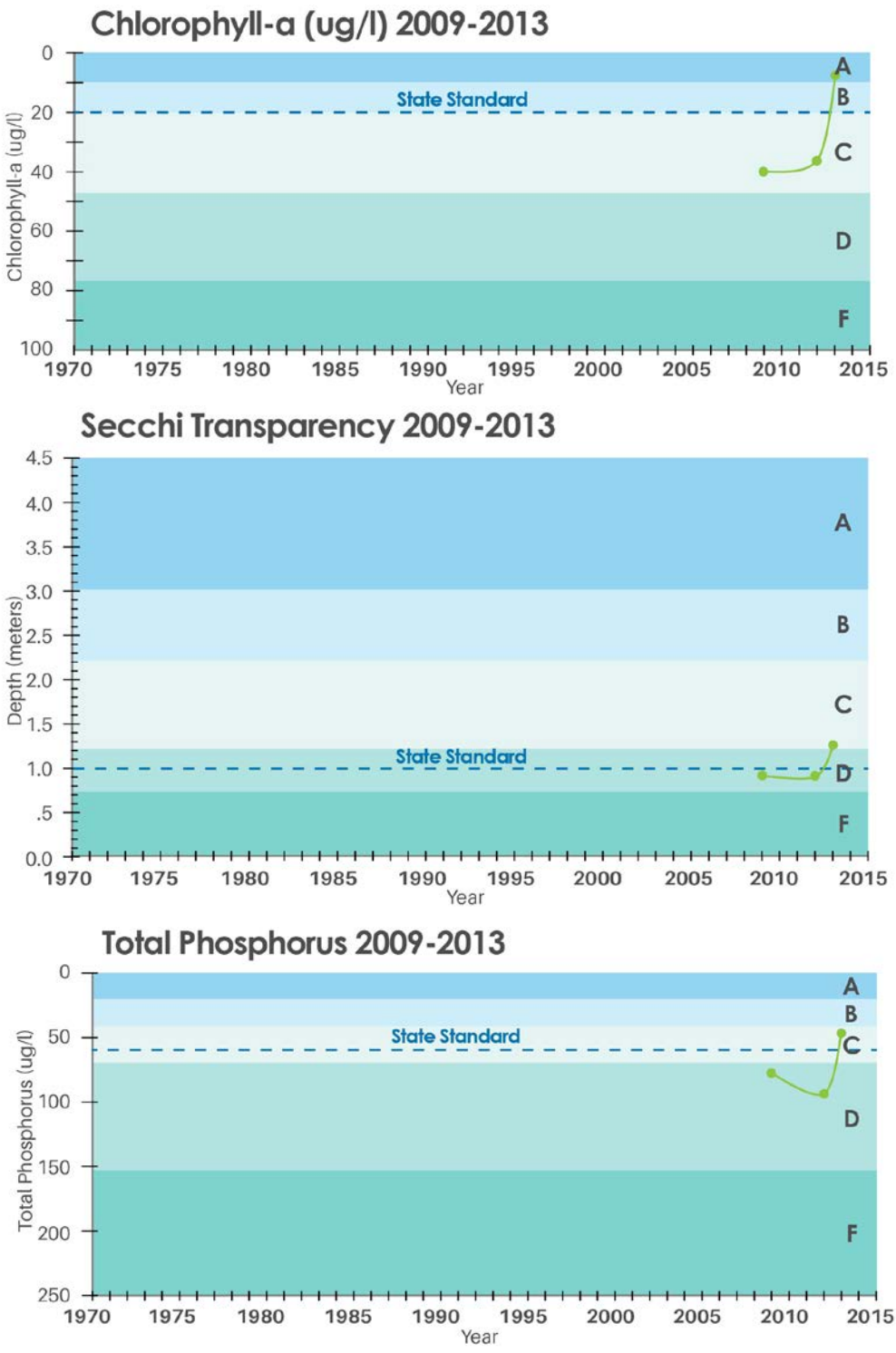


Figure 2.21-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Shoreview Lake (2009-2013)

2.21.2.2 Water Quality Goals

The water quality goals for Shoreview Lake are consistent with the MPCA's lake eutrophication standard for the North Central Hardwoods Forest Ecoregion described in Section 1.10.1 and Table 1-3. The RWMWD will assess Shoreview Lake water quality data as it becomes available and adjust its water quality classification and management activities accordingly.

The District will continue to consider opportunities to improve water quality in the Shoreview Lake subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. Through December 31, 2015, no projects have been implemented in the Shoreview Lake subwatershed through these programs (see Figure 2.21-4).

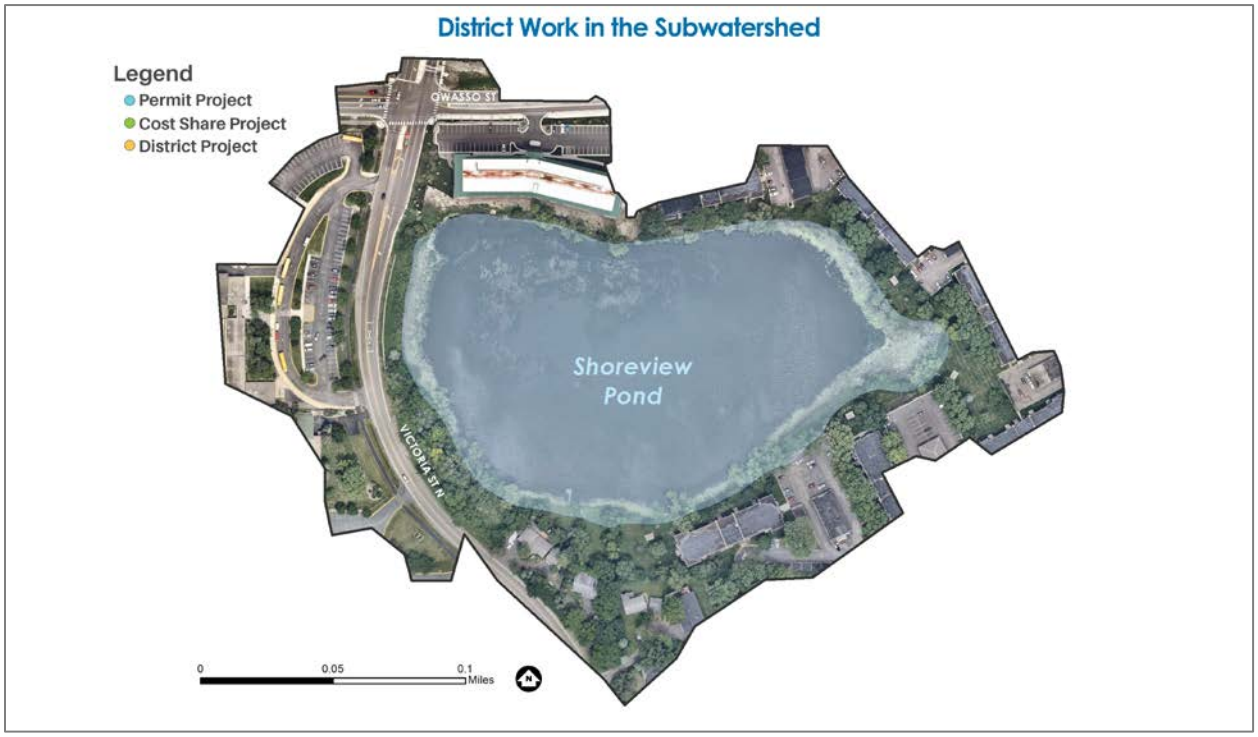


Figure 2.21-4 District work in the Shoreview Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.21.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Shoreview Lake subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Shoreview Lake subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Shoreview Lake subwatershed are the new 100-year flood elevations shown in Figure 2.21-5. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.21.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Shoreview Lake subwatershed are shown in Figure 2.21-6, indicating areas where the water levels of waterbodies in the Shoreview Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.21.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Shoreview lake subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Shoreview Lake subwatershed.

2.21.6 Future Implementation Activities

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Shoreview Lake subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Shoreview Lake subwatershed are identified (see Table 2.21-2). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

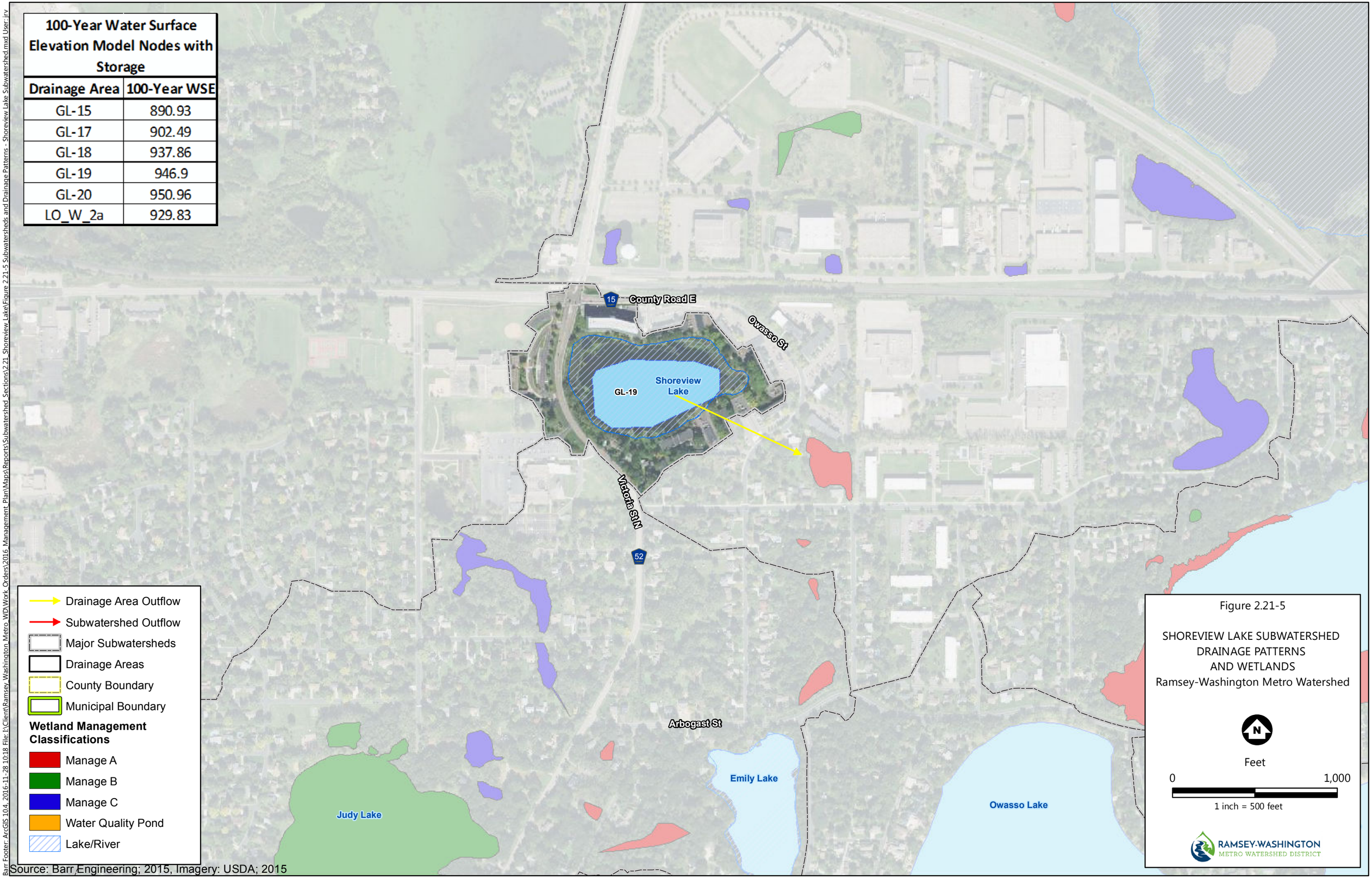
Table 2.21-2 Shoreview Lake Subwatershed Implementation Activities

Activity ID No.	Shoreview Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
ShL-1*	Perform a feasibility study of retrofit opportunities throughout the Shoreview Lake Subwatershed to improve water quality	**2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
ShL-2*	Implement projects that are deemed feasible in the Shoreview Lake Subwatershed Feasibility Study	**2018-2026**	**$200,000**	**WQ2, WQ17, WQ18, WQ19, FL9, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	**100-Year WSE**
GL-15	890.93
GL-17	902.49
GL-18	937.86
GL-19	946.9
GL-20	950.96
LO_W_2a	929.83



- Drainage Area Outflow
- Subwatershed Outflow
- Major Subwatersheds
- Drainage Areas
- County Boundary
- Municipal Boundary

Wetland Management Classifications

- Manage A
- Manage B
- Manage C
- Water Quality Pond
- Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.21-5

SHOREVIEW LAKE SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

N

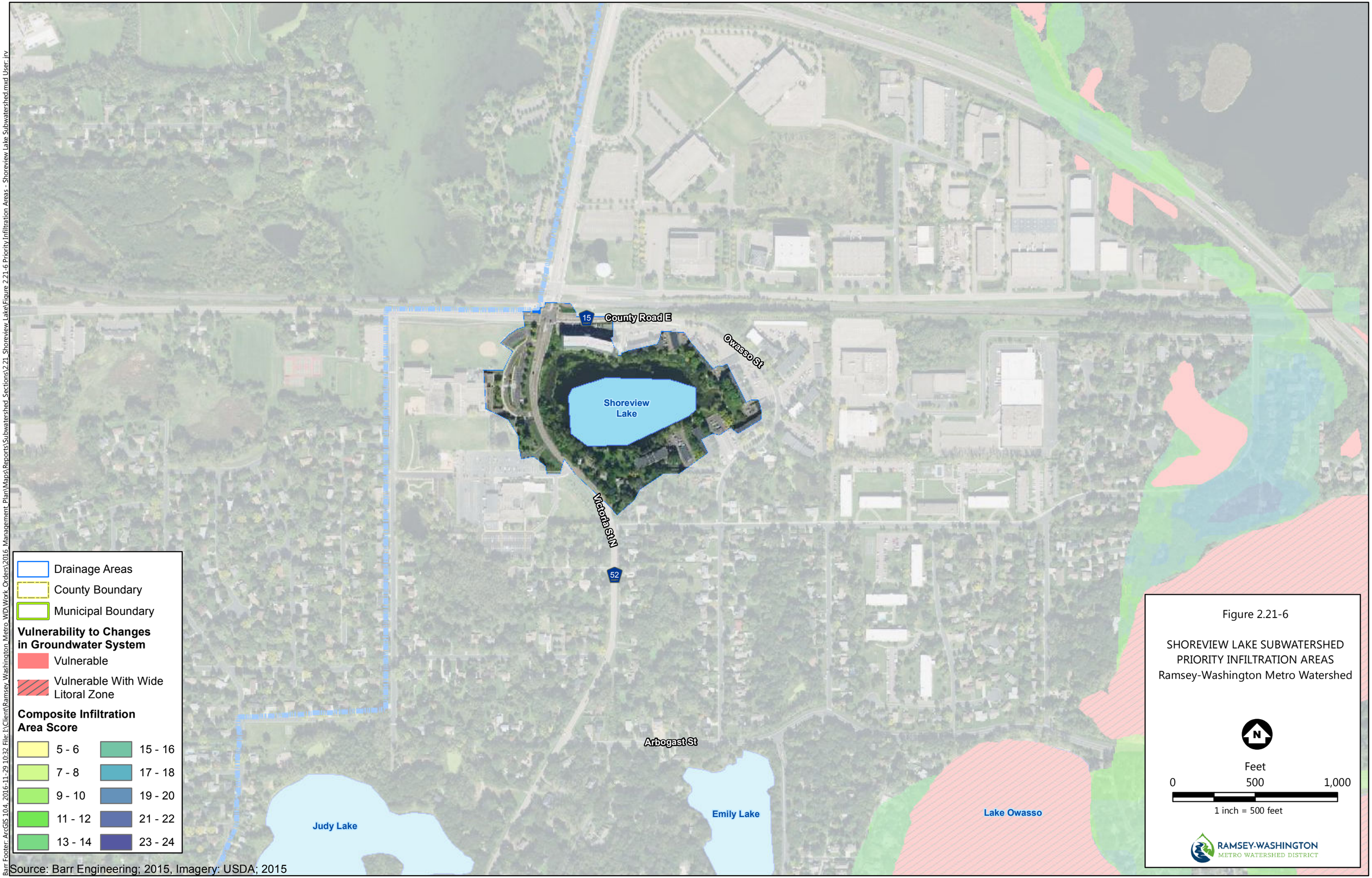
Feet

0 1,000

1 inch = 500 feet

RAMSEY-WASHINGTON
METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-28 10:18 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.21_Shoreview_Lake\Figure 2.21-5 Subwatersheds and Drainage Patterns - Shoreview Lake Subwatershed.mxd User: jrv



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Barr Footer: ArcGIS 10.4 2016-11-29 10:32 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.21_Shoreview_Lake\Figure 2.21-6 Priority Infiltration Areas - Shoreview Lake Subwatershed.mxd User: jrv

2.22 Snail Lake Subwatershed

2.22.1 General Description

The Snail Lake subwatershed includes 961 acres in the city of Shoreview in Ramsey County (see Figure 2.22-1). Snail Lake is the only District-managed waterbody within the Snail Lake subwatershed. The subwatershed is landlocked under normal hydrologic conditions. A high water overflow was constructed to prevent flooding of homes adjacent to Snail Lake during high water conditions. The overflow drains to the Grass Lake subwatershed.

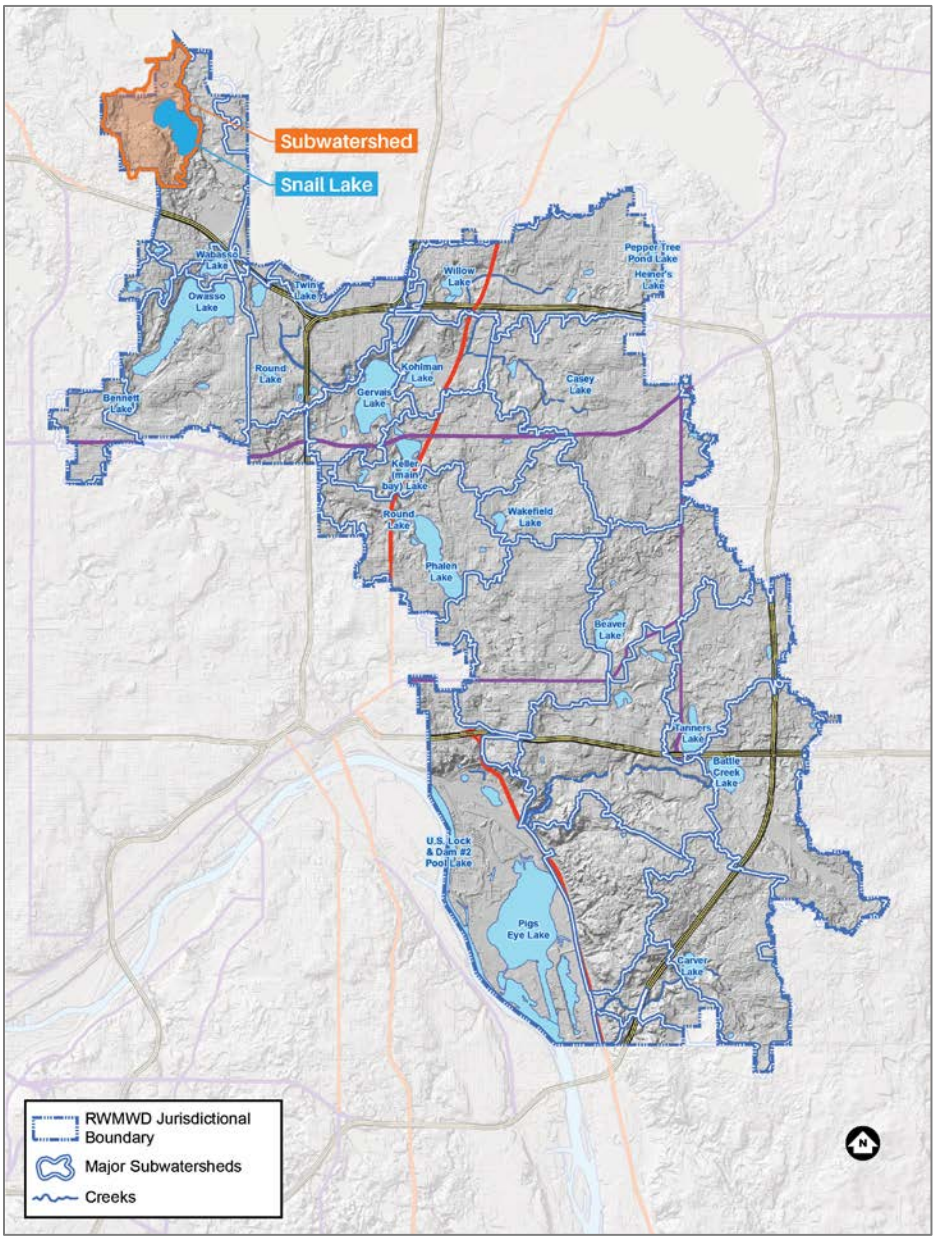


Figure 2.22-1 Snail Lake Location Map

Snail Lake (MDNR# 62-0073P) is 190 acres in size, including a 35-acre wetland on the northwest side of the lake. During low-water periods, inflows to Snail Lake are augmented by pumping water from nearby Sucker Lake. Snail Lake is a major recreational resource in the area. The lake is bordered by Snail Lake Regional Park to the south. The park includes public access to the lake and a swimming beach. The lake is used for fishing, boating, and swimming.

The City of Shoreview operates the Snail Lake augmentation system to maintain acceptable water levels in Snail Lake. The City of Shoreview records the volume of water pumped from Sucker Lake during the spring season (ice-off to April 30), summer season (May 1 to August 14) and fall season (August 15 to October 31).

Table 2.22-1 Snail Lake Subwatershed Facts

Tributary Area (Direct)	**961 acres**
Tributary Area (Total)	**961 acres**
Downstream Watershed	**Grass Lake**
MDNR Designation[1]	**62-0073P**
Lake Surface Area[1]	**190 acres**
Lake Maximum Depth[1]	**28 ft**
Lake Outlet Type[1]	**None (Landlocked)**
Lake Outlet Elevation[1]	**887.90 ft (overflow elevation)**
100-Year Flood Level[2]	**-- (land-locked)**
Lake Littoral Area[1]	**87%**
MPCA Designations[1]	**Deep Lake; Impaired for Aquatic Consumption (mercury food consumption advisory)**
MS4s in the Direct Tributary Area	**Shoreview, Ramsey County**
RWMWD Nutrient Water Quality Classification[1]	**Stable**

[1] Data based on Snail Lake

[2] 100-year flood level for land-locked basins not established (see Section 1.12.3)

2.22.1.1 Past Studies

The following list is a summary of past studies related to Snail Lake and its tributary subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.

2.22.1.2 Land Use

The Snail Lake subwatershed is fully developed. Land use is predominantly single-family residential, with significant amounts of park, recreational, or preserve land uses (see Figure 2.22-2). Significant changes in land used in the Snail Lake subwatershed are not expected (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

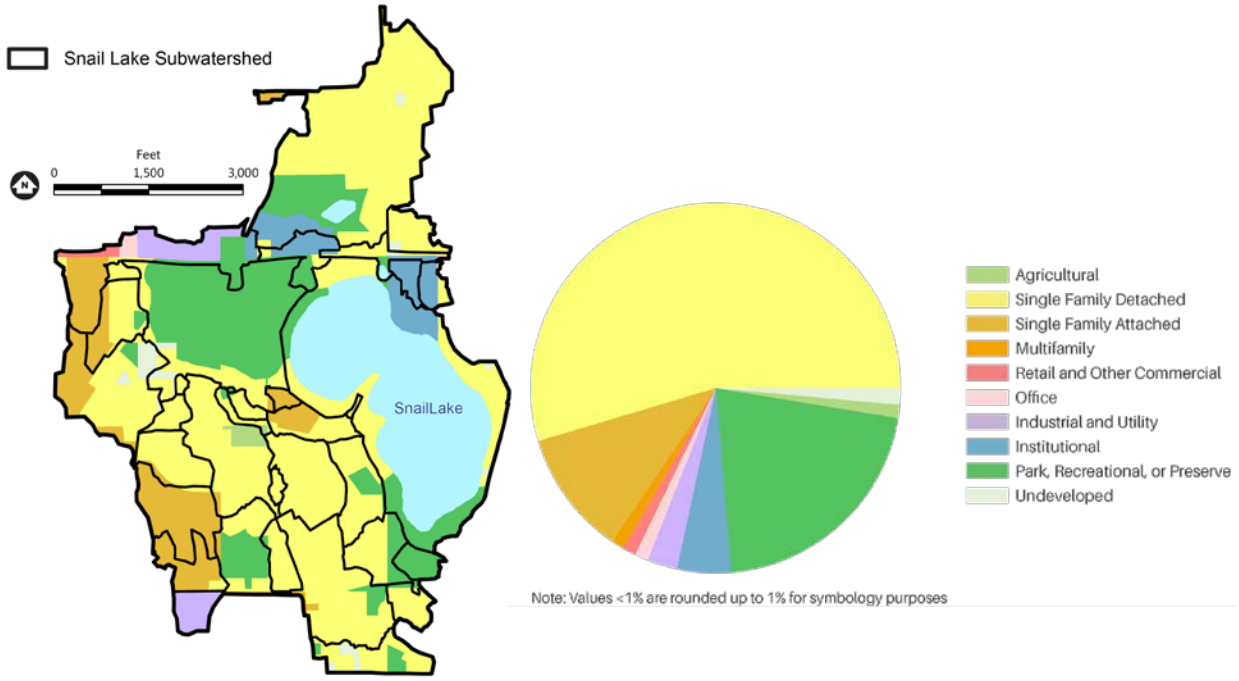


Figure 2.22-2 Breakdown of land uses throughout the Snail Lake Subwatershed (2010 Metropolitan Council)

2.22.1.3 Drainage Patterns and Waterbodies

Much of the Snail Lake subwatershed drains towards a large wetland located northwest of Snail Lake, which is hydrologically connected to Snail Lake. Snail Lake is typically landlocked, although a constructed high water overflow drains towards Grass Lake.

The Snail Lake subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.22-8). Figure 2.22-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Snail Lake subwatershed include Snail Lake.

Wetlands within the Snail Lake subwatershed are shown in Figure 2.22-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.22.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Snail Lake.

2.22.2.1 Historical Water Quality

Snail Lake is classified by the MPCA as a deep lake despite a littoral area exceeding 80% of the lake. The Ramsey County Department of Public Works staff samples the water quality of Snail Lake about 7 times per year on average, between the months of May and September. Figure 2.22-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.22-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Snail Lake relative to MPCA standards. The RWMWD has assigned a water quality classification of "Stable" to Snail Lake based on recent water quality data.

Table 2.22-2 Snail Lake historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Snail Lake (2003-2012) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	18.4
Chlorophyll-a (µg/L)	≤ 14	3.7
Secchi disk transparency (m)	≥ 1.4	3.1

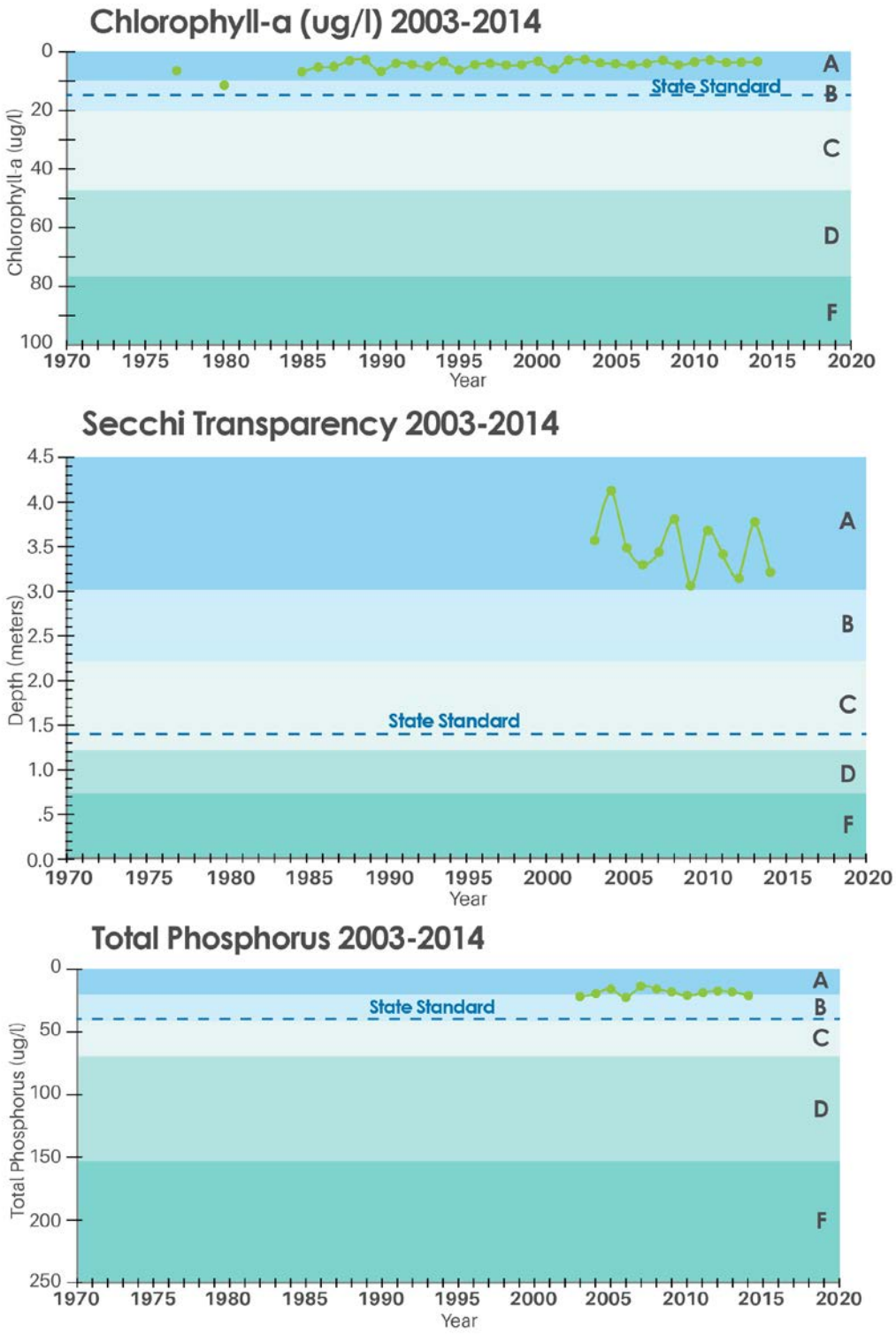


Figure 2.22-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Snail Lake (1903-2014)

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Snail Lake water quality data. The results of these analyses are shown in Table 2.23-3.

Table 2.22-3 Trend Analysis Results for Snail Lake's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Snail Lake	1974 – 2012	Secchi Depth	Improving	Improving*
		Total Phosphorus	Improving	No Trend
		Chlorophyll-*a*	Improving	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

2.22.2.2 Status of the Fishery

The MDNR manages the fishery in Snail Lake for walleye. Walleye were stocked in 2006, 2008, 2010, 2013, 2014, and 2015. Black crappie and largemouth bass were also stocked in 2014. The MDNR performed a fishery survey in 2010 (http://www.dnr.state.mn.us/lakefind/index.html). The 2010 survey found bluegill in average abundance. While bluegills exceeding 8 inches were sampled, the average size was only 4.85 inches. Black crappies were found in low abundance. Walleye were not sampled during the 2010 survey. Northern pike were found in above average abundance; lengths ranged from 18 to 31 inches in the gill net sample, with an average length of approximately 22 inches. Other fish observed in the 2010 survey included black crappie, green sunfish, hybrid sunfish, pumpkinseed sunfish, yellow bullhead, and yellow perch.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Snail Lake based on the presence of mercury. More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.22.2.3 Status of Macrophyte Community

On August 30, 2013, District staff conducted a macrophyte survey of Snail Lake. The results of this survey are summarized below in Figure 2.22-4. In total, 141 sites were surveyed for macrophytes. Of these, 131 had vegetation, indicating that Snail Lake is a macrophyte dominated lake with a diverse macrophyte community.

Where white waterlily, filamentous algae and muskgrass were found in the lake, they were present in high abundance relative to other macrophyte species in Snail Lake. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating an aesthetic and recreational nuisance.

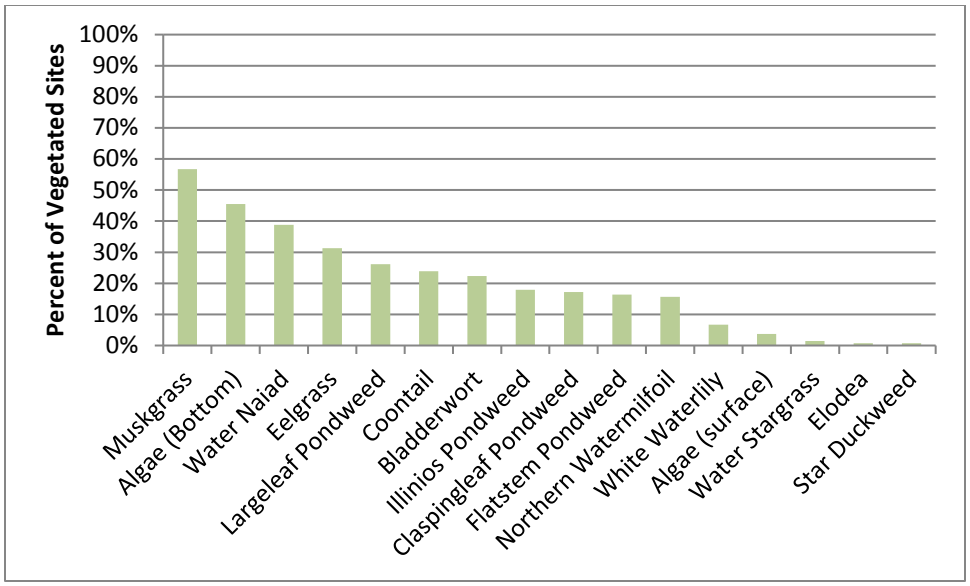


Figure 2.22-4 August, 2013 Snail Lake Macrophyte Survey Results

2.22.2.4 Water Quality Modeling

As part of the RWMWD WRAPS study, the District performed water quality modeling of the Snail Lake subwatershed. The goal of the modeling was to understand the impact of both point and non-point sources of pollution on the water quality in Snail Lake. 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 P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) was used to estimate pollutant loading from different areas of the watershed, referred to as drainage districts. Figure 2.22-5 shows the main drainage districts contributing flow and phosphorus loading to Snail Lake. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake.

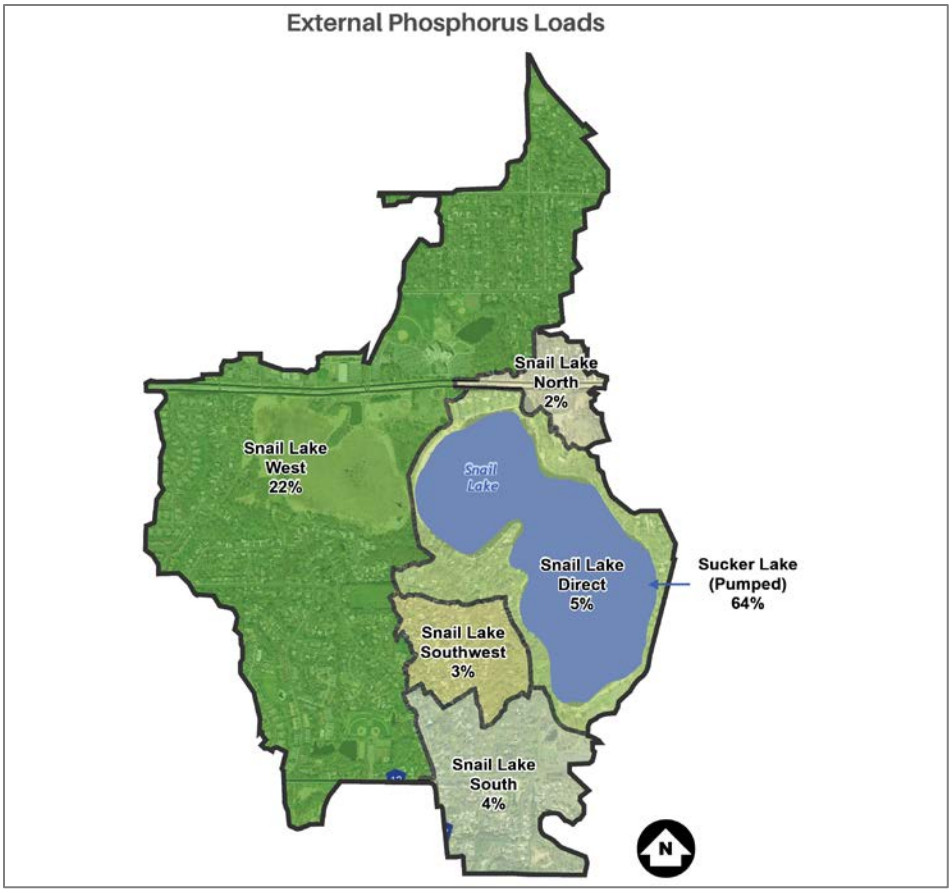


Figure 2.22-5 Drainage Districts in the Snail Lake Subwatershed

The watershed loading and in-lake water quality models of Snail Lake were used to estimate the relative contribution of the lake's internal and external (watershed) phosphorus loads for the average growing season (see Figure 2.22-6). The water quality modeling methodology and results for Snail Lake are described in detail in the RWMWD WRAPS report (Draft, Barr Engineering, 2016).

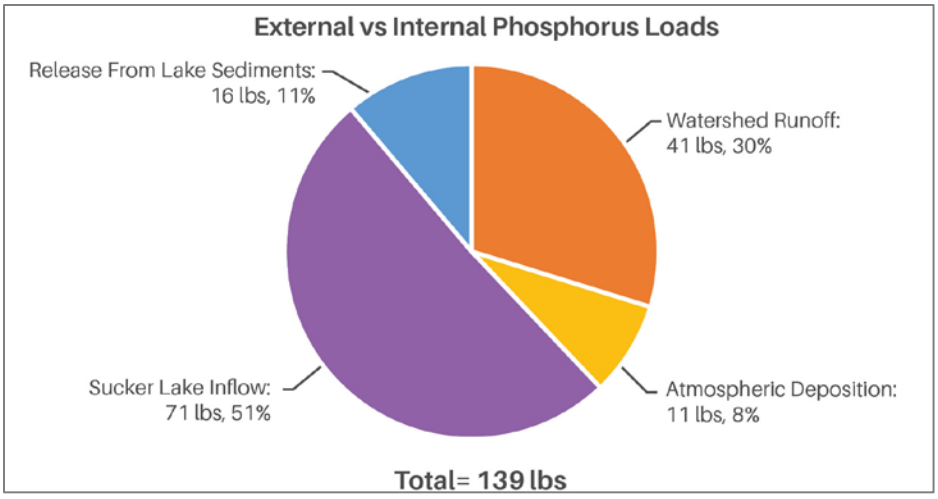


Figure 2.22-6 Snail Lake growing season total phosphorus budget

2.22.2.5 Water Quality Goals

The water quality goals for Snail Lake are consistent with the MPCA's deep lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.22-2. The RWMWD will continue to evaluate Snail Lake water quality data for trends and adjust its water quality classification and management activities accordingly to achieve District goals. Projects implemented in Snail Lake subwatershed through the District capital improvement (and other) projects, the District's cost share program and the District's permit program are shown in Figure 2.22-7.

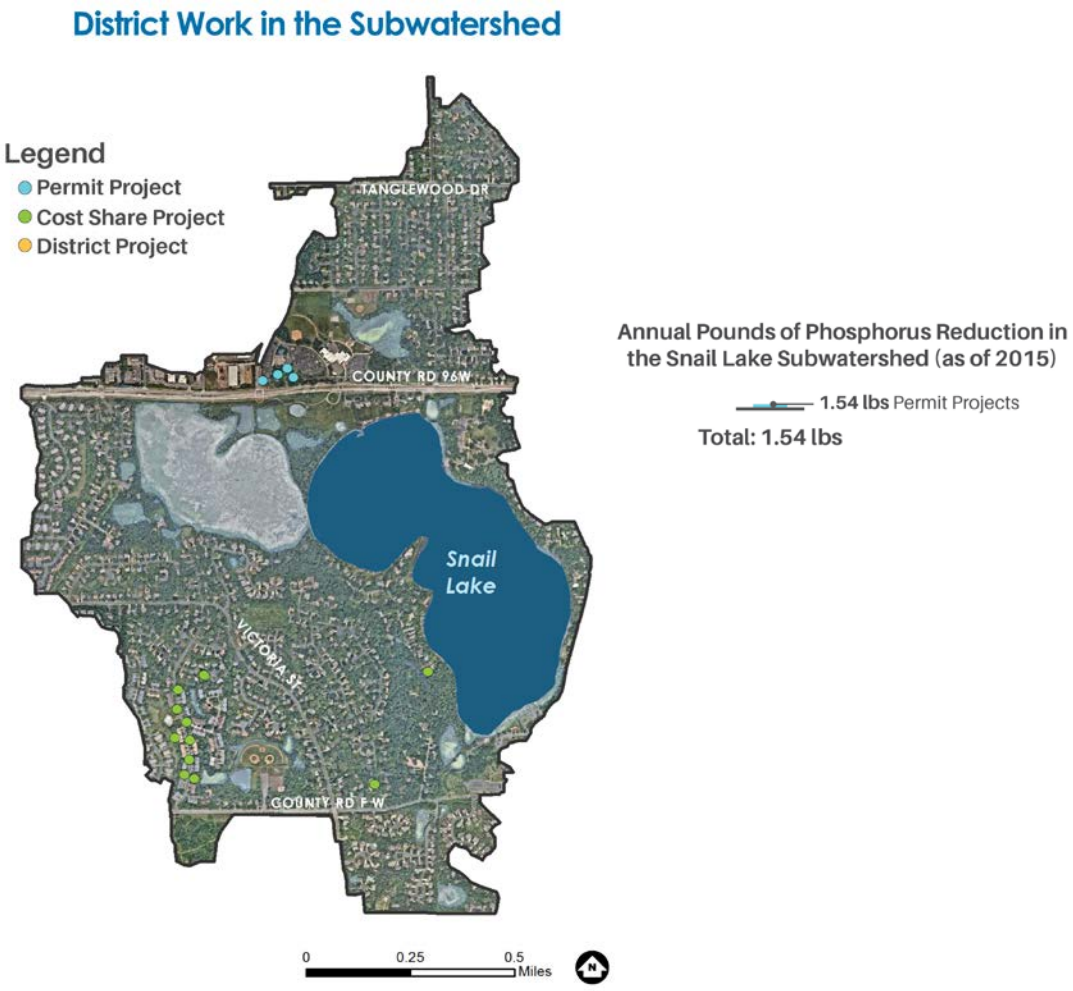


Figure 2.22-7 District work in the Snail Lake Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.22.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Snail Lake subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Snail Lake subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Snail Lake subwatershed are the new 100-year flood elevations shown in Figure 2.22-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member

cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.22.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Snail Lake subwatershed are shown in Figure 2.22-9, indicating areas where the water levels of waterbodies in the Snail Lake subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.22.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Snail Lake subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Snail Lake subwatershed.

2.22.6 Future Implementation Activities

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Snail Lake subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Snail Lake subwatershed are identified (see Table 2.22-4). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.22-4 Snail Lake Subwatershed Implementation Activities

Activity ID No.	Snail Lake Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
SL-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

Drainage Area	100-Year WSE
SL-01	Land-Locked*
SL-02	898.68
SL-03	884.26
SL-04	905.71
SL-05a	885.06
SL-05b	885.06
SL-06	897.11
SL-07	892.31
SL-08b	903.59
SL-09	965.48
SL-10a	921.25
SL-10b	920.97
SL-10c	919.24
SL-11	906.12
SL-12	896.69
SL-13	991.14
SL-14	914.77
SL-15	942.24
SL-16	964.73
SL-17	968.38
SL-18	968.38
SL-19	973.04
SL-20	969.31
SL-21	894.41
SL-22	888.8
SL-23	902.6
SL-24	890.1
SL-25	888.37
SL-26	899.92
SL-27	888.64
SL-28a	909.52
SL-28b	891.95
SL-29	901.17
SL-31	910.8

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

*100-Year WSE not determined for land-locked waterbodies; see Section 1.12.3

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Tanglewood Dr
Mound Ave
Brennans Pond Lake
Snail Lake Lake
Snail Lake Blvd
96
52

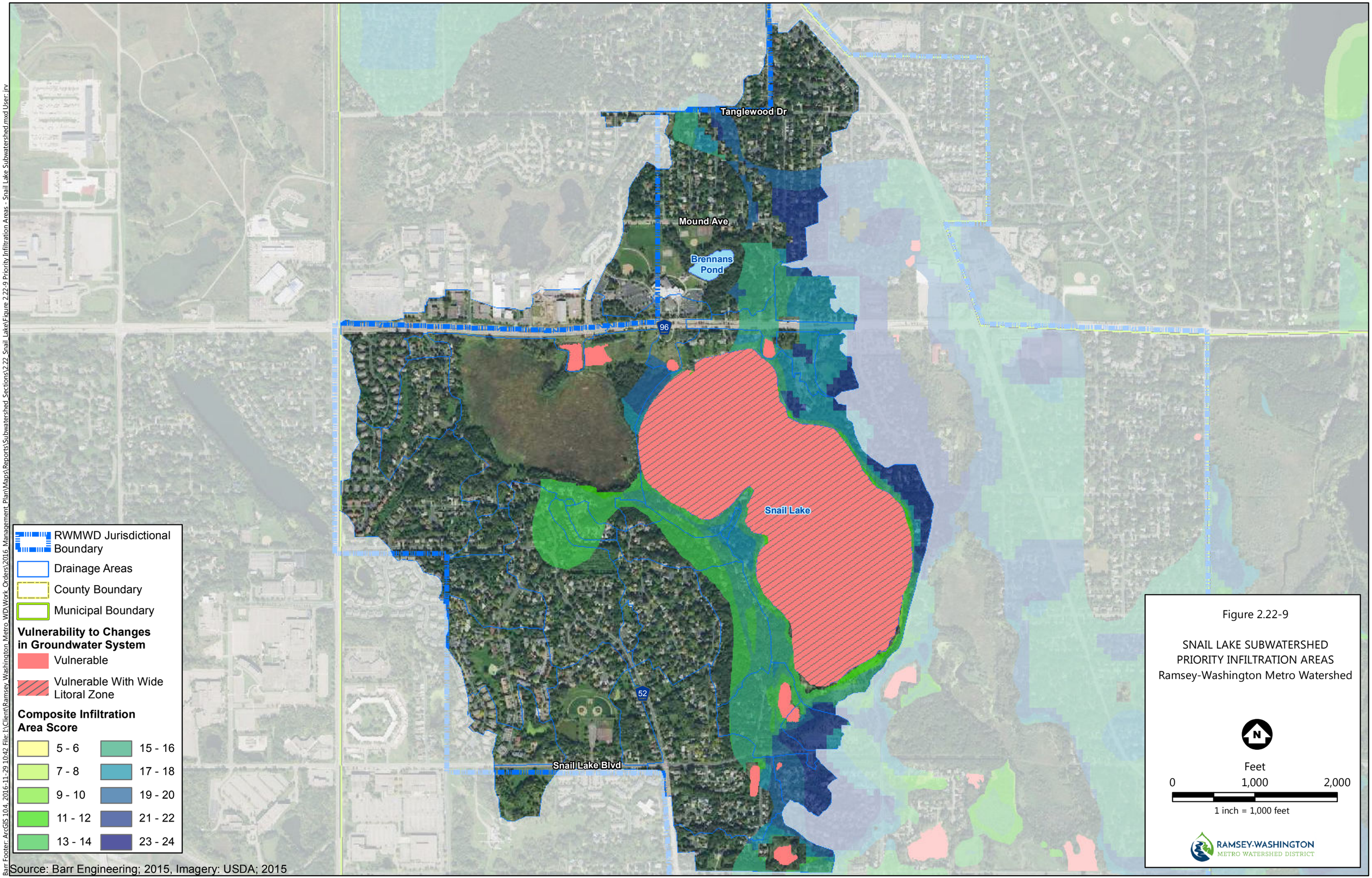
Figure 2.22-8

SNAIL LAKE SUBWATERSHEDS
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,000 2,000
1 inch = 1,000 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4.1, 2017-09-06 15:54 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatersheds_Sections\2.22_Snail_Lake\Figure 2.22-8 Subwatersheds and Drainage Patterns - Snail Lake Subwatershed.mxd User: jrv



Barr Footer: ArcGIS 10.4 2016-11-29 10:42 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatersheds_Sections\2.22_Snail_Lake\Figure 2.22-9 Priority Infiltration Areas - Snail Lake Subwatershed.mxd User: jrv

2.23 Lake Owasso Subwatershed

2.23.1 General Description

The Lake Owasso subwatershed spans 2,175 acres including portions of the cities of Roseville and Shoreview in Ramsey County (see Figure 2.23-1). The Lake Owasso subwatershed receives inflow from the Bennett Lake subwatershed (see Section 2.20) and Lake Emily subwatershed (see Section 2.24), increasing the total drainage area of the subwatershed to 3,140 acres. The Lake Owasso subwatershed discharges toward Lake Wabasso.

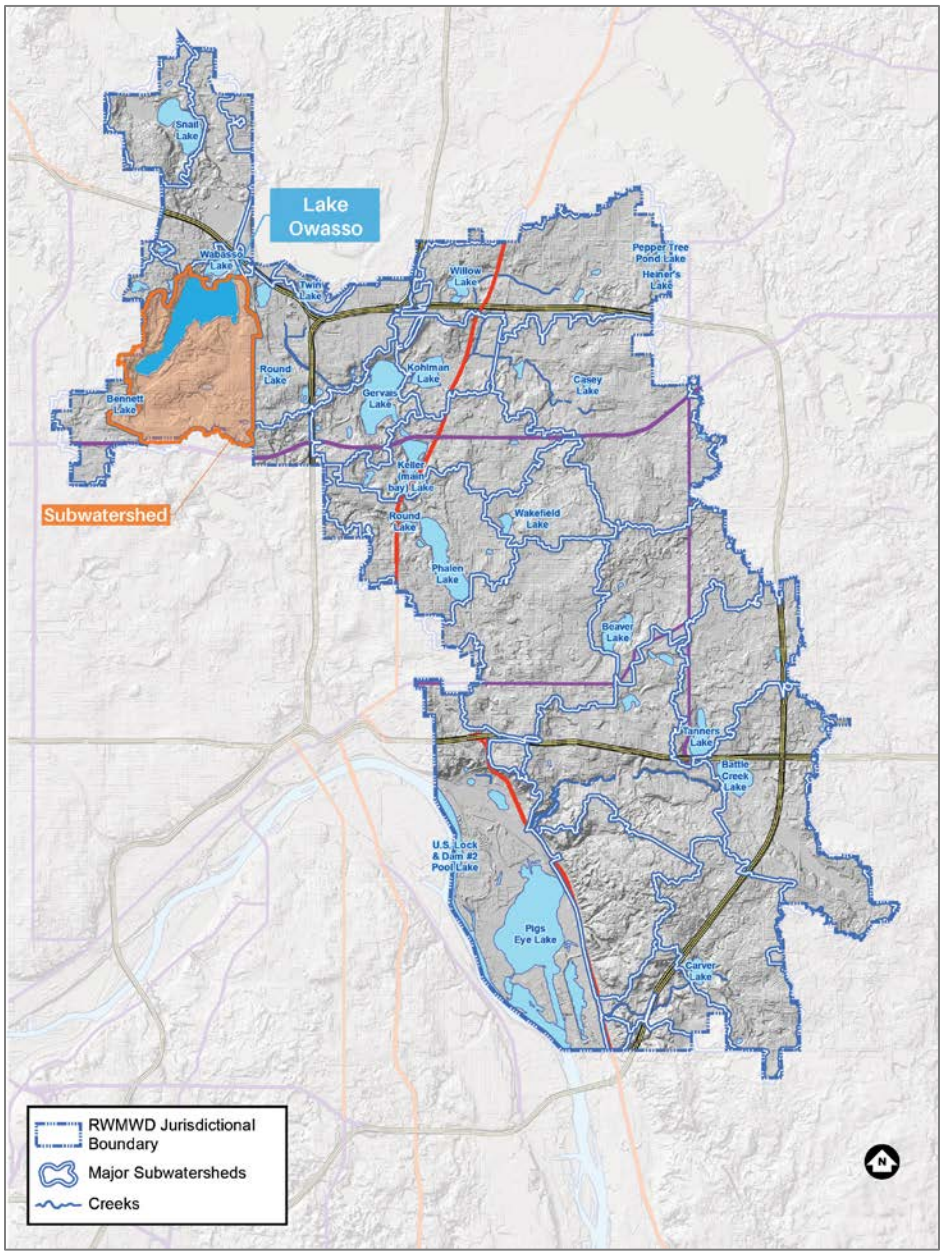


Figure 2.23-1 Lake Owasso Location Map

Lake Owasso is MDNR public water (MDNR# 62-0056P) and is the only District-managed waterbody in the Lake Owasso subwatershed. The lake has an area of 375 acres, a maximum depth of 37 feet, and an average depth of approximately 11 feet. Approximately 78% of the lake is classified as littoral (less than 15-feet deep). Lake Owasso is major regional recreational resource used for fishing, boating, waterskiing, and swimming. The city of Roseville's Central Park North (along the south shore of the lake) and Owasso County Park (on the north side of the lake) provide two public access points on the lake and include a boat launch and a public swimming beach.

Table 2.23-1 Lake Owasso Subwatershed Facts

Tributary Area (Direct)	2,175 acres
Tributary Area (Total)	3,140 acres
Downstream Watershed	Lake Wabasso
MDNR Designation[1]	62-0056P
Lake Surface Area[1]	375 acres
Lake Mean Depth[1]	11 ft
Lake Maximum Depth[1]	37 ft
Lake Outlet Type[1]	30 foot wide Weir
Lake Outlet Elevation[1]	886.71 ft
100-Year Flood Level[1]	889.0 ft
Lake Littoral Area[1]	78%
MPCA Designations[1]	Deep Lake; Impaired for Aquatic Consumption (mercury food consumption advisory)
MS4s in the Direct Tributary Area	Roseville, Shoreview, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data based on Lake Owasso

2.23.1.1 Past Studies

The following list is a summary of past studies related to Lake Owasso and the Lake Owasso subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey- Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.
- *Lake Owasso Use Attainability Analysis.* Prepared for GLWMO by Barr Engineering, April 2009.

2.23.1.2 Land Use

The Lake Owasso watershed is fully developed. Single-family residential land use occupies most of the subwatershed (see Figure 2.23-2). Significant areas of park, recreational, or preserve land use are also present. Some higher-density residential, institutional, and commercial land use is concentrated along Rice Street on the east side of the subwatershed. Significant changes in land used in the Lake Owasso subwatershed are not expected, based on the Metropolitan Council's 2030 land use data (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

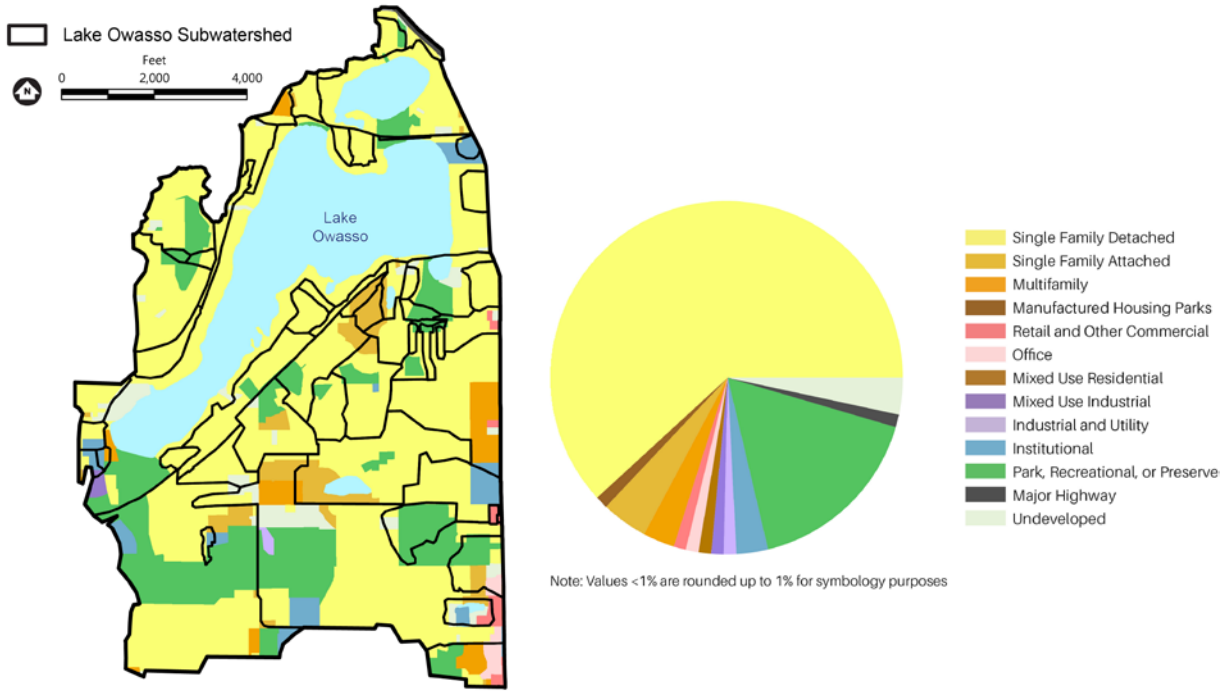


Figure 2.23-2 Breakdown of land uses throughout the Lake Owasso Subwatershed (2010 Metropolitan Council)

2.23.1.3 Drainage Patterns and Waterbodies

The Lake Owasso subwatershed receives inflow from Bennett Lake through a series of wetlands south of Lake Owasso. Much of the Lake Owasso subwatershed south of County Road C also drain to Lake Owasso through these wetlands. Overflow from the Lake Emily subwatershed enters the Lake Owasso subwatershed in the northwest. Lake Owasso discharges to the north to Lake Wabasso.

The Lake Owasso subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.23-8). Figure 2.23-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year

storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Lake Owasso subwatershed include only Lake Owasso.

Wetlands within the Lake Owasso subwatershed are shown in Figure 2.23-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.23.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Lake Owasso.

2.23.2.1 Historical Water Quality

Lake Owasso is classified by the MPCA as a deep lake based on its maximum depth and littoral area (the area less than 15-feet deep) of less than 80% of the lake area. The Ramsey County Department of Public Works staff samples the water quality of Lake Owasso about 7 times per year on average, between the months of May and September. Figure 2.23-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.23-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Lake Owasso relative to MPCA standards. The RWMWD has assigned a water quality classification of "At Risk" to Lake Owasso based on recent water quality data at or near the MPCA and RWMWD nutrient water quality standards.

Table 2.23-2 Lake Owasso historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Lake Owasso (2003-2012) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	40
Chlorophyll-a (µg/L)	≤ 14	18
Secchi disk transparency (m)	≥ 1.4	1.4

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Lake Owasso water quality data. The results of these analyses are shown in Table 2.23-3.

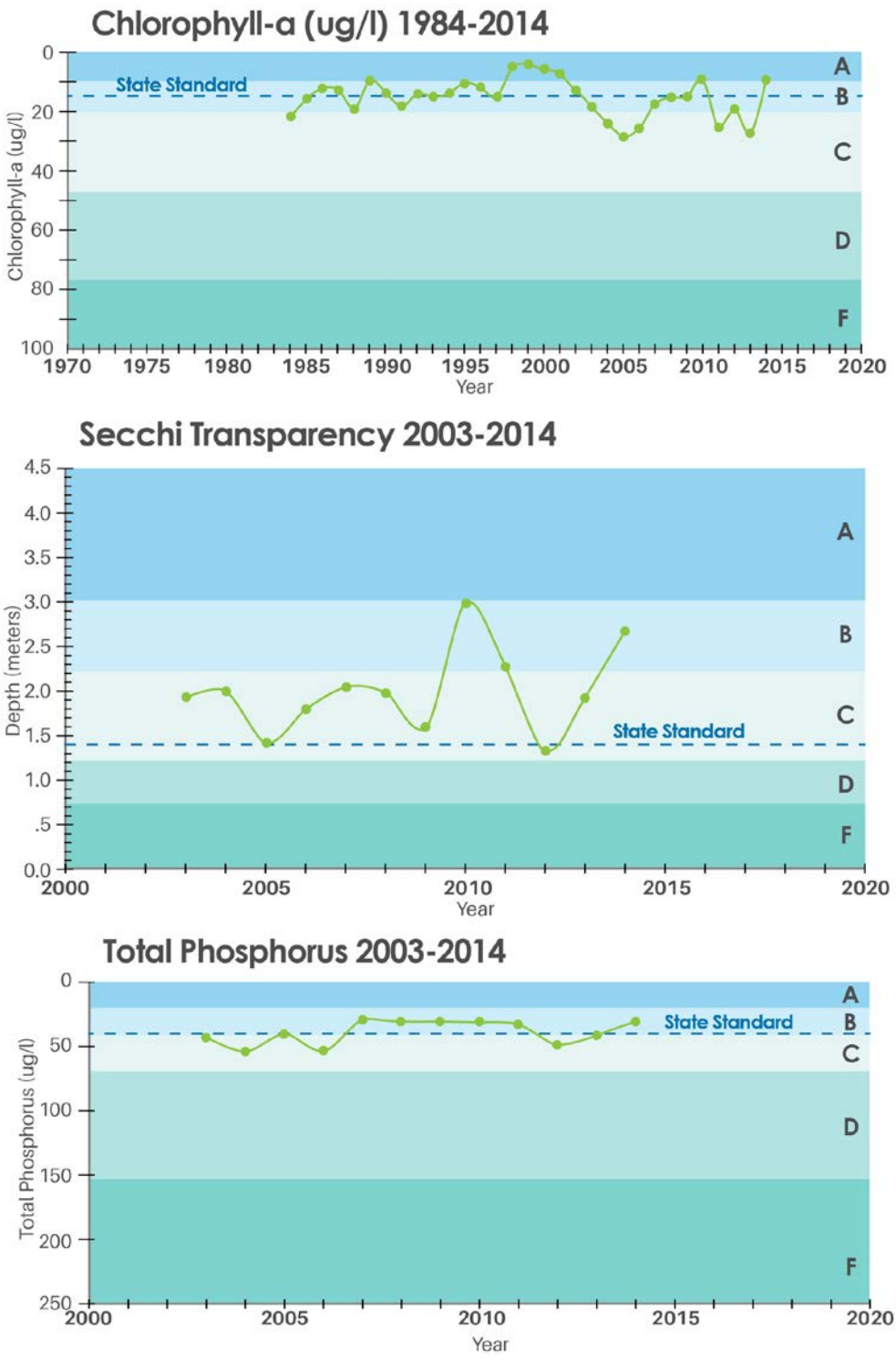


Figure 2.23-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Lake Owasso (1984-2014)

Table 2.23-3 Trend Analysis Results for Lake Owasso's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Lake Owasso	1948 – 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving	Improving*
		Chlorophyll-*a*	No Trend	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

2.23.2.2 Status of the Fishery

The MDNR manages the fishery in Lake Owasso for walleye and pure strain muskellunge. The MDNR stocks walleye and muskellunge in Lake Owasso in even numbered years. Walleye were also stocked in 2015, and muskellunge in 2013. The MDNR last performed a fishery survey of Lake Owasso in 2012 (http://www.dnr.state.mn.us/lakefind/index.html).

The catch of walleye in 2012 was the highest recorded for this lake. The average size of walleye sampled in 2012 measured over 19 inches in length and weighed 2.8 lbs. More than 50% the walleye sampled exceeded 20 inches in length. Northern pike were also sampled in high numbers. The pike observed were of quality size, averaging more than 5 pounds each. Largemouth bass were sampled in average numbers and were average size. Bluegill and crappie were abundant, but small. Yellow perch were also common, but small. No muskellunge were sampled in this investigation, and the MDNR planned further investigation of the muskellunge population in 2013.

The Minnesota Department of Health (MDH) has set a fish consumption advisory for Lake Owasso based on the presence of mercury. More information is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.23.2.3 Status of Macrophyte Community

On August 29, 2013, District staff conducted a macrophyte survey of Lake Owasso. The results of this survey are summarized below in Figure 2.23-4. In total, 111 sites were surveyed for macrophytes. Of these, 67 had vegetation, indicating that Lake Owasso has some areas of open water outside of its littoral zones.

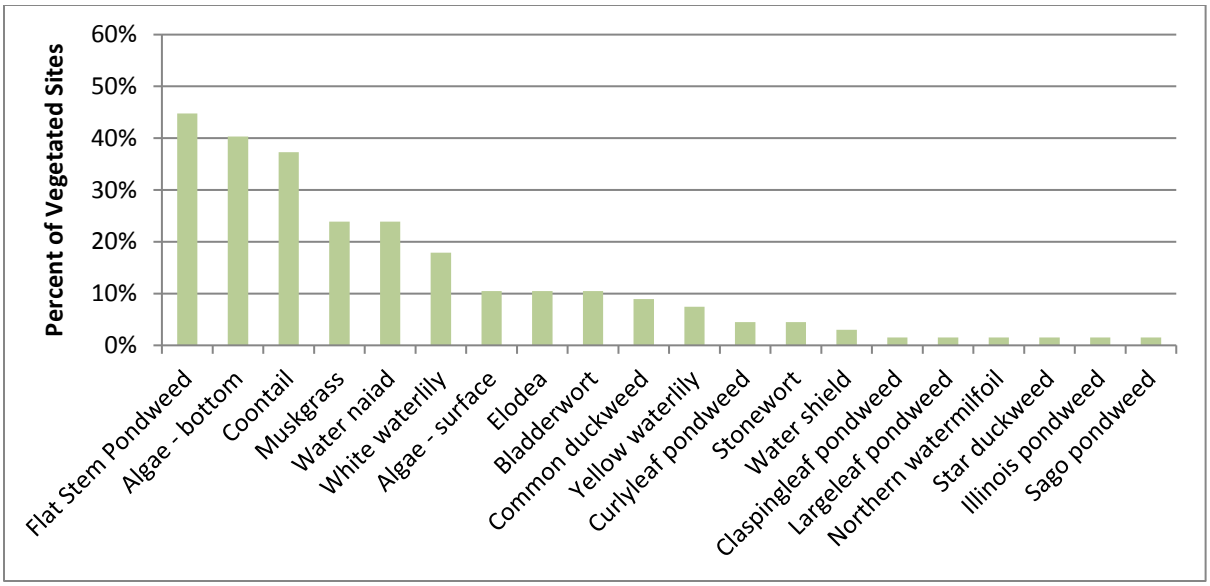


Figure 2.23-4 August, 2013 Lake Owasso Macrophyte Survey Results

Where white waterlily, coontail, and filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Lake Owasso. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Also, curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.23.2.4 Water Quality Modeling

As part of the *2009 Lake Owasso Use Attainability Analysis* (Barr, 2009), the District performed water quality modeling of the Lake Owasso subwatershed. The goal of the modeling was to understand the impact of both point and non-point sources of pollution on the water quality in Lake Owasso. Watershed and in-lake water quality modeling for the lake was used to identify and quantify pollutant sources and to identify, target, and prioritize water quality improvement actions.

The P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) was used to estimate pollutant loading from different areas of the watershed, referred to as drainage districts. Figure 2.23-5 shows the main drainage districts contributing flow and phosphorus loading to Lake Owasso. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake.

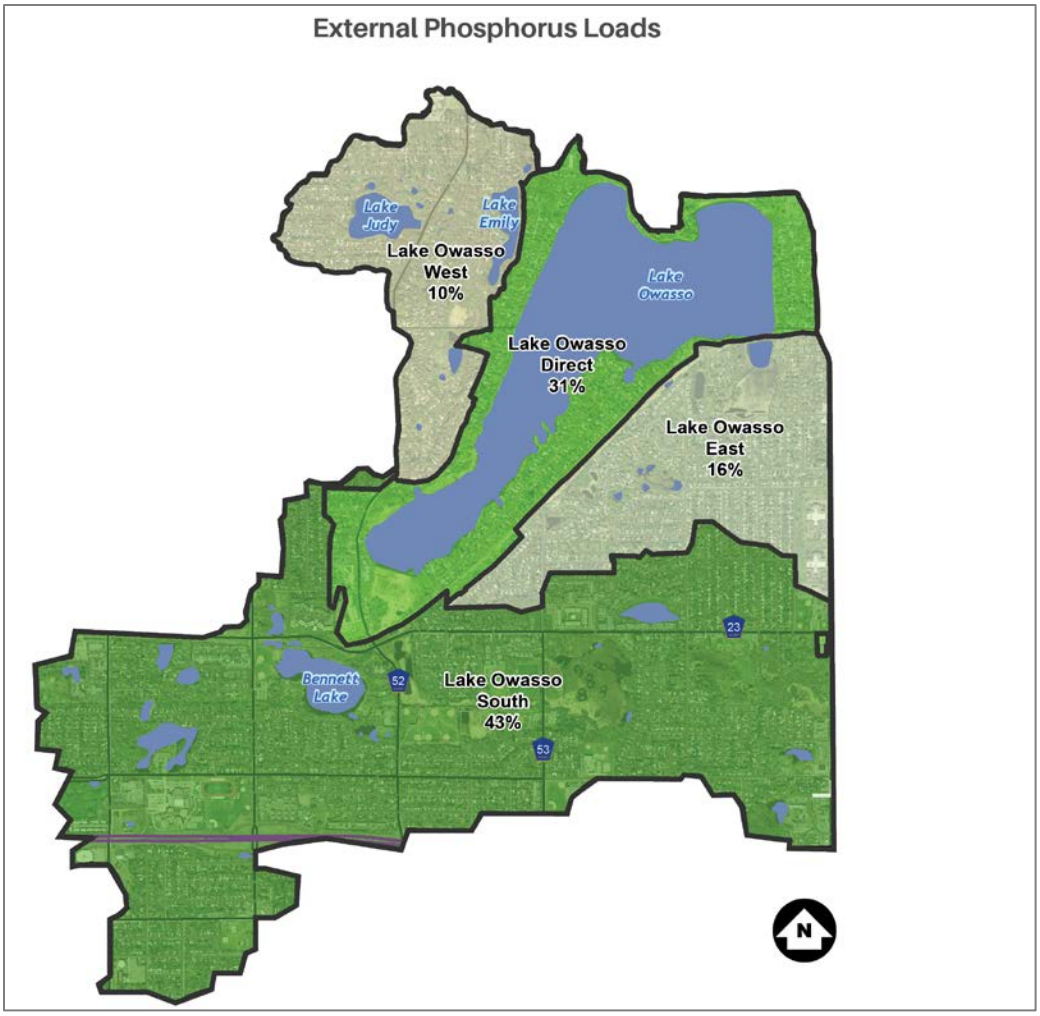


Figure 2.23-5 Drainage Districts in the Lake Owasso Subwatershed

An in-lake mass balance model was used to assess the impact of watershed loading on the lake and determine the amount of internal phosphorus loading in Lake Owasso. The water quality modeling methodology and results for Lake Owasso are described in detail in the RWMWD WRAPS Report (Draft, Barr Engineering, 2016).

The watershed loading and in-lake water quality models of Lake Owasso were used to estimate the relative contribution of the lake's internal and external (watershed) phosphorus loads for the average growing season (see Figure 2.23-6). The water quality modeling methodology and results for Lake Owasso are described in detail in the RWMWD WRAPS report (Draft, Barr Engineering, 2016).

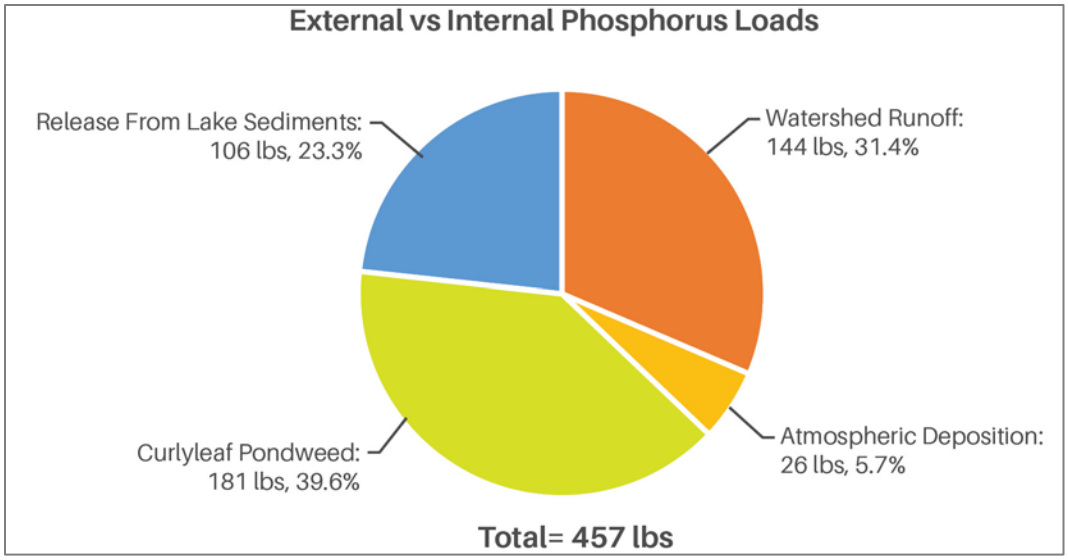


Figure 2.23-6 Lake Owasso growing season total phosphorus budget

2.23.2.5 Water Quality Goals

The water quality goals for Lake Owasso are consistent with the MPCA's deep lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.23-2. The RWMWD will continue to evaluate Lake Owasso water quality data for trends and adjust its water quality classification and management activities accordingly to achieve District goals.

The District will continue to consider opportunities to improve water quality in the Lake Owasso subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.23-7.

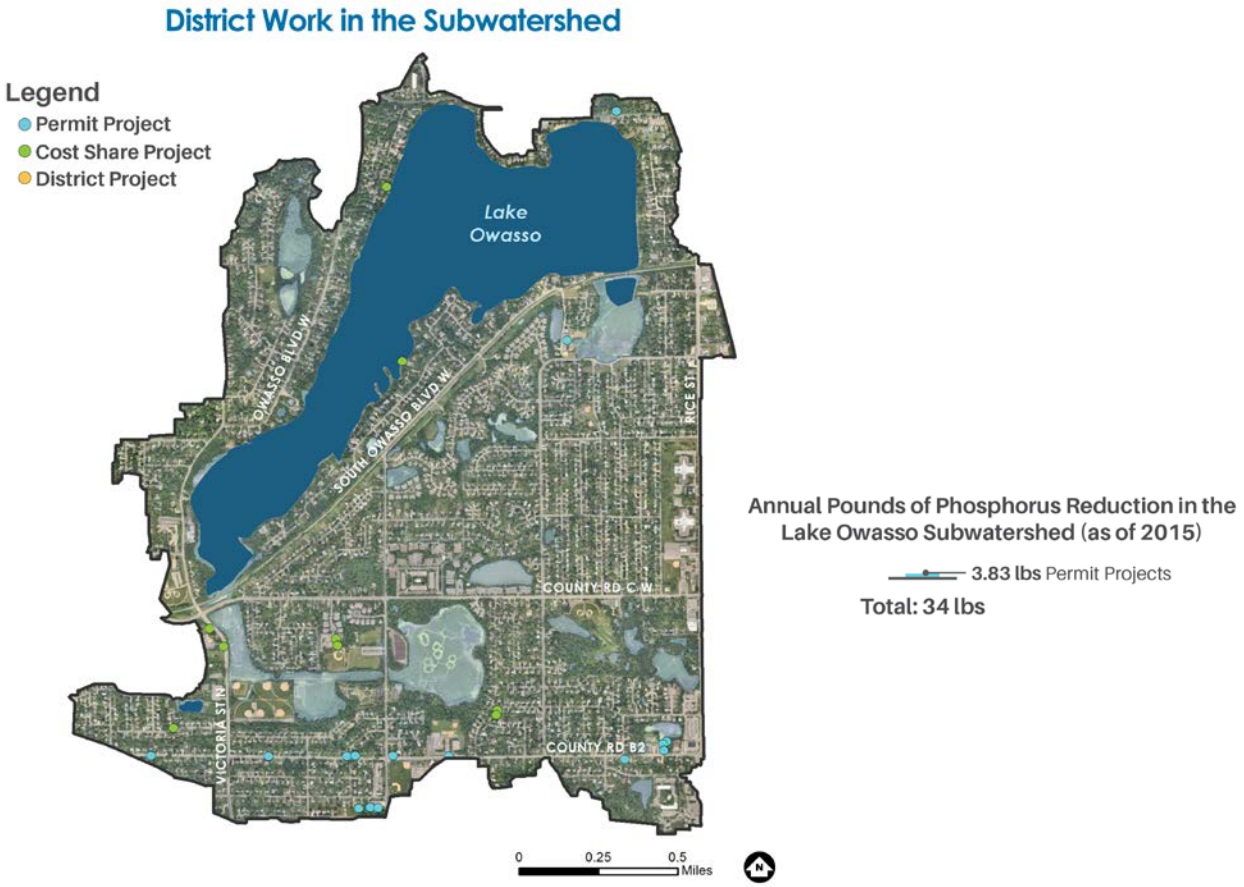


Figure 2.23-7 District work in the Lake Owasso Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.23.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Lake Owasso subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Lake Owasso subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Lake Owasso subwatershed are the new 100-year flood elevations shown in Figure 2.23-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.23.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Lake Owasso subwatershed are shown in Figure 2.23-9, indicating areas where the water levels of waterbodies in the Lake Owasso subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.23.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Lake Owasso subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Lake Owasso subwatershed.

2.23.6 Future Implementation Activities

Based on the 2009 Use Attainability Analysis and the RWMWD WRAPS study, several implementation activities are recommended to meet the District goals for Lake Owasso (see Table 2.23-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.23-4 Lake Owasso Subwatershed Implementation Activities

Activity ID No.	Lake Owasso Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LO-1*	Assess and conduct buffer and natural areas restoration along the Owasso Lakes Area	**2024-2026**	**$70,000**	**EC3, EC6**	**Tier 1**
LO-2	Create and implement an Emergency Response Plan for Owasso Lake.	**2017-2026**		**WQ19, FL5, FL9**	**Tier 2**
LO-3*	Perform a feasibility study of retrofit opportunities throughout the Lake Owasso Subwatershed to improve water quality, such as reducing the phosphorus load from tributary wetland systems (Westwood Village Pond, the Central Park Wetlands and Charlie Pond) and implementing a sedimentation pond at the City of Roseville's compost facility.	**2018**	**$30,000**	**WQ17, WQ19, FL8, IE7, IE17, MO6, MO21**	**Tier 1**
LO-4*	Implement water quality projects that are deemed feasible in the Lake Owasso Subwatershed Feasibility Study	**2019-2026**	**$750,000**	**WQ2, WQ17, WQ18, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
LO-5*	Research options for control of Lake Owasso's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
LO-6*	Evaluate the carp population in the Lake Owasso-Central Park Wetlands- Bennett Lake chain	**2017-2018**	**$150,000 (representative of assessment cost throughout the Owasso Chain of Lakes)**	**EC3, EC5**	**Tier 2**
LO-7*	Manage the carp population in the Lake Owasso-Central Park Wetlands-Bennett Lake chain if deemed necessary.	**2019-2026**	**$240,000 (representative of management cost throughout the Owasso Chain of Lakes)**	**WQ2, EC3, EC5**	**Tier 2**

Activity ID No.	Lake Owasso Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LO-8*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Owasso Lake.	**2018**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation Model Nodes with Storage			
Drainage Area	100-Year WSE	Drainage Area	100-Year WSE
Dschg18	898.87	LO_LL_3	892.52
Dschg2	920.21	LO_LL_4	915.34
Dschg21	891.91	LO_LL_5	900.96
Dschg22	889.95	LO_N_1	891.7
Dschg23	892.91	LO_S_1	890.6
Dschg27	889.95	LO_S_10	902.63
Dschg29	914.15	LO_S_11	902.72
Dschg3	923.11	LO_S_12	913.27
Dschg30	904.51	LO_S_13	919.92
Dschg34	899.16	LO_S_1a	890.6
Dschg35	900.84	LO_S_2a	892.76
Dschg36	897.57	LO_S_2b	954.7
Dschg50	913.27	LO_S_2c	950.12
Dschg52	904.05	LO_S_3a	948.84
LakeOwasso	888.98	LO_S_3b	927.45
LO_E_1a	896.82	LO_S_4	932.33
LO_E_1b	891.53	LO_S_5	906.03
LO_E_1c	889.43	LO_S_6a	892.18
LO_E_1d	888.98	LO_S_6b	893.06
LO_E_1e	890.89	LO_S_7	892.15
LO_E_1f	895.13	LO_S_8	908.7
LO_E_1g	891.14	LO_S_9	908.7
LO_E_1h	888.98	LO_W_1a	907.7
LO_E_1i	888.98	LO_W_1b	904.79
LO_E_1j	888.98	LO_W_1c	904.75
LO_E_1k	888.98	LO_W_1d	904.79
LO_LL_1	889.81	LO_W_2	919.91
LO_LL_1a	896.15	LO_W_2a	929.83
LO_LL_2a	881.86	LO_W_3	927.77
LO_LL_2b	889.44	LO_W_4	944.3
LO_LL_2c	903.05		

Drainage Area Outflow
Subwatershed Outflow
Major Subwatersheds
Drainage Areas
County Boundary
Municipal Boundary

Wetland Management Classifications

Manage A
Manage B
Manage C
Water Quality Pond
Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.23-8

LAKE OWASSO SUBWATERSHED
DRAINAGE PATTERNS AND WETLANDS
Ramsey-Washington Metro Watershed

Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4 2016-11-23 13:05 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.23_Lake_Owasso\Figure 2.23-8 Subwatersheds and Drainage Patterns - Lake Owasso Subwatershed.mxd User: jrv

Shoreview Lake
Lake Wabasso
Emily Lake
Judy Lake
Owasso Blvd N
18
Lake Owasso
Unnamed (Black Tern Pond)
Twin Lake
Owasso Blvd
Round Lake
Gervais Mill Pond
Bennett Lake
23
53
111

Drainage Areas
County Boundary
Municipal Boundary
Creeks

Vulnerability to Changes in Groundwater System

Vulnerable
Vulnerable With Wide Litoral Zone

Composite Infiltration Area Score

5 - 6
7 - 8
9 - 10
11 - 12
13 - 14
15 - 16
17 - 18
19 - 20
21 - 22
23 - 24

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.23-9

LAKE OWASSO SUBWATERSHED
PRIORITY INFILTRATION AREAS
Ramsey-Washington Metro Watershed

N

Feet
0 1,500 3,000
1 inch = 1,500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-29 10:45 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatersheds_Sections\2.23_Lake_Owasso\Figure 2.23-9 Priority Infiltration Areas - Lake Owasso Subwatershed.mxd User: jrv

2.24 Lake Emily Subwatershed

2.24.1 General Description

The Lake Emily watershed is located within the City of Shoreview and is entirely within Ramsey County (see Figure 2.24-1). The total watershed area is about 244 acres and includes Lake Judy (Mud Lake), which the MPCA now classifies as a wetland. Lake Emily is part of the larger Lake Owasso watershed. Lake Emily is the only District-managed waterbody within the subwatershed.

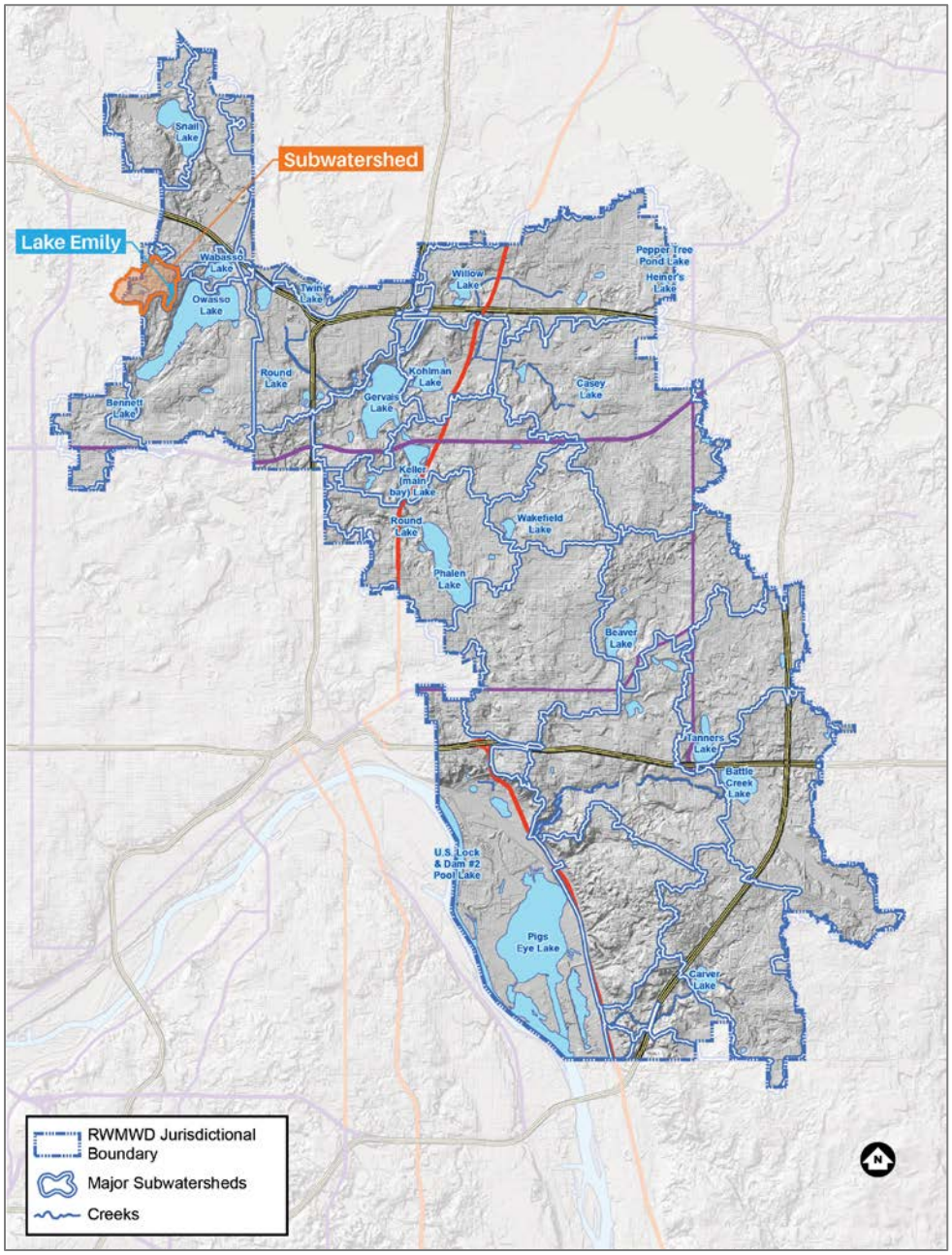


Figure 2.24-1 Lake Emily Location Map

Lake Emily is a 13 acre MDNR public water lake (MDNR# 62-0080) with a maximum depth of 15 feet and an average depth of 7 feet. The lake is located in completely surrounded by private land. There is no public access, but the lake residents use the lake for fishing, canoeing, and aesthetic enjoyment.

Table 2.24-1 Lake Emily Subwatershed Facts

Tributary Area (Direct)	244 acres
Tributary Area (Total)	244 acres
Downstream Watershed	Lake Owasso
MDNR Designation[1]	62-0080P
Lake Surface Area[1]	13 acres
Lake Mean Depth[1]	7 ft
Lake Maximum Depth[1]	15 ft
Lake Outlet Type[1]	48" Reinforced Concrete Pipe
Lake Outlet Elevation[1]	919.53 ft
100-Year Flood Level[1]	919.9 ft
Lake Littoral Area[1]	100%
MPCA Designations[1]	Shallow Lake
MS4s in the Direct Tributary Area	Shoreview, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	At Risk

[1] Data based on Lake Emily

2.24.1.1 Past Studies

The following list is a summary of past studies related to Lake Emily and the Lake Emily Subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey Washington Metro Watershed District.* Prepared by the MPCA, October 2015.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.
- *Lake Owasso Use Attainability Analysis.* Prepared for GLWMO by Barr Engineering, April 2009.

2.24.1.2 Land Use

The Lake Emily subwatershed is fully developed. Land use is predominantly single-family residential, with some areas park, recreational, or preserve land use and institutional land uses (see Figure 2.24-2). Changes in land used in the Lake Emily subwatershed are not expected, based on the Metropolitan Council's 2030 land use data (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

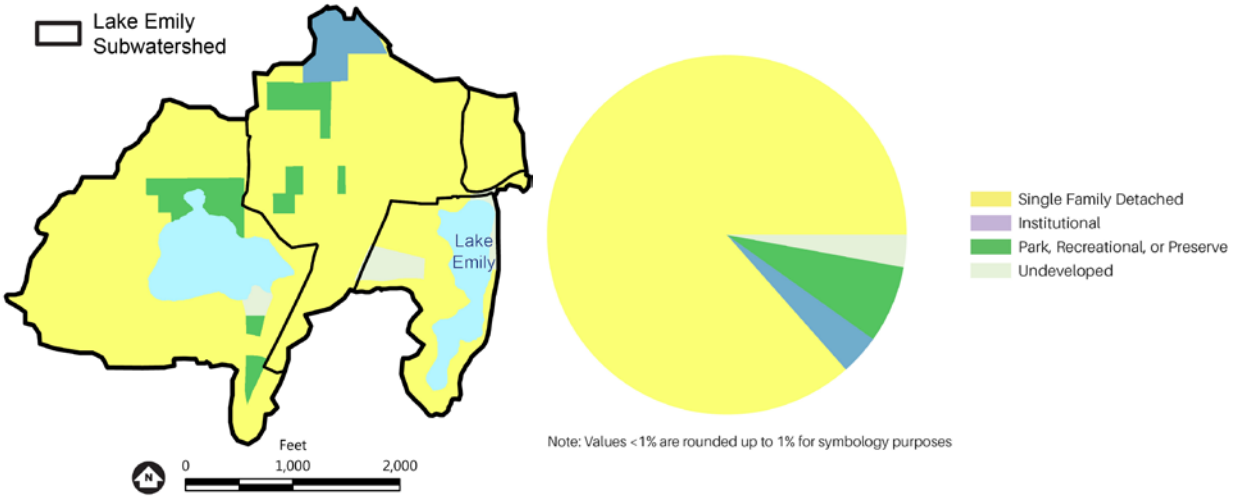


Figure 2.24-2 Breakdown of land uses throughout the Lake Emily Subwatershed (2010 Metropolitan Council)

2.24.1.3 Drainage Patterns and Waterbodies

Lake Emily is located in the western portion of the subwatershed. Discharge from Lake Emily flows east through Lake Judy (Mud Lake), a large wetland, before reaching Lake Owasso. The Lake Emily subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.24-8). Figure 2.24-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Lake Emily subwatershed include only Lake Emily.

Wetlands within the Lake Emily subwatershed are shown in Figure 2.24-8 according to the RWMWD wetland management classification (see Section 1.11.3). Lake Judy is a high quality wetland located at the downstream end of the subwatershed.

2.24.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Lake Emily.

2.24.2.1 Historical Water Quality

Lake Emily is classified by the MPCA as a shallow lake based on a littoral area (area with depth less than 15 feet) exceeding 80% of the total lake area. Dating back to 1980, the MPCA has collected a limited amount of water quality data for Lake Emily thought their Citizen Lake Monitoring Program (CLMP). Figure 2.24-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.24-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Lake Emily relative to MPCA standards. The RWMWD has assigned a water quality classification of "At Risk" to Lake Emily based on water quality data that exceed the MPCA standards and RWMWD goals.

Table 2.24-2 Lake Emily historic nutrient related water quality parameters

Water Quality Parameter	MPCA Shallow Lake Eutrophication Standard (NCHF Ecoregion)	Lake Emily (2003-2012) Growing Season Average
Total Phosphorus (µg/L)	≤ 60	98
Chlorophyll-a (µg/L)	≤ 20	34
Secchi disk transparency (m)	≥ 1.0	1.4

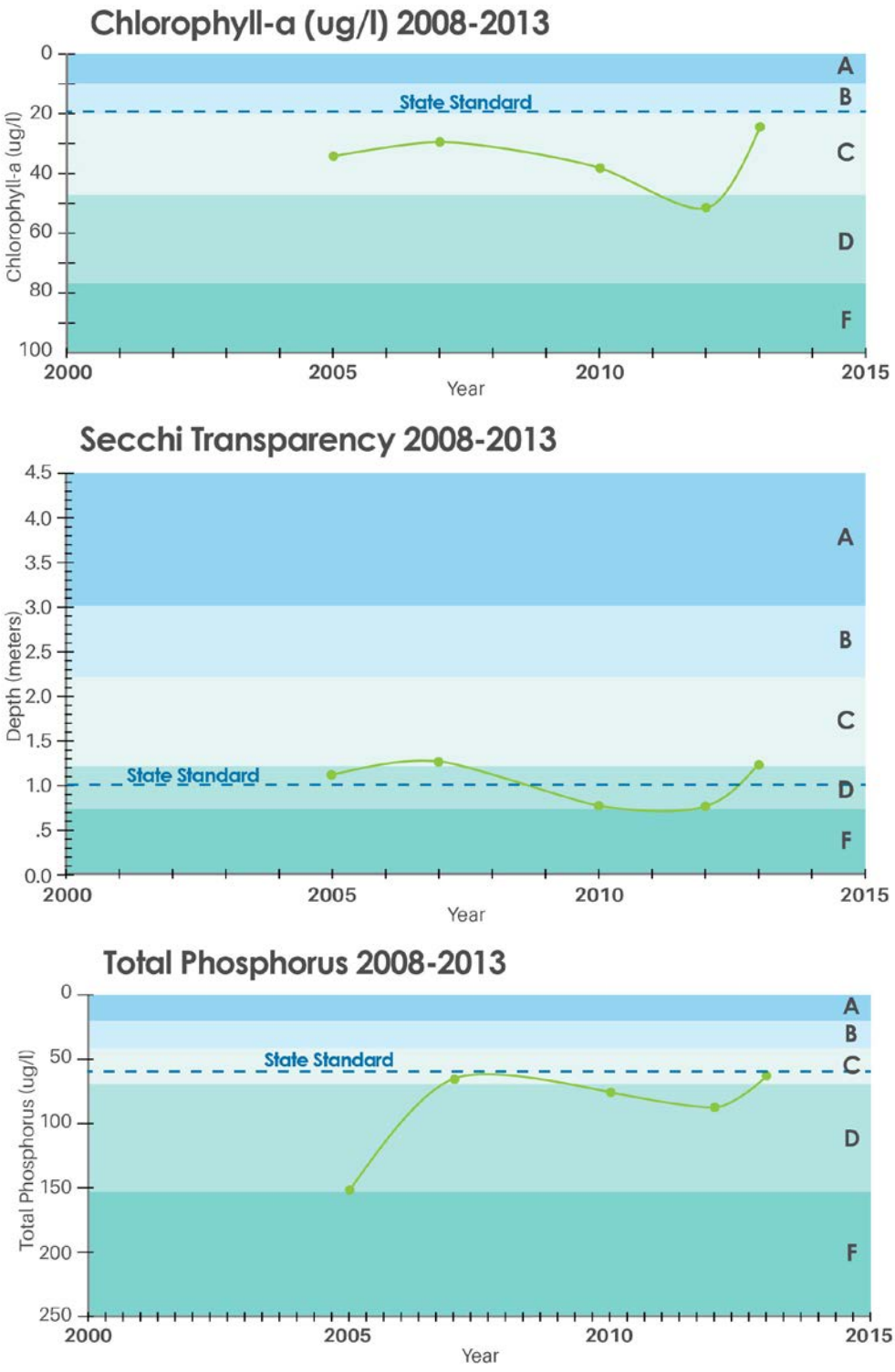


Figure 2.24-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Lake Emily (200-2013)

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Lake Emily water quality data. The results of these analyses are shown in Table 2.24-3.

Table 2.24-3 Trend Analysis Results for Lake Emily's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Lake Emily	1980 – 2012	Secchi Depth	Improving*	Degrading*
		Total Phosphorus	No Trend	No Trend
		Chlorophyll-*a*	No Trend	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval
Green values indicate an improving trend in water quality for that parameter

2.24.2.2 Status of the Fishery

The MDNR does not actively manage the fishery in Lake Emily, and fishing in Lake Emily is limited by the lack of public access. The MDNR last performed a fishery survey of Lake Emily in 2006 (http://www.dnr.state.mn.us/lakefind/index.html). The 2006 survey found three species present: black bullhead, black crappie, and bluegill. Black bullhead and black crappie were abundant. Black bullhead lengths ranged from 4.5 to 11.5 inches, with most fish between 5 and 6 inches. The largest black crappie sampled was 12 inches, but most were less than 6 inches. Bluegill were sampled in moderate numbers. Average length was 5 inches and the largest bluegill sampled was 7 inches.

The Minnesota Department of Health (MDH) has not established fish consumption advisories for Lake Emily. More information about fish consumption advisories is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.24.2.3 Status of Macrophyte Community

On August 27, 2013, District staff conducted a macrophyte survey of Lake Emily. The results of this survey are summarized below in Figure 2.24-4. In total, 96 sites were surveyed for macrophytes. Of these, 89 had vegetation, indicating that Lake Emily is a macrophyte dominated lake.

Where yellow waterlily and filamentous algae were found in the lake, they were present in high abundance relative to other macrophyte species in Lake Emily. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance.

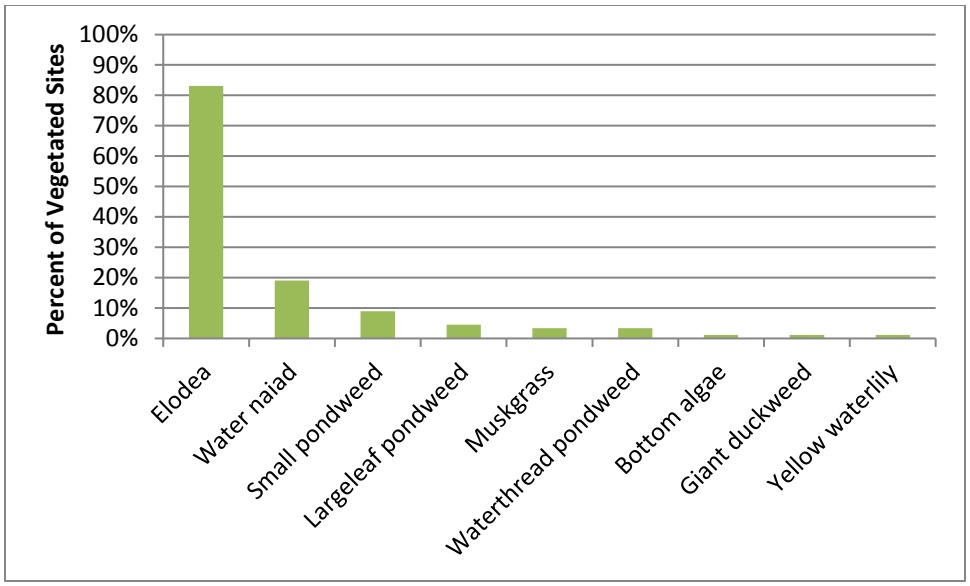


Figure 2.24-4 August, 2013 Lake Emily Macrophyte Survey Results

2.24.2.4 Water Quality Modeling

As part of the RWMWD WRAPS study, the District performed water quality modeling of the Lake Emily subwatershed. The goal of the modeling was to understand the impact of both point and non-point sources of pollution on the water quality in Lake Emily. 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 P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) was used to estimate pollutant loading from different areas of the watershed, referred to as drainage districts. The P8 model used in this study was originally developed as part of the *Lake Owasso Use Attainability Analysis* (Barr, 2009), and was calibrated as part of the larger Lake Owasso P8 model. Figure 2.24-5 shows the main drainage districts contributing flow and phosphorus loading to Lake Emily. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake.

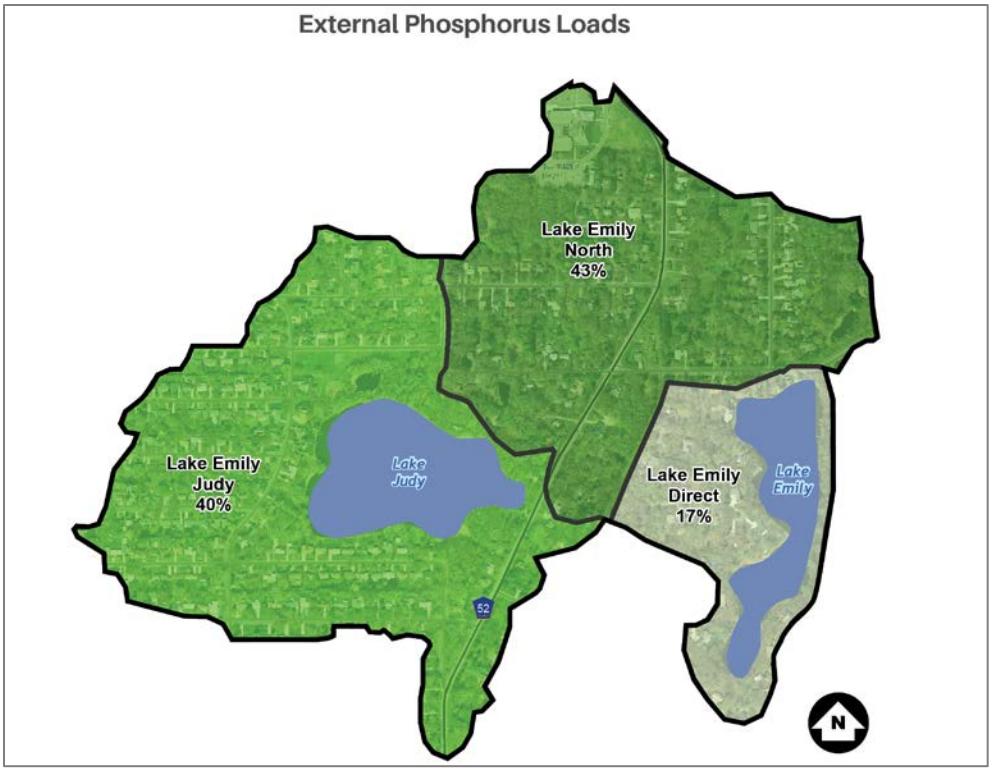


Figure 2.24-5 Drainage Districts in the Lake Emily Subwatershed

The watershed loading and in-lake water quality models of the Lake Emily subwatershed were used to estimate the relative contribution of the lake's internal and external (watershed) phosphorus loads for the average growing season (see Figure 2.24-6). The water quality modeling methodology and results for Snail Lake are described in detail in the RWMWD WRAPS report (Draft, Barr Engineering, 2016).

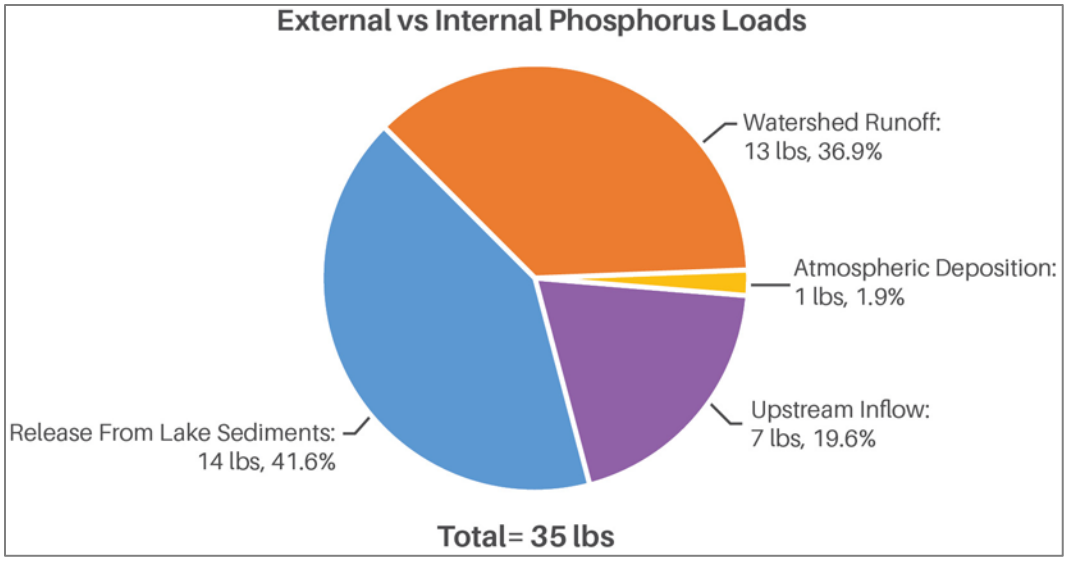


Figure 2.24-6 Lake Emily growing season total phosphorus budget

2.24.2.5 Water Quality Goals

The water quality goals for Lake Emily are consistent with the MPCA's shallow lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.24-2. The RWMWD will continue to evaluate Lake Emily water quality data for trends and adjust its water quality classification and management activities accordingly to achieve District goals.

The District will continue to consider opportunities to improve water quality in the Lake Emily subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.24-7.

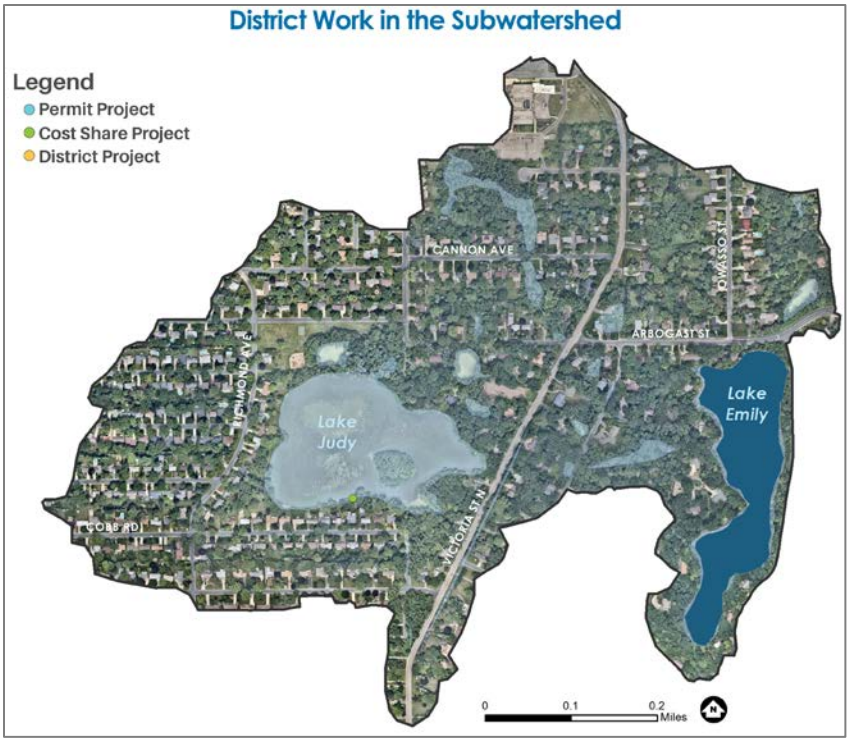


Figure 2.24-7 District work in the Lake Emily Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.24.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Lake Emily subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Lake Emily subwatershed.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic information provided through LiDAR. The results of this effort in the Lake Emily subwatershed are the new 100-year flood elevations shown in Figure 2.24-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

2.24.4 Support Sustainable Groundwater

The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Lake Emily subwatershed are shown in Figure 2.24-9, indicating areas where the water levels of waterbodies in the Lake Emily subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

2.24.5 Achieve Healthy Ecosystems

Natural resources management has become an important component of RWMWD flood control and water quality projects, as well as an overall watershed management strategy. Specifically stated, it is the goal of the RWMWD to manage water and related natural resources to create and preserve healthy ecosystems. This involves focusing on preserving and restoring aquatic, wetland and associated upland habitats and is typically accomplished through partnerships with both public and private entities.

The RWMWD will continue to promote its BMP Cost Share Program to encourage ecological restoration and management activities within the Lake Emily subwatershed. The RWMWD will also continue to seek opportunities to integrate natural resource benefits into its activities and projects implemented within the Lake Emily subwatershed.

2.24.6 Future Implementation Activities

Based on the 2009 Use Attainability Analysis and the RWMWD WRAPS study, several implementation activities are recommended to meet the District goals for Lake Emily (see Table 2.24-4). Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.24-4 Lake Emily Subwatershed Implementation Activities

Activity ID No.	Lake Emily Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LE-1*	Implement a shoreline management study and assist with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
LE-2*	Perform a feasibility study of retrofit opportunities throughout the Lake Emily Subwatershed to improve water quality, including outflows from Lake Judy	**2016-2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
LE-3*	Implement projects that are deemed feasible in the Lake Emily Subwatershed Feasibility Study	**2019-2026**	**$300,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
LE-4*	Research options for control of Lake Emily's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$50,000**	**WQ8, MO13**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

100-Year Water Surface Elevation for Model Nodes with Storage	
Drainage Area	**100-Year WSE**
LO_W_2	919.91
LO_W_2a	929.83
LO_W_3	927.77
LO_W_4	944.3

Shoreview Lake

LO_W_2a

Victoria St N

LO_W_3

Arbogast St

Lake Wabasso

52

LO_W_4

Judy Lake

LO_W_2

Emily Lake

- Drainage Area Outflow
- Subwatershed Outflow
- Major Subwatersheds
- Drainage Areas
- County Boundary
- Municipal Boundary

Wetland Management Classifications

- Manage A
- Manage B
- Manage C
- Water Quality Pond
- Lake/River

Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.24-8

LAKE EMILY SUBWATERSHED
DRAINAGE PATTERNS
AND WETLANDS
Ramsey-Washington Metro Watershed

N

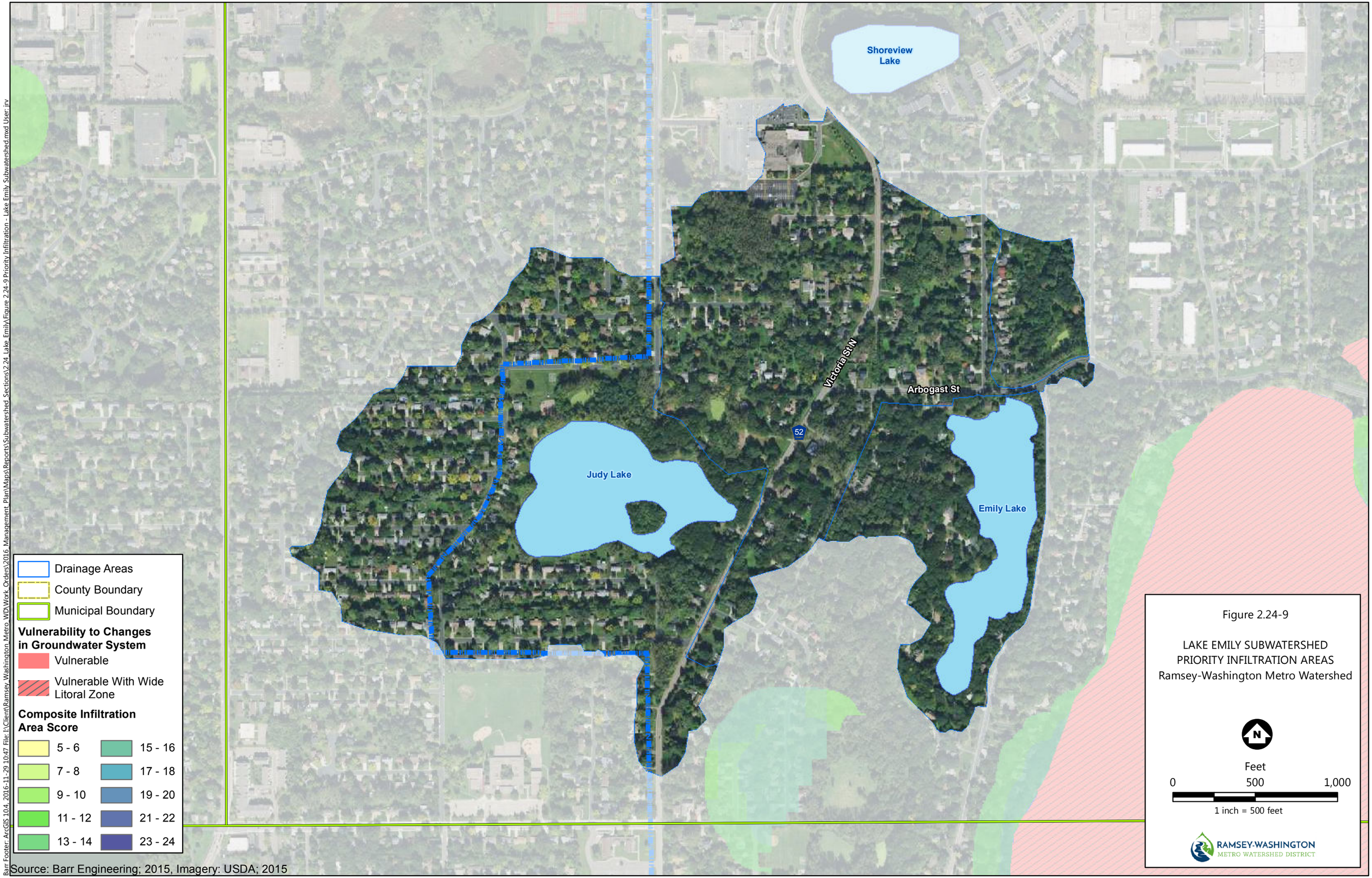
Feet

0 500 1,000

1 inch = 500 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-28 10:25 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.24_Lake_Emily\Figure 2.24-8 Subwatersheds and Drainage Patterns - Lake Emily Subwatershed.mxd User: jrv



Barr Footer: ArcGIS 10.4 2016-11-29 10:47 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.24_Lake_Emily\Figure 2.24-9 Priority Infiltration - Lake Emily Subwatershed.mxd User: jrv

2.25 Lake Wabasso Subwatershed

2.25.1 General Description

The immediate watershed to Lake Wabasso covers 147 acres within the city of Shoreview and is entirely within Ramsey County. However, the total area tributary to Lake Wabasso is 3,287 acres and includes subwatersheds of Lake Emily (see Section 2.24), Bennett Lake (see Section 2.20), and Lake Owasso (see Section 2.23). The Lake Wabasso subwatershed drains north and discharges to the Grass Lake subwatershed. Lake Wabasso is the only District-managed waterbody in the Lake Wabasso subwatershed.

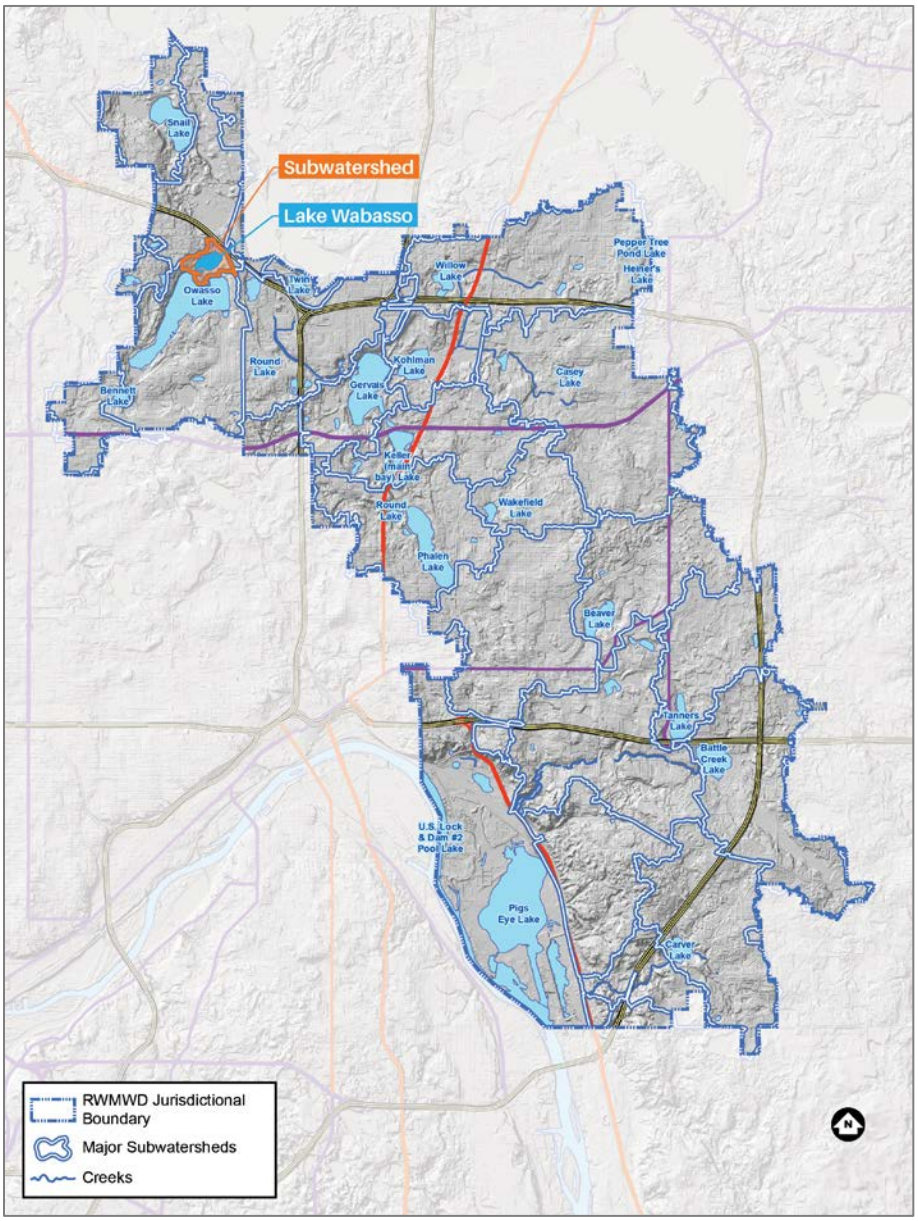


Figure 2.25-1 Lake Wabasso Location Map

Lake Wabasso is a 52-acre MDNR public water lake (MDNR# 62-0082P). It has a maximum depth of 66 feet and an average depth of approximately 16 feet. Lake Wabasso is used for many recreational activities, including fishing, boating and swimming. Boat access is provided in Lake Owasso County Park on the south side of the lake which is operated and maintained by Ramsey County.

Table 2.25-1 Lake Wabasso Subwatershed Facts

Tributary Area (Direct)	147 acres
Tributary Area (Total)	3,287 acres
Downstream Watershed	Grass Lake
MDNR Designation[1]	62-0082P
Lake Surface Area[1]	52 acres
Lake Mean Depth[1]	16 ft
Lake Maximum Depth[1]	66 ft
Lake Outlet Type[1]	7.3 foot wide Weir
Lake Outlet Elevation[1]	885.73 ft
100-Year Flood Level[1]	887.7 ft
Lake Littoral Area[1]	60%
MPCA Designations[1]	Deep Lake; At risk of Impairment for Aquatic Life (chloride)
MS4s in the Direct Tributary Area	Shoreview, Ramsey County
RWMWD Nutrient Water Quality Classification[1]	Stable

[1] Data based on Lake Wabasso

2.25.1.1 Past Studies

The following list is a summary of past studies related to Lake Wabasso and the Lake Wabasso Subwatershed.

- *RWMWD Atlas 14 Hydrologic/Hydraulic Model Update Project. Barr Engineering Company, 2015.*
- *Watershed Restoration and Protection Strategies Report – Ramsey-Washington Metro Watershed District.* Barr Engineering Co., Draft 2016.
- *GLWMO Watershed Management Plan.* Grass Lake Watershed Management Organization, June 2011.

2.25.1.2 Land Use

The Lake Wabasso subwatershed is fully developed. Land use is predominantly single-family residential, with some areas park, recreational, or preserve land use (see Figure 2.25-2). A significant portion of the

subwatershed is occupied by the lake itself. Changes in land use in the Lake Wabasso subwatershed are not expected, based on the Metropolitan Council's 2030 land use data (see Figure 1-5). Redevelopment areas that exceed 1 acre are subject to the RWMWD's volume reduction rule that limits runoff rate and volume of the redeveloped site.

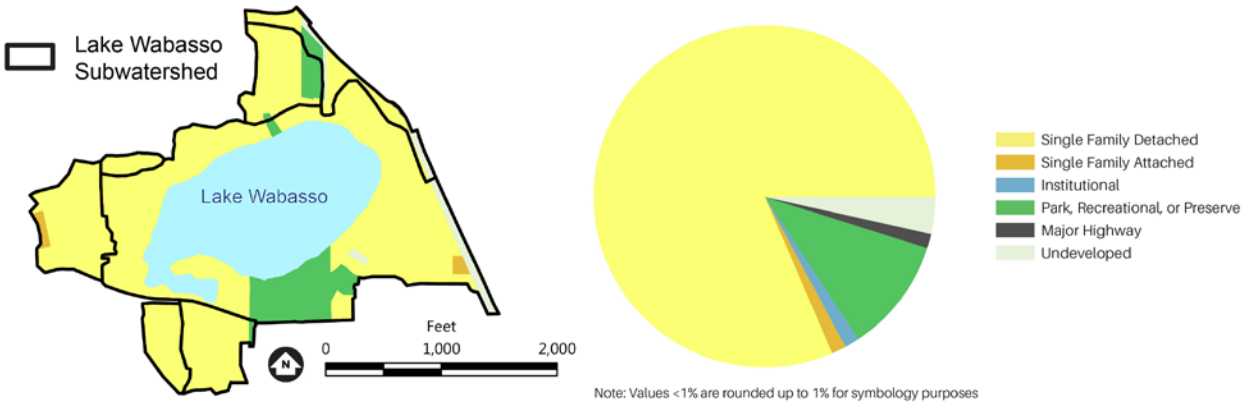


Figure 2.25-2 Breakdown of land uses throughout the Lake Wabasso Subwatershed (2010 Metropolitan Council)

2.25.1.3 Drainage Patterns and Waterbodies

Lake Wabasso receives inflow from Lake Owasso to the south. The Lake Wabasso outlet is a 7.3 foot wide weir located at the north end of the lake. Discharge is conveyed under Interstate 694 and into the Grass Lake subwatershed. The Lake Owasso subwatershed has been divided into several drainage areas for hydrologic modeling and management purposes (see Figure 2.25-8). Figure 2.25-8 indicates the direction of flow from each drainage area and includes the estimated flood elevation in storage areas corresponding to the 100-year storm event, based on hydrologic modeling using NOAA's Atlas 14 precipitation amounts (see Section 1.12.3).

District-managed waterbodies within the Lake Wabasso subwatershed include only Lake Wabasso.

Wetlands within the Lake Wabasso subwatershed are shown in Figure 2.25-8 according to the RWMWD wetland management classification (see Section 1.11.3).

2.25.2 Achieve Quality Surface Water

One of the primary goals of the RWMWD is to maintain or improve surface-water quality to support healthy ecosystems and provide the public with a wide range of water-based benefits. The following Section discusses the water quality conditions and goals for Lake Wabasso.

2.25.2.1 Historical Water Quality

Lake Wabasso is classified by the MPCA as a deep lake based on its depth and littoral area (area with depth less than 15 feet). The MPCA has collected water quality data for Lake Wabasso through their

Citizen Lake Monitoring Program (CLMP) since 1973. The Ramsey County Department of Public Works staff samples the water quality of Lake Wabasso about 7 times per year on average, between the months of May and September. Figure 2.25-3 shows the growing season (June through September) average total phosphorus, chlorophyll *a*, and Secchi disk measurements, over the lake's period of record.

Table 2.25-2 summarizes the most recent 10-year averages of nutrient-related water quality parameters for Lake Wabasso relative to MPCA standards. The RWMWD has assigned a water quality classification of "Stable" to Lake Wabasso based on recent water quality.

Table 2.25-2 Lake Wabasso historic nutrient related water quality parameters

Water Quality Parameter	MPCA Deep Lake Eutrophication Standard (NCHF Ecoregion)	Lake Wabasso (2003-2012) Growing Season Average
Total Phosphorus (µg/L)	≤ 40	26
Chlorophyll-a (µg/L)	≤ 14	8.4
Secchi disk transparency (m)	≥ 1.4	2.7

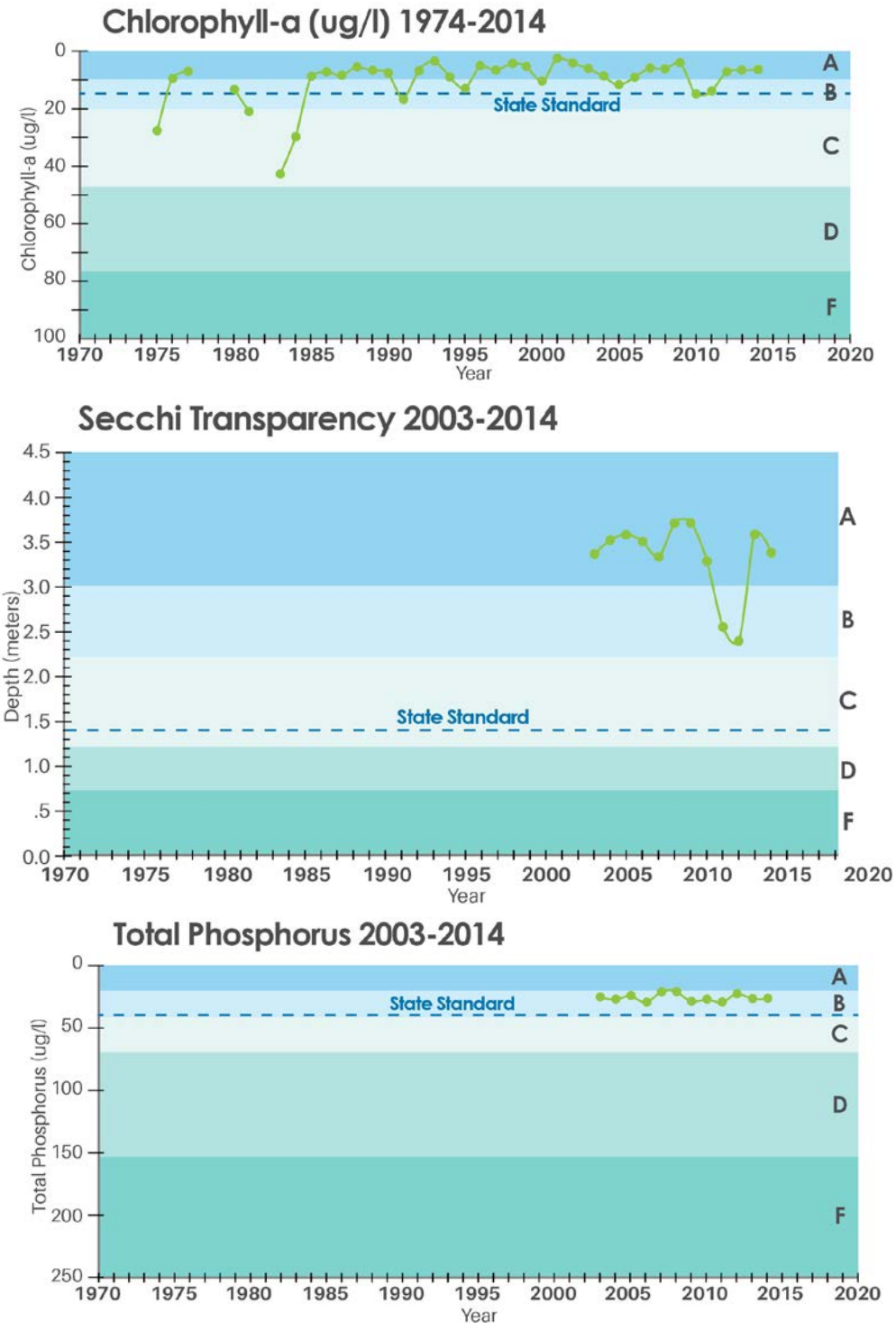


Figure 2.25-3 Growing season average total phosphorus concentrations, chlorophyll *a* concentration and Secchi disk transparency measurements in Lake Wabasso (2003-2014)

As part of the RWMWD WRAPS Report (Barr, Draft 2016), trend analyses were performed on the Lake Wabasso water quality data. The results of these analyses are shown in Table 2.25-3.

Table 2.25-3 Trend Analysis Results for Lake Wabasso's Historical Water Quality Data

Waterbody	Dataset Date Range	Parameter	Trend, Entire Historic Dataset	Trend, Last 10 Years (2003-2012)
Lake Wabasso	1959 – 2012	Secchi Depth	No Trend	No Trend
		Total Phosphorus	Improving*	No Trend
		Chlorophyll-*a*	No Trend	No Trend

* Trend was detectable, but was below the 95th percentile confidence interval

Green values indicate an improving trend in water quality for that parameter

2.25.2.2 Status of the Fishery

The MDNR does not actively manage the fishery in Lake Wabasso. Fishing access is available via a small boat access located on the south shore in the county park. Shore access is limited to the boat access area. The MDNR last performed a fishery survey of Lake Wabasso in 2005 (http://www.dnr.state.mn.us/lakefind/index.html). The most abundant species of fish present in the 2005 survey were bluegills. Bluegill size was small, with an average length of 5.3 inches. Only 5% of the bluegills sampled were over 7 inches. Northern pike were found in average abundance and averaged 22.8 inches in length. Black crappies were sampled in low numbers and small size. The MDNR survey sampled only one largemouth bass, but notes that Lake Wabasso has had a history of good largemouth bass fishing. Other species present include black bullhead, pumpkinseed sunfish, yellow bullhead, and yellow perch.

The Minnesota Department of Health (MDH) has not established fish consumption advisories for Lake Wabasso. More information about fish consumption advisories is available from the MDH at: http://www.health.state.mn.us/divs/eh/fish/index.html

2.25.2.3 Status of Macrophyte Community

On June 24, 2014, District staff conducted a macrophyte survey of Lake Wabasso. The results of this survey are summarized below in Figure 2.25-4. In total, 105 sites were surveyed for macrophytes. Of these, 105 had vegetation, indicating that Lake Wabasso is a macrophyte dominated lake with a diverse macrophyte community.

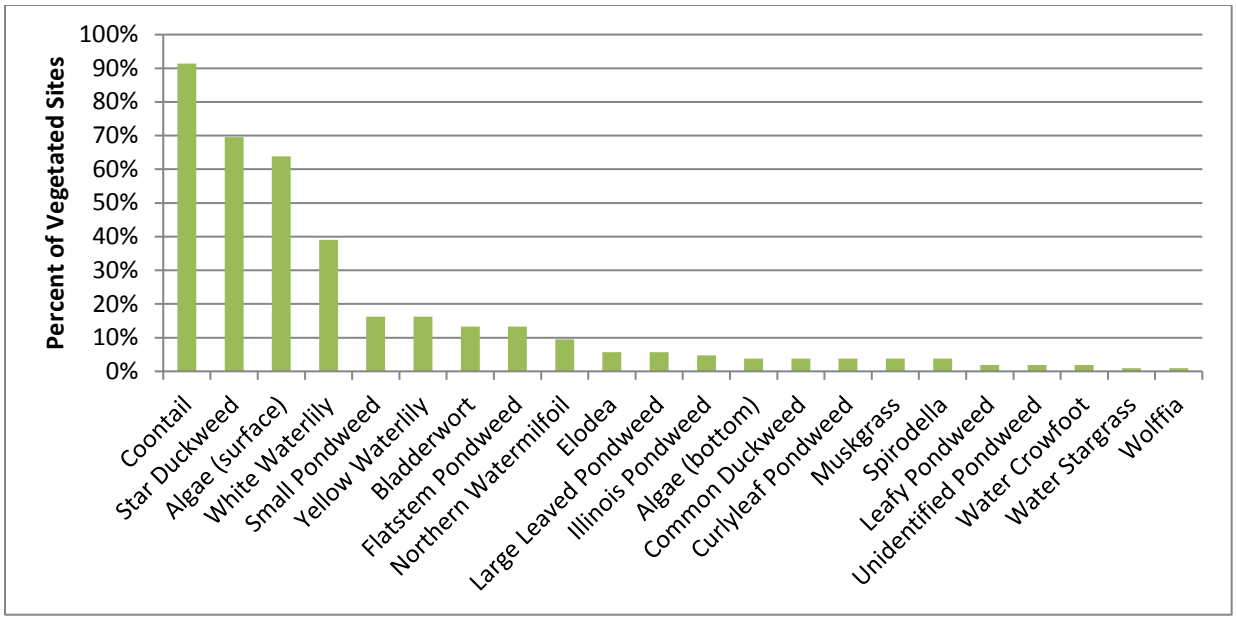


Figure 2.25-4 June, 2014 Lake Wabasso Macrophyte Survey Results

Where filamentous algae, coontail and Star Duckweed were found in the lake, they were present in high abundance relative to other macrophyte species in Lake Wabasso. Filamentous algae, while not actually macrophytes, are notable because they can grow in abundance on other lake macrophytes, creating and aesthetic and recreational nuisance. Also, curlyleaf pondweed is an invasive species that can add phosphorus to the water column as it dies back in mid-summer.

2.25.2.4 Water Quality Modeling

As part of the RWMWD WRAPS study, the District performed water quality modeling of the Lake Wabasso subwatershed. The goal of the modeling was to understand the impact of both point and non-point sources of pollution on the water quality in Lake Wabasso. 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 P8 computed model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds, IEP Inc. 1990) was used to estimate pollutant loading from different areas of the watershed, referred to as drainage districts. Figure 2.25-5 shows the main drainage districts contributing flow and phosphorus loading to Lake Wabasso. A drainage district is described as a network of drainage areas that all drain to the same point before entering the lake.

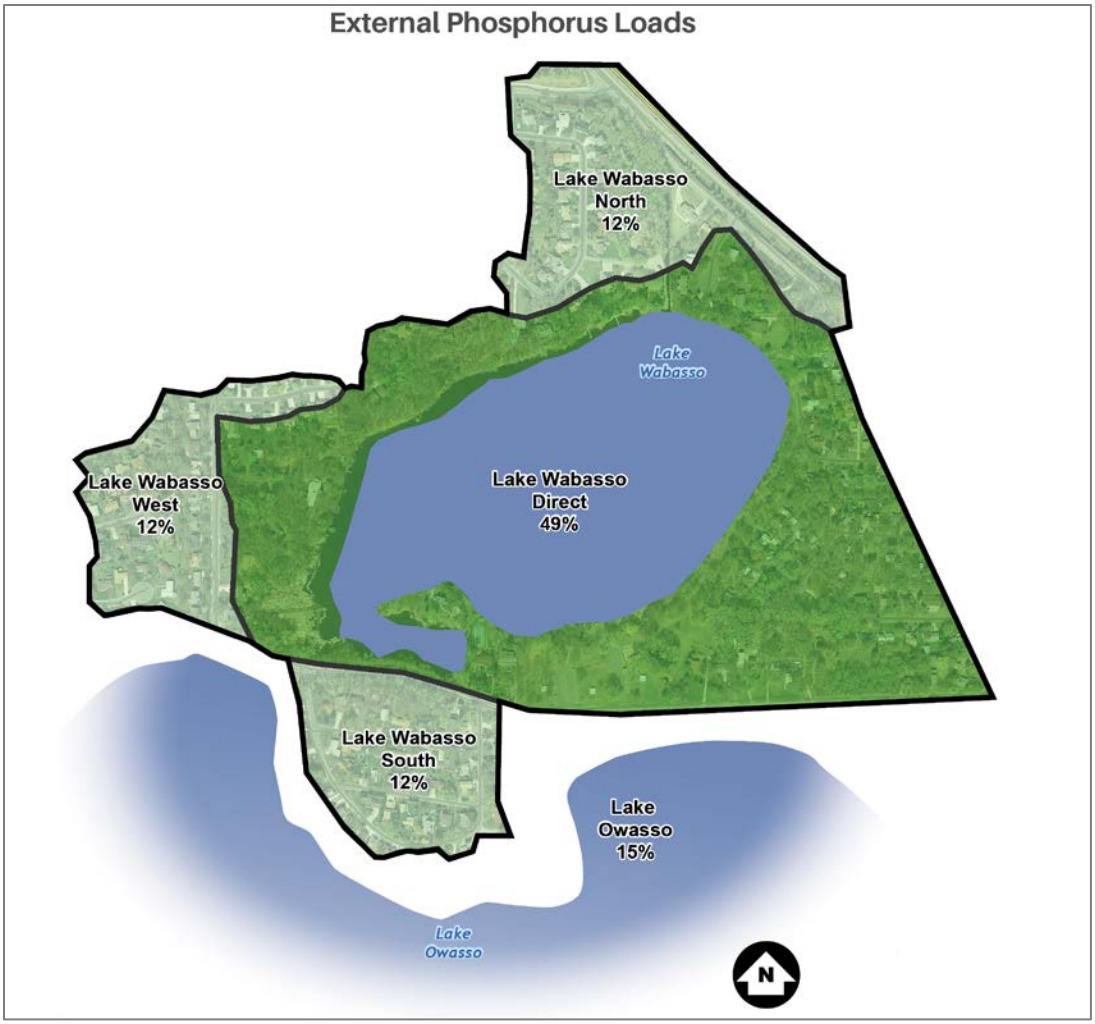


Figure 2.25-5 Drainage Districts in the Lake Wabasso Subwatershed

The watershed loading and in-lake water quality models of the Lake Wabasso subwatershed were used to estimate the relative contribution of the lake's internal and external (watershed) phosphorus loads for the average growing season (see Figure 2.25-6). The water quality modeling methodology and results for Lake Wabasso are described in detail in the RWMWD WRAPS report (Draft, Barr Engineering, 2016).

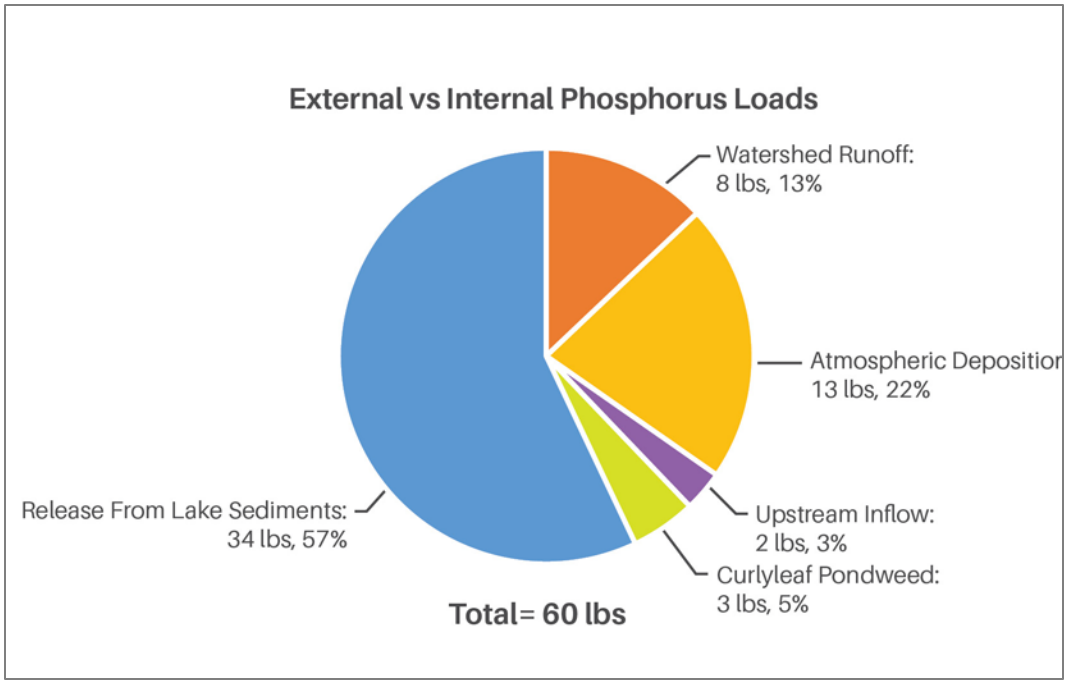


Figure 2.25-6 Lake Wabasso growing season total phosphorus budget

2.25.2.5 Water Quality Goals

The water quality goals for Lake Wabasso are consistent with the MPCA's deep lake eutrophication standard for the North Central Hardwoods Forest Ecoregion, shown in Table 2.25-2. The RWMWD will continue to evaluate Lake Wabasso water quality data for trends and adjust its water quality classification and management activities accordingly to achieve District goals.

The District will continue to consider opportunities to improve water quality in the Lake Wabasso subwatershed through implementation of District capital improvement (and other) projects, the District's cost share program and implementation of the District's permit program. The proliferation of projects that have arisen from these programs through December 31, 2015 are shown in Figure 2.25-7.

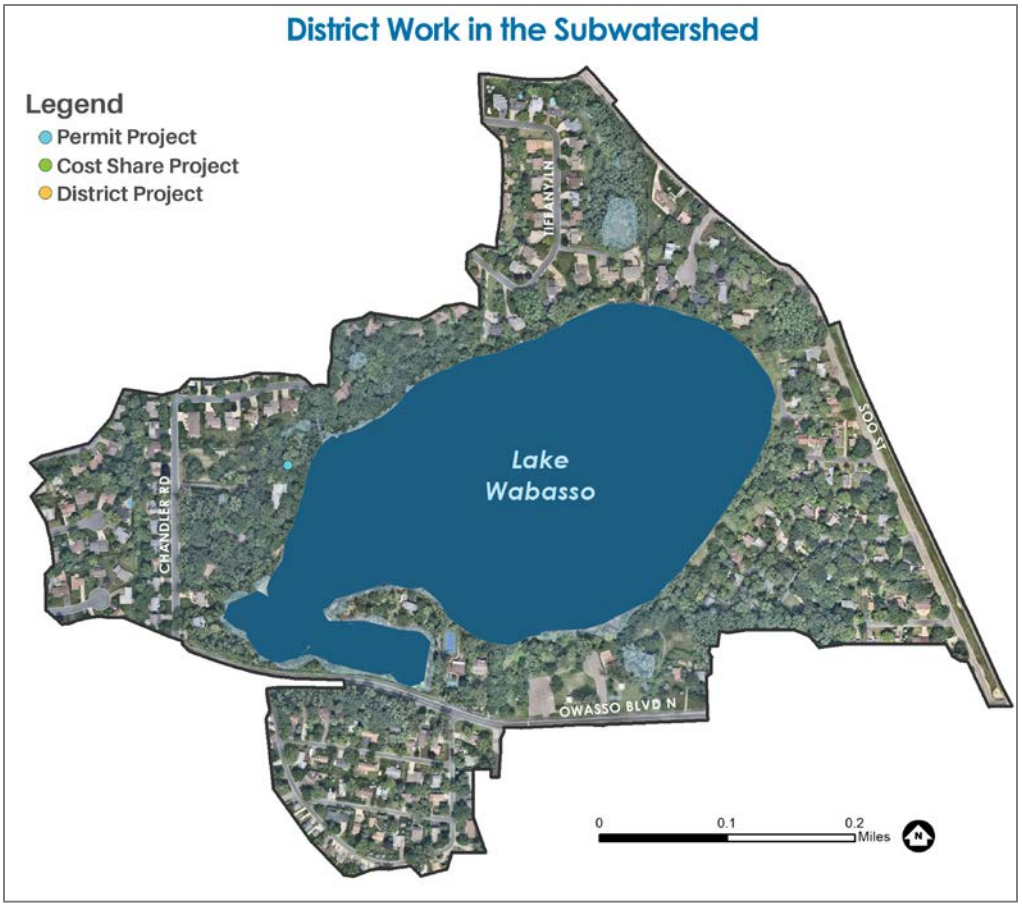


Figure 2.25-7 District work in the Lake Wabasso Subwatershed: Permit, Cost Share, Capital Improvement and Other District Projects through December 31, 2015

2.25.3 Manage Risk of Flooding

One of the goals of the RWMWD is to reduce the public's risk to life and property from flooding through programs and projects that protect public safety and economic well-being. Since the incorporation of the Lake Wabasso subwatershed into the RWMWD in 2013, the District has not implemented any flood control projects in the Lake Wabasso subwatershed.

The 2001 GLWMO Watershed Management Plan noted that high water levels have historically been a concern in the Lake Wabasso subwatershed. The channel downstream of Lake Wabasso has overflowed in the past, resulting in localized flooding of adjacent yards. According to the 2001 GLWMO Watershed Management Plan, the insufficient downstream capacity in the culvert under I-694 was thought to be the cause of the ditch overflowing. The District evaluated the issue in 2015 and determined that no modifications to the Lake Wabasso outlet should be made.

In 2015, the District updated their hydrologic and hydraulic models District-wide to reflect updated design precipitation levels published through NOAA's Atlas 14, as well as more up-to-date topographic

information provided through LiDAR. The results of this effort in the Lake Wabasso subwatershed are the new 100-year flood elevations shown in Figure 2.25-8. The new inundation extents that have been modeled throughout the District are currently being evaluated to determine the level of future flooding risk. During the lifespan of this Watershed Management Plan, the District will be communicating with its member cities about these areas, and in some cases, working to implement flood control projects to mitigate the flooding from future 100-year storm events.

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The RWMWD supports sustainable groundwater by considering groundwater management in its decisions and by collaborating with others responsible for groundwater management and protection.

In 2015, the RWMWD completed a study of surface water-groundwater connections throughout the District (Section 1.6.1). The results of the study for the Lake Wabasso subwatershed are shown in Figure 2.25-9, indicating areas where the water levels of waterbodies in the Lake Wabasso subwatershed might be particularly affected by (and therefore, may be vulnerable to) changes in groundwater level, as well as areas in the subwatershed that might be particularly well suited for groundwater recharge through targeted infiltration projects. An area with a higher number is relatively better suited for recharging aquifers than one with a lower number.

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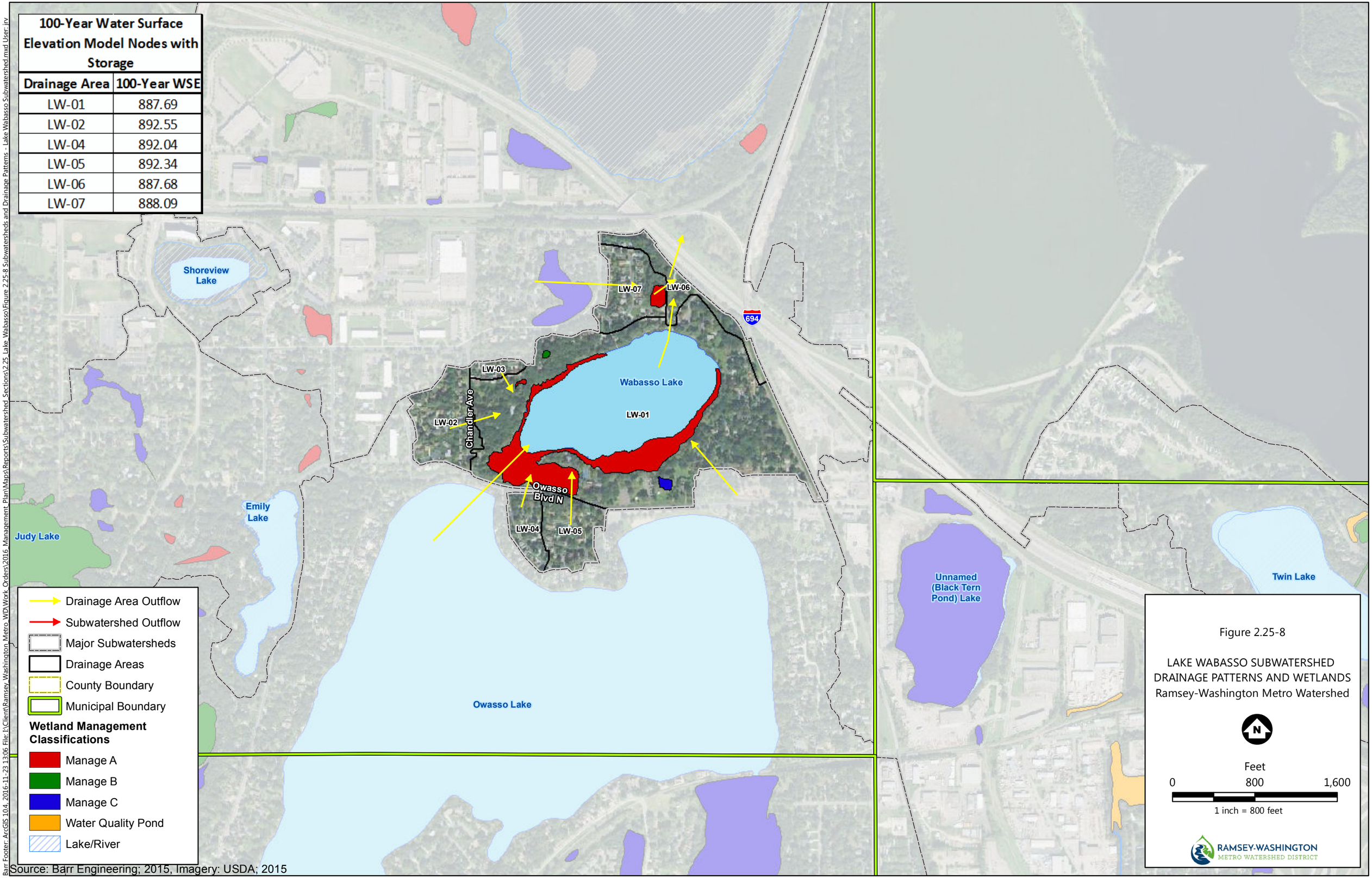
2.25.6 Future Implementation Activities

Table 4-1 contains the implementation activities for the entire RWMWD implementation program, which lists District-wide and subwatershed-specific projects and programs. Many of the District-wide implementation activities are applicable to the Lake Wabasso subwatershed (e.g., implementation of the RWMWD permit program). No additional activities specific to the Lake Wabasso subwatershed are identified (see Table 2.25-4). Both tables list the individual implementation program components, the implementation schedule, and a planning-level cost estimate (in 2017 dollars) for each component.

Table 2.25-4 Lake Wabasso Subwatershed Implementation Activities

Activity ID No.	Lake Wabasso Subwatershed Activity	Estimated Implementation Year	Estimated Cost (2017 Dollars)	Relevant Strategic Overview Action Items	Priority Tier
LW-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	Continuous	--	See DW items in Table 4-1	See DW items in Table 4-1

100-Year Water Surface Elevation Model Nodes with Storage	
Drainage Area	100-Year WSE
LW-01	887.69
LW-02	892.55
LW-04	892.04
LW-05	892.34
LW-06	887.68
LW-07	888.09



Source: Barr Engineering; 2015, Imagery: USDA; 2015

Figure 2.25-8

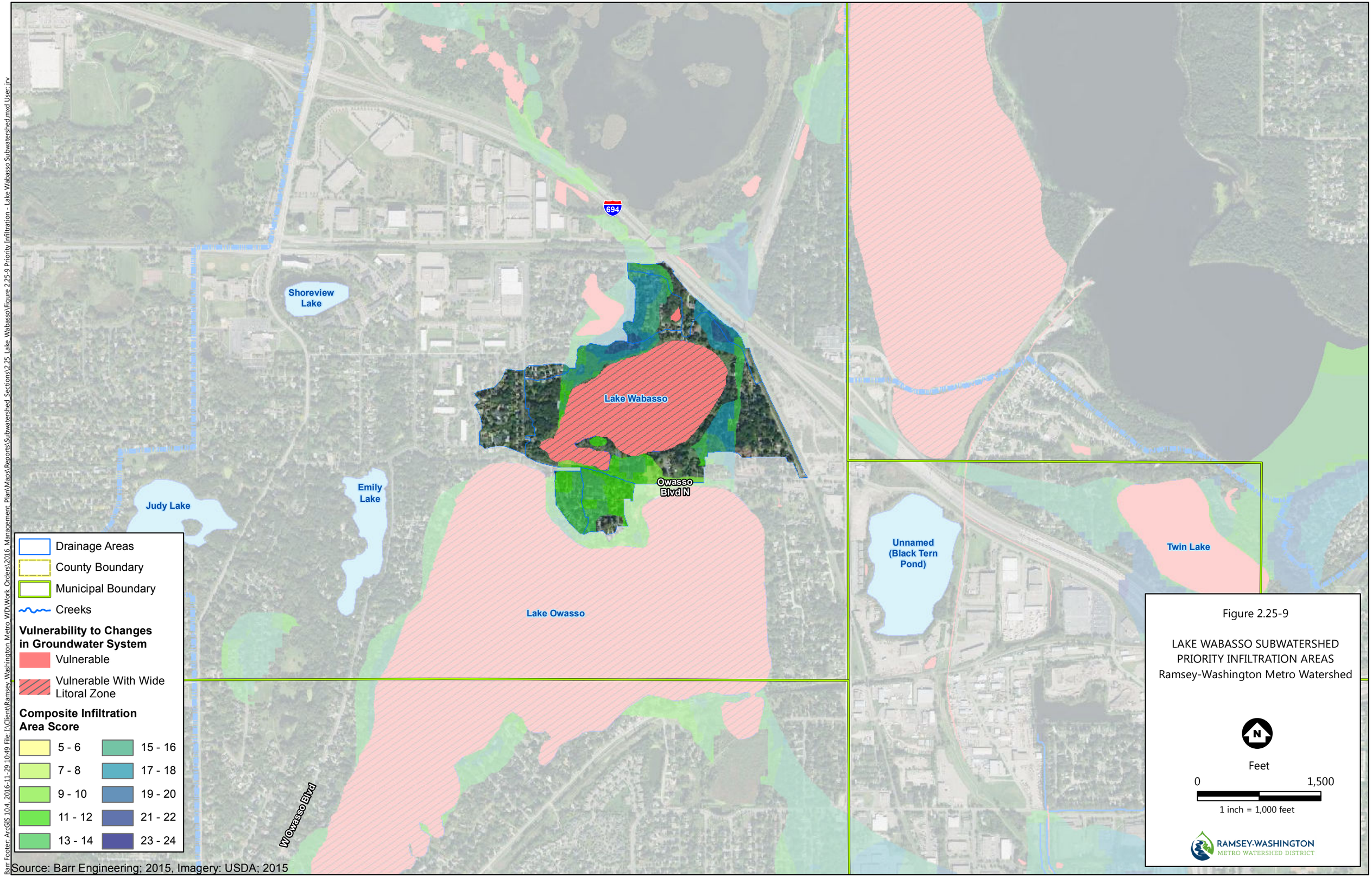
LAKE WABASSO SUBWATERSHED
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N

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1 inch = 800 feet

RAMSEY-WASHINGTON METRO WATERSHED DISTRICT

Barr Footer: ArcGIS 10.4, 2016-11-23 13:06 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.25_Lake_Wabasso\Figure 2.25-8 Subwatersheds and Drainage Patterns - Lake Wabasso Subwatershed.mxd User: jrv



Barr Footer: ArcGIS 10.4, 2016-11-29 10:49 File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2016_Management_Plan\Maps\Reports\Subwatershed_Sections\2.25_Lake_Wabasso\Figure 2.25-9 Priority Infiltration - Lake Wabasso Subwatershed.mxd User: jrv

3.0 Purpose, Roles, and Responsibilities

In order for District staff and board of managers to "manage the organization effectively" (goal from Strategic Overview), it is essential to understand the District's background and statutory purposes, and to establish specific roles and responsibilities in relation to other units of government and stakeholders.

3.1 RWMWD Organizational History and Function

3.1.1 Background Information

Like all watershed districts, the RWMWD is a special purpose unit of local government that manages water resources on a watershed basis. Recognizing that water does not follow political boundaries, the State of Minnesota established the Watershed Act (Minnesota Statutes 103D) in 1955, which provided for the creation of watershed districts anywhere in the state. Establishing a local governmental unit according to hydrologic boundaries allows for an overall, holistic approach to resource conservation. Since enacting the Watershed Act, 46 watershed districts have been created in the state (as of 2015). Of these, fourteen are located in the seven county Twin Cities metropolitan area.

In 1982, the Minnesota Legislature enacted the Metropolitan Surface Water Management Act (Minnesota Statutes 103B.201 – 103B.255). This act required the formation of a watershed management organization (WMO), and the development and implementation of a watershed management plan, for each of the watersheds in the seven county Twin Cities metropolitan area. WMOs can be organized as watershed districts (e.g., RWMWD), as joint powers agreement organizations among municipalities (e.g., Vadnais Lake Area Watershed Management Organization), or under county government (e.g., Carver County).

Watershed districts within the Twin Cities metropolitan area, including the RWMWD, are subject to the guidance of both the Watershed Act (Minnesota Statutes 103D) and the Metropolitan Surface Water Management Act (Minnesota Statutes 103B).

Minnesota Statutes 103B and 103D require watershed districts to prepare watershed management plans. In addition to the plan requirements given in statute, watershed districts in the Twin Cities metropolitan area must also follow the detailed plan requirements of Minnesota Rules 8410. The rules, adopted by the Minnesota Board of Water and Soil Resources (BWSR) in 1992 and updated in 2015, also contain requirements for local (i.e., city) plans, and require the establishment of the necessary processes, controls, or other authorities to ensure implementation of programs.

3.1.2 Statutory Purposes and Authority

As given in Minnesota Statutes 103D.201, the general purposes of a watershed district are:

> *To conserve the natural resources of the state by land use planning, flood control, and other conservation projects by using sound scientific principles for the protection of the public health and welfare and the provident use of the natural resources.*

Watershed districts may be formed for number of specific purposes, including protection or enhancement of water quality, prevention and alleviation of flood damage, prevention and alleviation of soil erosion and sedimentation, regulation of streams, lakes and water courses for domestic, recreational and public use, and protection and regulation of groundwater uses (Minnesota Statutes 103D.201).

For watershed management organizations in the Twin Cities metropolitan area, the following purposes also apply (quoted from Minnesota Statutes 103B.201):

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

To achieve their intended purposes, Minnesota Statutes 103D (MS 103D.335 in particular) gives watershed districts a number of broad authorities. These include, but are not limited to, the authority to:

- Collect data
- Conduct studies and investigations
- Construct improvements
- Levy property taxes and assess properties for benefits received
- Adopt rules to regulate, conserve, and control the use of water resources
- Contract with private and public entities for the construction, maintenance, and operation of projects and other activities
- Hire staff and consultants
- Acquire property
- Incur debts, liabilities, and obligations
- Acquire, operate, construct and maintain dams, dikes, reservoirs, and water supply systems
- Enter lands for surveying and other investigations

3.1.3 Board of Managers

Watershed districts in the Twin Cities metropolitan area are governed by a local board of between five and nine managers. The managers are appointed by the boards of the counties with land in the watershed district. In the RWMWD, a five-member board of managers is responsible for the control and management of the water resources of the District. Four managers are appointed by the Ramsey County Board and one manager is appointed by the Washington County Board. Managers are appointed for staggered three-year terms. Watershed district managers must be voting residents in the watershed, and cannot be a public officer of the county, state, or federal government (except that a soil and water conservation district supervisor may be a manager). For watershed districts within the Twin Cities metropolitan area, the managers must fairly represent the various hydrologic areas within the watershed district (Minnesota Statutes 103D.311), and the managers cannot be staff of local units of government that are members of the watershed management organization (Minnesota Statutes 103B.227).

The regularly scheduled meetings of the RWMWD Board of Managers are held once a month, on the first Wednesday. The meetings are open to the public and are held at the District office in Little Canada, located at 2665 Noel Drive. Meeting information is posted on the District website: www.rwmwd.org.

3.1.4 District Location

The RWMWD is located in eastern Ramsey County and western Washington County. The RWMWD covers approximately 65 square miles that ultimately drain into the Mississippi River. The District is generally bounded on the west by downtown St. Paul and Interstate 35E, on the north by County Road E in White Bear Lake, on the east by I-694/I-494, and on the south by the Mississippi River (see Figure ES-1). A small part of the District extends southeast of I-494 in the city of Woodbury. Another small Section of the District (approximately 8 square miles in the former Grass Lake Watershed Management Organization, or GLWMO) extends to the northwest of I-35 E roughly bounded by Highway 36, Lexington Avenue, Highway 96, Rice Street, and I-694. The RWMWD includes all or part of 12 communities, including:

- Gem Lake
- Landfall
- Little Canada
- Maplewood
- North St. Paul
- Oakdale
- Roseville
- St. Paul
- Shoreview
- Vadnais Heights
- White Bear Lake
- Woodbury

Approximately 53.4 square miles of the area lie within Ramsey County; the remaining 11.6 square miles are within Washington County.

The RWMWD is adjacent to the following watershed districts and joint powers watershed management organizations:

- Capitol Region Watershed District, along west boundary of RWMWD
- Vadnais Lake Area Watershed Management Organization, along north boundary of RWMWD
- Rice Creek Watershed District, along northwest boundary of RWMWD
- Valley Branch Watershed District, along east boundary of RWMWD
- South Washington Watershed District, along southeast boundary of RWMWD
- Lower Mississippi River Watershed Management Organization, across the Mississippi River from RWMWD along the southwest boundary of RWMWD

3.1.5 RWMWD History

The RWMWD was established on February 24, 1975, by the Minnesota Water Resources Board (now the Minnesota Board of Water and Soil Resources, or BWSR) pursuant to the Minnesota Watershed Act, to effect the protection and provident use of water resources.

In December 1975, an ad hoc citizens' group was formally appointed as an Advisory Committee to advise and assist the managers in all matters affecting the District. The board of managers adopted the first iteration of its rules and regulations for the District on February 27, 1976 (the District's current rules and regulations are described in Section 3.2.1.1).

Since its creation, the District has prepared four overall watershed management plans. This Plan is the fifth watershed management plan for RWMWD. The previous RWMWD Plans include:

1. 1977 – *Overall Plan – Ramsey-Washington Metro Watershed District*
2. 1986 – *Stormwater Runoff and Water Quality Management Plan*
3. 1997 – *Ramsey-Washington Metro Watershed District Watershed Management Plan*
4. 2007 - *Watershed Management Plan for the Ramsey-Washington Metro Watershed District 2006-2016*

The managers adopted the first overall plan for the District on February 28, 1977; the plan was approved by the Minnesota Water Resources Board. Management plans for specific areas of the district were published in November 1977 (Battle Creek drainage area), February 1979 (area tributary to Carver Lake), January 1985 (Fish Creek/Bluff watershed) and November 1988 (Phalen Chain of Lakes watershed).

The District began to revise its overall plan in 1982, involving other governmental units in the process. The revised plan was officially completed in September 1986, when the Water Resources Board approved the new surface water management plan, "Stormwater Runoff and Water Quality Management Plan." The 1982 plan merged the District's watershed regulation and planning and construction activities with the related activities of municipalities, counties and soil and water conservation districts located within District boundaries.

The 1986 plan identified a major need to address resource management in the Phalen Chain of Lakes watershed. Studies identified specific improvement needs including the Phalen Chain of Lakes flood control project, the Target Pond project, and water quality improvements including the Gervais Mill Pond Project and the Kohlman Basin Project.

In 1994, the District began preparation of its "second generation" Watershed Management Plan. This District planning process was completed in late 1996 and the plan was approved by BWSR in May 1997. The completion of this plan marked the beginning of an integrated resource management approach for the District. A new generation Watershed Management Plan was adopted in early 2007. The 2007 Plan continued the integrated resource management approach and included greater emphasis on improving water quality through education and outreach efforts.

In 2013, the District performed a major plan amendment to incorporate an additional 8.5 square miles of the former Grass Lake Watershed Management Organization (GLWMO). This area includes portions of the cities of Roseville and Shoreview. The new area was included in the District's WRAPS study (see Section 1.10.5.2) and the capital improvement program developed as part of this Plan (see Section 4.0).

3.2 Roles and Responsibilities

This Section summarizes the roles and responsibilities of the District and the cities and counties within its borders. Many agencies have jurisdiction within the RWMWD; the roles and responsibilities of those agencies relevant to the management of water resources are also discussed in this section. Additional detail regarding the processes and programs the District uses to perform its roles and responsibilities is included in Section 4.1.

3.2.1 RWMWD Responsibilities

The RWMWD serves many water resource management roles, as listed in Minnesota Statutes 103D (see Section 3.1.2). While the District is the entity ultimately responsible for fulfilling the duties of Minnesota Statutes 103D, the RWMWD seeks to collaborate with its cities, community groups, and others to achieve its goals.

The District has many specific responsibilities, as identified in its action items (see Strategic Overview) and as described in the following sections. Major responsibilities of the District include:

- Implementation of the District's Rules, Regulations, and Permitting Program
- Wetland and Natural Resource Management
- Projects and Studies
- Maintenance of District Facilities and MS4 Permit Responsibilities
- Monitoring
- Reporting and Evaluation
- Assistance to Local Governmental Units
- Collaboration with Other Agencies and Organizations
- WRAPS and TMDL Implementation

Enhancement of recreational opportunities (including improving/increasing public access) is not a primary goal of the RWMWD, but it can be a secondary benefit of a water quality improvement project.

In general, the RWMWD is responsible for addressing water resource management issues that affect more than one city or issues defined by the RWMWD to be of District-wide significance. This usually means the watershed of the affected water resource spans more than one city. Specifically, the RWMWD is responsible for managing water quantity and water quality issues for certain water resources. These "District-managed" resources include the following 20 lakes and five streams:

Lakes

- Battle Creek Lake
- Beaver Lake
- Bennett Lake
- Carver Lake
- Eagle Lake
- Emily Lake
- Gervais Lake
- Keller Lake
- Kohlman Lake
- Lake Owasso
- Lake Phalen
- Round Lake (Maplewood)
- Round Lake (Little Canada)
- Shoreview Lake
- Snail Lake
- Tanners Lake
- Twin Lake
- Wabasso Lake
- Wakefield Lake
- Willow Lake

Streams:

- Battle Creek
- Fish Creek
- Gervais Creek
- Kohlman Creek
- Willow Creek

The District-managed resources listed above are described in the subwatershed management sections (see Section 2.0).

Generally, the District performs roles and responsibilities similar to those described in the 2007 Watershed Management Plan. With this Plan, the District has added several new action items targeting water and natural resource management issues identified and prioritized by stakeholders during Plan development (see Section 4.5.1). Emerging areas of focus receiving greater emphasis in this Plan relative to past District plans are highlighted in the Strategic Overview and include:

- Monitoring and management of aquatic invasive plans and animals
- Planning for anticipated changes in precipitation and hydrology
- Increasing knowledge of groundwater resources and addressing groundwater resource sustainability

The action items included in the Strategic Overview and the implementation items included in Table 4-1 reflect the increased emphasis on these issues. Other changes to the implementation program include

more water quality improvement projects resulting from the RWMWD WRAPS study and TMDLs completed since the 2007 Watershed Management Plan.

3.2.1.1 RWMWD Rules, Regulations, and Permit Program

Per the authorities given in Minnesota Statutes 103D, the District has adopted rules, last revised in 2015, to regulate the use and development of land within its jurisdiction (see Section 4.2). To ensure District rules are followed, the District maintains a permit program. A District permit is required for projects meeting specific criteria related to the area of land disturbing activity and the project's location relative to floodplains, wetlands, or public waters. The District's permitting program is described in greater detail in Section 4.1.2. Cities seeking permitting authority may petition the District to transfer permitting authority to the city, via the process described in Section 4.1.2.1.

3.2.1.2 Wetland and Natural Resource Management

The RWMWD is the Local Government Unit (LGU) responsible for administering the Wetland Conservation Act (WCA) within the watershed, except in the City of St. Paul, and except for Minnesota Department of Transportation (MnDOT) projects. As the LGU, the District has taken on the responsibility of managing the wetlands in the watershed, including the permitting of projects with potential wetland impacts (see Section 4.1.2). As part of this management responsibility, the RWMWD completed a wetland inventory, functional assessment, and classification of the District's wetlands (see Section 1.11.2 for more information about this effort). The RWMWD shares this wetland assessment information with the local units of government in the District.

As of the writing of this Plan, the District has not assumed, and does not plan to assume, jurisdiction to enforce the Minnesota Buffer Law (MN Statutes 103F.48). The District will cooperate with the Board of Water and Soil Resources (BWSR), Ramsey Conservation District, and/or Washington Conservation District (WCD), as requested, in activities related to implementation of, and updates to, the Minnesota Buffer Law.

3.2.1.3 Projects and Studies

The District is responsible for performing studies and implementing its capital improvement program (CIP). In order to achieve its goals, the District has identified action items related to the study and investigation of key water resource management issues (see Strategic Overview). The District performs studies to obtain the knowledge needed to implement effective solutions. Through previous studies (e.g., RWMWD WRAPS study) and other planning efforts, the District has identified projects to be implemented over the life of this Plan. These projects are included in the District's implementation program, summarized in Table 4-1

As the RWMWD's priority has increasingly shifted toward water quality improvement and natural resources protection projects, the District is finding that the resultant projects are smaller in scale than the earlier flood control and regional water quality improvement projects. These smaller-scale projects often include activities at the individual homeowner/property owner level (e.g., rainwater gardens). This change in project scale makes it more difficult for the RWMWD to determine when a project is a District versus local (e.g., city) responsibility (i.e., who will fund the project?). To assist in determining responsibility, the

RWMWD developed funding guidelines, which places various types of projects and programs into one of three tiers. In general, Tier 1 and Tier 2 projects/programs will be funded 100% by the RWMWD, whereas Tier 3 projects/programs will require some type of cost-sharing with the local unit of government. The local units of government are responsible for funding projects or programs not identified as Tier 1, Tier 2, or Tier 3. See Section 4.1.1.1 for more information about the "tier" and the RWMWD funding of projects and programs.

3.2.1.4 Maintenance of District Facilities, Public Ditches, and MS4 Permit Responsibilities

Under the U.S. Environmental Protection Agency's (EPA) Storm Water National Pollutant Discharge Elimination System (NPDES) Rules, small municipal separate storm sewer systems (referred to as MS4s) serving populations under 100,000 that are located in urbanized areas are required to obtain a NPDES Storm Water permit (i.e., MS4 permit) under the Clean Water Act, administered by the Minnesota Pollution Control Agency (see Section 3.2.4.3). MS4s must develop, implement, and enforce a Storm Water Pollution Prevention Plan (SWPPP) designed to minimize the discharge of pollutants from the MS4, to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. As the owner and operator of stormwater facilities including the Beltline Interceptor (see Section 1.9.3), the RWMWD is considered an MS4 and has obtained an MS4 permit.

Consistent with its MS4 permit, the District is responsible for inspection and maintenance of its stormwater management infrastructure. As part of the RWMWD's ongoing inspection of its stormwater management systems, the RWMWD checks for non-stormwater (illicit) discharges into the stormwater system. The RWMWD will continue to conform to the NPDES MS4 requirements that apply to the RWMWD stormwater system. The current RWMWD Storm Water Pollution Prevention Plan is available on the RWMWD website (http://www.rwmwd.org/) or at the RWMWD office.

Within the RWMWD, all cities and counties except St. Paul were identified as MS4s by the MPCA. The City of St. Paul is subject to an individual (Phase I) NPDES stormwater permit based on a population greater than 100,000. To minimize duplication and increase efficiency, the RWMWD will also collaborate with the cities to help them implement their NPDES MS4 requirements (see Section 3.2.1.7).

The District also serves as the public ditch authority within its jurisdictional boundary. The original function of public ditches was to provide drainage for agricultural lands. The District will continue to manage public ditches in a manner that recognizes their current use as urban drainage systems and as altered natural waterways.

3.2.1.5 Monitoring

The RWMWD will continue to monitor water quantity and water quality of waterbodies within the District, focusing on those waterbodies identified as impaired or at risk (see Section 1.10.3). The District coordinates its monitoring efforts with other programs, where possible, to avoid duplication of effort. Water quantity monitoring efforts include flow monitoring in creeks and water level monitoring in several lakes. Water quality monitoring may include detailed water chemistry performed at regular intervals, zooplankton and phytoplankton sampling in lakes, aquatic plant monitoring of lakes, and invertebrate

monitoring in streams. Water quality and biological monitoring programs are described in greater detail in Section 4.1.7.

3.2.1.6 Reporting and Evaluation

The RWMWD is responsible for evaluating progress towards achieving its goals and reporting annually to the Board of Water and Soil Resources (BWSR), per Minnesota Rules 8410.0150. Within the first 120 days of the calendar year, the District must submit to BWSR an activity report for the previous calendar year. The District must submit an audit report for the previous fiscal year within 180 days of the end of the District's fiscal year. The required contents of the annual activity report are specified in Minnesota Rules 8410. Generally, the District's annual report includes:

- An assessment of the previous year's annual work plan that indicates whether the stated activities were completed, including the expenditures of each activity with respect to the approved budget (unless included in the audit report).
- A work plan and budget for the current year specifying which activities will be undertaken.
- At a minimum of every 2 years, an evaluation of progress on goals and the implementation actions, including the capital improvement program, to determine if amendments to the implementation actions are necessary.
- A summary of significant trends of monitoring data.

The District will communicate with cities, as necessary, to ensure compliance with the goals, action items, and requirements established in this Plan and the District rules document. As part of its annual evaluation process, the District will review the status of city and township local water plans. At least every 2 years, the District will evaluate the completion of tasks listed in local plan implementation programs. The District may also review city and township ordinance revisions addressing management of water resources (e.g., wetlands, erosion and sediment control), including their enforcement. If annual review of city practices reveals implementation inconsistent with this Plan or District rules, the District will communicate the inconsistency to the city governing body. If the issue is not resolved, the District may consider taking action to ensure that District rules and requirements are being implemented by the cities.

The District will continue to maintain its website. The website will contain the location, time, agenda, and minutes for organization meetings; contact information for the organization staff; the current watershed management plan; annual activity reports; rules and requirements; a list of the RWMWD board members; and a list of employees including postal and electronic mailing addresses and telephone numbers. The website will be kept current. The RWMWD website is located at: www.rwmwd.org.

3.2.1.7 Assistance to Local Units of Government

The RWMWD looks to the cities to address water resource management issues that are more local in nature. However, the RWMWD may provide assistance in solving local issues when requested by the cities. The RWMWD will work closely with the cities to continue to provide support in the areas of water quality, natural resources, and wetlands management. The District also coordinates with cities to accommodate

municipal benefits beyond the charge of the RWMWD (e.g., recreational benefits) into District projects. The District will work with cities in identifying redevelopment areas as opportunities to implement shoreline buffers, water quality treatment, or other water resource protection strategies

The RWMWD expects that common intercommunity disputes will be resolved by the involved cities. The District will supply pertinent data or comment as requested. If the dispute impacts RWMWD interests, the communities cannot mutually resolve the issue, or the District's involvement is requested, the RWMWD will provide research and data support, mediate the dispute, and develop recommendations for a solution. Depending on the nature of the dispute, affected projects and activities may be suspended during dispute resolution.

All cities (as well as the District) are required to maintain MS4 permits. The RWMWD will work with the cities and counties to determine the most efficient way for the cities and counties (and the RWMWD) to meet their NPDES MS4 responsibilities. In the case of St. Paul, which has a NPDES Phase I permit, the RWMWD is willing to work with the city to determine if the RWMWD can also assist them in meeting their Phase I permit requirements. If it is more efficient for the RWMWD to provide certain services that will assist the cities and counties in meeting their NPDES obligations, the RWMWD will provide those services, as requested. For example, the RWMWD could perform stormwater system maintenance-related services, such as outfall inspections, stormwater pond inspections, and illicit discharge detection. Also, the RWMWD will continue to coordinate its education programs with city education efforts, through the Public Works Forum (see Section 4.1.3) and local city staff, to further assist the cities in meeting their MS4 obligations.

The RWMWD also works with local units of government in the preparation of their local (city) water management plans. The RWMWD reviews the local plans for consistency with this Plan, and has the sole authority to approve the local plans (along with any other water management organizations within a city). More information about local water management plan requirements is presented in Section 4.4.

3.2.1.8 Collaboration with Other Agencies and Organizations

The RWMWD will continue to assist and/or collaborate with other agencies and organizations in addressing issues of mutual interest. Cooperators may include cities, counties, adjacent watershed management organizations, and state agencies. Past examples include collaboration with the Capitol Region Watershed District (CRWD) in developing standards and rules/regulations in 2006. More recently, the District collaborated CRWD and Mississippi Watershed Management Organization (MWMO) on strategic communication tasks that included a shared plan and services. .

The RWMWD also collaborates/collaborated with Ramsey and Washington Counties on a number of efforts, including:

- Ongoing collaboration with Ramsey and Washington County on water quality monitoring efforts in the RWMWD portions of the counties.
- Participation and membership in the Washington County Water Consortium.

- Ongoing collaboration with Ramsey Conservation District (RCD) and Washington County on groundwater management initiatives.
- Assist the Board of Water and Soil Resources (BWSR) and/or RCD, as requested, in activities related to implementation of, and updates to, the Minnesota Buffer Law (MN Statutes 103F.48).
- Ongoing collaboration with Washington Conservation District's public involvement and education efforts and low impact development technologies.
- Ongoing support for Ramsey and Washington County Aquatic Invasive Species initiatives.
- Ongoing support for RCD's Cooperative Weed Management Program.
- Participation in the Ramsey County GIS User's Group.
- Ongoing collaboration and consultation with public involvement and education staff of other watershed management organizations, as well as counties.

The RWMWD also collaborates in larger regional and state-wide watershed management efforts. The RWMWD believes this is an important way for the District to improve the performance of RWMWD and improve watershed management overall.

As part of its water management role, the RWMWD shares a large amount of data, including water quality monitoring, water quality modeling, and hydrologic (e.g., flood level) data with local units of government, state agencies, and others. The District will annually share its quality-controlled monitoring data with appropriate agencies consistent with MN Rules 8410.0105.

3.2.1.9 WRAPS and TMDL Implementation

The RWMWD also has a general responsibility to improve the water quality of stormwater runoff reaching the Mississippi River from the District. Several District-managed waterbodies are included in the MPCA's impaired waters 303(d) list (see Section 1.10.2). To address impaired waters and protect designated uses, the MPCA uses processes known as a total maximum daily load (TMDL) analysis and/or a watershed restoration and protection strategy (WRAPS). Both TMDLs and WRAPS may result in implementation plans containing specific programs or projects to improve and/or protect the water quality of assessed waterbodies. The District assisted the MPCA in completing a WRAPS study from 2012-2016 (see Section 1.10.5.2) and multiple TMDLs (see Section 1.10.5.3) within the District; results of these studies are incorporated into this Plan. Planned water quality improvement activities identified in the WRAPS and TMDL studies are included in the RWMWD implementation program presented in Table 4-1.

The District will continue to participate in future WRAPS and TMDL studies and may assume a lead role in carrying out the resulting TMDL implementation plans, if appropriate.

3.2.2 City Responsibilities

Coordination of District and City responsibilities is necessary for the District to remain an effective and successful organization. To this end, the following expectations are designated to the cities within the District:

1. **Local Water Management Plan:** Cities shall prepare a local water management plan that conforms to the requirements of Minnesota Rules 8410 and this Plan. The RWMWD shall review and approve each local plan. Section 4.4.1 contains more information about local plan requirements.
    - Cities shall prepare or amend their local plans according to the schedule specified in Minnesota Rules 8410.
    - Cities shall amend their official controls (e.g., ordinances and/or standards), as necessary, to be consistent with this Plan within 2 years of the adoption of this Plan.
    - City local plans shall meet the plan content requirements contained in Section 4.4.1.
    - Cities are encouraged to consult with the RWMWD during the preparation of the local plan to seek the District's input and assistance.
2. **Public Works Group:** The RWMWD formed this group to provide regular opportunities for important communication between the cities, the RWMWD, and other units of government. The forum provides opportunities to organize staff training and discuss public works issues and NPDES MS4 implementation.
    - All cities and counties should participate in this group to provide consistent communication and coordination.
    - All cities should participate in and implement training recommended by the Public Works Group.
3. **Project Review & Permitting**: Cities are responsible for informing developers and other project applicants regarding RWMWD rules and the potential need to obtain a RWMWD permit. Cities are encouraged to develop and implement permit programs for projects that fall below the threshold for a RWMWD permit (e.g., projects less than 1 acre). If cities assume permitting responsibility from the District, those cities are responsible for implementing a permit program consistent with the District. See Section 4.1.2.1 for information about the process for transferring RWMWD permitting authority to the cities.
    - Cities should inform permit applicants, for projects over 1 acre, that they must obtain a Minnesota Construction Site Permit from the MPCA.
    - Cities should inform permit applicants of the need for RWMWD approval and a RWMWD permit for projects meeting specific criteria (see *RWMWD Permit Guidance and Information*

Handbook) and direct them to District staff or to the District website at www.rwmwd.org for more information.

- Cities shall adopt and enforce erosion and sediment control ordinances for all construction activity in the City consistent with a city's MS4 requirements and shall coordinate with the District as needed to ensure compliance.

- Cities should coordinate with the District on city projects early in the planning process to ensure consideration of District rules, standards, and criteria.

4. **Maintenance of City Stormwater Management Systems:** Cities are responsible for the inspection, maintenance, cleaning, repair, and reconstruction of the city's stormwater management system (storm sewers, ponding areas, ditches, water level control structures, etc.) to keep it in good working order to prevent flooding and water quality problems. Such maintenance requirements are addressed in the city's NPDES MS4 stormwater permit (see Section 3.2.4.3) and the city's local water management plan.

   - Cities shall implement good housekeeping and maintenance practices as identified in their MS4 SWPPP.

   - The city's local water management plan shall include a pond maintenance plan to maintain the function and performance of stormwater ponds in the city, consistent with MS4 permit requirements. The city should coordinate with the District on prioritization of ponds that are the most needed for water quality of District resources.

   - Cities should consider the latest research in determining street sweeping frequency and should coordinate with the District on prioritization of street sweeping locations and frequencies.

   - Cities should upgrade their winter street de-icing practices and equipment to be consistent with the recommendations implementation strategies included in the MPCA's *Twin Cities Metropolitan Area Chloride Management Plan*, including the use of the WMAt tool, once available.

5. **City Official Controls:** Future updates to city ordinances and official controls must be consistent with, or adopt by reference, this Plan and the RWMWD Rules. The District encourages the cities to revise their ordinances to be consistent with low impact development principles.

6. **Wetlands Management:** The RWMWD is the LGU responsible for administering the WCA for all the cities in the District except the City of St. Paul. As the LGU, the City of St. Paul is required to manage wetlands in accordance with the WCA.

   - Cities shall promptly refer permit applicants whose projects contain possible wetlands to the RWMWD to identify wetland management issues, review WCA requirements, and identify RWMWD wetland buffer requirements.

- Cities shall reference RWMWD wetland classifications and buffer requirements in local rules or permit information. Cities may implement more stringent buffer requirements than the District; in such cases, the more stringent buffer requirements will apply.

7. **Groundwater:** Cities that operate groundwater wells for drinking water supplies are responsible for developing, adopting, and implementing wellhead protection programs.

    - Cities meeting the above criteria shall submit their wellhead protection plans to the RWMWD during the review process.

    - Cities meeting the above criteria shall submit updates to their water supply plans to the RWMWD for review and comment prior to local adoption. Any District comments are advisory to the City.

    - Cities should coordinate with the District and consider potential for groundwater recharge when planning stormwater management projects.

3.2.3 County Responsibilities

Counties have a wide variety of duties, including property assessment, record-keeping, road maintenance (including street sweeping, and snow/ice control), administration of election and judicial functions, social services, corrections, child protection, library services, hospitals and rest homes, public health services, planning and zoning, economic development, parks and recreation, water quality, and solid waste management and recycling (including yard waste and compost sites).

The counties' responsibilities directly related to RWMWD include:

- Appointing the RWMWD board of managers – Ramsey County appoints four managers and Washington County appoints one manager.

- Levying taxes for the RWMWD.

- Providing bonds for RWMWD capital improvement projects, if needed.

- Groundwater management, including preparing and adopting groundwater plans. The Ramsey Conservation District prepared the county's groundwater plan, which remains in draft form, in 2010. Washington County's groundwater plan received state approval in August 2014 and was adopted by the county in September 2014.

- Adopting and implementing the county's MS4 SWPPP. These plans should include provisions water quality and stormwater best management practices, including maintenance of county-owned stormwater infrastructure.

3.2.4 State and Federal Agency Responsibilities

Various units of state and federal government are involved in regulating water resource related activities and have jurisdiction overlapping that of the RWMWD. The roles of these agencies are described in this Section and summarized in Table 3-1.

3.2.4.1 Minnesota Department of Natural Resources (MDNR)

The MDNR Division of Ecological and Water Resources manages water resources through a variety of programs related to lakes, rivers and streams, watersheds, wetlands, groundwater, and climate. The MDNR Waters administers the Public Waters Work Permit Program, the Water Use (Appropriations) Permit Program, and the Dam Safety Permit Program. MDNR Fisheries administers the Aquatic Plant Management Program and other fishery related permits. The MDNR supports the WCA by providing technical and coordination assistance and by providing recommendations in the development of state wetland regulations, programs, and policies. The MNDNR's shoreland program provides technical assistance to local governments in the adoption of shoreland ordinance controls and comments on land use applications with shoreland districts. The MDNR also has model shoreland ordinances that cities and counties can adopt.

Public Waters

The MDNR's Public Waters Work Permit Program (Minnesota Statutes 103G) requires an MDNR permit for any work below the Ordinary High Water (OHW) level or any work that will alter or diminish the course, current, or cross-Section of any protected water, including lakes, wetlands and streams. For lakes and wetlands, the MDNR's jurisdiction extends to designated U.S. Fish and Wildlife Service Circular #39 Types 3, 4, and 5 wetlands which are 10 acres or more in size in unincorporated areas, or 2.5 acres or more in size in incorporated areas. The program prohibits most filling of protected waters and public waters wetlands for the purpose of creating upland areas. The Public Waters Work Permit Program was amended in 2000 to minimize overlapping jurisdiction with the WCA. Under certain conditions, work can be performed below the OHWL without a Public Waters Work Permit. Examples include docks, watercraft lifts, beach sand blankets, ice ridge removal/grading, riprap, and shoreline restoration. The MDNR public waters in the RWMWD are shown in Figure 1-9 (PWI).

Water Appropriations and Transport

The MDNR regulates surface water and groundwater usage rate and volume as part of its charge to conserve and use the waters of the state. Water appropriations are regulated under Minnesota Rule 6115.0620. Generally, all appropriations of more than 10,000 gallons per day, or one million gallons per year, including construction dewatering, flood control, emptying storm water ponds for maintenance, and storm water use for irrigation, need to be approved under a MDNR Water Appropriation. Appropriation Permits from the MDNR are not required for domestic uses serving less than 25 persons for general residential purposes. An additional permit is required to appropriate or transport water from waters designated as infested with invasive species, regardless of the volume appropriated or transported.

Groundwater

In addition to regulating appropriations from groundwater, the MDNR is also responsible for mapping sensitive groundwater areas, conducting groundwater investigations, addressing well-interference problems, and maintaining the observation well network.

Dam Safety

The MDNR administers the state's Dam Safety Program (MN Rules 6115.0300 – 6115.0520), which applies to all impoundments that pose a potential threat to public safety or property. Dams 6 feet or lower in height and dams that impound 15 acre-feet or less of water are exempt from the rules. Dams less than 25 feet high that impound less than 50 acre-feet of water are also exempt, unless there is a potential for loss of life. The dam safety rules require that the downstream impacts of a dam failure be analyzed under high-flow conditions (i.e., greater than a 100-year flood).

Other Regulations

In addition to permit programs, the MDNR oversees the Floodplain Management Program, the Public Waters Inventory Program, the Shoreland Management Program, the Flood Damage Reduction Grant Program, the Wild and Scenic Rivers Program, various surface and groundwater monitoring programs, and the Climatology Program.

Questions concerning the MDNR's role in water resource management should be directed to the MDNR Division of Ecology and Water Resources, Metro Region, 1200 Warner Road, St. Paul, MN 55106 (651-259-5774). More information is available at the MDNR website: http://www.dnr.state.mn.us.

3.2.4.2 Minnesota Board of Water and Soil Resources (BWSR)

BWSR oversees the state's watershed management organizations (joint powers, county and watershed district organizations), oversees the state's Soil and Water Conservation Districts (SWCDs), and administers the rules for the WCA and metropolitan area watershed management. BWSR, in cooperation with the MDNR and soil and water conservation districts, administers the statewide buffer rule (MN Statutes 103F.48) which establishes minimum buffer requirements for certain public waters. BWSR also administers the Clean Water Fund (CWF) grant program, funded by the Clean Water Land and Legacy amendment passed in 2008. The purpose of the CWF is to protect, enhance, and restore water quality in lakes, rivers, and streams and to protect groundwater and drinking water sources from degradation. Applicants eligible for CWF grants include counties, watershed districts, watershed management organizations, soil and water conservation districts, and cities working under a current BWSR-approved and locally adopted local water management plan.

Questions concerning BWSR's role in water resource management should be directed to the Minnesota Board of Water and Soil Resources, 520 Lafayette Road North, St. Paul, MN 55107 (651-296-3767). More information is available at the BWSR website: http://www.bwsr.state.mn.us.

3.2.4.3 Minnesota Pollution Control Agency (MPCA)

The MPCA administers the State Discharge System/National Pollutant Discharge Elimination System (NPDES) Permit program (point source discharges of wastewater), the NPDES General Stormwater Permit for Construction Activity, the NPDES General Industrial Stormwater Permit Program, the NPDES Storm Water Permit program, and the individual sewage treatment system regulations (7080 Rules). The MPCA

also reports the state's "impaired waters" to the U.S. Environmental Protection Agency. Spills should be reported directly to the MPCA.

The MPCA administers and enforces laws relating to pollution of the state's waters, including groundwater. The MPCA monitors ambient groundwater quality and administers subsurface sewage treatment system (SSTS) design and maintenance standards. The MPCA is responsible for administering the programs regulating construction and reconstruction of SSTS. The MPCA requires an inspection program for SSTS that meets MPCA standards. Minnesota Rules 7080 govern administration and enforcement of new and existing SSTS. The Tanks and Spills Section of the MPCA regulates the use, registration, and site cleanup of underground and above-ground storage tanks.

The MPCA resumed selective administration of Section 401 of the Clean Water Act Water Quality Certification program in 2007. The program is primarily administered by the U.S. Army Corps of Engineers (USACE). Section 401 Certification is required to obtain a federal permit for any activity that will result in a discharge to navigable waters of the United States. Formal applications for 401 Certification must be sent to the MPCA.

Construction Stormwater Permitting

Proposers of projects smaller than 1 acre that are a part of a larger common plan of development or sale that is 1 acre or more must also obtain permit coverage. The NPDES General Stormwater Permit for Construction Activity (construction stormwater permit), which went into effect in 2003, regulates discharges of stormwater affected by construction activity to waters of the state. The MPCA updated the construction stormwater permit in 2013. A key permit requirement is the development and implementation of a stormwater pollution prevention plan (SWPPP) with appropriate best management practices (BMPs). The SWPPP must be a combination of narrative and plan sheets that address foreseeable conditions, include a description of the construction activity, and address design requirements including temporary and permanent BMPs to control the discharge of stormwater, sediment, and/or other potential pollutants from the site. The project's plans and specifications must incorporate the SWPPP before applying for NPDES permit coverage. The permittee must also ensure final stabilization of the site, which includes final stabilization of individual building lots.

The SWPPP must address the following construction activity requirements (from Section IV of the construction stormwater permit):

- Temporary and permanent erosion prevention practices
- Sediment control practices
- Dewatering and basin draining
- Inspections and maintenance
- Pollution prevention management measures
- Final stabilization

A significant change in the 2013 update of the construction stormwater permit is the inclusion of a volume control requirement. For projects that replace vegetation or other pervious surfaces with 1 or more acres of cumulative impervious surface, the permittee must retain on-site a volume of stormwater equal to 1 inch of runoff over the new impervious surface. In situations where infiltration is prohibited, the construction stormwater permit requires stormwater treatment using wet ponds, filtration, regional ponding, or other equivalent methods.

Municipal Separate Storm Sewer System (MS4) Permitting

The federal Clean Water Act (CWA) established the National Pollutant Discharge Elimination System (NPDES) to regulate point sources of pollution, with the MPCA as the delegated permitting authority. This program was later expanded to include both point and non-point sources of pollution, including the regulation of stormwater runoff, and created a two-phase comprehensive national program to address stormwater runoff. Phase I of the program was implemented in 1990 and covered two general categories of stormwater discharge including 11 categories of industrial activities (including construction) and Municipal Separate Storm Sewer Systems (MS4s) serving populations of 100,000 or more (e.g., St. Paul). A few years later, Phase II of the program was implemented. Phase II was a broader program that included smaller construction sites, municipally owned or operated industrial activities, and many more municipalities (MS4s).

In 2013, the MPCA reissued the MS4 General Permit, which replaced the Phase II permit. The permit focus shifts from permit program development to increasing emphasis on measured progress and beginning some of the implementation measures. Some of the requirements of the reissued MS4 permit include:

- More stringent construction related erosion control
- Post-construction controls to reduce volume, total phosphorus, and total suspended solids
- Documented enforcement response procedures
- Submittal of additional information on all stormwater ponds and outfalls
- Inventories of municipal facilities that could contribute pollutants to stormwater discharges

All of the cities within the RWMWD are required to maintain an MS4 permit from the MPCA. As part of the permit program, each member city must annually submit an MS4 report to the MPCA. The numerous and expanded requirements of the MPCA's MS4 permit present opportunities for the RWMWD to cooperate with member cities to prevent redundancy in implementing or reporting on activities related to water quality.

More information about the MPCA's stormwater program can be found at the MPCA's website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/index.html.

Impaired waters and Total Maximum Daily Loads (TMDLs)

In administering the CWA in Minnesota, the MCPA also maintains a list of impaired waters (see Section 1.10.2). The CWA requires the development of a total maximum daily load (TMDL) study for

impaired waterbodies. A TMDL is a threshold calculation of the amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL establishes the pollutant loading capacity within a waterbody and develops an allocation scheme amongst the various contributors, which include point sources, non-point sources, and natural background levels, as well as a margin of safety. As a part of the allocation scheme a waste load allocation (WLA) is developed to determine allowable pollutant loadings from individual point sources (including loads from storm sewer networks). A load allocation (LA) establishes allowable pollutant loadings from non-point sources and natural background levels in a waterbody.

A watershed restoration and protection strategy (WRAPS) is similar to a TMDL and may examine other waterbodies in the watershed in addition to impaired waterbodies. Both TMDLs and WRAPSs may result in implementation plans to address water quality issues of the affected waterbodies. Impaired waters with approved TMDLs within the RWNWD are identified in Table 1-4.

Guidance for Dredged Materials

The MPCA considers material excavated below the OHW level of waterbasins, watercourses, public waters, or public waters wetlands (as defined by Minnesota Statutes 103G.005) to be dredged material. Dredged material is defined as waste and regulated by the MPCA. The MPCA provides guidance for the management of dredged material on its website: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/wastewater/dredged-materials-management.html.

In 2012, the MPCA developed specific guidelines for the removal of sediment from stormwater ponds. Guidance for the removal of sediment from municipal stormwater ponds differs from guidance for other dredged materials in three primary ways:

1. Permits are not required when performing routine maintenance on stormwater conveyance and collection systems.

2. The MPCA does not need to be notified of sediment removal activities. The MPCA recommends that cities keep records and documentation of sediment removal projects.

3. Best management practices were revised to include guidance from cities that have experience performing sediment removal projects.

Disposal options for sediment dredged from municipal stormwater ponds vary according to the level of contamination present in the excavated material. The document provides guidance for collecting samples and testing sediment, and calculating chemical concentrations relative to soil reference values (SRVs). The number of samples to be collected depends on the surface area of the pond. More detailed information regarding the disposal of sediment from stormwater ponds is available from the MPCA website: http://www.pca.state.mn.us/index.php/view-document.html?gid=18075.

Questions concerning MPCA's role in water resource management should be directed to the Minnesota Pollution Control Agency, 520 Lafayette Road, St. Paul, MN 55155-4194 (651-296-6300). More information is available at the MPCA website: http://www.pca.state.mn.us.

3.2.4.4 Minnesota Department of Health (MDH)

The MDH is the official state agency responsible for addressing all public health matters, including drinking water protection. The MDH administers the Well Management Program, the Wellhead Protection Program, and the Safe Drinking Water Act rules. The MDH also issues fish consumption advisories. The MDH is responsible ensuring safe drinking water sources and limiting public exposure to contaminants. Through implementation of the federal Safe Drinking Water Act, the MDH conducts the Public Water Supply Program, which allows the MDH to monitor groundwater quality and train water supply system operators. The 1996 amendments to the federal Safe Drinking Water Act require the MDH to prepare source water assessments for all of Minnesota's public water systems and to make these assessments available to the public.

Through its Well Management Program, the MDH administers and enforces the Minnesota Water Well Code, which regulates activities such as well abandonment and installation of new wells. The MDH also administers the Wellhead Protection Program, which is aimed at preventing contaminants from entering public water supply wells.

The Wellhead Protection Program rules (Minnesota Rules 4720.5100 to 4720.5590) went into effect in 1997. These rules require all public water suppliers that obtain their water from wells to prepare, enact, and enforce wellhead protection plans (WHPPs, see Section 1.6.4). The MDH prepared a prioritized ranking of all such suppliers in Minnesota. Regardless of the ranking, Minnesota Rules 4720 required all public water suppliers to have initiated wellhead protection measures for the inner wellhead management zone prior to June 1, 2003. If a city with an existing WHPP drills a new well and connects it to the distribution system, the WHPP must be amended.

Wellhead protection plans include: delineation of groundwater "capture" areas (wellhead protection areas), delineation of drinking water supply management areas (DWSMA), an assessment of the water supply's susceptibility to contamination from activities on the land surface, management programs such as identification and sealing of abandoned wells, and education/public awareness programs. As part of its role in wellhead protection, the MDH developed the guidance document *Evaluating Proposed Stormwater Infiltration Projects in Drinking Water Supply Management Areas* (MDH 2016).

Questions concerning the MDH's role in water resource management should be directed to the Minnesota Department of Health, P.O. Box 64975, St. Paul, MN (651-201-5000). See the Minnesota Department of Health website for more information about these programs: http://www.health.state.mn.us/divs/eh/water/index.html.

3.2.4.5 Minnesota Environmental Quality Board (EQB)

The EQB administers the state's environmental review program, including Environmental Assessment Worksheets (EAW), Environmental Impact Statements (EIS), and Alternative Urban Area-wide Reviews

(AUAR). EAWs and EISs prepared for projects within RWMWD or that could affect the RWMWD's resources must be submitted to the RWMWD for review and comment. With respect to water resources, the EQB is responsible for developing the state water plan, a state water monitoring plan, biennial water policy and priorities reports, and biennial reports on trends in water quality and availability and research needs. Questions concerning the EQB's role in water resource management should be directed to the Minnesota Environmental Quality Board, 520 Lafayette Road North, St. Paul, MN 55155 (651-296-9027). More information is available at the EQB website: http://www.eqb.state.mn.us

3.2.4.6 Minnesota State Historic Preservation Offices (SHPO)

Following the National Historic Preservation Act of 1966, Minnesota's State Historic Preservation Office (SHPO) was established by state statute in 1969. The director of the Minnesota Historical Society serves as State Historic Preservation Officer. The mission of the SHPO is to preserve and promote Minnesota history by identifying, evaluating, registering, and protect Minnesota's historic and archaeological properties and assisting government agencies in carrying out their historic preservation responsibilities. The SHPO maintains the National Register of Historic Places (NRHP) for the state. This includes listed or eligible to be listed places within the RWMWD. To ensure the protection of places eligible for listing or listed in the NRHP, SHPO review is required for all state and federally funded projects, and all United States Army Corps of Engineers (USACE) projects.

Questions concerning SHPO's role in historical resource management should be directed to the Minnesota State Historic Preservation Office, 345 Kellogg Boulevard West, St. Paul, MN 55102-1903 (651-259-3450). More information is available at the SHPO website: http://www.mnhs.org/shpo/.

3.2.4.7 Minnesota Department of Transportation (MnDOT)

The MnDOT is responsible for major maintenance and reconstruction of stormwater infrastructure associated with state highways. In the RWMWD, these locations include Interstate 494, Interstate 694, Interstate 35E, and US Highway 61.

Questions concerning MnDOT's role in water resource management should be directed to the Minnesota Department of Transportation, 395 John Ireland Boulevard, St. Paul, MN 55101-1638 (651-296-3000). More information is available at the MnDOT website: http://www.dot.state.mn.us.

3.2.4.8 U.S. Army Corps of Engineers (USACE)

The USACE administers several regulatory permit programs, including Section 10 of the Rivers and Harbors Act permit program, the Section 404 permit program, and Section 401 Certifications. The USACE updated Section 10 of the Rivers and Harbors Act Permit and the Section 404 Permit in March 2012 to streamline the requirements of the Clean Water Act (CWA). The updated permits provide expedited review of projects that have minimal impact on the aquatic environment. These projects may include linear transportation projects, bank stabilization activities, residential development, commercial and industrial development, aids to navigation, and some maintenance activities. Permit programs are described briefly in this section.

Through Section 10 of the Rivers and Harbors Act, the USACE is responsible for administering this program, which regulates the placement of structures and/or work in, or affecting, navigable waters of the United States.

The Federal Clean Water Act requires that anyone who wants to discharge dredged or fill material into U.S. waters, including wetlands, must first obtain a Section 404 Permit from the USACE. Examples of activities that require a Section 404 Permit include: construction of boat ramps, placement of riprap for erosion protection, placing fill in a wetland, building a wetland, construction of dams or dikes, stream channelization, and stream diversion. When Section 404 Permit applications are submitted to the USACE, the applications are typically posted for the U.S. Fish and Wildlife Service, the U.S. Forest Service, the U.S. EPA, and other federal agencies to review and provide comments. The USACE evaluates permit requests for the potential impact to various functions and values of the wetland.

Section 401 Certification is required to obtain a federal permit for any activity that will result in a discharge to navigable waters of the United States. The program is primarily administered by the USACE along with the MPCA. A Section 401 Water Quality Certification may be granted if the applicant demonstrates that the proposed activity "will not violate Minnesota's water quality standards or result in adverse long-term or short-term impacts on water quality." Greater protection is given to a category of waters designated by the MDNR as Outstanding Resource Value Waters (ORVW). The waters in this category have received this designation because of their exceptional value. These waters include such groups as scientific and natural areas, wild, scenic and recreational river segments, and calcareous fens.

Questions concerning the USACE's role in water resource management should be directed to the U.S. Army Corps of Engineers, St. Paul District, 180 East 5th Street, St. Paul, MN 55101-1678 (651-290-1678). More information is available at the USACE website: http://www.usace.army.mil/.

3.2.4.9 The Metropolitan Council

The Metropolitan Council provides regional planning and wastewater services (collection and treatment) for the seven county metropolitan area. The Metropolitan Council provides review and comment on watershed management plans, local water management plans, and local comprehensive (land use) plans; conducts lake monitoring (including the Citizen Assisted Monitoring Program); and conducts river and stream monitoring.

Questions concerning the Metropolitan Council's role in water resource management should be directed to the Metropolitan Council, 390 Robert Street North, St. Paul, MN 55101 (651-602-1000). More information is available from the Metropolitan Council's website: http://www.metrocouncil.org/.

Table 3-1 Summary of State and Federal Regulatory Authorities within the RWMWD

Agency	Type of Approval	Description
Federal		
U.S. Army Corps of Engineers (USACE)	Section 10 of the Rivers and Harbors Act	Applies to placement of structures and/or work in, or affecting, navigable waters of the United States.
	Section 404 Permit	Applies to the discharge of dredged or fill material into waters of the United States. There are two types of Section 404 permits: regional and nationwide general permits, and individual permits.
Note: Section 401 Certification is implemented in coordination with the MPCA.	Section 401 of the Clean Water Act Water Quality Certification	Applies to activities that require a Corps of Engineers Section 10, Corps of Engineers Section 404 or Federal Energy Regulatory Commission permit. These activities must first obtain Section 401 water quality certification.
State		
Minnesota Department of Natural Resources (MDNR)	Public Waters Work Permit	Applies to any work that will alter the course, current or cross-Section of any MDNR public water lake, wetland or watercourse; also applies to any work below the ordinary high water mark of MDNR public waters.
	Groundwater or Surface Water Appropriation Permit	Applies to suppliers of domestic water to more than 25 people or for any use of groundwater or surface water that exceeds 10,000 gallons/day or 1,000,000 gallons/year.
	Dam Safety Permit	Applies to impoundments that pose a potential threat to public safety or property. Dams 6 feet high or less and dams that impound 15 acre-feet of water or less are exempt from the rules. Dams less than 25 feet high that impound less than 50 acre-feet of water are also exempt unless there is a potential for loss of life.
	Riprap Shore Protection Permit	Applies to the placement of riprap shore protection or placement of fill to recover shoreland lost to erosion.
	Aquatic Plant Management Permit	Applies to chemical or mechanical removal of aquatic plants, including submerged, emergent, and floating vegetation.
	Fisheries Permit	Applies to transport and stocking of fish and the removal of rough fish.
Minnesota Environmental Quality Board (EQB)	Environmental Assessment Worksheet	Broad environmental assessment required for certain proposed developments and other activities.

Agency	Type of Approval	Description
Minnesota Department of Health (MDH)	Well Management Program	Applies to drilling of new water wells and sealing of abandoned water wells. Includes Wellhead Protection Program.
	Safe Drinking Water Act	Applies to construction of new water wells and other public water supply systems
Minnesota Pollution Control Agency (MPCA)	State Discharge System/National Pollutant Discharge Elimination System (NPDES) Permit	Applies to all discrete sources of wastewater discharge to surface waters, including sanitary wastewater, process wastewater, etc.
	NPDES/SDS Construction Stormwater Permit	Applies to construction activities that disturb 1 or more acres of land.
	NPDES General Industrial Stormwater Permit	Applies to certain industrial/ commercial activities that come into contact with stormwater. Requires preparation of stormwater pollution prevention plan.
Minnesota Pollution Control Agency (MPCA) Note: Section 401 Certification is implemented in coordination with the USACE.	NPDES General Storm Water Permit for small Municipal Separate Storm Sewer Systems (MS4s) Note: St. Paul is a large MS4 and operates under an individual permit.	Applies to municipal storm sewer systems serving populations fewer than 100,000 located in urbanized areas, MnDOT, counties, and other public systems (e.g., universities). Requires permitees to implement public education programs, detect and eliminate illicit discharges, control construction site and post-construction stormwater runoff on sites that disturb 1 or more acres of land, and address pollution prevention at municipal operations.
	NPDES Phase 1 MS4 Storm Water Permit	Applies to municipal storm sewer systems serving populations over 100,000 (in Minnesota, only Minneapolis and St. Paul). Requires practices similar to permit for small MS4s, plus additional requirements.
	Permit for disposal of dredged material (permit not required for stormwater ponds)	Applies to material excavated at or below the ordinary high water level of waterbasins, watercourses, public waters, or public waters wetlands (note: specific guidance provide for material removed from stormwater ponds).
	Section 401 of the Clean Water Act Water Quality Certification	Applies to activities that require a Corps of Engineers Section 10, Corps of Engineers Section 404 or Federal Energy Regulatory Commission permit. These activities must first obtain Section 401 water quality certification.

4.0 District Operations and Implementation

This Section describes District operational programs and presents the District's implementation program (Table 4-1). The implementation program summarizes the activities the District seeks to accomplish during the life of this Plan, including ongoing programs, studies, and capital improvement projects. Methods for prioritizing and funding capital projects are also discussed in this section.

4.1 District Operations

4.1.1 Administrative Programs

The RWMWD administrative programs are an integral part of the RWMWD strategy to achieve the goals set by the RWMWD Plan and the Board of Managers. It is through the RWMWD administrative programs that the RWMWD will manage the operations of the District, provide fiscal management, and develop and implement methods/programs for measuring, tracking, and reporting progress towards meeting the goals of the RWMWD Plan (as stated in the Strategic Overview). Measurement methods/programs could include monitoring efforts, such as water quality monitoring and lake water-level monitoring (all of these are discussed in Section 4.1.7); surveys; tracking the numbers and types of participants in RWMWD programs, projects, and events; and financial audits; to name a few. As part of this effort, the RWMWD will review this Plan on an annual basis to assess its progress towards plan implementation.

4.1.1.1 RWMWD Fiscal Management

The RWMWD will fund its operations and implementation program using three primary sources:

1. Property tax levy
2. Grant funds
3. Local cost-share funding

Approximately 95% of the RWMWD's funds for implementing capital projects, programs, and other operations are raised through a property tax levy. This tax is an ad valorem tax (a tax on all taxable parcels in the District that is based on property value). The RWMWD legal boundary defines the area of land that comes under the District's jurisdiction and the area upon which the ad valorem tax is applied. The legal boundary must follow property boundaries or other legally definable boundaries (e.g., roads), and a single property cannot be in more than one watershed district. This can result in significant differences between the legal boundary and the hydrologic boundary. The RWMWD will keep the District's legal boundary matched to its hydrologic boundary as accurately as possible, so that the land that drains to RWMWD water resources is captured within the legal boundary to the maximum extent possible.

In the Twin Cities metropolitan area, watershed districts have the authority to levy an ad valorem tax to pay for the costs of implementing their watershed management plan. This includes costs related to the District's operations (e.g., facilities and staff), programs, capital improvement projects, and maintenance. The District also has the authority to finance large capital projects by selling bonds or securing loans.

4.1.1.2 Work Program and Budget Process

The following process provides a method for the development of each year's budget and assessing consistency with the RWMWD Plan (e.g., goals, action items). The RWMWD will develop a work plan annually. The process will incorporate program evaluation (evaluation of the "Signs of Success"), track changes to the original plan content and projections, and determine if plan amendments are required.

I. Content.

a. Review of previous year's work program and accomplishments. Did we complete tasks identified? What were the documented "Signs of Success"?

b. Discussion of studies, data, and public input that influences proposed projects, schedules, and budgets.

c. Identification of new issues for potential inclusion in work program and budget. What influence or effect does the new issue have on established priorities, programs, or projects?

d. Identification of funding issues presented by proposed work program – bonding needs, levy adjustments, budget/levy policy impacts, new funding approaches.

e. Summary of the projects and programs identified in the plan for each subwatershed (including ongoing administrative programs) with scheduling and funding estimates provided in the plan and any proposed adjustments (identifying completed efforts, ongoing efforts, and updated project schedules and budgets). For each of the identified projects and programs, the responsible entity/entities and funding source(s) will be recommended.

f. Need for plan amendments – identify whether changes require amendments (see Section 4.5.3 or fall within the discretion of the District under its current Plan.

g. Estimated annual budget by major program area. This budget table shall reference the applicable RWMWD goals.

II. Development of work program and review process.

a. Information identified in "I" shall be collected and developed beginning in March of each year and presented to the Board of Managers by July 1 for use in the development of the preliminary budget.

b. The proposed work program, budget, and levy will be presented to the Board of Managers for discussion no later than the August Board meeting.

c. The preliminary budget (including annual capital improvement budget [CIB]) and levy shall be presented at a public hearing, deliberated by the Board, and approved at the September Board meeting, prior to September 15 of each year.

d. The preliminary levy shall be certified to Ramsey and Washington Counties by September 15 of each year.

e. Identified plan amendments shall be drafted and submitted to the Board of Managers for review and approval at the September Board meeting and to the agencies for review by September 15.

f. Following local review of the proposed District work program and budget, the Board of Managers shall revise, if necessary, and approve the final work program, budget, and levy. The levy shall be certified to the counties by December 28 of each year.

4.1.1.3 Staffing Plan

The RWMWD has 12 full-time employees as of the writing of this Plan. The District also hires seasonal interns to help with permit inspection, water quality monitoring, natural resources management, and site maintenance. Current employees provide program support in the following program areas:

Program Area	Number of Staff	Number Seasonal Staff
Administration	4	--
Natural Resource Management	2	2
Education and Communications	1	--
Permit and BMP Incentive Programs	2	1
Water Quality Monitoring	2	1
GIS and Data Management	1	--

As the District implements its Strategic Communications Plan, the District may need to hire additional staff to support the education and communications programs. For example, future changes in state or federal law requiring additional program activity or responsibility may require additional staff resources. Staff will be added as needed to accomplish the District's programs.

Other possible staff needs could result from the request for services from adjacent WMOs or from local units of government within the RWMWD. These requests are now being met with existing resources. Requests for assistance will be considered under the following conditions:

- The requested assistance is a service or expertise that the requesting unit of government does not currently have available.
- The requested service is a technical or administrative skill that does exist within the RWMWD staff and the provision of this staff time and expertise will not detract from existing or planned District work program commitments.
- The requesting unit of government will pay for the full cost of District staff time, benefits, and equipment charges and will pay adjusted rates as requested.
- Any equipment required is either currently available at the District or will be provided by the requesting unit of government.

- The requesting unit of government will sign a letter of agreement stipulating services to be provided, rates, and termination conditions.
- Any outside consulting services required in the completion of the agreement will be contracted directly with the requesting unit of government.

Small increases in staffing needs will first be met through hiring qualified temporary staff (interns) or engaging strategic consulting services. Consultant services provide a specific technical expertise directed at a specific service need and require minimal administrative support and no District support services, space, or long-term commitment.

4.1.1.4 Office Space and Equipment

The RWMWD moved into its own office headquarters building in December 2005. The District headquarters provides for staff offices, support facilities, and meeting facilities. The office and grounds were designed to meet the needs of the District into the foreseeable future.

The RWMWD offices are equipped with the necessary office equipment and program support equipment to perform required staff functions such as staff computing and communications, water quality monitoring, site maintenance activities, classroom education, and site inspection. District vehicles are also housed at the office headquarters building.

It is the intent of the RWMWD to provide necessary space, support services, vehicles, and equipment for District staff to perform their required tasks in an efficient and cost-effective manner. The RWMWD's budget will provide for routine equipment replacement to reduce maintenance costs and provide technology consistent with the current state of the practice.

The RWMWD office and grounds will be maintained in good operating condition through staff support and contracted services where needed.

4.1.2 RWMWD Permit Program

The stormwater runoff from new development, redevelopment, and other project sites poses water quality and quantity concerns. To address these issues, the RWMWD implements a regulatory program that:

- Requires grading permits for projects with 1 acre or more of land disturbance and those involving any alteration to wetlands or floodplain areas.
- Provides for inspection of sites where permits have been issued.
- Provides for enforcement of permit provisions.

As part of the permit process, the RWMWD reviews the grading permit applications from municipalities, counties, state agencies, and private developers that propose the alteration of land. The RWMWD will issue permits based on the project's compliance with the District's standards and rules and regulations; the RWMWD will not approve permits for projects that appear detrimental to the best interests of the District's water resources.



Erosion control at a construction site

The RWMWD rules and regulations are available under the "Permit Program" tab on the RWMWD website (www.rwmwd.org) or through the District office. Permit applicants must comply with rules for stormwater management, wetland management, erosion and sediment control, flood control, and illicit discharge and connection.

Through its permit inspection program, the RWMWD inspects all active, permitted project sites for compliance with RWMWD permit requirements. Permit holders found to be non-compliant are contacted and directed to conform to permit guidelines. If no action is taken in response to staff requests, the RWMWD may issue a Stop-Work Order or take other legal action to compel compliance.

The RWMWD grading permit application deadlines and RWMWD grading permit application form, which includes the submittal requirements and permit fee schedule, are available on the RWMWD website or through the RWMWD office.

The RWMWD has a process for granting variances from the District rules and regulations. The process is outlined in the RWMWD rules and regulations.

The RWMWD is the Local Government Unit (LGU) responsible for administration and enforcement of the Wetland Conservation Act (WCA) rules (Minnesota Rules 8420) for all cities in the District, except the City of St. Paul, and except for Minnesota Department of Transportation (MnDOT) projects (see Section 3.2.1.2). The WCA requires that all wetlands be protected regardless of type or size. As part of administering the WCA rules, the RWMWD is responsible for making determinations on the accuracy of wetland delineations, wetland functions and values assessments, and wetland replacement plans, often with review and input by the Technical Evaluation Panel (TEP). The District also issues certificates of exemption or replacement when appropriate. Requests for wetland filling or modification must be accompanied by information that indicates there are no options available except to fill, that the fill or impact is minimal, and that any impacts are mitigated by creating wetland habitat or restoring old wetlands (i.e., the District requires the sequence of "avoid, minimize, and mitigate" for wetland impacts). The WCA requires that the RWMWD notify the TEP, Minnesota Department of Natural Resources (MDNR), and any persons who have requested notification, of all wetland replacement plan applications. For projects where less than 10,000 square feet of wetland impacts are proposed, the notice must contain at least a summary of the application. For projects where more than 10,000 square feet of wetland will be impacted, the notice must include the complete application.

The RWMWD also requires wetland buffer protection and pretreatment of stormwater prior to discharge to a wetland. These requirements vary depending on the classification of the wetland (see Section 1.11.3). The District provides a method for challenging the RWMWD wetland classification, if necessary. The classification system is based on a scientific assessment methodology which provides an accurate and quantifiable ranking of the wetland function and values. The method is documented so it may be applied by others in the scientific community. The first step in challenging a wetland classification is to have the wetland assessed by a qualified wetland specialist using MnRAM version 3.4 or later. MnRAM 3.4 is available free of charge at the Minnesota Board of Water and Soil Resources website (www.bwsr.state.mn.us). The wetland assessment must occur between May 1 and October 15 and allow adequate time for a field review by District staff within those dates. The assessment must be accompanied by the complete MnRAM 3.4 data with documented reasons for a management classification change. District staff will review the data and provide a recommendation to the RWMWD Board of Managers. The proposed management classification change will be decided upon by the Board of Managers at their monthly meeting.

In addition to meeting RWMWD requirements and the requirements of other local units of government, proposers of projects that disturb 1 or more acres of land must obtain a National Pollutant Discharge Elimination System (NPDES) Construction Stormwater Permit from the Minnesota Pollution Control Agency (MPCA). Additional information about the NPDES Construction Stormwater Permit is presented in Section 3.2.4.3 and available at the MPCA website: http://www.pca.state.mn.us/water/stormwater/stormwater-c.html.

Proposers of projects requiring surface water or groundwater appropriation of more than 10,000 gallons per day or 1 million gallons per year, including construction dewatering, emptying of stormwater ponds for maintenance, and stormwater use for irrigation, must obtain a water appropriations permit from the MDNR. District projects are also subject to this requirement.

The District will collaborate whenever necessary with the following federal and state permit programs.

- MPCA NPDES Individual Discharge Permits (e.g., industrial process wastewater discharges, wastewater treatment plant discharges, etc.)
- MPCA Solid Waste Permits
- MPCA Hazardous Waste Permits
- MPCA Liquid Storage Permits
- MDNR Public Waters Work Permits – the RWMWD receives a copy of these applications for review and comment
- MDNR Water Appropriation Permit – the RWMWD receives a copy of these applications for review and comment

4.1.2.1 Transfer of RWMWD Permitting Authority to Local Units of Government

If a local unit of government within RWMWD wishes to re-establish its permitting authority for all land alteration activities (i.e., take over permitting authority from the RWMWD), the local unit of government must first prepare a local water management plan (local plan), obtain RWMWD approval of the local plan, and then adopt and enforce stormwater management and erosion control ordinances. These ordinances must conform to the RWMWD Plan and the RWMWD standards/rules and regulations.

The final step in the process is for the RWMWD and the local unit of government that wishes to re-establish permitting authority (i.e., take over permitting from RWMWD) to enter into a joint powers agreement. The agreement will define regulatory responsibilities and will stipulate that the local unit of government issue and enforce permits consistent with their approved local plan. Under the joint powers agreement concept, the RWMWD and the local unit of government will be able to adjust their permitting powers to best suit the needs and abilities of each party. The RWMWD will not issue permits within a local unit of government after execution of such a joint powers agreement, but it will retain the right to monitor the local unit of government's permitting activity with regard to enforcement and consistency with approved management plans. For the first year following execution of a joint powers agreement, the monitoring will be accomplished through the local unit of government forwarding development and project plans and computations to RWMWD that show compliance with the local plan and the RWMWD Plan. No construction may begin until at least 2 weeks after RWMWD receives this information. Assuming the first year's monitoring shows satisfactory implementation of the local unit of government's permit program, future monitoring will be accomplished through normal teamwork communications and through spot checks where appropriate and necessary. The RWMWD will continue to administer the RWMWD permitting program in areas where local units of government choose not to enter into a joint powers agreement with the District.

As provided in the joint powers agreement, the RWMWD may appeal a local unit of government's approval of a project if the RWMWD believes the project is not consistent with the community's local water management plan.

4.1.3 Best Management Practices (BMP) Incentive Program

The RWMWD Best Management Practices (BMP) Incentive Program offers financial, educational, and technical assistance to public and private landowners to install practices to protect and improve water and natural resources within the watershed. Assistance is available to homeowners, government agencies, churches, schools, and homeowner associations, as well as commercial sites implementing projects that improve stormwater runoff which are above and beyond any permit requirements. Project goals include:

- Protecting and restoring clean water by capturing pollutants in rain water runoff
- Enhancing and restoring native plant communities
- Preserving and protecting groundwater quality and quantity
- Preventing flooding or lessening the effects of drought

Projects eligible for cost share coverage include habitat restoration, cisterns, rain gardens, infiltration or filtration basins, underground treatment systems, pervious pavement, tree trenches, green roofs, and shoreline restoration. All applications are reviewed by staff and any request for over $5,000 must be approved by the RWMWD Board of Managers. Funds provide reimbursement for a portion of material and labor costs and are available for up to 1 year after project approval.

Since the inception of the District's BMP Incentive Program in 2006, about 280 cost-share projects have been implemented using over $3.1 million in cost-share funds. A little over half of these projects are installed on residential property. The rest are divided between a variety of larger projects installed by public and private landowners. The level of the RWMWD's fiscal involvement in each project depends on project type, treatment provided, and location within the watershed district. Projects within a subwatershed that drains to an impaired or at-risk waterbody can currently receive up to 100% funding. RWMWD also offers free technical assistance through the BMP Incentive Program. Technical assistance includes project location guidance, BMP design, and assistance with plant selection. Staff work with property owners to design a project that works on their property and will provide the treatment necessary to meet RWMWD goals. Pollutant removal and volume reduction are calculated for each BMP and maintained in the District's database. Results for each BMP are used to track progress in meeting water quality goals in each subwatershed.

RWMWD requires a 5-year maintenance commitment for residential projects and a 20-year contract for larger projects receiving BMP Incentive Program funds. RWMWD staff conducts annual inspections to ensure each BMP installed through this program is maintained properly and functioning as designed. Any BMP found to be out of compliance is issued an inspection report with detailed findings and a timeline for taking corrective action. The District will share inspection reports with a city at the city's request.

4.1.4 Public Involvement and Education Program

4.1.4.1 Program Development

The RWMWD vision for the Public Involvement and Education (PIE) Program is that District residents will accept their citizenship responsibility towards protecting local water resources. The mission of the PIE program is to inform and empower communities and engage them in being partners in the improvement and protection of the watershed through collaborative and individual efforts.

The RWMWD has established target audiences for the PIE program and tracks progress in reaching these audiences. These target audiences are:

- Schools and youth groups
- City staff and officials
- Businesses
- Faith communities
- Peer education and other specialists who partner with RWMWD
- Neighborhoods and targeted subwatershed communities
- The general public

All RWMWD staff members are involved in the education, engagement, and empowerment of the community. Each District program has targeted clientele – for example, the RWMWD Permit Program and project management staff interact with and provide information for developers and related groups, schools, churches, and businesses. The Natural Resources Program staff engage with a wide variety of audiences and provide education for other agencies, peers, city and county park staff, those who want to learn about or partner on demonstration projects, environmental commissioners, citizens, schools, Master Gardeners and other volunteers, lakeshore associations, the District's Landscape Ecology Award Program team, and the Citizen Advisory Commission. Because of their emphasis on research, Natural Resources Program staff play an important role in sharing new information about natural resources, ecological practices, and recommended new approaches to address ecological and water quality issues with District staff, peers, and the community.

The PIE Program staff and its consultants interact with and engage schools, city staff, the general public, community organizations, faith communities, businesses, volunteers, lakeshore associations, the Citizen Advisory Commission, peer educators, and media representatives. The GIS Specialist supports community outreach through many communication efforts and provides maps and data for education and reporting. All of these interactions provide opportunities for RWMWD staff to be educators. Cooperation and collaboration among RWMWD staff has given rise to programs that offer many opportunities to interface and engage with multiple audiences. Staff from these departments and the District's administrative staff are also involved in communications and education through RWMWD's website, social media, and blog/newsletter.

The PIE program has evolved over time. Since 1998, the PIE staff has applied sustainable education principles to build focus, continuity, community spirit, and longevity into the growing practice of watershed stewardship as a citizenship responsibility. The PIE program intentionally includes activities and stewardship actions designed to:

1. Attract people of all ages, interests, and skill levels
2. Provide multiple entry points for engagement
3. Ensure relevance based on interests and audiences
4. Build technical knowledge and expertise
5. Empower participants to take action and understand why this is important
6. Encourage citizens to teach others and pass on their skills and knowledge
7. Create institutional support for change

4.1.4.2 Citizen Advisory Committee

The RWMWD created a Watershed Advisory Commission (WAC) in January 2007 to expand public involvement in RWMWD programs and projects and open new opportunities for creative activities. In 2013, this commission was reorganized to develop a Citizen Advisory Committee (CAC) with

representation from citizens who live in each of the District's cities and fulfill other criteria (e.g., Master Gardener and Master Naturalist program representatives).

The CAC meets bi-monthly to support District programs, projects, and events. They are kept informed of initiatives in the District, offer feedback on programs, review the annual budget, and participate in an annual District tour to become more familiar with District projects. They are responsible for soliciting and recommending nominations for the Watershed Excellence Award programs and recruiting artists to create these awards. They offer volunteer support at WaterFest and other watershed events, participate in an annual restoration/planting project, and engage in special CAC-driven projects such as the Water Trail project on Keller Creek designed to encourage more people to explore the Phalen Chain of Lakes via watercraft and on trails. The CAC advises the Board of Managers on topics as requested.

4.1.4.3 Engaging the Public and Communities in Water and Natural Resource Management

Key roles in the PIE program are to educate and support the engagement of citizens, institutions, cities, and communities in the implementation of BMPs that support improved water quality, enhance natural resources, reduce non-point pollution, limit chloride use, manage invasive species, and respond to emerging issues related to groundwater use and climate change. The District's approach to education needs to be adaptive and responsive to keep up with evolving environmental concerns, communication approaches, and strategies for community organizing and dissemination of information.

These are some of the driving forces behind the District's adaptive educational strategies:

1. As of March 2003, all cities in the Twin Cities metropolitan area are permittees under the NPDES Municipal Separate Storm Sewer System (MS4) Stormwater Permit and must therefore meet certain requirements related to stormwater pollution control. See Section 3.2.4.3 for more information about the NPDES MS4 program.

2. The RWMWD has completed many of the large regional water quality improvement projects identified in previous studies. With much of the District fully developed, water quality improvements are demanding a large increase in small-site BMPs, which require the involvement and action of property owners including residents, businesses, schools, churches, and builders/developers. This creates a strong need for a comprehensive education program and use of different approaches and strategies with each of these audiences.

3. There is growing incentive to increase cooperation and collaboration amongst metro-area watershed districts with shared resources and budgets allocated for the implementation of collaborative and synchronized communication. Education campaigns and strategies using joint messaging across the metro area are intended to create more visibility, drive residents to actions, and increase positive impacts in our communities.

4. A program called Master Water Stewards, initiated in 2012, has begun to spread across the metro area. Initiated in January 2016 in RWMWD and other east metro watersheds, this program has the

potential to enhance community involvement and provide education support for a variety of initiatives related to implementation of infiltration projects. It also offers the opportunity to develop on-going volunteer support for a variety of initiatives that could benefit from local leader involvement.

5. Recent research studies on community capacity, socially based marketing, and behavior change conducted in our watershed, across the metro area, and nationally point to refining the watershed's approaches to affect positive change and successfully engage a variety of audiences within our communities.

The factors described above affect the RWMWD Public Information and Education (PIE) program in the following ways:

1. City responsibilities for stormwater improvement have increased greatly under the new NPDES MS4 program. Staff from each city meet monthly with the RWMWD staff (as the Public Works Group) to engage in discussion, share resources, receive updates, discuss policies and strategies, and organize trainings. The RWMWD works to help cities meet their obligations under the MS4 program, identify areas for collaboration and efficiency, and refine and improve all MS4 SWPPPs. This includes collaboration with cities to implement TMDL requirements, including implementing recommendations from the *TCMA Chloride Management Plan* (see Section 1.10.5.3).

2. The use of small-site BMPs requires the involvement of individual property owners, institutions, and local governments. The number of these projects is increasing exponentially. Public involvement and education plays a strong role in planning and implementing such BMPs. Using large Clean Water Fund grants, the District has implemented a series of infiltration projects with faith-based communities and schools. RWMWD will continue to seek opportunities to work with large land owners on projects that can make a sizeable impact on decreasing stormwater runoff from their properties. Landowners carry the responsibility for the maintenance of these BMPs, which demands ongoing education and engagement with city, school, and church staff. In the case of large school projects funded by state grants, school maintenance staff, school teachers, and students will be involved in aspects of maintenance along with the watershed district, which will require education and on-going training. This need for education and maintenance support is also true for subwatershed-based infiltration projects to assist residents in keeping up the level of care needed to maintain BMP features.

3. In this new era of watershed protection, the RWMWD is no longer the sole entity designing and constructing capital improvements. Each high-priority watershed will require a combination of BMPs implemented by a combination of entities. Site improvements will need to be acceptable to the site owner and complementary efforts will be needed from infrastructure owners (the cities). In special cases, volunteer support may come from the community and technical assistance will be needed from the RWMWD and other entities. Incentive programs will be used, as well as relevant individual education or neighborhood education via social media, city newsletters and events.

4. The evolving role of the PIE program and its approach to communications is a constant consideration. Approaches for coordinating volunteers and reaching and engaging audiences will have to be adapted as needed. As the District's communications reach and engage a wider audience, coordination with projects becomes more complex, demanding more support from volunteers, PIE staff, or both.

5. As the RWMWD increases its interaction with residents, it will experience increased demand for services. To meet growing demand from District constituents for information and support, the PIE program encourages community institutions to share responsibilities and take ownership of the watershed stewardship efforts of their members. In this way, over time, watershed stewardship becomes a program or activity of each community organization in the District (just as recycling has become a basic practice everywhere). For example, schools are increasingly participating in projects to support RWMWD-promoted watershed stewardship efforts, local churches are undertaking the creation of rain gardens, and neighborhoods are engaging in subwatershed infiltration projects to protect nearby impaired or at-risk water bodies.

The RWMWD PIE program responsibilities include:

- Schools and Youth Program
- Volunteer support for natural resources restoration projects
- Public Works Group and staff trainings
- Partnerships with nature centers
- Application of RWMWD GIS and database information to identify potential target areas for outreach and engagement
- WaterFest and other annual celebrations
- Annual Volunteer Recognition Dinner
- Watershed Excellence Awards program
- Media projects
- BMP project support and volunteer coordination for churches, schools, and residents doing subwatershed-based projects – including grant-writing
- Signage development and design input
- Blue Thumb Steering Committee representation and Partner meetings
- Website
- Ripple Effect E-News and blog
- Social media
- Press releases
- Clean Water Campaign collaboration with Watershed Partners
- Production and dissemination of educational materials
- Neighborhood demonstration projects
- Master Gardener, Master Naturalist, and Master Water Stewards Program collaboration
- Volunteer coordination for planting projects, watershed cleanups, demonstration projects, and neighborhood education efforts
- Workshop development
- Public speaking
- Participation in Watershed Partners

The RWMWD anticipates implementing the following new initiatives as part of the PIE program during the life of this Plan:

- Collaboration with Watershed Partners Clean Water Minnesota campaign
- Joint communications projects with Capitol Region Watershed District and Mississippi Watershed Management Organization
- Revision of the District's website, development of a new logo and branding, and new educational materials and signage
- Increased educational involvement and policy discussions with city officials, staff, and commissions
- Strengthening the roles of extension programs, school districts, professional landscape managers, public works departments, environmental commissions, churches, and businesses in support of BMPs
- Stronger collaboration among adjacent watershed district education programs
- Development of education outreach opportunities and materials on climate change as it relates to water and natural resources
- Information outreach for residents, city staff, and other stakeholders about supporting sustainable groundwater (e.g., groundwater-surface water interaction, impacts of withdrawal, and conservation practices)
- Collaboration with agencies to provide information and technical assistance to assist cities in implementing chloride reduction and management strategies included in the *TCMA Chloride Management Plan* (see Section 1.10.5.3)

4.1.5 Information Gathering, Research, and Studies

An important role of the RWMWD is to gather information and perform research and studies. The information gathered allows the RWMWD to identify emerging topics; whereas, research and studies provide necessary information, guidance, and recommendations to address particular resource management issues.

Typically, the RWMWD begins capital improvement projects with the preparation of a feasibility study and report on the proposed project. Such focused studies result in projects tailored to specific water resource management issues.

The RWMWD will continue to gather information about new and innovative technologies and methods for water resource management. The RWMWD will also continue to use field tests, pilot projects, and demonstration projects/sites to test, refine, and promote appropriate new and innovative practices.

The RWMWD supports continued watershed management research. Research is needed in the areas of stormwater BMP techniques and performance, lake management (aquatic plant management, sediment phosphorus control, carp management), upland plant management and restoration techniques (reed canary grass control, invasive plant management), and more. Recently, the RWMWD completed

hydrologic and/or hydraulic studies for nearly the entire District and updated the District's modeling to reflect Atlas 14 information.

The RWMWD's goal is to undertake research projects that will provide direct benefit to the RWMWD by shaping its watershed program or refining the District's management techniques. The RWMWD will seek partnership opportunities for research projects that achieve District objectives. Past partners have included the University of Minnesota, the MPCA, MDNR, and MnDOT.

Much of this research benefits the watershed management community in general, as well as the District itself. The RWMWD will continue to share it research results through the District's Public Involvement and Education Program, conferences, seminars, and/or publications. Research results will be collected, analyzed, and published when appropriate. Data collected will include system or BMP performance, as well as capital, operating, and maintenance costs.

The RWMWD has developed and maintains a geographic information system (GIS) to store and retrieve data on the District's features and resources. The RWMWD will expand and improve the GIS as needed to support the District's programs.

Grant funds are often available for research projects; the RWMWD will seek these funds whenever available. Collaborations with other watershed districts, local units of government, or agencies will be pursued on projects that have clear, broad watershed community benefits.

4.1.6 Natural Resources Programs

The District's integrated approach to resource management incorporates preservation and restoration of aquatic, wetland, and associated upland habitats into its projects, programs, and other watershed management strategies. To accomplish this, the District has established a Natural Resources Program.

As of the writing of this Plan, the Natural Resources Program has established four objectives in support of the overall District goal to achieve healthy ecosystems (see Strategic Overview). These objectives include:

1. Watershed buffers and natural areas are ecologically diverse and provide high-quality habitats.
2. The invasive common carp is effectively managed to improve water quality and water resources.
3. Other aquatic invasive species (AIS) are managed to preserve water and natural resources.
4. Natural resources and watershed management knowledge is gained and shared with citizens and the scientific community.

The District performs a variety of projects and activities aimed at achieving the above objectives. Specific implementation items included in the Natural Resources Program are detailed in the District implementation program (Table 4-1) and in the individual subwatershed sections (Section 2.0), where applicable. Information about the RWMWD Natural Resources Program may also be found by clicking on the Natural Resources tab on the RWMWD website (http://www.rwmwd.org), or by contacting the RWMWD office.

Primary roles and responsibilities for the Natural Resources Program and its staff include:

- **Maintain Ecological Restoration Projects** – Natural resources staff members actively monitor and manage over 20 natural areas totaling approximately 100 acres of high-quality shoreline, wetlands, and upland buffer habitat. A majority of the day-to-day maintenance work is conducted by an ecological restoration technician and summer interns. Some prescribed burning, mowing, and miscellaneous labor is contracted out. The District will continue with this approach because of the cost savings, the ability to effectively manage the time required for these activities, and the overall quality of the results. When feasible, the District will continue to partner with volunteer groups on certain management tasks.

- **Continue RWMWD Carp Management Program** – In 2009, the District partnered with the University of Minnesota to study common carp in the Phalen Chain of lakes. The results of the study led to the development of an aggressive carp management plan for the Phalen Chain of Lakes. To date, thousands of adult carp have been removed from Gervais and Kohlman Lakes (60% reduction), and carp in three key nursery areas have been eliminated. The District will continue to manage carp in the Phalen Chain of Lakes. Management efforts may include trapping, monitoring carp movement, and maintaining and activating carp barriers to prevent carp migration. The District plans to expand its carp study and management efforts to the Owasso-Bennett Lake system. Long-term carp management efforts will be performed in cooperation with other agencies and organizations, when possible.

- **Monitor and Manage Aquatic Plants** – The District will continue to use quantitative monitoring (point-intercept method) and GPS mapping to assess lake system aquatic plant communities. Major lakes will be monitored on a 4-year rotational basis. Additional monitoring efforts may take place on lakes where invasive plant management is underway, for example, Casey Lake, Kohlman Lake, and Lake Phalen. Aquatic plant data will be shared with cities, counties, the MDNR, research organizations, lake homeowner's associations, and the general public.

  Since 2008, the District has led aquatic plant management activities in several District-managed waterbodies (e.g., Kohlman Lake, Casey Lake). The District will continue to perform aquatic plant management activities where aquatic plants have a demonstrated negative effect on water quality. These activities may include the design of plans to manage invasive plants , mechanical harvesting, or herbicide treatments.

  Aquatic invasive species (AIS) are a serious threat to our surface waters. In 2014, a county tax bill was passed that provides funds for AIS prevention. Each year, Ramsey and Washington counties receive funding for activities such as boat ramp inspections, lake monitoring, and education. The District will work with county staff and other partners to develop AIS prevention plans. We will evaluate cost-share opportunities, staffing needs, and share all monitoring data to further AIS prevention in the watershed.

- **Implement Ecological Restoration Projects –** The District will continue to seek opportunities to create, restore, and protect natural areas. For example, over the last 15 years, the District has led or partnered on the ecological restoration of 63 acres of land in the Lake Phalen corridor. The District will continue to lead restoration activities in this corridor. The District also supports cities and counties with restoration projects associated with water resource improvement and preservation; a high priority is given to projects that are visible and provide recreational and educational value. The District partners with local agencies on a number of restoration projects, including wetland buffer projects on the Pond of Battle Creek Golf Course, Phalen Golf Course, and city and county open space restoration projects. The District will continue to seek partnerships.

  Historically, the District has been able to secure grant funding for a majority of its ecological restoration projects. In addition, the District has been able to work with city and county partners to leverage cost-share funding and other resources. The District will continue to seek grant funding and partnership opportunities to facilitate economical ecological restoration projects.

- **Support Natural Resources Research** – Staff will continue to support applied research activities that directly benefit the watershed. The District looks for opportunities to collaborate on innovative research projects and publish findings from watershed-directed projects. Research topics that are currently being addressed or are considered a priority for future research studies include:

  - **Carp Management in the Phalen Chain of Lakes** – Work collaboratively with University of Minnesota researchers to publish a peer-reviewed paper on controlling carp in key nursery areas.

  - **Aquatic Plant Harvesting and Phosphorus Removal** – Analyze data and publish results of work from the *Kohlman Lake Macrophyte Harvesting Study*.

  - **The Ecological Value of Urban Natural Areas Restoration** – Conduct a quantitative assessment of established sites within the watershed – potential collaborative research.

  - **Early Management Response to Aquatic Invasive Species** – Support regional studies.

  - **The Phalen Corridor** – A quantitative assessment of pollinators and wildlife – potential collaborative research.

  - **Urban Shore Buffers** – Water quality benefits and management implications – potential collaborative research.

- **Provide Opportunities for Environmental Education and Recreation** – One of the primary reasons for RWMWD staff to lead large ecological restoration projects is the opportunity these provide to efficiently engage local schools and civic groups. This is a key component of all large-scale restoration projects in our watershed. This hands-on approach provides educational benefits for area schools and empowers community leaders. This is an excellent way for the community as a whole to learn about watershed and natural areas management. The District also supports recreation through our Natural Resources Program. The District will seek opportunities to assist other organizations in creating and improving lake access points, promoting water routes, promoting urban fishing, and managing aquatic plants.

- **Provide Technical Services** – Members of the Natural Resources Program staff enjoy opportunities to share knowledge with local and state organizations, as well as residents within the watershed. The District will continue to work with city and county natural resources, parks, and golf course staff on restoration and management of natural areas, as well as invasive species control efforts. The District also provides support to individuals taking on water management and natural resources restoration projects.

Lake water quality sampling



4.1.7 Water Quality Monitoring Programs

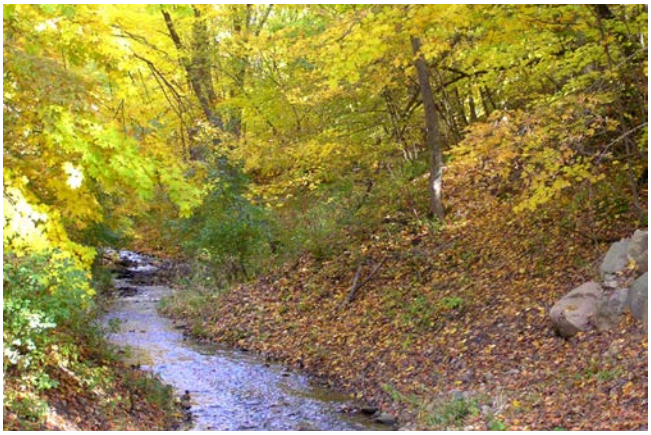
The purpose of the RWMD water quality monitoring program is to collect chemical information on RWMWD water resources. This data is used to assess the health of the resources and determine whether additional management activities are necessary. Monitoring has also been implemented to evaluate the effectiveness of completed projects.

4.1.7.1 Water Quality Monitoring

The RWMWD water quality monitoring program tracks water quality and quantity in District lakes and streams. The annual program includes in-lake monitoring of 15 District lakes. RWMWD collaborates with the Ramsey County Environmental Services Office on monitoring 12 of the lakes. For these lakes, Ramsey County collects and analyzes the samples and RWMWD pays the staff and laboratory costs and reports the results. The remaining lakes are monitored by RWMWD staff. In addition, all District lakes are monitored right after ice out for chlorides and conductivity. To learn more about the water quality in District lakes, go to the RWMWD website (www.rwmwd.org), click on Water Quality, and follow the links to lake monitoring.

The District will continue to enter the RWMWD data into the STORET database; Ramsey County will continue to do likewise.

The RWMWD also monitors the water levels of major District lakes every 2 to 3 weeks and following major storm events. RWMWD has three automatic lake-level stations on Battle Creek Lake, Tanners Lake, and Spoon Lake; these take measurements every 15 minutes.



Fish Creek is monitored through WOMP
(Photograph courtesy of City of Maplewood)

The RWMWD stream monitoring program is part of a larger monitoring effort carried out by Metropolitan Council Environmental Services (MCES). The Watershed Outlet Monitoring Program (WOMP) is coordinated by MCES and consists of a network of monitoring stations throughout the metro area. The RWMWD WOMP sites are located at the Fish Creek, Battle Creek, and Beltline Interceptor outlet locations near the Mississippi River. RWMWD has been monitoring these outlets since 1995. The objective of this program is to collect the water quality and quantity (stream flow) data needed to assess current conditions, develop target pollutant loads, and provide continued monitoring of water quality improvement measures implemented in the watersheds.

RWMWD has installed automatic sampling equipment at each outlet. Data collection consists of continuous measurements of stream flow, monthly base-flow grab samples, and storm event composite samples. The samples are analyzed in the MCES laboratory for many water quality parameters. The majority of WOMP program costs (75%) have been supported by grants from the MCES. The monitoring data is published by the MCES and used by multiple natural resource management entities. Follow this link to read details of the MCES Stream Monitoring program: (www.metrocouncil.org/environment/RiversLakes/Streams/index.htm)

The MCES compiles a report of conditions found in monitored streams. To read the most recent MCES report on the streams monitored in RWMWD, go to the RWMWD website (www.rwmwd.org), click on Water Quality, and follow the links to stream monitoring.

RWMWD has set up permanent stations on Gervais Creek and Kohlman Creek. These have automatic samplers that measure flow; in addition, grab and stormwater samples are taken and analyzed for total phosphorus, orthophosphorus, chlorides, and total suspended solids. The objective of this program is similar to the WOMP program: to assess current conditions and provide continued monitoring after water quality improvement measures are implemented in the watersheds.

4.1.7.2 Monitoring to Evaluate the Effectiveness of Completed Projects

RWMWD also implements monitoring to evaluate the effectiveness of completed projects. Such monitoring evaluates project performance and compliance as required by the RWMWD's operations (NPDES) permit from the MPCA. An example of this is the ongoing monitoring program at the Tanners Lake Alum Treatment Facility; this program monitors flow rate, outlet pH, total aluminum, dissolved aluminum, total phosphorus, dissolved phosphorus, and total suspended solids. Similar monitoring is done at the RWMWD building site, Maplewood's iron-enhanced sand filter, and the Wakefield spent-lime

filter. At these sites, information on flow rate, total phosphorus, orthophosphorus, chlorides, and total suspended solids is collected. The District's Maplewood Mall project contains multiple BMPs and will continue to be monitored to assess BMP performance and overall project effectiveness. The mall cistern and the tree trenches surrounding the mall are monitored for water level. The cistern is also monitored for *E. coli*.

4.1.8 Groundwater Management

Under Minnesota Statutes 103D.201 the RWMWD has the authority to regulate groundwater, although its specific role in groundwater management is somewhat ambiguous. Historically, the RWMWD has not assumed a lead role in groundwater regulation and currently does not have a defined groundwater program. The RWMWD has collaborated with other entities responsible for the management and protection of groundwater resources. Activities the District performs related to groundwater management include:

- Conducting groundwater studies independently or in collaboration with other agencies and organizations (e.g., 2015 *Groundwater/Surface Water Interaction Study*).
- Participating in regional and county groundwater planning efforts (e.g., Ramsey County [2010] and Washington County [2014] groundwater planning efforts).
- Providing technical assistance to cities during development of municipal wellhead protection plan, as requested.
- Cooperating with local government units to educate the general public concerning the use and importance of BMPs in preventing contamination of groundwater supplies.
- Preventing negative quality and quantity impacts to groundwater and groundwater-dependent surface waters through permit review and education efforts.
- Reviewing and commenting (as necessary) upon all MDNR appropriation permits.

Minnesota Statutes 103B.255 requires Counties to develop and implement a county groundwater management plan. The *Washington County Groundwater Plan 2014–2024* and draft *2009 Ramsey County Groundwater Plan* identify several groundwater management strategies that require collaboration with WDs and water management organizations (WMOs) that are applicable to the RWMWD. These include:

- Working with WMOs to strengthen education efforts.
- Developing a county-wide (Washington County) groundwater monitoring plan and a data-tracking and mapping system in coordination with WMOs.
- Establishing a central source ("data deli") for groundwater quality data collected in Ramsey County, to be maintained by the Ramsey Conservation District (RCD).
- Collaborating with LGUs and WMOs to identify and preserve regional recharge areas. Supporting open space as a land use that protects groundwater and encouraging WMOs and LGUs to incorporate protection of recharge areas in plan updates.

- Collaborating with the Minnesota Department of Health (MDH) and Metropolitan Council to develop guidelines on placement of infiltration BMPs in wellhead and source water protection areas and working with LGUs and WMOs to develop a map showing areas where infiltration is not recommended.
- Encouraging water organizations to emphasize stormwater reuse.
- Assisting LGUs with developing land-use management practices to protect drinking water management supply areas (DWSMAs).
- Assembling a GIS database of stormwater infiltration structures that pose threats to groundwater in emergency response spill situations.

Some of these initiatives may benefit the RWMWD, or may benefit from District participation. The implementation of the draft *2009 Ramsey County Groundwater Plan* and *Washington County Groundwater Plan 2014–2024* provide opportunities for the District to collaborate with counties and other stakeholders to address groundwater issues.

As noted in the Strategic Overview and in Section 3.2.1.8, the RWMWD will continue its collaborative efforts with Washington and Ramsey counties in the area of groundwater management. The Strategic Overview also describes RWMWD's goal, accomplishments, challenges, and action items related to groundwater management.

4.1.9 District Facility Maintenance

The District has completed over 40 capital improvement projects since 1989. The District is committed to maintaining all RWMWD capital improvements to ensure they function as originally intended/designed. The District is also committed to performing maintenance on the District-managed streams to ensure they provide adequate stormwater conveyance and minimize flood risk. The RWMWD accomplishes this through its annual maintenance and repair project, unless more immediate or specialized attention is warranted.

To provide better protection of the District's water resources, the RWMWD's maintenance program continues to be a formal and more efficient program. Prior to 2000, the RWMWD identified maintenance needs through an informal program of inspections and reports from the public, city staff, and District staff. Those maintenance items were previously addressed individually through an on-going process. This former approach was more time-consuming to administer than the current formalized, systematic approach. Now, the maintenance program includes an inspection of every District-managed facility annually and District-managed streams biannually. Through the RWMWD's NPDES MS4 permit, the District is required to track inspections and maintenance, thus formalizing the program even further.

During the scheduled inspections, RWMWD staff performs minor maintenance (e.g., removal of collected debris) and notes any performance issues, maintenance needs, and minor improvements that would reduce future maintenance costs. Maintenance that can be accomplished with District staff resources and without heavy equipment is completed by District staff immediately following the inspection. Maintenance items that require heavy equipment or special materials are noted and reinspected by the

District Engineer. The RWMWD collects and packages identified maintenance needs into a single project and assembles contract bid documents in the fall of each year. In the fall of each year, the Board of Managers approves the project for bidding. The RWMWD then issues a contract with a general contractor; the contractor generally completes the projects during the winter and early spring and completes site restoration work in May and June.

The RWMWD maintenance program includes annual visual inspections of the District's water quality and flood control facilities and ponds for maintenance needs and evidence of sediment accumulation. When visual evidence suggests that the ponds may require sediment removal, a pond depth survey is completed. The pond depth survey is compared to the original pond profile to determine whether sediment has accumulated to greater than 50% of the pond's original storage volume. If the accumulated sediment is at or near the 50% standard, the pond is scheduled for excavation of the accumulated sediment. The RWMWD coordinates with its member cities and offers to include their stormwater pond cleanouts on the District's contract. The water bodies must be within the District boundary and help improve the overall water quality in the District. RWMWD manages the projects and then gets reimbursed by the partner for the contractor work completed. When a District facility is in a park and aesthetic considerations demand attention, or when a habitat concern warrants earlier attention, the facility will be scheduled for maintenance when the accumulated sediment is less than the 50% standard.

The District also inspects and maintains the Beltline and Battle Creek storm sewer systems. These systems will be inspected every 5 years using the National Association of Sewer Service Companies (NASSCO) certification program. Repairs are placed on a maintenance schedule if deemed necessary.

The District also serves as the public ditch authority within its jurisdictional boundary. The District will continue to maintain public ditches so as to allow their continued function as urban drainage systems and as altered natural waterways.

The annual capital improvements repair and maintenance project has generally cost between $250,000 and $500,000 per year and is funded using the RWMWD CIP Maintenance Fund. By packaging a number of small maintenance projects into a single, larger project, the RWMWD has kept the overall cost down (both construction and project administration costs). Past maintenance projects include:

- New lake outlet structures for Beaver and Savage Lakes
- Gully erosion repairs along Gervais Creek
- Sediment excavation in McKnight Basin on Battle Creek
- Sediment excavation in the 7th Street Wetland Treatment Project north of Tanners Lake
- Repair of the outlet structure on the boat launch treatment pond at Tanners Lake
- Sediment excavation from the North St. Paul Urban Ecology Center pond
- Alum floc removal from the Tanners Lake Alum Treatment Facility

- Tanners 7th Street Wetland Complex
- Soil replacement at the Valley Creek Road infiltration system
- Installation of trash skimmer at the outlet of Target Pond
- Gervais Lake Beach pond sediment removal
- Gervais Mill Pond filter strip
- Battle Creek channel cleaning
- Battle Creek tunnel repair
- Kohlman Creek channel restoration and sediment removal
- Kohlman Creek inlet structure repair at Kennard Street
- Wakefield Spent-Lime Project
- Beltline and Battle Creek Pipe Maintenance

4.2 Implementation Program

The implementation program includes the projects, programs, studies, and other activities necessary to accomplish the District's goals. The RWMWD implementation program includes both capital improvement (i.e., structural) projects and non-structural activities. Table 4-1 lists the components of the RWMWD implementation program, the planned implementation schedule, and a planning-level cost estimate (in 2016 dollars) for each component. Table 4-1 lists District-wide projects and activities first, with the remainder of the activities organized according to subwatershed. This Section also describes the District's prioritization and funding approach for projects and programs.

It is through the execution of the programs and projects listed Table 4-1 that the District accomplishes its goals. Thus, the implementation items included in Table 4-1 are directly correlated to the District goals and action items listed in the Strategic Overview. For each implementation item included in Table 4-1 the corresponding District goal(s) and action item(s) are identified. Many of the projects and programs listed in Table 4-1 have multiple benefits and, therefore, may be related to a number of different action items. For example, implementation item #DW-6 pertains to action items WQ2, WQ14, WQ17, WQ18, FL8, IE17, MO16, MO17 and MO21. The letters in the prefix of each action item pertain to its relevant District goal ("WQ" pertains to the "Achieve Quality Surface Water" and so on, as indicated in the footnotes of the table). Also, implementation items with asterisks indicate that these items pertain to strategies developed in the *RWMWD WRAPS Report*. The District will use the information in the table to assess progress towards its District goals as part of its annual review and evaluation efforts.

The capital projects listed in the implementation program include projects identified as part of WRAPS and TMDL studies and other investigations. In many cases, the RWMWD will be the lead agency for implementing the activities. In some cases, the District will cooperate with other agencies and organizations. Many of the projects included in Table 4-1 are included at the feasibility/conceptual level.

As projects become better-defined, so will the estimated project costs and responsibilities of the RWMWD and the other participating agencies/organizations. The estimated costs given in the table are the total project cost; the District will pursue collaborative and grant opportunities to reduce the portion of the total cost borne by the District. Costs for projects included in Table 4-1 are estimates and may be revised as part of feasibility studies completed prior to implementation. If the funding mechanism changes for any of the capital improvement projects listed in Table 4-1 such that the financial obligation to the District is increased, the District may hold a public hearing on the proposed change to the funding method before ordering the project. BWSR may require a plan amendment if the anticipated cost is significantly greater than the original estimate, as adjusted to reflect inflation. Any proposed amendments to the Plan will follow the procedures described in Minnesota Rules 8410 (see Section 4.5.3).The RWMWD may implement the activities and projects listed in Table 4-1 at a different time than shown in the table, as circumstances dictate, and to fit in with the District's financing strategies. For example, the availability of grants and partnerships could result in either the acceleration or delay of projects. For capital projects not included in its BWSR-approved implementation program (Table 4-1), the RWMWD will initiate a plan amendment to add the proposed capital project to Table 4-1 prior to implementation. Section 4.5.3 contains more information regarding plan amendments.

The District will fund the implementation program as described earlier in this section. District staff recommend projects or programs to the RWMWD Board of Managers annually for budget consideration, as described in the "Work Program and Budget Process" (see Section 4.1.1.2)

The District will follow the process outlined in the applicable statutes for implementing proposed capital improvement projects. The District will coordinate with and involve the affected local units of government and other agencies in the implementation of capital projects. If the District orders the project, then the District prepares project plans and bidding documents, finalizes the funding mechanism, and advertises the project for bid. Through its capital improvements program, the District completes the work, oversees the project construction, manages the project's finances, and provides monitoring and evaluation.

4.2.1 Project and Program Prioritization

As discussed in Section 3.2.1, the RWMWD is responsible for addressing water and related land resource management issues that generally affect more than one community or are defined by the District to be of "District-wide" significance. This generally means issues that span more than one community. Specifically, the District is responsible for addressing water-level management (flood control) and water quality issues for "District-managed" water resources (20 lakes and five streams, as identified in Section 1.9).

The opportunities available to the District in pursuit of its goals exceed the limited staffing and financial resources available. At times, significant demands can be placed on the District to respond to problems and issues brought forward by cities or citizens. Thus, the District must prioritize implementation activities according to needs and resources. District staff has developed guidance to assist the Board in making decisions regarding the priorities for funding and staffing projects and/or programs.

In general, the Board of Managers will base its funding and staffing decisions for RWMWD projects and programs on the following factors:

- Annual budget commitments from previous years (i.e., ongoing responsibilities)
- Available tax revenues, grants, and cost-share funding (e.g., from cities or agencies)
- Project or program merit and consistency with this Plan
- Project or program feasibility
- Project or program risk
- Project or program inclusion and prioritization in TMDL or WRAPS implementation plans
- Nutrient classification of affected waterbodies
- Consideration of balance with other proposed projects and programs

When presented with annual work program, budget, and levy constraints and the need to prioritize among competing programs and projects, the Board will apply a **three-tier priority framework**:

> **Tier 1** – Tier 1 projects and programs are considered the most relevant to the District's goals and have the highest priority for implementation. In general, the RWMWD will assume 100% funding responsibility for Tier 1 projects and programs.
>
> **Tier 2** – Tier 2 projects and programs are placed at a priority lower than those in Tier 1, but remain critical to accomplishing the goals of the District. In general, the RWMWD will assume 100% funding responsibility for Tier 2 projects and programs.
>
> **Tier 3** – Tier 3 projects and programs generally contribute towards accomplishing District goals in a less-direct manner than Tier 1 and Tier 2 projects and are considered lower priority. Typically, the District will pursue Tier 3 projects only when funded in collaboration with other sources.

This three-tier priority framework is a guideline that can be adjusted by the Board as necessitated by specific circumstances. Factors that may impact the priority of a project may include availability of partners, outside funding support, coordination with other activities (e.g., redevelopment), or other factors. Examples of Tier 1, Tier 2, and Tier 3 projects and programs are provided in the following sections. Projects and programs included in Table 4-1 are assigned a Tier 1, Tier 2, or Tier 3 classification.

It should be noted that Table 4-1 includes several projects identified and prioritized in the RWMWD WRAPS and RWMWD TMDL studies (see Section 1.10.5). The implementation program included in this Plan leverages the evaluation of project feasibility and benefits performed as part of the WRAPS and TMDL studies and resulting prioritization published in those reports. The highest priority WRAPS and TMDL projects for which the District is the lead agency have been included in this Plan and are identified in Table 4-1.

4.2.1.1 Tier 1 Projects/Programs

The following are examples of projects/programs generally categorized as Tier 1:

a. Flood mitigation projects to protect habitable structures or major arterial roadways

b. Projects to protect or restore the conveyance capacity of District outflow conveyors (see Section 1.9.3) and District-managed streams (see Section 1.9.2)

c. Projects to maintain or restore RWMWD's capital improvement projects (CIP) and structures

d. Projects and programs identified as a District responsibility to implement an approved WRAPS and/or TMDL study in impaired and at-risk subwatersheds (see Section 1.10.3)

e. Completion of a required WRAPS or TMDL study

f. Projects that correct existing erosion problems on District outlet conveyors or District-managed streams

g. Projects that maintain or establish native habitats at RWMWD CIP sites and publicly owned sites adjacent to District-managed water resources

h. Continuation and expansion of the RWMWD permit program, including site inspection, enforcement, and WCA administration

i. Continuation and necessary expansion of the District water quality program to document lake, stream, wetland, and subwatershed runoff water quality and project performance

j. Watershed education programs required by the RWMWD's MS4 stormwater pollution prevention plan (SWPPP) and as recommended in an approved WRAPS or TMDL.

k. Continuation of administrative support functions, facilities, equipment, and staff support.

4.2.1.2 Tier 2 Priority Projects/Programs

The following are examples of projects/programs generally categorized as Tier 2:

a. Water quality projects not identified in an approved WRAPS or TMDL study that are located in subwatersheds tributary to RWMWD-identified impaired or at-risk waterbodies in need of additional water quality treatment. This could include assisting RWMWD permit applicants in providing additional water quality treatment on their project sites above and beyond the RWMWD permit requirements as well as projects identified in the RWMWD BMP Incentive Program (e.g., additional infiltration).

b. Projects that would improve the water quality in stable District-managed water resources.

c. Projects that maintain or establish native habitats on sites with clear water quality, vegetative, or wildlife benefits as well as sites that connect or continue important habitat corridors.

d. Research activities and studies that directly benefit RWMWD projects and programs.

e. Watershed education programs for RWMWD residents and school classrooms.

f. Projects and activities that assist and support cities in complying with their NPDES MS4 permits.

g. Activities to manage and control aquatic plants when there is a clear water quality benefit.

h. Activities to manage and control aquatic invasive species when deemed appropriate.

4.2.1.3 Tier 3 Priority Projects/Programs

The following are examples of projects/programs generally categorized as Tier 3:

a. Water quality projects tributary to District-managed water resources, but not tributary to impaired or at-risk waterbodies

b. Projects that maintain or establish native habitats on sites without clear water quality, vegetative, or wildlife benefits

c. Research activities that are of less direct benefit to the District than to the greater watershed community

d. Activities to manage and control aquatic invasive species without a clear water quality benefit

4.2.2 Project Funding and Cost-Sharing

The District funds its operations and implementation program using the funding sources available to watershed districts, as described in Section 4.1.1.1. With respect to capital projects, the District's current financing approach is to pay for District capital improvements in the year they are constructed, if possible. Larger projects may be financed in multiple years or through bonds or loans. Current and past bond issues and loans and their original amounts are listed below:

Project	Finance Type	Year	Amount	Note
Beltline Interceptor Repair I	Bonds	1997	$ 800,000	Through Public Facilities Authority (PFA)
Beltline Interceptor Repair II	Bonds	1998	$ 600,000	Through PFA
Tanners Lake Water Quality Improvement Project	Loan	1995	$ 1,800,000	MPCA water quality project loan (zero interest)
Battle Creek Project 1	Bonds	1980	$ 6,000,000	Bonds sold by Ramsey County
District Office Building	Bonds	2005	$ 2,400,000	District bond issue
Maplewood Mall	Loan	2012	$ 1,177,217	Clean Water State Revolving Fund Loan through PFA and MPCA

Grants and loans are an important funding source for the District. The District will continue to apply for grants and loans to offset project costs whenever possible and cost effective. The District will also seek partnerships or cost-sharing to reduce its portion of project costs.

Typically, the District will assume up to 100% of the cost for Tier 1 and Tier 2 projects. While the District may pursue outside funding for Tier 1 and Tier 2 projects to reduce District costs, the availability of such funds is not requisite to the District undertaking those projects. The District will typically implement Tier 3 projects only if additional, non-District funding is available through a grant or project cost-share opportunity.

To accelerate program implementation, the District will continue to develop, implement, and support programs that provide cost-share funds to individuals and cities as an incentive. The District will also seek funding for District programs and projects through cost-share programs and grants. Where known cost-share opportunities are lacking, partnerships may be developed for cost and workload sharing if possible. Costs and responsibility will be shared with cities whenever possible.

Local units of government wishing to undertake projects and activities listed in Tier 2 or Tier 3 are eligible for total or partial funding or reimbursement by the District if the project or activity is determined to be of watershed-wide benefit and a collaboration opportunity is present. By agreement of the Board of

Managers, the District may participate in projects or programs not anticipated in this Section or may adjust the level of participation in funding.

4.3 RWMWD Rules and Standards

The RWMWD adopted its first rules in 1976, which provided the framework for the District. The 1976 rules required:

1. Permits for construction within the floodplain, construction or land development disturbing 1 or more acres of ground cover, and wetland impacts.
2. Board review for development plats; road construction; municipal drainage plans; water-related ordinances; construction of drains, tile, sewer, and pipe; withdrawal of ground or surface waters; and lake or pond augmentation.
3. Prohibition of waste disposal into the District's surface water system and underground pumping of waste

The RWMWD developed new standards as part of the *1997 RWMWD Plan*; the focus of these standards turned to water quality and wetland protection. As described in the *1997 RWMWD Plan*, the District's regulatory programs included the permit review and approval process, the enforcement and inspection programs, and the use of required BMPs.

The 1976 District rules gave the RWMWD authority to implement the regulatory programs outlined in the *1997 RWMWD Plan*. The standards included in the *1997 RWMWD Plan* were aimed primarily at improving water quality through the implementation of stormwater treatment ponds and erosion and sediment control practices during construction. The District's policy was to attain 55% total phosphorus removal in on-site treatment basins. On-site treatment basins were required for all new developments in drainage areas where water quality could not be effectively improved by regional treatment basins. The RWMWD required on-site and regional basins to meet the criteria outlined in the *1997 RWMWD Plan*.

The *1997 RWMWD Plan* also included flood control standards to protect homes and public facilities and wetland management standards. The District serves as the LGU for the administration of the Wetland Conservation Act for all cities except St. Paul. See 1.11.3 for information about the RWMWD wetland classification and wetland management standards.

As planning started for the 2006 Plan, the RWMWD decided to update the District's standards and then incorporate them into RWMWD rules and regulations. Although water quality management was already being implemented with the use of traditional stormwater BMPs such as stormwater treatment ponds, these traditional methods did not treat dissolved phosphorus. For the RWMWD to make greater strides in water quality improvement, the District needed to find ways to treat dissolved phosphorus. As a result, volume reduction techniques became the focus of the new standards, since they also reduce dissolved phosphorus.

In early 2005, an opportunity arose for the RWMWD to collaborate with the neighboring Capitol Region Watershed District (CRWD) on establishing new rules and standards. The RWMWD recognized the importance of collaborating with CRWD, especially considering the common local government units shared between the two districts. The collaboration allowed the districts to provide consistency for cities and other permit applicants across watershed boundaries.

Based on the analysis completed during the rule-making process, the RWMWD and the CRWD jointly developed and adopted technical standards for the rules. The two districts emphasized the need to reduce stormwater runoff volumes to achieve water quality goals through the removal of dissolved phosphorus throughout the watershed. The draft technical standards for rules included standards for rate control, volume reduction, water quality, flood control, wetland management, and erosion and sediment control. In January of 2006, the RWMWD and the CRWD established a joint Technical Advisory Committee (TAC) to evaluate the proposed technical standards and provide input to the two District Boards. Members of the TAC included various city, county, and state agency representatives.

Since its conception, the joint TAC meets annually with RWMWD and CRWD to discuss concerns of the affected regulated parties. The TAC also reviews questions that arise while achieving compliance with the rules and to discuss emerging stormwater management technologies and trends. Substantial changes were proposed and adopted in 2015. Changes were based on current modeling and research and included increasing the volume-reduction requirement, establishing credit given for filtration basins and iron-enhanced filtration systems, requiring use of Atlas 14 rainfall data, and implementing a stormwater reuse calculator to determine volume reduction provided by reuse projects.

The RWMWD's rules adopted in 2006 and updated in 2015 include standards (organized as separate rules) for:

- **Stormwater Management (Rule C)** – includes runoff volume control criteria (through infiltration or other means) to protect and improve surface water quality, as well as runoff rate control and water quality treatment criteria.
- **Flood Control (Rule D)** – regulates activities in the floodplain and includes criteria restricting the placement of fill and freeboard requirements to protect structures from flooding.
- **Wetland Management (Rule E)** – includes no-net-loss of wetlands requirements, buffer width (average and minimum), and buffer management criteria.
- **Erosion and Sediment Control (Rule F)** – requires the preparation and implementation of erosion and sediment control plans that meet the standards of the MPCA NPDES Phase II Construction Stormwater Permit.
- **Illicit Discharge and Connection (Rule G)** – regulates connections and discharges to the RWMWD MS4, including a requirement for a District permit for new direct connections to the District's MS4 and specific requirements for the Beltline Interceptor.

Current RWMWD rules and guidance documents are available on the RWMWD website (www.rwmwd.org) or at the RWMWD office.

4.4 Local (City) Water Management

In accordance with Minnesota law (Minnesota Statute 103B.235), once a watershed plan is approved and adopted or amended, local units of government must prepare a local water management plan, capital improvement program, and official controls as necessary to bring local watershed management into conformance with the watershed district's watershed plan, within the time period prescribed in the watershed plan. Most of the cities and townships within the RWMWD will likely need to revise their local plans and official controls to bring them into conformance with the District's revised Plan, Minnesota law (Minnesota Statutes 103B), and Minnesota rules (Minnesota Rules 8410). Cities must revise and adopt local water management plans according to the timeline established in Minnesota Rules 8410 and Minnesota Statutes 103B.235. BWSR approved this Plan on March 22, 2017 and the RWMWD Board of Managers adopted this Plan on April 5, 2017. The local units of government within the RWMWD must revise their official controls and management programs to be consistent with this Plan within 2 years from the date of adoption of the RWMWD Plan.

If a city will not be assuming permitting authority from the RWMWD, it may conform to the requirements of Minnesota Statutes 103B and Minnesota Rules 8410 by adopting all or part of this RWMWD Plan by reference through a resolution or other RWMWD-approved official means. If a city wishes to assume the permitting authority from the RWMWD, it must first prepare its own local water plan and obtain RWMWD approval of the local plan. Any city may prepare its own local water plan. The RWMWD will notify each community of the District's requirements regarding local water plan revisions and adoption.

Section 3.2.2 provides additional information about ordinance requirements for cities, and Section 4.1.2.1 provides information regarding requirements for cities that wish to take over permitting authority from the RWMWD.

Within 30 days of the RWMWD Board of Managers' adoption of this RWMWD Plan, the RWMWD will notify each city of the RWMWD's requirements regarding local planning requirements and adoption.

A city can assume as much management control as it wishes through its approved local water management plan. For example, the city can assume the permitting authority for all land alteration activities. In this case, RWMWD would require the city to adopt all of the RWMWD rules by ordinance and to outline its permitting process, including the preliminary and final platting process, in the local water management plan. Wetland alteration activities would require a separate RWMWD permit or action unless the city takes over as the LGU for the WCA and adopts all of the RWMWD wetland rules and regulations. See Section 4.1.2.1 for more information regarding requirements for cities that wish to take over permitting authority from the RWMWD.

Any proposed zoning changes in a city with an approved local plan will be reviewed by RWMWD for conformance with the local plan. If the proposed zoning change will result in changes to the approved

rates and volumes of stormwater runoff, the local plan will need to be amended and the amendment reviewed and approved by RWMWD.

The RWMWD reserves the right to recommend to the city that a project be denied if the District considers it to be inconsistent with the local water management plan. If the local unit of government proceeds to approve such a project, the RWMWD reserves the right to take legal action.

4.4.1 Requirements for Local Water Management Plans

Local water management plans are required to conform to Minnesota Statutes 103B.235, Minnesota Rules 8410, and the RWMWD Plan. Minnesota Rules 8410 and Minnesota Statutes 103B.235 Subd. 2 include specific requirements for local water management plan content.

The policies and goals established in each city's local water management plan must be consistent with the RWMWD plan. The Section of the local water management plan covering assessment of problems must include those problems identified in the RWMWD Plan that affect the city, including those issues identified in the Strategic Overview and individual subwatershed sections (see Section 2.0). The corrective action proposed must consider the individual and collaborative roles of the city and the RWMWD and must be consistent with the RWMWD Plan.

In general, the RWMWD expects the cities to take the lead in addressing problem areas that the RWMWD believes to be local in nature. Local plans should identify problems and corrective actions that affect District concerns stated in this Plan or require RWMWD collaboration to address.

Cities are to maintain stormwater systems (storm sewers, ponding areas, ditches, water-level control structures, etc.) under their jurisdiction in good working order to prevent flooding and water quality problems. The RWMWD requires that local plans assess the need for periodic maintenance of public works, facilities, and natural conveyance systems.

Cities are encouraged to consult with the RWMWD staff early on in their planning process to determine collaboratively the most practical approach to meeting the requirements of the RWMWD Plan and Minnesota Statute and Rules. The RWMWD will work closely with cities as needed in local plan preparation, review, and implementation. In particular, the cities are urged to review District data (e.g., hydrologic and water quality), maps, and other information available to assist local units of government in preparing their local plans with the RWMWD staff and to go over the timeline for local plan review, approval, and adoption. Furthermore, the RWMWD staff will work with city staff regarding financial considerations, implementation priorities, and programs for plan elements of mutual concern.

City ordinances, management programs, and other official controls required by the RWMWD Plan must be implemented within 2 years of RWMWD Plan adoption. Revisions to local water management plans or local controls that are potentially inconsistent with the RWMWD Plan must be submitted by the cities to the RWMWD for review.

The RWMWD's requirements for local plan content coincide with or add to the requirements of Minnesota Statutes and Rules. The RWMWD set two levels of requirements for local plans:

- **Level 1** – a shorter list of plan requirements for cities that do not wish to take over permitting authority from the RWMWD (i.e., RWMWD continues its permitting role).

- **Level 2** – a longer list of plan requirements for cities that do wish to take over all permitting authority from the RWMWD. As described in Section 4.1.2.1, if a city wishes to take over permitting authority from the RWMWD, it must first prepare a local water management plan, obtain RWMWD approval of the plan, and then adopt and enforce stormwater management and erosion control ordinances. In this situation, the local water management plan needs to meet additional requirements.

The detailed requirements are described below. In general, the RWMWD encourages the cities to use RWMWD data, modeling results, etc. as much as possible to meet these requirements. Although RWMWD has completed hydrologic, hydraulic, and water quality modeling throughout the District, cities will need to perform additional modeling in areas where more detailed analysis is needed or to fill gaps in the District's modeling.

Level 1: RWMWD Requirements for local water plan content (applies to local units of government that do not wish to take over permitting authority from the RWMWD):

1. For cities subject to NPDES MS4 permit requirements, the local water management plan must identify reference policies, goals, and actions based on their SWPPP performed in accordance with MPCA requirements and schedules. Non-degradation requirements, policies, goals, and actions, must also be included in the local water management plan, if applicable.

2. Impaired waters, TMDL studies, WRAPS studies, and SLMPs – the local plan must include a listing of any impaired waters (as included on the MPCA's 303(d) list) within the city's jurisdiction. The local plan must describe the city's role/level of participation in preparing and implementing TMDL studies. The local plan must also address issues identified in the RWMWD WRAPS study and stormwater lakes management plans (SLMPs) prepared for water bodies within the jurisdiction of the city and implementation recommendations that involve local implementation or coordination with the RWMWD.

3. The local water management plan must identify official controls and programs (e.g., ordinances, management plans) which are used to enforce the policies and requirements of the RWMWD. The local plan must reference the city's stormwater management requirements, including erosion and sediment controls for land alteration activities that do not require a RWMWD permit (e.g., projects that disturb less than 1 acre of land). The local plan must identify the city's relevant ordinances or proposed ordinances to address this. Particular attention should be paid to addressing redevelopment and reducing total suspended sediment and total phosphorus loadings from redevelopment sites.

4. The local plan must describe the city's responsibilities for maintenance, repair, etc. of "non-District-managed" public and private stormwater management systems. The local plan must address maintenance issues and identify the situations where the city needs to coordinate with RWMWD on maintenance activities

5. Local water management plans must assess the need to establish a waterbody management classification system to provide for water quality and quantity management. If a different classification system than the RWMWD classification system is used, it must be correlated to the RWMWD system and approved by the RWMWD. Local water management plans must evaluate the need for other management programs, if necessary.

6. The local plan must describe local flood control and water quality issues (including those issues discussed in the *RWMWD Plan*), and the city's responsibility for addressing these local issues.

7. The local plan must describe the city's role in wetland management (e.g., acknowledge RWMWD's role as LGU for the Wetland Conservation Act and the RWMWD wetland management standards). If a city is already the LGU (i.e., the City of St. Paul) or wishes to accept responsibility as the LGU, the city must adopt a wetland management ordinance that incorporates the RWMWD wetland management classification system and standards.

8. The local plan must include an implementation program (including funding methods) to address all of the items listed above.

Level 2: RWMWD requirements for local water plan content (applies to local units of government that do wish to take over all permitting authority):

In addition to the requirements listed for Level 1, the following **additional** requirements apply:

1. The local plan must describe existing and proposed physical environment and land use – the city's latest comprehensive land-use plan and maps, along with information from the RWMWD, can be used to meet much of this requirement. The local plan must include maps showing the MDNR public waters, the RWMWD-inventoried wetlands, and the RWMWD wetland classifications. This description must include a groundwater Section incorporating available groundwater quantity and quality information. The local plans should also include references to completed groundwater studies that affect the city.

2. The local plan must include drainage areas and the volumes, rates, and flow paths of stormwater runoff. Cities are encouraged to use the RWMWD modeling data presented in this Plan or otherwise available from the District to help meet this requirement. The following criteria apply:

    a. Design storms and storm durations shall conform to the RWMWD standards (e.g., Atlas 14).

    b. The preliminary size of future pipes or channels must be identified.

    c. Allowable runoff rates to prevent flooding must be determined.

    d. Any minor watersheds within those identified in the RWMWD Plan must be identified.

    e. Waterway locations must be identified.

    f. A storm sewer system map must be provided, if available.

    g. The local plan must demonstrate that its hydrology conforms to the hydrology in the *RWMWD Plan*.

3. The local plan must identify storage sites not identified in the *RWMWD Plan*, including wetlands. The following criteria apply:
    a. Storage volumes must be provided.
    b. Normal water level elevations and flood elevations must be provided.
    c. Outflow rates must be provided.

4. The local plan must describe the city's regulations and specific regulatory provisions in place or that need to be developed to satisfy and incorporate the RWMWD standards and RWMWD rules and regulations, as revised.

5. The local plan must acknowledge and describe the respective roles of the RWMWD and the city in managing the water quality of the District-managed water bodies. The local plan must adopt the RWMWD waterbody classification system and water quality goals for the District-managed water bodies and the RWMWD wetland classifications for the non-District-managed water bodies.

6. The local plan must identify the city's goals, objectives, policies, standards, and guidelines pertaining to water resource management.

7. The local plan must describe the city's permitting process (or proposed process) for land and wetland alteration work (if the local unit of government is or takes on the LGU role for the Wetland Conservation Act). This description should include outlining the process for:
    - Reviewing development proposals and permit applications
    - Review of preconstruction plans
    - Coordinating permit requests with other simultaneous reviewers
    - Coordinating timelines with other permitting agencies

4.4.2 RWMWD Review of Local Water Management Plans

Before a city adopts its local water management plan, the new or revised plan must be submitted to all of the affected WMOs, the Metropolitan Council, and the county in which the city is located (if the county has adopted a groundwater plan) for concurrent review. Within 60 days of receipt of the local plan, the RWMWD will review the local plan for conformance with the *RWMWD Plan*. During its review, the RWMWD will take into consideration any comments received from the Metropolitan Council and the applicable county. The RWMWD will approve or disapprove all or part of the local plan within the 60-day time frame, unless the city agrees to an extension. If the RWMWD does not complete its review or fails to approve or disapprove the plan within the allotted time and the city has not given an extension, the local plan will be considered approved (Minnesota Rules 8410 and Minnesota Statutes 103B.235, Subd. 3 and 3a).

Upon RWMWD approval of the local plan, the city must adopt and implement its plan within 120 days and amend its official controls within 180 days of plan approval. Each city must notify the RWMWD (and the other affected WMOs) within 30 days of plan adoption and implementation and adoption of necessary official controls.

Any amendments to the local plan must be submitted to the RWMWD and the Metropolitan Council for review and approval prior to their adoption by the city. The RWMWD review process for local plan amendments is the same as for the original local plan.

4.4.3 Impact on Local Governments

The RWMWD's intention is to limit additional requirements imposed upon local units of government as much as possible while still accomplishing the RWMWD's purposes and implementing the Plan. The RWMWD's implementation program will be funded through tax levies. These taxes would not affect the local unit of government's finances directly since the RWMWD tax levies do not apply towards the local unit of government's levy limits. However, there would be a financial impact to the residents of the cities in the RWMWD watershed.

Some of the RWMWD implementation program elements reflect the goals, policies, and requirements of state and regional units of government that local units of government would need to address irrespective of RWMWD requirements. Examples of this include, but are not limited to, Metropolitan Council planning requirements, NPDES MS4 permit requirements, and local storm sewer system maintenance.

Some of the cities already have ordinances in place that address many of the RWMWD requirements. Applicable ordinances address shorelands, floodplains, wetland protection, stormwater management, erosion control, and stormwater system maintenance.

The RWMWD is not changing the wetland regulation burden for the member cities since the RWMWD is willing to continue to act as the LGU responsible for administering the WCA.

4.5 RWMWD Plan Development, Review, and Revision

4.5.1 Plan Development and Stakeholder Engagement

This Plan was developed with input from a wide range of stakeholders. The District developed and implemented a strategy to engage stakeholders in issue identification, assessment, and prioritization consistent with the process in Minnesota Rules 8410.0045. Initially, the District solicited input from local and state Plan review agencies. During Plan development, District staff met with agency and city staff as part of a Plan Technical Advisory Committee (Plan TAC). The Plan TAC provided review and feedback throughout the plan development process.

This Plan was developed simultaneously with the completion of the RWMWD WRAPS study (see Section 1.10.5.2). District staff leveraged the Plan TAC to provide feedback on the WRAPS study and its incorporation into this Plan, as well as provide information about other city and agency studies and activities. Prior to submitting the *RWMWD Plan* for formal review, the RWMWD solicited comments on a preliminary draft of the *RWMWD Plan* from the Plan TAC. The District's stakeholder engagement strategy also included efforts to get input from watershed residents. Early on in the planning process, the District hosted a series of public meetings around the watershed to give citizens the opportunity to offer input and insight on issues that affect RWMWD lakes and streams. This effort involved sending thousands of digital e-mail invitations and hard-copy letters to encourage residents and city and county personnel to

help spread the word about providing input at these community meetings. District staff made phone calls, wrote articles for the Ripple Effect, other newsletters and newspapers, and got the word out by putting postings on websites, Facebook, and other social media.

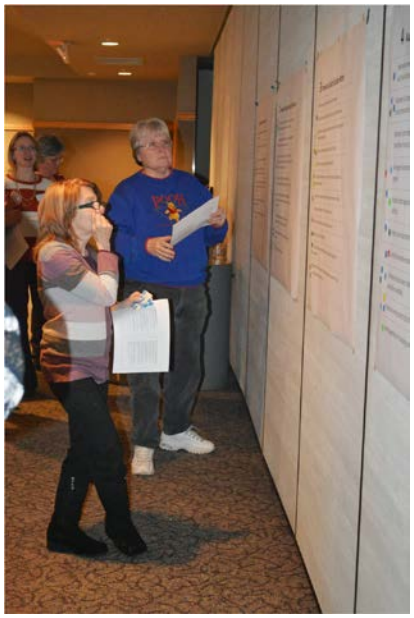
During this effort, the District collected information from about 100 people about which lakes, streams, and wetlands they visit, how they use them, what they value about them, and their issues of concern and suggested solutions. Watershed staff also met with public works staff members in each of the cities in the watershed to hear their concerns, provide updates, and gain input. The Board reviewed the data we collected at three meetings in the fall of 2013 and provided further input.

4.5.1.1 Community Confluence Event

The results of all stakeholder engagement activities were compiled and organized in preparation for a "Community Confluence" event held on January 30, 2014, at Maplewood Community Center. At this event, dozens of residents from all around the district participated in voting to prioritize key issues and actions regarding clean water and related ecological issues. Attendees include city commission members, lakeshore property owners, a mayor, naturalists, business owners, Master Gardeners, and others. For this event, 1,500 ideas and concerns generated at the earlier "Community Conversations" meetings were grouped into 62 actions that fit within eight categories.

Eight posters with lists of actions were placed around the room and participants were asked to vote for two actions under each of the goals. There was an additional poster designated for people to add potential actions and ideas that were missed. Of the 70 attendees, 57 voted. Watershed staff and the Board of Managers did not submit votes at this event. Residents unable to attend the event were afforded the opportunity to weigh in via the District's website.

The results of the "dot-mocracy" exercise were summarized and presented to the Board of Managers. The Board performed its own similar exercise with consideration of the dot-mocracy results from the Community Confluence meeting (and all other prior stakeholder input). This process resulted in the identification of the issues presented in the Strategic Overview and discussed throughout this Plan. Results of the stakeholder involvement process are included at the District website: www.rwmwd.org.



Residents voting at the Community Confluence event.

4.5.2 RWMWD Plan Review, Approval, and Adoption

In accordance with Minnesota Statutes, the *RWMWD Plan* was submitted for formal review to the following. Additional reviewers are noted.

RWMWD Cities	R
Gem Lake	Ra
Landfall	Ra
Little Canada	W
Maplewood	W
North St. Paul	
Oakdale	**A**
Roseville	Ca
Shoreview	Ri
St. Paul	Sc
Vadnais Heights	Va
White Bear Lake	Va
Woodbury	

The Plan was submitted for formal 60-day review in June 2016 and revised per comments received during that period. After formal review of the *RWMWD Plan*, the RWMWD held a public hearing on the *RWMWD Plan* on November 2, 2016. BWSR subsequently approved the *RWMWD Plan* on March 22, 2017. The RWMWD Board of Managers formally adopted the *RWMWD Plan* on April 5, 2017.

4.5.3 Plan Update and Amendments

This Plan will guide RWMWD activities through 2026, or until superseded by adoption and approval of a subsequent Plan. The RWMWD may revise its Plan through an amendment prior to a Plan update if (1) minor changes are required, (2) problems arise that are not addressed in the Plan, or (3) new projects need to be added to the implementation program (see Section 4.2. However, this Plan, authorities, and official controls of the RWMWD will remain in full force and effect until a Plan revision is approved by BWSR. All amendments to this Plan will follow the procedures set forth in this section, or as required by Minnesota laws and rules (as revised). Plan amendments may be proposed by any person to the RWMWD Board, but only the RWMWD Board may initiate the amendment process. All recommended plan amendments must be submitted to the RWMWD in writing, along with a statement of the problem and need, the rationale for the amendment, and an estimate of the cost.

Approximately 2 years prior to the expiration date of this Plan (in 2024), RWMWD will begin the process of updating its Plan. The updated Plan will meet the requirements of the applicable Minnesota laws and rules.

The RWMWD recognizes that the District's plan may need to be periodically amended to remain useful as a long-term planning tool. The RWMWD will review and revise its implementation program through the RWMWD annual CIB process (see Section 4.1.1.2).

Technical information (especially water quality data) will require frequent updating whenever new site-specific data are generated by state, federal, and regional agencies, counties, cities, the District, individuals, or developers. The RWMWD intends to post this updated information on the RWMWD website (www.rwmwd.org), with hard copies available upon request. Other parts of the *RWMWD Plan* may also require occasional revision.

4.5.3.1 General Amendment Procedure

The RWMWD will follow the plan amendment process described in Minnesota Statutes 103B.231, Subd. 11 unless the proposed amendment is considered minor according to the criteria described in Minnesota Rules 8410 (see Section 4.5.3.2). In accordance with Minnesota Statutes 103B.231, Subd. 11, the plan amendment process (for non-minor amendments) is the same as the Plan review process and is as follows:

1. The RWMWD must submit the amendment to the RWMWD cities, Washington County, Ramsey County, Washington Conservation District, Ramsey Soil and Water Conservation District, state review agencies (the MDNR, MPCA, MDA, and MDH), the Metropolitan Council, and BWSR for a 60-day review.

2. The RWMWD must respond in writing to any concerns raised by the reviewers.

3. The RWMWD must hold a public hearing on the proposed amendment.

4. The RWMWD must submit the revised amendment and response to comments to the BWSR for 90-day review and approval.

The RWMWD will consider sending drafts of proposed general plan amendments to all plan-review authorities to receive input before beginning the formal review process.

Examples of situations where a general plan amendment may be required include:

- Addition of a capital improvement project that is not included in the existing Plan.
- Addition of new RWMWD action items or programs that have the potential to create significant financial impacts or controversy.

A plan amendment (general or minor) will not be required in the following situations:

1. The capital projects, annual activities, or studies listed in Table 4-1 are implemented at a different time than shown in the table.

2. The estimated project/activity/study costs are different than shown in Table 4-1 (BWSR may require a plan amendment if estimated project/activity/study costs are significantly greater than shown in Table 4-1).

3. The RWMWD modifies annual activities and/or studies to/from Table 4-1 within its discretion, consistent with Minnesota Rules 8410.0140, Subp. 1a (note that some modifications to program activities may require a plan amendment). Such modifications will be proposed, discussed, and adopted as part of the RWMWD annual budgeting process (see Section 4.1.1.2).

4. The proposed funding method (or combination of methods) for a capital improvement project listed in Table 4-1 is different than shown in the table (e.g. watershed-wide tax instead of subwatershed tax). In this situation, RWMWD will hold a public hearing on the proposed change to the funding method.

4.5.3.2 Minor Plan Amendments

The minor plan amendment process is more streamlined than the general plan amendment process. The RWMWD will consider changes to be a minor plan amendment if it satisfies all of the criteria established in Minnesota Rules 8410, which include the following (as applied to the RWMWD):

- BWSR has either agreed that the amendments are minor or failed to act within 5 working days of the end of a 30-day comment period (unless an extension is mutually agreed to with the RWMWD).

- The RWMWD has sent copies of the amendments to the plan-review authorities for review and comment allowing at least 30 days for receipt of comments, has identified the procedure for minor amendment is being followed, and directed that comments be sent to the RWMWD and BWSR.

- No county board has filed an objection to the amendments with the RWMWD and BWSR within a 30-day comment period (unless an extension is mutually agreed upon by the county and the RWMWD).

- The RWMWD has held a public meeting to explain the amendments and published a legal notice of the meeting twice, at least 7 days and 14 days before the date of the meeting.

- The amendments are not necessary to make the plan consistent with an approved and adopted county groundwater plan.

If an amendment is considered minor, the RWMWD will follow the following review process, consistent with Minnesota Rules 8410.0140 and Minnesota Statutes 103B.231 Subd. 11:

1. The RWMWD will send copies of the proposed minor plan amendment to the affected counties, cities, soil and water conservation districts (SWCDs), the Metropolitan Council, and the state review agencies for review and comment.

2. The RWMWD will hold a public meeting to explain the amendments and publish a legal notice of the meeting twice, at least 7 days and 14 days before the date of the meeting. The RWMWD will also post the notice of the public meeting on the RWMWD website and mail the notices to each affected city, township, and county not less than 14 days before the public meeting.

The minor plan amendment process is more streamlined than the general plan amendment process since it requires only one (30-day) review. As noted in Minnesota Rules 8410, the following actions will not require a plan amendment:

- Formatting or reorganization of the plan
- Revision of a procedure meant to streamline administration of the plan
- Clarification of existing plan goals or policies
- Inclusion of additional data not requiring interpretation
- Expansion of public process
- Adjustments to how an organization will carry out program activities within its discretion

For changes not requiring a plan amendment, the RWMWD will distribute replacement pages in accordance with Minnesota Rules 8410.0140, Subp. 1a and Subp. 5.

4.5.3.3 Amendment Format and Distribution

The RWMWD will prepare and distribute plan amendments in a format consistent with Minnesota Rules 8410. The RWMWD will maintain a distribution list of everyone who receives a copy of the Plan. Within 30 days of adopting an amendment, the RWMWD will distribute copies of the amendment to everyone on the distribution list and post the amendment on the RWMWD website.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	District-wide:				
DW-1*	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.**	**$100,000 (average annual cost)**	**EC3**	**Tier 1**
DW-2*	Monitor water quality of District lakes and streams to assess trends and evaluate achievement of water quality goals.	**Continuous**	**$75,000 (average annual cost)**	**WQ1, WQ3, WQ4**	**Tier 1**
DW-3*	Implement or continue subwatershed outlet monitoring to measure subwatershed pollutant reduction performance.	**Continuous**	**$25,000 (average annual cost)**	**WQ4**	**Tier 1**
DW-4*	Implement the District's lake aquatic plant (macrophytes) and filamentous green algae monitoring program and assess data for trends, implementing macrophyte management plans if needed.	**Continuous**	**$30,000 (average annual cost)**	**EC2**	**Tier 2**
DW-5*	Inspect and maintain District facilities and consider opportunities to support maintenance activities of others.	**Annual**	**$700,000 (average annual cost)**	**WQ9, WQ10, FL1**	**Tier 1/Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
DW-6*	Implement BMP cost-share program to assist citizens, institutions, local agencies, and businesses in implementing water quality improvements.	**Continuous**	**$800,000 (average annual cost)**	**WQ2, WQ14, WQ17, WQ18, FL8, IE17, MO16, MO17, MO21**	**Tier 1/Tier 2/Tier 3**
DW-7*	Implement, track, and update (as necessary) District rules and permitting program.	**Continuous**	**$70,000 (average annual cost)**	**WQ12, EC1, FL2, FL8, GW4, MO15, MO20**	**Tier 1**
DW-8*	Monitor and maintain District restoration sites and natural areas.	**Continuous**	**$40,000 (average annual cost)**	**EC4**	**Tier 1**
DW-9*	Identify, assess, and address potential flooding problems in the District, in cooperation with applicable stakeholders.	**As needed**	**$300,000 (average annual cost)**	**WQ19, FL3, FL7, FL9**	**Tier 1**
DW-10*	Collaborate with local and state agencies to address groundwater issues, including identify data gaps, identify areas of vulnerability, and develop management strategies and tools.	**As needed**	**$30,000 (average annual cost)**	**GW1, GW3, GW6, GW7, GW8, GW9**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
DW-11*	Implement public information and education program 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.	**Continuous**	**$60,000 (average annual cost)**	**WQ3, WQ6, WQ10, WQ13, WQ15, WQ16, EC6, EC7, EC8, EC9, EC10, GW10, IE1, IE3, IE4. IE5, IE7, IE8, IE9, IE10, IE11, IE14, IE15, IE17, MO16, MO21**	**Tier 1/Tier 2**
DW-12*	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.	**Continuous**	**$300,000 (average annual cost)**	**WQ1, WQ7, WQ8, WQ10, WQ11, MO12, MO13, MO14**	**Tier 2/Tier 3**
DW-13	Manage District organization and operation effectively by providing effective and qualified staff, efficient office facilities, operational expenses, services and equipment, Board and staff training, planning support, and accounting and audit services.	**Continuous**	**$2,000,000 (average annual cost)**	**MO1, MO7, MO8, MO9, MO10, MO18, MO19**	**Tier 1**
DW-14*	Collaboratively manage invasive species that threaten water resources and associated upland habitats.	**Continuous**	**$20,000 (average annual cost)**	**EC5**	**Tier 2/Tier 3**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
DW-15*	Maintain the District's MS4 permit and assist local communities in meeting the water quality components of their NPDES MS4 permit requirements**.**	**Continuous**	**$10,000 (average annual cost)**	**WQ5, WQ10, FL6, IE6**	**Tier 1/Tier 2**
DW-16	Study the connection between surface water and groundwater throughout the District.	**2017**	**$50,000**	**GW2**	**Tier 2/Tier 3**
DW-17*	Maintain an inventory of infiltration projects and share information with agencies with groundwater jurisdiction.	**Continuous**	**$5,000 (average annual cost)**	**GW5**	**Tier 1**
DW-18*	Monitor lake levels within the District.	**Continuous**	**$5,000 (average annual cost)**	**FL4**	**Tier 1**
DW-19	Implement flood emergency response plans for homes and businesses where a complete structural solution is not feasible or cost-effective and develop additional flood emergency response plans as necessary.	**Continuous**	**$25,000 (average annual cost)**	**FL5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
DW-20*	Develop and implement methods/programs for measuring, tracking, and reporting progress towards achieving District goals, including the bi-annual evaluation process required by BWSR. Develop an annual plan and budget, and periodically review vision and mission.	**Continuous**	**$10,000 (average annual cost)**	**MO2, MO3, MO4, MO5, MO6, MO11, MO12, MO15**	**Tier 1**
DW-21*	Implement tours, workshops, trainings and other events to increase MS4 and community participation and awareness of watershed issues.	**As needed**	**$40,000 (average annual cost)**	**IE2, IE12, IE13**	**Tier 1/Tier 2**
DW-22	Develop a program to incorporate public art into District projects and programs.	**2017-2018**	**$50,000**	**IE16**	**Tier 3**
	Willow Creek Subwatershed:				
WC-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	--	--	--
	Kohlman Creek Subwatershed:				
KC-1*	Implement improvements described in the Markham Ecosystem Restoration Report (2013)	**2017-2026**	**$2,000,000**	**WQ2, WQ18, EC3, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
KC-2	Study the effect of increasing flood storage in upstream areas on improving flood resiliency in Kohlman Creek and implement recommended projects	**2018-2022**	**$2,000,000**	**FL9, IE7, IE17, MO6, MO21**	**Tier 1**
KC-3*	Manage macrophytes in Casey Lake Wetland	**2017-2026**	**$100,000**	**EC4, EC5**	**Tier 2**
	Kohlman Lake Subwatershed:				
KL-1*	Implement a shoreline management study and assist homeowners with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
KL-2*	Research options for control of Kohlman Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
KL-3*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Kohlman Lake.	**2017-2026**	**$200,000**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
KL-4*	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**$240,000 (representative of management cost throughout the Phalen Chain of Lakes)**	**WQ2, EC3, EC5**	**Tier 2**
KL-5	Visually inspect the connection between Kohlman Lake and Gervais Lake and assess its condition	**2017**	**$2,000**	**EC4**	**Tier 1**
	Twin Lake Subwatershed:				
TL-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	**--**	**--**	**--**
	Gervais Creek Subwatershed:				
GC-1	Continue to coordinate with DNR and Little Canada to improve habitat in Gervais Mill Park and maintain the urban fishing pond status.	**Continuous**	**$1,500 (average annual cost)**	**EC6**	**Tier 3**
GC-2*	Research options for control of Round Lake's (Little Canada) internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$50,000**	**MO13**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
GC-3	Prepare and implement a plan for increasing flood resiliency around Owasso Basin	**2018-2020**	**$500,000**	**WQ8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
	Gervais Lake Subwatershed:				
GL-1	Implement the Gervais Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**WQ19, FL5, FL9**	**Tier 2**
GL-2	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Gervais Lake.	**2017-2026**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
GL-3	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**
	Keller Lake Subwatershed:				
KeL-1	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Keller Lake.	**Continuous**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
KeL-2*	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Lake Phalen Subwatershed:				
LP-1	Coordinate with the City of St. Paul Parks Department, the Minnesota DNR and other agencies and citizen organizations, to address concerns about lake management and conditions.	**Continuous**	**$5,000 (average annual cost)**	**EC6**	**Tier 2**
LP-2*	Work with the City of St. Paul to improve the PHAL-08 pond	**2020**	**$150,000**	**WQ2, WQ17, WQ18, WQ19, FL8, IE7, IE17, MO6, MO21**	**Tier 1**
LP-3*	Implement a shoreline management study for Round Lake (Maplewood) to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC6**	**Tier 2**
LP-4	Restore park areas in the Phalen Corridor	**2017-2020**	**$140,000**	**WQ18, EC3, EC6, IE7, IE17, MO6, MO21**	**Tier 3**
LP-5	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Lake Phalen and Round Lake (Maplewood).	**2017-2026**	**$50,000**	**WQ2, EC3, EC5**	**Tier 2**
LP-6	Manage the carp population in the Phalen Chain of Lakes	**2017-2026**	**See KL-4**	**WQ2, EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Wakefield Lake Subwatershed:				
WL-1*	Implement regional stormwater treatment BMPs in the subwatershed as prescribed in the Wakefield TMDL (Examples include: Enhanced treatment of flows through PHAL-05, Wakefield Park and expansion of spent lime treatment cell on the south end of Wakefield Lake)	**2017-2020**	**$1,000,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
WL-2*	Implement a shoreline management study and assist property owners/homeowners with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
WL-3*	Research future options for control of Wakefield Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
WL-4*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Wakefield Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
WL-5*	Evaluate water quality benefit of removing accumulated sediment from south end of Wakefield Lake to the improve Lake Phalen water quality.	**2018**	**$20,000**	**WQ2**	**Tier 1**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Beaver Lake Subwatershed:				
BL-1*	Implement improvements identified in the Beaver Lake SLMP, including implementation of BMPs in the lake's direct drainage area (BL-203)	**2018-2022**	**$400,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BL-2*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Beaver Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
BL-3*	Research future options for control of Beaver Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BL-4*	No other subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed, using past infiltration study work to help inform project decisions.	**Continuous**	**--**	**WQ17, MO13**	**--**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Beltline Subwatershed:				
BELT-1	Implement water quality and flood control improvements listed in the Beltline CIP Feasibility Report, as identified in the Atlas 14 District remodeling effort, and as recommended by additional analyses.	**2017-2026**	**$500,000**	**WQ2, WQ17, WQ18, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
BELT-2	Complete Beltline tunnel repair projects as recommended in 2015 inspections, Re-inspect tunnel every 5 years.	**2017-2026**	**$5,000,000**	**FL1**	**Tier 1**
BELT-3	Prepare and implement a plan for increasing resiliency and controls for overflow from Lake Phalen	**2018-2026**	**$5,000,000**	**FL7, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
	Mississippi River Bottomlands Subwatershed:				
MR-1	Collaborate with the City of St. Paul and Ramsey County on water management issues related to stormwater runoff from the Beltline Interceptor, Battle Creek, and Fish Creek Subwatersheds.	**Continuous**	**$5,000 (average annual cost)**	**WQ19, FL7, FL9**	**Tier 3**
MR-2	Coordinate with the Metropolitan Council and the MPCA on results and issues related to potential phosphorus discharge limits to the Mississippi River.	**Continuous**	**$5,000 (average annual cost)**	**WQ2**	**Tier 3**

*WRAPS strategy

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Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)		Relevant Strategic Overview Action Items**	Priority Tier
	Tanners Lake Subwatershed:					
TaL-1	Implement the Tanners Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**		**WQ19, FL5, FL9**	**Tier 2**
TaL-2*	Continue alum treatment system operations and maintenance	**Continuous**	**Utilities (electric, water, comm.)**	**$3,000**	**WQ9**	**Tier 1**
			Chemical supply (alum)	**$60,000**		
			Pond floc removal	**$25,000**		
			$88,000 (average annual cost)			
TaL-3*	Continue alum system monitoring and reporting as required by current and future NPDES permit. Continue to monitor research of alum use for stormwater treatment, identifying best practices.	**Continuous**	**$40,000 (average annual cost)**		**WQ7**	**Tier 1**

*WRAPS strategy

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Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Battle Creek Lake Subwatershed:				
BCL-1	Implement the Battle Creek Lake Flood Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**FL5**	**Tier 2**
BCL-2*	Research future options for control of Battle Creek Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BCL-3*	Perform a feasibility study of retrofit opportunities throughout the Battle Creek Lake Subwatershed to improve water quality	**2018**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BCL-4*	Implement projects deemed feasible in the Battle Creek Lake Subwatershed Feasibility Study	**2019-2026**	**$500,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BCL-5*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Battle Creek Lake.	**2017-2026**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
	Battle Creek Subwatershed:				
BC-1	Implement the McKnight Basin Emergency Response Plan	**Continuous**	**$5,000 (average annual cost)**	**FL5, FL9**	**Tier 2**

*WRAPS strategy

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Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BC-2*	Perform a feasibility study of retrofit opportunities throughout the Battle Creek Subwatershed to reduce watershed TSS load	**2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BC-3*	Implement water quality projects deemed feasible in the Battle Creek Subwatershed Feasibility Study	**2018-2026**	**$1,000,000**	**WQ2, WQ17, WQ18, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
BC-4	Study the effect of increasing flood storage in McKnight Basin and upstream of Weir Drive on improving flood resiliency in Battle Creek and implement recommended projects	**2018-2022**	**$500,000**	**WQ2, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
	Blufflands Subwatershed:				
BLUFF-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	**--**	**--**	**--**
	Carver Lake Subwatershed:				
CL-1*	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	**--**	**--**	**--**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
	Fish Creek Subwatershed:				
FC-1*	Assist MS4s in implementing the Fish Creek TMDL, such as educating citizens about proper management of pet waste.	**2017-2026**	**$5,000**	**IE3, IE5, IE6**	**Tier 2**
FC-2	Study the effect of increasing flood storage upstream of I-494, in Bailey Nursery and other upstream areas on improving flood resiliency in Fish Creek and implement recommended projects.	**2018-2022**	**$500,000**	**WQ2, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
	Grass Lake Subwatershed:				
GrL-1	Survey the connection between Grass Lake and Vadnais Lake, assess conditions and implement any needed improvements.	**2017**	**$20,000**	**FL1, FL7, FL9**	**Tier 1**
	Bennett Lake Subwatershed:				
BeL-1*	Implement a shoreline management study and assist with lakeshore restoration to enhance lakeshore native habitat and stabilization (partner with existing efforts)	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BeL-2*	Perform a feasibility study of retrofit opportunities throughout the Bennett Lake Subwatershed to improve water quality, including enhanced treatment of Willow Pond outflows, regional stormwater treatment within Central Park and other options identified in previous studies, including the Bennett Lake TMDL.	**2016-2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BeL-3*	Research future options for control of Bennett Lake's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
BeL-4*	Implement projects deemed feasible in the Bennett Lake Subwatershed Feasibility Study	**2018-2026**	**$750,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
BeL-5*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Bennett Lake.	**2020**	**$100,000**	**WQ2, EC3**	**Tier 2**
BeL-6*	Evaluate the carp population in the Lake Owasso-Central Park Wetlands- Bennett Lake chain	**2017-2018**	**See LO-6**	**EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
BeL-7*	Manage the carp population in the Lake Owasso-Central Park Wetlands-Bennett Lake chain if deemed necessary.	**2019-2026**	**See LO-7**	**WQ2, EC3, EC5**	**Tier 2**
	Shoreview Lake Subwatershed:				
ShL-1*	Perform a feasibility study of retrofit opportunities throughout the Shoreview Lake Subwatershed to improve water quality	**2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
ShL-2*	Implement projects that are deemed feasible in the Shoreview Lake Subwatershed Feasibility Study	**2018-2026**	**$200,000**	**WQ2, WQ17, WQ18, WQ19, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
	Snail Lake Subwatershed:				
SL-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	**--**	**--**	**--**
	Lake Owasso Subwatershed:				
LO-1*	Assess and conduct buffer and natural areas restoration along the Owasso Lakes Area	**2024-2026**	**$70,000**	**EC3, EC6**	**Tier 1**
LO-2	Create and implement an Emergency Response Plan for Owasso Lake.	**2017-2026**	**$50,000**	**WQ19, FL5, FL9**	**Tier 2**

*WRAPS strategy

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Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LO-3*	Perform a feasibility study of retrofit opportunities throughout the Lake Owasso Subwatershed to improve water quality, such as reducing the phosphorus load from tributary wetland systems (Westwood Village Pond, the Central Park Wetlands and Charlie Pond) and implementing a sedimentation pond at the City of Roseville's compost facility.	**2018**	**$30,000**	**WQ17, WQ19, FL8, IE7, IE17, MO6, MO21**	**Tier 1**
LO-4*	Implement water quality projects that are deemed feasible in the Lake Owasso Subwatershed Feasibility Study	**2019-2026**	**$750,000**	**WQ2, WQ17, WQ18, WQ19, FL8, FL9, IE7, IE17, MO6, MO21**	**Tier 1**
LO-5*	Research options for control of Lake Owasso's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$100,000**	**WQ8, MO13**	**Tier 2**
LO-6*	Evaluate the carp population in the Lake Owasso-Central Park Wetlands- Bennett Lake chain	**2017-2018**	**$150,000 (representative of assessment cost throughout the Owasso Chain of Lakes)**	**EC3, EC5**	**Tier 2**

*WRAPS strategy

Relevant Strategic Overview Action Items with "WQ**" pertain to the **"Achieve Quality Surface Water"** goal, with **"EC"** pertain to the **"Achieve Healthy Ecosystems"** goal, with **"FL"** pertain to the **"Manage Risk of Flooding"** goal, with **"GW"** pertain to the **"Support Sustainable Groundwater"** goal, and with **"IE"** pertaining to the **"Inform and Empower Communities**" goal and with **"MO"** pertain to the **"Manage Organization Effectively"** goal.

Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LO-7*	Manage the carp population in the Lake Owasso-Central Park Wetlands-Bennett Lake chain if deemed necessary.	**2019-2026**	**$240,000 (representative of management cost throughout the Owasso Chain of Lakes)**	**WQ2, EC3, EC5**	**Tier 2**
LO-8*	Use results of the District's macrophyte harvesting study to inform implementation of macrophyte management in Owasso Lake.	**2018**	**$100,000**	**WQ2, EC3, EC5**	**Tier 2**
	Lake Emily Subwatershed:				
LE-1*	Implement a shoreline management study and assist with lakeshore restoration to enhance lakeshore native habitat and stabilization	**2018**	**$25,000**	**EC3, EC9**	**Tier 2**
LE-2*	Perform a feasibility study of retrofit opportunities throughout the Lake Emily Subwatershed to improve water quality, including outflows from Lake Judy	**2016-2017**	**$30,000**	**WQ17, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**
LE-3*	Implement projects that are deemed feasible in the Lake Emily Subwatershed Feasibility Study	**2019-2026**	**$300,000**	**WQ2, WQ17, WQ18, WQ19, IE7, IE17, MO6, MO21**	**Tier 1**

*WRAPS strategy

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Table 4-1 RWMWD 2017-2027 Implementation Program

Implementation Item ID	Activity Description	Estimated Implementation Year	Estimated Cost[1] (2017 Dollars)	Relevant Strategic Overview Action Items**	Priority Tier
LE-4*	Research options for control of Lake Emily's internal load of phosphorus and implement reduction measures if deemed necessary to maintain water quality.	**2020**	**$50,000**	**WQ8, MO13**	**Tier 2**
	Lake Wabasso Subwatershed:				
LW-1	No subwatershed-specific projects/programs are identified for this subwatershed; District-wide projects and activities will be implemented in this subwatershed.	**Continuous**	**--**	**--**	**--**

*WRAPS strategy

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