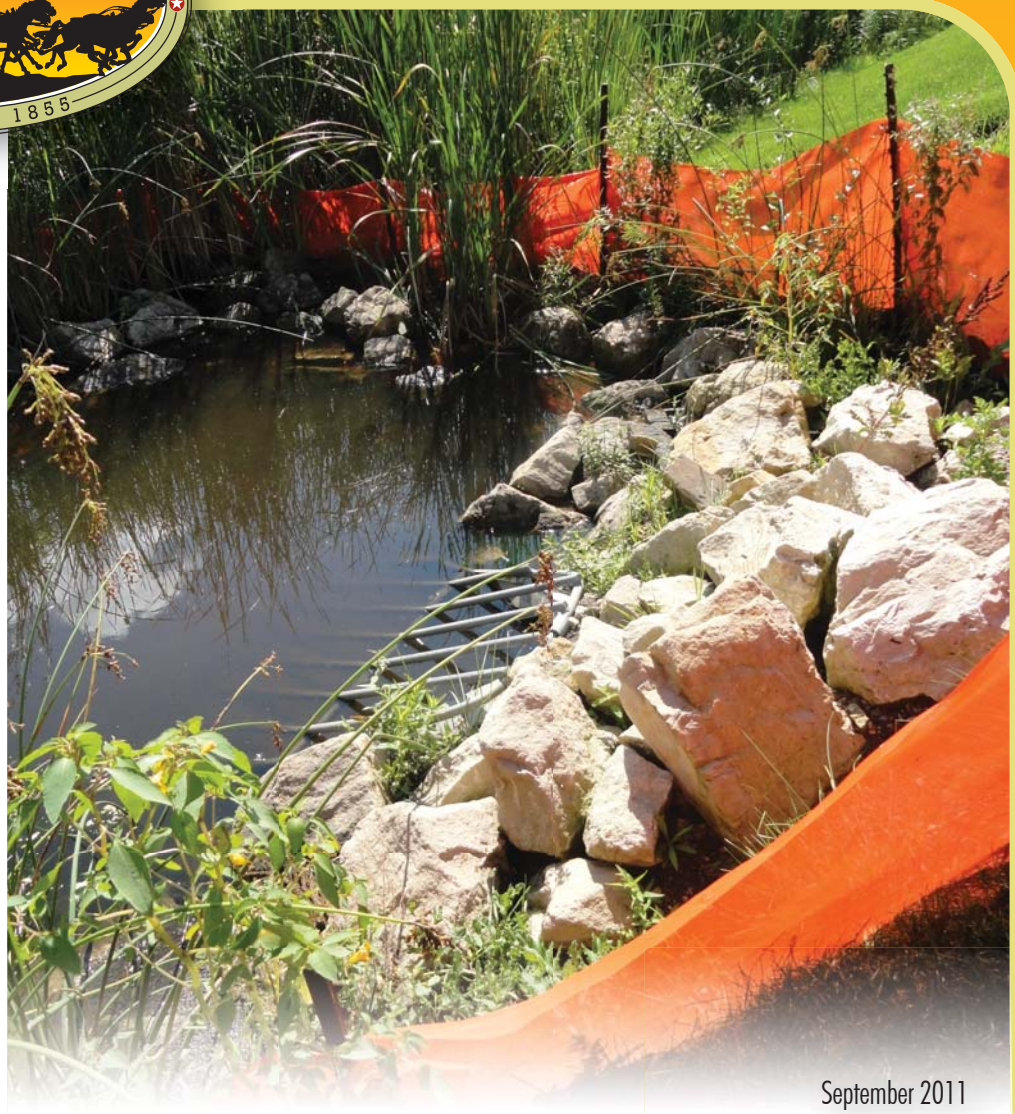
CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855



September 2011

water resource GUIDANCE DOCUMENT

WSB Project No. 1688-69

WSB & Associates, Inc.

WATER RESOURCE GUIDANCE DOCUMENT
FOR THE CITY OF WYOMING, MINNESOTA

WSB Project No. 1688-69

September 2011

PREPARED BY

City of Wyoming
26885 Forest Boulevard
P.O. Box 188
Wyoming, MN 55092

WSB & Associates, Inc.
701 Xenia Avenue – Suite 300
Minneapolis, MN 55416
(763) 541-4800

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Todd Hubmer, PE
Reg. No. 24043

Jacob Newhall, PE
Reg. No. 49170

TABLE OF CONTENTS

I. Executive Summary

II. Introduction and Purpose
- A. General
- B. Personnel Contacts
- C. Water Resource Related Agreements

III. Land and Water Resource Inventory
- A. Climate and Precipitation Data
  - 1. Climate
  - 2. Precipitation
- B. Geology and Groundwater Resources
  - 1. Geology
  - 2. Topography
- C. Surface Water Resource Information
  - 1. Wetlands
  - 2. Major Bodies of Water
  - 3. Stormwater Conveyance System
  - 4. Hydrologic Modeling
  - 5. Watersheds
- D. Flood Insurance Studies
- E. Water Quality Data
  - 1. 2010 List of Impaired Waters (Section 303d)
  - 2. Data
- F. Floodplain Management
- G. Shoreland Management
- H. Wetland Management
- I. Ground Water Appropriations
- J. Ground Water Resource Data
- K. Soils Information
- L. Land Use and Public Utilities Services
- M. Public Areas for Water Based Recreation and Access
- N. Fish and Wildlife Habitat
- O. Unique Features and Scenic Areas
- P. Pollutant Sources
- Q. NPDES Phase II

IV. Establishment of Goals, Strategies, and Policies
- A. Cooperation with other Agencies
- B. Education
  - 1. Policies
- C. Regulation
  - 1. Policy Threshold
  - 2. City Permit
  - 3. Water Quality and Quantity Policies

4. Freeboard Policies
5. Landlocked Basin Policies
6. Floodplain Policies
7. Wetland Policies
8. Buffer Policies
9. Groundwater Policies
10. Erosion and Sediment Control Policies

D. Internal Operations
1. Internal Operations Policies

V. Glossary of Acronyms

LIST OF TABLES

Table III-1 Average Monthly Temperature, Precipitation, and Snowfall Data for Wyoming Area
Table III-2 Rainfall/Runoff Events for the City of Wyoming
Table III-3 DNR Public Waters Surface Water Classification
Table IV-1 Permitted Bounce and Period of Inundation

LIST OF APPENDICES

Appendix A – Figures
Figure 1 – 1% Chance Rainfall Event in 24-Hours
Figure 2 – Annual Normal Precipitation
Figure 3 – Location Map
Figure 4 – National Wetlands Inventory (NWI)
Figure 5 – DNR Public Water Inventory Map
Figure 6 – Watershed Map
Figure 7 – Water Resource Problem Areas
Figure 8 – Water Quality Monitoring Locations
Figure 9 – Groundwater Appropriations
Figure 10 – Depth (ft) to Groundwater
Figure 11 –Hydrologic Soils Map
Figure 12 – Existing Land Use Map
Figure 13 – Proposed Land Use Map
Figure 14 – Presettlement Vegetation
Figure 15 – Native Plant Communities and Scientific Areas
Figure 16 – Pollutant Sources

Appendix B – Hydraulic/Hydrologic Modeling Information (from CLFLWD)

Appendix C – MPCA Water Quality Monitoring Date
Comfort Lake – Forest Lake Watershed District 2010 Water Monitoring Report

SECTION I

I. EXECUTIVE SUMMARY

This Water Resource Guidance Document is intended to provide a comprehensive inventory of pertinent water resource related information that affects the City in the management of its water resources. This document has been developed to be in conformance with the City's Comprehensive Plan and to meet or exceed the requirements of applicable State and Federal laws. Both the City Comprehensive Plan and this Water Resource Guidance Document will be utilized by the City to manage development, planning, and water resource related activities. This Water Resource Guidance Document contains water resource goals, policies, and strategies to help the City manage its water resources.

The following are the water resource goals of the City:

- Reduce occurrence of flooding and improve flood protection to properties.
- Manage the quality of water in local lakes, wetlands, and streams.
- Reduce erosion and sedimentation of soil into surface water systems.
- Preserve wetlands, lakes, and all surface waters.
- Minimize public capital expenditures needed to address water resource problems.
- Promote groundwater recharge.
- Enhance fish and wildlife habitat and water recreational opportunities to greatest extent feasible.
- Educate residents, business owners, City Staff, City Council, developers, and others about proper water resource management.
- Complete inspection and maintenance of stormwater infrastructure regularly and efficiently to ensure desired performance is achieved.

An inventory of the City's water resources, along with the policies and strategies that have been developed to help the City meet their goals, is contained within the sections described below.

SECTION II

Section II of this document provides an introduction and purpose. The Water Resource Guidance Document has been developed to provide the City with guidance concerning the administration and implementation of water resource activities within the City. This section also lists the contact information for individuals and agencies involved in the administration and implementation of this document.

SECTION III

Section III of this document provides an inventory of land and water resources within the City including a general description and summary of data related to climate, precipitation, geology, topography, wetlands, lakes, hydrologic modeling, known water resource problem areas, water quality, water management ordinances, groundwater, soils, land use, public utilities services, public areas for water-based recreation, fish and wildlife habitat, unique features, scenic areas, pollutant source locations, and existing Best Management Practices (BMPs) within the City. A number of maps were also developed as part of the document to assist in summarizing this information and are included as Appendix A.

SECTION IV

Section IV of this document outlines water resource related goals and policies of the City. Goals and policies have been developed for regulation of water resources, enhancement of public participation and education, and administration of the City's internal operations. The goals and policies described in this section have been developed to accommodate economic growth and reduce the adverse affects of development while enhancing the City's water resources.

SECTION V

Section V contains a glossary of frequently used water resource acronyms.

APPENDICES

Appendices are included in the back of the document and are summarized below. These appendices are included because they provide supporting information to the main body of the document.

Appendix A: Figures. Figure III-1 through **Figure III-16** are located in this appendix.

Appendix B: Hydrologic/Hydraulic Modeling Data. Modeling information completed by the Comfort Lake Forest Lake Watershed District is provided in this appendix.

Appendix C: MPCA Water Quality Data. Water quality assessments and data summaries for monitoring locations within City are provided in this appendix.

Additional materials are referenced within this report and are available from the City's Engineering Department.

This Water Resource Guidance Document will be amended into a 10 year Surface Water Management Plan by November of 2013, which is the date a Surface Water Management Plan for the City of Wyoming is required by the CLFLWD and State Statute.

SECTION II

II. INTRODUCTION AND PURPOSE

A. General

This Water Resource Guidance Document has been developed to provide the City with guidance concerning the administration and implementation of water resource management activities and to meet local and regional environmental and planning requirements. This document has been developed to be in conformance with the City's Comprehensive Plan, both of which will be used to manage development, planning, and water resource related activities throughout the City of Wyoming.

In addition to meeting the requirements of state law, this document has also been developed to be in conformance with the City's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Stormwater Discharge permit and the City's Stormwater Pollution Prevention Plan (SWPPP). This document incorporates the approach and direction currently provided by the NPDES into a comprehensive plan that can be consistently applied across the City.

B. Personnel Contacts

To implement this document, a coordinated water resource management approach must be used. This approach utilizes the services of staff personnel within the City, County, Comfort Lake Forest Lake Watershed District, and surrounding communities. Assistance from the surrounding municipalities and counties will also be expected. Outlined below is the contact information for personnel having responsibilities for overseeing or implementing various aspects of the Document.

Fred Weck
Zoning Administrator
City of Wyoming
P.O. Box 188
Wyoming, MN 55092
(651)- 462-4947

C. Water Resource Related Agreements

Currently the City does not have any water resource related agreements.

III. LAND AND WATER RESOURCE INVENTORY

The City of Wyoming contains and is surrounded by valuable water and land resources. Managing these important resources is a high priority for the City and the surrounding area. Information has been collected regarding land and water resources for the City from a variety of sources. This section of the document provides a general description and summary of the climate, geology, surficial topography, surface and ground water resource data, soils, land use, public utilities services, water based recreation, fish and wildlife habitat, unique features, scenic areas, and pollutant sources. This section also identifies where detailed information can be obtained for many of these areas. Refer to **Appendix A** for **Figure III-1** through **Figure III-16**.

A. Climate and Precipitation

1. Climate

The climate in Chisago County is described as a humid continental climate with moderate precipitation, wide daily temperature variations, warm humid summers and cold winters. The average annual precipitation is approximately 29 inches, of which approximately 21 inches occurs between April and September. The annual snowfall average is about 39 inches. Average monthly temperature, precipitation and snowfall are shown on **Table III-1**.

2. Precipitation

A rainfall event having a 99% chance of occurrence in a 24-hour period is approximately 2.3 inches (1-year event). A rainfall event having a 1% chance of occurrence in a 24-hour period is approximately 5.8 inches (100-year event). The 100-year, 10-day runoff (snowmelt) is 7.4 inches. Additional rainfall events and probabilities are listed in **Table III-2**.

Figures III-1 and **III-2** show the 1% rainfall event and the annual normal precipitation with the State of Minnesota. Additionally, climatological information for the area can be obtained from the U.S. Weather Bureau Technical Paper 40.

B. Location, Geology, and Topographic Information

1. Location

The City of Wyoming is located in the southwest portion of Chisago County (**Figure III-3**). The City of Forest Lake is located on the south border of the City. The City of Stacy is located just north of the City on Interstate 35. Chisago City is located directly east of Wyoming. Total area within the corporate limits of Wyoming is approximately 22 square miles.

2. Geology

Information from the *Chisago County Geologic Atlas* indicates the bedrock geology of the City consists of a combination of St. Lawrence Formation, Jordan Sandstone, Tunnel City Group, and Wonewoc Sandstone. The depth of the bedrock ranges from 400 to 450 feet in the western part of the City to as little as 0 to 50 feet in areas located in the eastern and northern parts of the City.

3. Topography

The topography of the City can be described as flat to gently rolling with more relief along the Sunrise River. Stormwater runoff from the City is generally directed toward the Sunrise River which runs north through the north central part of the City.

TABLE III-1 AVERAGE MONTHLY TEMPERATURE, PRECIPITATION, AND SNOWFALL DATA FOR WYOMING AREA

Month	Average Temp F^o	Precip. inches	Snowfall inches
January	9.8	0.96	10
February	17.1	0.63	5.5
March	29.2	1.4	7.6
April	44	2.1	2
May	57.1	3.18	0
June	65.2	4.39	0
July	70	4.3	0
August	67.4	4.08	0
September	57.5	2.95	0
October	45.7	2.37	0.4
November	29.5	1.89	6.3
December	15.4	0.85	7.6
Annual Average:	42.3 **Total:**	29.1 **Total:**	39.4

Source: Midwestern Regional Climate Center, Data for Cambridge

TABLE III-2 RAINFALL/RUNOFF EVENTS FOR THE CITY OF WYOMING

RECURRENCE INTERVAL	EVENT DURATION	PROBABLILITY OF OCCURRENCE IN ANY GIVEN YEAR	RAINFALL AMOUNT (INCHES)
1 – Year	24 – Hour	99%	2.3
2 – Year	24 – Hour	50%	2.7
5 – Year	24 – Hour	20%	3.5
10 – Year	24 – Hour	10%	4.1
25 – Year	24 – Hour	4%	4.7
50 – Year	24 – Hour	2%	5.2
100 – Year	24 – Hour	1%	5.8
25 – Year	10 – Day	4%	8.6
50 – Year	10 – Day	2%	9.8
100 – Year	10 – Day	1%	10.7
100 – Year	10 – Day Runoff	1%	7.4 (runoff)

Source: 24-hour rainfall values are from USWB TP 40; 10-day rainfall values are from USWB TP49; 10-day runoff values are from SCS TR60, Hydrology Guide for Minnesota

C. Surface Water Resource Data

1. Wetlands

The general locations of wetlands within the City can be seen on **Figure III-4**, which shows wetlands from the National Wetland Inventory. These wetlands provide habitat to many species of plants and animals. Wetlands also affect the local water quality. The aquatic plants present in a healthy wetland will slow and filter water moving through the wetland take up pollutants and provide additional settling time for sediment.

2. Major Bodies of Water

The City has multiple major bodies of water within its corporate limits: the South Branch of the Sunrise River and its tributaries, Ashton Lake, Comfort Lake, and Heims Lake. The Sunrise River is also tributary to the Sunrise Pools which are located in the north part of the City within the Carlos Avery State Wildlife Management Area. Multiple wetlands, small lakes, and streams are also located in and around the City. Refer to **Figure III-5** for a map showing the public waters, wetlands, and waterways. More information about these water bodies is included in various portions of this section.

3. Stormwater Conveyance System

The City's stormwater conveyance system consists of ditches, rivers, streams, lakes, ponds, wetlands, and storm sewer pipes.

Refer to **Figure III-6a** for a map showing the stormwater conveyance system. Only the conveyance system within the old City limits is included in the figure. The other components of the system will need to be inventoried and mapped (this is an implementation activity in this document).

4. Hydrologic Modeling

The Forest Lake/Comfort Lake Watershed District has developed an XP-SWMM hydrologic/hydraulic model for the entire watershed district. This model encompasses the southern portion of the City. Refer to **Appendix B** for more hydrologic/hydraulic modeling information.

At the time this document was adopted, the City had not yet developed a hydrologic/hydraulic model for the portion of the City outside the CLFLWD. The City is considering completing the modeling for this remaining portion of the City (area outside CLFLWD).

Refer to **Figure III-6b** for a map showing the Minnesota DNR delineation for the City and the surrounding area.

5. Watersheds

The Comfort Lake Forest Lake Watershed District has jurisdiction over the southern portion of the City (approximately 7 square miles). The remainder of the City limits is not located within a Watershed Management Organization or Watershed District. The Sunrise River Watershed Management Organization borders the western boundary of the City. Refer to **Figure III-6c** for the jurisdictional boundaries of the Comfort Lake

Forest Lake Watershed District and the Sunrise River Watershed Management Organization.

D. Flood Insurance Studies

The Federal Emergency Management Agency (FEMA) completed a Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs) to identify flood risk within Chisago County in 1993. The FIS and FIRMs from 1993 did not include the City limits of Wyoming at that time. In February 2010, FEMA completed a new preliminary FIS and FIRMs for Chisago County. The final FIS and FIRMs are anticipated to be completed after the adoption of this document.

E. Water Quality

1. 2010 List of Impaired Waters (Section 303d)

The MPCA lists the following water bodies located within or near the City as being impaired:

- The Sunrise River (AUID – 070300005-526) upstream of Comfort Lake, is listed as impaired by the MPCA due to Fecal Coliform Bacteria. The Sunrise River was added to the impaired waters list by the MPCA in 2010.
- Comfort Lake (ID – 13-0053-00) is listed as impaired by the MPCA due to Nutrients/Eutrophication and Biological Indicators. Comfort Lake was listed as impaired in 2002 and is part of the “Six Lake” TMDL Study that was completed in March of 2010.
- Forest Lake (ID – 82-0159-00), just south of the City, is listed as impaired by the MPCA due to Polychlorinated biphenyls (PCBs) in fish tissue. Forest Lake added to the impaired waters list in 2002.
- The following water bodies located just east of the City were listed as impaired by the MPCA: School Lake (ID – 13-0057-00) (Nutrients/Eutrophication and Biological Indicators, 2008), unnamed creek (AUID – 070300005-522) between Little Comfort Lake and School Lake (Dissolved Oxygen Depletion, 2010), and unnamed creek (AUID – 070300005-521) between School Lake and Birch Lake (Dissolved Oxygen Depletion, Fecal Coliform Bacteria, 2010).

The locations of these impaired water bodies are shown on **Figure III-7.**

In addition to the water bodies listed above, the City is upstream of the following impaired water bodies: Sunrise River, St. Croix River, Lake St. Croix, and Lake Pepin. The City will be required to implement the TMDL plans for these water bodies once complete. Many of the implementation activities used to achieve the goals in the TMDL plans are anticipated to be consistent with activities listed in the implementation plan in **Section VI**. These implementation activities will contribute to the City meeting its waste load reductions outlined in TMDL plans.

2. Data

Water quality data for the City has been obtained from the Minnesota Pollution Control Agency (MPCA) Environmental Data Access site. This database is utilized by participating agencies to compile water quality testing data and is almost entirely used for the storage of water quality parameters. Monitoring site locations listed on the MPCA website are shown on **Figure III-8.**

Refer to **Appendix C** for some of the Water Quality Data that has been collected in Wyoming. More water quality monitoring information/data can be found at the MPCA's Environmental Data Access site at http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-monitoring-and-reporting.html.

F. Floodplain Management

The City of Wyoming has adopted floodplain management regulations. A copy of these regulations can be found on the City's website at http://www.wyomingmn.org or obtained at City Hall**.** These regulations generally prohibit uses or activities within the floodplain that include structures of fill that obstruct flood elevations.

G. Shoreland Management

The City has adopted shoreland management regulations which control development in shoreland zones. A copy of these regulations can be found on the City's website at http://www.wyomingmn.org or obtained at City Hall. The City's shoreland management regulations contain the following classifications:

TABLE III-3 DNR PUBLIC WATERS SURFACE WATER CLASSIFICATION

Water Body	Location	PWI ID	Shoreland Ordinance Classification
Higgins	Southwest Wyoming	02P	Natural Environment Lake
Sam Lake	East Wyoming	45W	Natural Environment Lake
Shallow Pond	South Wyoming	55W	Natural Environment Lake
Peterson's Slough	East Wyoming	52W	Natural Environment Lake
Sunrise Pools	North Wyoming	59P	Natural Environment Lake
Tyra Slough	Southwest Wyoming	137W	Natural Environment Lake
Ashton	Central Wyoming	51W	Recreational Development Lake
Heims	South Wyoming	56P	Recreational Development Lake
White Stone	East Wyoming	48P	Recreational Development Lake
Comfort	Southeast Wyoming	53P	General Development Lake
Little Comfort	Southeast Wyoming	54P	General Development Lake
Sunrise River	From Comfort Lake north to the Sunrise Pools	-	Transition River
Sunrise River	From Birch Lake north to School Lake north to Comfort Lake	-	Tributary River
Sunrise River	From the Washington County line north to Comfort lake	-	Tributary River
Sunrise River	From the Anoka County line northeast to the Sunrise Pools	-	Tributary River
Houle Marsh	North Wyoming	136W	Public Waters Wetlands
Smith's Slough	East Wyoming	109W	Public Waters Wetlands
-	Northeast Wyoming	62W	Public Waters Wetlands

Source: City of Wyoming Shoreland Ordinance

H. Wetland Management

The City has adopted wetland management into its ordinance in accordance with the Wetland Conservation Act of 1991, as amended. The City of Wyoming is the LGU for the Wetland Conservation Act within the City limits. Requirements for the LGU are outlined in Minnesota Rule 8420. Administration of certain LGU functions of MN Rules 8420, including decision authority for exemption, no loss, and wetland boundary and type determinations, is delegated to the City of Wyoming Engineer. The decision authority for replacement plan and wetland banking determinations are placed with the City Council. The City of Wyoming Engineer, may defer decision authority to the City Council for exemption, no loss, wetland boundary and type, violations, and sequencing determinations.

For more information on the Wetland Conservation Act and related responsibilities of the LGU, refer to Minnesota Rule 8420.

I. Ground Water Appropriations

Within the City, ground water wells serve the City and private water needs. Each of these wells has a ground water appropriation permit from the DNR. **Figure III-9** shows the locations of the DNR permitted ground water appropriation sites within the City.

J. Ground Water Resource Data

Ground water resource data for areas within the City is contained in the *Chisago County Local Water Management Plan (2010-2013)* and the *City Comprehensive Water System Plan.*

Ground water aquifers are the primary source of water for the City and surrounding areas. The aquifers are recharged from infiltration through the soils and by lateral flow from adjacent areas. Surficial aquifers are susceptible to contamination in the majority of the City due to sandy soils and high infiltration rates.

The City appropriates the majority of its ground water from the Mt. Simon- Hinckley (bedrock) Aquifer. The top of the aquifer is located 50 to more than 250 feet below the surface. The Mt. Simon, as found in the wells, is sandstone. Geophysical studies have identified multiple faults in the Mt. Simon near Wyoming, which are currently being investigated during the completion of the City's Wellhead Protection Plan. More information on these faults can be obtained through the Minnesota Geological Survey.

Refer to **Figure III-10** for an approximation of the depth to groundwater throughout the City. The depth to groundwater was interpolated using known land elevation data and known groundwater elevation information. A groundwater elevation raster (digital image) was created using known lake, wetland, and soil boring information. The depth to groundwater was then calculated by subtracting the groundwater elevations from ground elevations throughout the City. Groundwater elevations were then verified using well data from the County Well Index. For more detailed groundwater information it is suggested that soil borings be performed at the desired location.

The City of Wyoming is also currently in the process of developing its Wellhead Protection Plan. This document will identify Drinking Water Supply Management Areas

(DWSMAs) and provide a plan for managing these areas. Activities such as infiltration may not be allowed in DWSMAs due to the risk of contaminating drinking water sources. This City's Wellhead Protection Plan is anticipated to be completed in 2013.

K. Soils Information

The City of Wyoming is located on the eastern side of the Anoka Sand Plain therefore, soils within the area have generally higher infiltration rates and create an increased susceptibility to ground water contamination. The hydrologic soil classification map is shown in **Figure III-11**.

The four soil classifications shown on the map are defined as follows:

Group A - These soils have high infiltration rates even when thoroughly wetted. These soils consist chiefly of deep, well drained to excessively drained sands and gravel. Group A soils have a high rate of water transmission, therefore resulting in a low runoff potential.

Group B - These soils have moderate infiltration rates. Group B soils consist of deep moderately well to well drained soils with moderately fine to moderately coarse textures.

Group A/D – These soils function as Group A soils in a drained condition, Group D soils (low infiltration rates) in an undrained condition. The water table is typically within two feet of the surface. Infiltration rates for this group will vary based on the depth to the water table.

Group B/D – These soils function as Group B soils in a drained condition, Group D soils (low infiltration rates) in an undrained condition. The water table is typically within two feet of the surface. Infiltration rates will vary for this group based on the depth to the water table.

The City of Wyoming contains the following soil associations:

- Zimmerman-Isanti
- Seeyleville-Markey
- Braham-Blomford-Eckvoll
- Nebish-Talmoon

Additional information on the geology and soil for the City can be found in the *Soil Survey of Chisago County* and the *Chisago County Geologic Atlas*.

L. Land Use and Public Utilities Services

The City of Wyoming land use classifications include residential, agricultural, commercial, industrial, mixed use, public/semi public, rural research development, parks, and conservation and open space areas. The existing and proposed land use maps are shown in **Figure III-12** and **Figure III-13**, respectively**.**

Wyoming is served by both a sanitary sewer collection system and Subsurface Sewage Treatment Systems (SSTS). The sanitary sewer collection system serves properties

within the old City limits (City limits prior to annexation in 2008). Sewage from the City is conveyed to the Chisago Lakes Joint Sanitary Treatment Commission north of Chisago City where it is treated. The City has a significant number of SSTS, most of which are located outside of the old City limits. These sites are not anticipated to be abandoned and converted to city services in the near future. Refer to **Figure III-14** for a map of the areas in the City that are treated by SSTS.

The City is served by both municipal water and individual wells. For the most part, properties located within the old City limits are served by municipal water while the properties located outside the old City limits are served by individual wells. The Minnesota Department of Health maintains a record of new wells and existing wells that have changed ownership beginning in the year 1990. A copy of the well data can be obtained from the Minnesota Department of Health.

M. Public Areas for Water Based Recreation and Access

There are a multiple water bodies and areas that have both active recreation such as fishing and passive recreation such as walking. Some of these recreational resources are outlined below:

Carlos Avery Wildlife Management Area (Carlos Avery WMA): Carlos Avery WMA is managed by the Minnesota DNR. It is approximately 23,000 acres in size, some of which are located in northern part of the City of Wyoming. There are more than 23 miles of trails which are used for walking, hiking, and sightseeing. The wide range of habitat attracts approximately 272 species of birds making it a very popular bird watching area. Hunting and trapping of various species are also popular activities in the Carlos Avery WMA.

Comfort Lake: Comfort Lake is a 219 acre lake that is popular for fishing, swimming, water skiing, and other water activities. A Minnesota DNR boat launch is located on the north end of the lake.

Sunrise Trail: Sunrise Trail follows along the old Burlington Northern Railroad Bed. It runs from Hugo to North Branch, passing through Wyoming along the way. This trail offers passive recreation to hikers, bikers, and inline skaters during the spring, summer and fall seasons.

N. Fish and Wildlife Habitat

The City of Wyoming contains habitat for a variety of mammals, reptiles, birds, amphibians, and insects. Enhancing and preserving habitat for wildlife species is important in maintaining ecological stability in the City's natural areas. There are also many different species of fish located in the City's water bodies. Fish sampling information can be obtained to determine the species of fish in a given river or lake. This information can be found at www.dnr.state.mn.us/lakefind/index.html.

Information has been obtained from the DNR Natural Heritage database. This data indicates there is a presence of unique fish and wildlife within the City.

Species of special interest include:

- Eastern Hognose Snake *(Heterodon platirhinos)*
- Sandhill Crane *(Grus canadensis).*

Species of special concern include:

- Gophersnake *(Pituophis catenifer)*

Threatened species include:

- Blanding's Turtle *(Emydoidea blandingii)*

The DNR has completed the County Biological Survey for Chisago County. Based on this work, the City contains the following high quality natural communities:

- Dry oak savanna
- Emergent marsh
- Hardwood swamp forest
- Oak forest
- Oak woodland-brushland
- Shrub swamp
- Tamarack swamp
- Wet meadow
- White pine-hardwood forest
- Willow swamp

The presettlement vegetation in the City consisted of large portions of aspen-oak land and oak openings and barrens. The presettlement vegetation also included areas of big woods (oak, maple, basswood, hickory), conifer bogs and swamps, and wet prairie. **Figure III-15** shows the presettlement vegetation.

O. Unique Features and Scenic Areas

Unique features and scenic areas include DNR designated scenic areas, areas containing rare and endangered species, and historic areas.

As stated previously, the City of Wyoming has several natural areas as well as known occurrences of rare and endangered species. In addition, portions of the Carlos Avery Wildlife Management Area (WMA) are located within the City limits. Parts of both the Carlos Avery Unit and the Sunrise Unit are within the City limits.

Refer to **Figure III-16** for the location of native plant communities and the Carlos Avery WMA.

P. Pollutant Source Locations

Figure III-17 shows the approximate locations of a variety of sites that are listed with MPCA's "What's in My Neighborhood" database. The status of these sites varies from active sites to sites that have been cleaned up and closed by MPCA. Specific details of each site can be obtained from MPCA.

Other potential pollutant sources include industrial, commercial, residential, and other highly impervious land uses. Stormwater runoff from these land uses could carry

pollutants into the stormwater system (nonpoint source pollution), especially if there are direct inlets into the storm sewer system that do not drain first into a stormwater pond. Facilities within these land use types may be covered by a NPDES General Industrial Stormwater Permit, which requires preparation of stormwater pollution prevention plans to prevent nonpoint source pollution.

Q. NPDES Phase II

The MPCA implemented the National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Program in March 2003. Phase II requires Municipal Separate Storm Sewer Systems (MS4s) to obtain an NPDES permit. MS4s designated by rule are urban areas with populations over 10,000 or urban areas with populations greater than 5,000 with the potential to discharge to valuable or polluted waters. Permits for construction sites greater than one acre will also be required as part of Phase II. The new draft permit is currently (2011) out for review as the existing general permit has expired.

The City is anticipating being added to this list early in 2012. As an MS4, the City will be required to develop a Storm Water Management Plan that includes the following six minimum control measures:

1. Public Education and Outreach
2. Public Participation/Involvement
3. Illicit Discharge Detection and Elimination
4. Construction Site Stormwater Runoff Control
5. Post-Construction Stormwater Management
6. Pollution Prevention/Good Housekeeping for Municipal Operations

For more information on the MS4 Permit requirements refer to www.pca.state.mn.us.

SECTION IV

IV. ESTABLISHMENT OF GOALS, STRATEGIES, AND POLICIES

The City has developed a number of goals, strategies, and policies for the management of stormwater within the City. These goals and policies have been developed to complement county, regional, and state goals and policies and in anticipation that the City will become a regulated City under the MPCA NPDES MS4 Permit Program. The goals of the City are to:

- Reduce occurrence of flooding and improve flood protection to properties.
- Manage the quality of water in local lakes, wetlands, and streams.
- Reduce erosion and sedimentation of soil into surface water systems.
- Preserve wetlands, lakes, and all surface waters.
- Minimize public capital expenditures needed to address water resource problems.
- Promote groundwater recharge.
- Enhance fish and wildlife habitat and water recreational opportunities to greatest extent feasible.
- Educate residents, business owners, City Staff, City Council, developers, and others about proper water resource management.
- Complete inspection and maintenance of stormwater infrastructure regularly and efficiently to ensure desired performance is achieved.

In order to achieve the City's goals for managing water resources, four strategies were developed. These strategies will assist the City in targeting its main audiences for the purposes of water resource management.

A. **Cooperation with other agencies:** This strategy recognizes that the City is not alone in managing water resources within its boundaries. There are a number of other local, state, and federal agencies that also have rules and regulations related to water resource management. Through this strategy, the City has recognized these other agencies' role in this endeavor and will cooperate and coordinate with these agencies.

B. **Education:** This strategy includes educating various groups within the City about proper water resource management. Education of residents, City Staff, City Council, business owners, and developers is included in this strategy to assist in meeting the City's goals.

C. **Regulation:** Much of water resource management comes in the form of regulations placed on new development or redevelopment within the City. These regulations will assist the City in achieving their water management goals.

D. Internal operations: This strategy relates to the internal operations of the City. By outlining policies related to how the City's operations will treat and manage stormwater, the City can work to achieve its water resource management goals. These operations include many of the activities that would be required anticipating that the City will become a regulated City under the MPCA's NPDES MS4 (Municipal Separate Storm Sewer System) Permit Program early in 2012.

A. COOPERATION WITH OTHER AGENCIES

There are a number of local, state, and federal agencies that have rules and regulations related to water resource management. Through this strategy, the City recognizes these other agencies' role in this endeavor and will cooperate, coordinate, and when possible partner with these agencies to achieve the City's goals.

This document is in conformance with but does not restate all other agency rules that are applicable to water quality and natural resource protection. The following agencies should be contacted to determine the impact of their rules on any land disturbing or alteration activity:

- Minnesota Department of Health www.health.state.mn.us
- Minnesota Pollution Control Agency www.pca.state.mn.us
- Board of Water and Soil Resources www.bwsr.state.mn.us and the Wetland Conservation Act www.bwsr.state.mn.us/wetlands/wca/index.html
- Minnesota Department of Natural Resources www.dnr.state.mn.us
- US Army Corps of Engineers www.mvp.usace.army.mi
- Minnesota Department of Agriculture www.mda.state.mn.us
- US Fish and Wildlife Service www.fws.gov
- Comfort Lake Forest Lake Watershed District http://www.clflwd.org/
- Chisago Soil and Water Conservation District http://www.chisagoswcd.org/
- Chisago County http://www.co.chisago.mn.us/

While these other agency rules, policies, and guidelines are not all restated in this document, they are applicable to projects, programs, and planning within the City. The MPCA Minnesota Stormwater Manual, a document intended to be frequently updated, is also incorporated by reference into this document and can be found at www.pca.state.mn.us/water/stormwater/stormwater-manual.html.

It is important to note that this document has been written in anticipation that the City of Wyoming will become a regulated City under the MPCA NPDES MS4 Permit Program. As such, the City has incorporated many of these policies as well as policies contained in the CLFLWD Plan.

B. EDUCATION

The purpose of the education strategy in meeting the City's goals is to foster responsible water quality management practices by educating residents, business owners, City Staff, City Council, and developers about proper water resource management. If these targeted audiences recognize their role in responsible water resource management in their homes, businesses, and practices, it will assist the City in meeting its goals.

1. Education Policies

Policy 1

The City will provide public education as part of the National Pollutant Discharge Elimination System (NPDES) Phase II Program and its MS4 permit.

Policy 2

The City's website will be the primary means for disseminating information regarding water resource management, volunteer opportunities, public meeting notices, the City's SWMP (for its MS4 permit), and water resource contact information. The City may also provide information aimed at fostering responsible water resource management practices through the use of mailings, cable television, or other means as determined by the City. Topics may include, but are not limited to:

- Wetland buffers
- Groundwater quality and protection
- Controlling invasive species
- Water conservation and water cycle
- Proper hazardous waste disposal
- Yard waste management
- Pet waste disposal
- Illicit discharge to stormwater

Policy 3

The City will promote and encourage all landowners adjacent to wetlands and lakes to establish a buffer strip consisting of native non-mowed vegetation.

Policy 4

The City will provide annual training opportunities to City Staff regarding good housekeeping practices, construction of BMPs, and NPDES permit requirements.

Policy 5

The City will partner with relevant agencies to host training sessions with residents to educate them on the benefits of rain gardens, rain barrels, and other stormwater BMPs. The City will also investigate implementing a cost share program for City residents to implement these alternative stormwater management techniques on their property.

Policy 6
The City will submit a public notice 30 days in advance and hold an annual public meeting to review the SWMP, Surface Water Management Plan (once complete), and current BMPs employed by the City.

Policy 7
The City will maintain a phone line and website link to report construction site erosion control concerns, waste disposal infractions, flooding, water quality concerns, and illicit discharges to the stormwater system.

C. REGULATION

The policies developed in this strategy outline specific water resource management elements that are recommended to be implemented through City ordinances for the development and/or permitting process. Many of the policies have been taken from the Comfort Lake-Forest Lake Watershed Management Plan. These policies have been outlined to assist the public, developers, City Staff, and City Council.

1. Policy Threshold

Stormwater management policies shall apply to the following:

- Residential subdivision or development of three (3) or more lots within one thousand (1000) feet of a public water and residential subdivision or development of four (4) or more lots elsewhere.

- Non-residential or multi-residential development, including road and other linear projects not connected to a development parcel, creating new impervious surface or disturbing existing impervious surface that, in the aggregate, exceeds:

    - One (1) acre or five (5) percent of a site (whichever is less) within one thousand (1000) feet of a public water; or

    - One (1) acre or twenty-five (25) percent of a site (whichever is less) elsewhere.

- The criteria of this section will apply to all existing and new impervious surface on the project site. Notwithstanding, for road and other linear projects, only net new surface will be considered. For the purpose of this rule, mill and overlay of hard surface is not considered new surface. However, a road or other hard surface that is reconstructed by removing the pavement layer and exposing the underlying soil is considered new surface.

2. City Permit

Before commencing any activity that meets the threshold requirements described above, a permit shall be secured from the City. Applicants are encouraged to seek City input starting at the concept stage. An applicant for a stormwater management permit must demonstrate to the City that the proposed land-altering activity will meet the following policies.

3. Water Quality and Quantity Policies

Policy 1

Maintain peak stormwater flow rate from each point of discharge from the site for a 24-hour precipitation event with a return frequency of 2, 10, or 100 years in the drainage area in which the site is located at or below the peak stormwater flow rate calculated in accordance with the following:

Off-site flow shall be calculated using Soil Conservation Service TR-20 method. CN-values used to determine the pre-development rate and volume control standard will be as follows:

Hydrologic Soil Group	Curve Number
A	30
B	58
C	71
D	78

CN-values must be clearly stated. A composite CN-value approach shall be used to calculate runoff flows. An area of the site to be disturbed during construction shall be assigned a CN-value corresponding to a soil permeability class one step below that of the undisturbed soil unless the permit specifies a City-approved method to restore soil structure.

Policy 2

Maintain stormwater flow volume from each point of discharge from the site for a 24-hour precipitation event with a return frequency of 2 years, or 5 years within a landlocked basin or an area that drains to a landlocked basin, at or below the pre-development stormwater flow volume, calculated in accordance with *Water Quality and Quantity Policy 1*.

Policy 3

The following shall be used as guidelines when designing infiltration systems:

- Infiltration will not be required nor allowed in areas where there are known groundwater contaminants, where the soils are not suitable for infiltration (soils with infiltration rates less than 0.3 inches/hour), or in areas where there is less than three feet of separation between the bottom of the infiltration system and the groundwater or bedrock. Percolation tests shall be required to verify the infiltration rates of on-site soils during the construction of infiltration BMPs.

- An infiltration facility must be designed and maintained to provide for pretreatment of stormwater runoff. Pretreatment shall be sized to 25% of the infiltration volume.

- Soil borings are required for projects that propose infiltration practices. Borings must be spaced at every 100 linear feet or every 10,000 square feet, whichever is more restrictive. Borings must extend at least 10 feet below the proposed infiltration surface.

- Design infiltration rates may be estimated using the Kozeny-Carman formula. This method may not be used on soils classified as clayey.

- A double-ring infiltrometer test shall be conducted in accordance with ASTM D3385 by a registered geotechnical engineer at the proposed infiltration surface spaced every 100 linear feet or every 10,000 square feet, whichever is more restrictive, to verify infiltration rates.

- Measured and theoretical infiltration rates must be divided by a correction factor of 2.5.

Policy 4
Decrease phosphorus loading by fifty (50) percent from existing conditions for developed sites or sites with agricultural activity and not increase phosphorus loading from existing on all other sites.

Policy 5
The majority of the water bodies within the City are yet to be classified. Water bodies will be classified on a site by site basis as development plans are submitted. The following is a description of the four water body classifications:

Preserve: Provide the highest functions for one of the following: vegetative diversity, wildlife habitat, shoreline protection, and/or aesthetics, educational, cultural, and recreational opportunities; or are vegetatively diverse and highly sensitive to stormwater impacts.

Manage 1: Provide high functions for either vegetative diversity or wildlife habitat and also provide some functions for water quality protection, shoreline protection, and/or aesthetic, educational, cultural, and recreational opportunities in areas with moderate habitat quality.

Manage 2: Provide some functions for vegetative diversity, wildlife habitat, and/or aesthetic, educational, cultural, and recreational opportunities.

Manage 3: Provide the highest functions for water quality protection and flood attenuation.

Policy 6
Maintain the bounce in water level or duration of inundation, during a precipitation event of critical duration with a return frequency of 2, 5, or 100 years in the drainage area in which the site is located, for any downstream lake or wetland within the limit

specified for the lake or wetland susceptibility class shown in the **Table IV-1** below.

TABLE IV-1 PERMITTED BOUNCE AND PERIOD OF INUNDATION

Susceptibility Class	Permitted Bounce	Inundation Period for 1.5-Year Event	Inundation Period for 10-Year or Greater Event
Preserve Wetland	Pre-development	Existing	Existing
Manage 1 Wetland	Pre-development + 0.5 feet	Existing plus 1 day	Existing plus 2 days
Manage 2 Wetland	Pre-development + 1.0 feet	Existing plus 2 days	Existing plus 14 days
Manage 3 Wetland and Lakes	No limit	Existing plus 7 days	Existing plus 21 days

To ensure that the standards of this rule have been met, the City may require as-built drawings or impose additional requirements as a specific condition of approval. The City may require monitoring or performance evaluation as a condition of approving a stormwater management practice that has not been adequately demonstrated in the proposed application.

An applicant may be required to demonstrate that down-gradient stormwater conveyance structures and features will be adequate to handle proposed peak flow or flow volume from the site.

Policy 7
To meet the standards of *Policies 1-6*, site based stormwater management methods shall be used in the following sequence. A preferred method shall be used to the degree feasible before a less-preferred method is used.

a) The applicant shall comply with the stormwater volume reduction standard to the maximum extent practicable on-site through volume reduction methods approved by the City.

b) For the remaining volume reduction required to fully meet the standard, the applicant shall comply with the volume reduction standard at an offsite location or through the use of qualified volume banking credits (see *Water Quality and Quantity Policy 8*). Volume reduction may be accomplished at another site outside of the project area or through the use of banked credits as long as it yields the same volume reduction benefit, and is approved by the City. Offsite compliance and banking credits shall be achieved in the following sequence:

- within the same subwatershed as the project site
- within a subwatershed adjacent to the project site, or
- within the City at a site that provides water resource benefit.

c) As a last alternative for the remaining volume reduction required, the applicant shall pay into the City's Stormwater Utility. The required amount to contribute to the Stormwater Utility will be set by the City Council. This amount shall be amended from time to time, as the estimated cost of creating equivalent volume reduction within the subwatershed under generally favorable conditions changes.

- Funds contributed to the Stormwater Utility, will be spent within the subwatershed where the project impact occurred. If the City Council concludes there is no reasonable opportunity to use the funds in that manner, they may direct use of the funds, as far as possible, to serve similar water resource purposes within the same geographic area.

- Funds contributed to the Stormwater Utility shall be allocated to volume reduction projects by the City Council according to a stormwater utility implementation plan as approved by the City Council and as amended.

Policy 8

Excess volume reduction or runoff retention achieved onsite, up to the volume of the five-year 24-hour event, may be banked (as credit) for use on other projects within the City that are unable to fully meet the City's stormwater volume reduction standard onsite. The City will establish and maintain a list of available banked runoff retention Volume Credits.

(a) Volume reduction or runoff retention achieved onsite in excess of the volume reduction requirement may be listed in the City's bank for use on other projects within the City that are unable fully to meet the volume reduction standard of *Water Quality and Quantity Policy 2* on the project site.

(b) Stormwater management facilities or practices relied upon to create Volume Credits must be included in the recorded maintenance instrument or maintenance plan specified in *Water Quality and Quantity Policy 10.*

(c) Volume Credits may be utilized by permit applicants to meet the requirement of *Water Quality and Quantity Policy 2* only after the applicant has demonstrated to the City that:

i. One-half (1/2) inch of runoff from all new impervious surface on the parcel will be abstracted within parcel boundaries;

ii. Soil conditions and/or other site constraints prevent abstraction of additional runoff onsite. Infiltration is considered not feasible where soils do not support infiltration, documented soil contaminants preclude the use of infiltration practices, or there is inadequate separation from the water table; and

iii. The facility or practice generating the credit is providing the level of volume control for which the applicant seeks credit.

(d) Permit applicants are responsible for contacting a seller of Volume Credits and arranging the sale on terms established by the interested parties. The City will certify the sale through a form established by the Comfort Lake-Forest Lake Watershed District and completed by the buyer and seller of the Volume Credits.

Policy 9
As the City and the Watershed District develop the data to do so, they will create maps of the surface contributing areas of high priority groundwater-dependent natural resources. If a stormwater basin is proposed within a mapped surface contributing area, it must contain and infiltrate the volume generated by a 2-year, 24-hour storm event. The basin bottom should be at least three (3) feet above the seasonally high water table. If this infiltration standard is not met, basin outflow must be non-erosive and routed through a subsurface system, flow spreader or other device that discharges water through or across the ground to lower discharge temperature to that of the ambient soil.

Policy 10
If a developer proposes to meet the requirements of this Rule through construction of a wet detention basin, infiltration or pretreatment facility, outlet structure, culvert, outfall structure, or other stormwater management facility the developer must submit with the permit application a maintenance instrument. The maintenance instrument shall identify and protect areas of stormwater, detention, infiltration and overflow; specify the methods, schedule, and responsible parties for maintenance; provide for perpetual facility maintenance; and contain at a minimum the requirements in the City's standard maintenance declaration. The executed maintenance instrument must be recorded against the property deed with the County before permit issuance. If the City is responsible for maintaining the facility, a separate maintenance instrument is not required.

Policy 11
When possible and practical, runoff shall be directed away from neighboring properties to existing drainageways and vegetated soil surfaces to convey, store, filter, and retain stormwater runoff before discharge into public waters.

Policy 12
The design of stormwater storage facilities shall accommodate a 100-year critical duration rainfall event, with this storage being provided above the normal outlet elevation.

Policy 13
Lateral and collector systems shall be designed to accommodate a 10-year return frequency storm event. These systems shall be defined as storm sewer that collects and conveys runoff from catch basins or other inlets from a localized drainage area to a trunk system or ponding facility.

Policy 14
Trunk systems shall be designed to convey the anticipated 100-year critical event stormwater flow rate. A trunk system shall be defined as the main channel of the stormwater system that receives water from multiple laterals or collectors or, serves as an outlet and downstream conveyance system for a stormwater storage facility.

Policy 15
Identify all overland overflow routes for lateral, collector, and trunk systems to accommodate the 100-year critical duration rainfall event and prevent structural inundation should an obstruction occur in these systems.

Policy 16
For collection systems not designed to meet rate control standards (e.g. catch basins) a clogging factor of 50% will be utilized in sizing intake structures.

Policy 17
No orifice having a diameter less than 4" is allowed in the design of rate control structures within the City.

Policy 18
An emergency spillway (emergency outlet) from ponding areas shall be installed at a minimum of 2 foot below the lowest building opening and shall be designed to have a capacity to overflow water at an elevation below the lowest building opening at a rate not less than the anticipated 100-year peak inflow rate to the basin, or 3 times the 100-year peak discharge rate from the basin, whichever is greater.

Policy 19
If a permanent water quality pond is used to meet water quality requirements, the pond is required to meet the following criteria:

- Permanent pool average depth between 4 and 10 feet.
- An emergency outlet to control the 100-year storm event
- Basin slopes no steeper than 3:1
- A basin shelf of 10 feet wide and 1 foot below the normal water level to enhance wildlife habitat, reduce safety hazards, and improve maintenance access
- Flood pool volume above the normal outlet so that peak discharge rates from the 2-year, 10-year, and 100-year storm events are no greater than existing conditions

If a pond is designed using this criteria, it will meet the City standard of 50% total phosphorus removal.

Policy 20
New stormwater management BMPs (e.g. ponds, infiltration systems, swales) constructed as part of private development shall be covered by drainage and utility easements or outlets that are dedicated to the City. Maintenance responsibilities for these areas will be spelled out in the developer's agreement.

Policy 21
The City requires skimmers or other devices to remove floatables in the construction of new pond outlets and the addition of skimmers to existing systems whenever feasible and practical. The designs shall provide for skimmers that extend a minimum of 4 inches below the water surface and minimize the velocities of water

passing under the skimmer to less than 0.5 feet per second for rainfall events having a 99% frequency. Wood skimmers will not be allowed.

Policy 22
The City encourages the design of stormwater management features that provide an opportunity to enhance the habitat and aesthetics of the area. This includes providing upland buffers around ponds, seeding the area with native vegetation, and designing the slopes equal to or flatter than 4:1.

4. Freeboard Policies

Policy 1
Residential, non-residential, and other structures shall ordinarily be elevated on fill so that the low floor elevation is three (3) feet above the 100-year high water elevation or emergency overflow elevation. In the case where the high water level is unknown, the elevation of the line of permanent shoreland vegetation should be used as the high water elevation. Additional detail is provided in the City's floodplain ordinance. ***Policy***
Policy 2
For areas located within a drainage area to a landlocked basin, the separation between the lowest basement floor elevation and the 100-year high water elevation shall be at least three (3) feet.

5. Landlocked Basin Policies

Policy 1
Areas with landlocked basins shall be modeled to accommodate a back-to-back 100-year, 24-hour rainfall event and the 100-year, 10-day runoff event. The highest water elevation in the basin from this analysis shall be the 100-year high water level. ***Policy***
Policy 2
Landlocked areas may be allowed an outlet, provided that the outlet complies with wetland and floodplain regulations and that the basin provides storage below the outlet for either the back-to-back 100-year, 24-hour event or the 100-year, 10-day runoff event; whichever is greater. In addition, there must be no negative downstream impacts resulting from the outlet.

6. Floodplain Policies

Policy 1
No structure, fill, deposits, obstruction, storage of materials, equipment, or other uses may be allowed in the floodplain that reduces the floodwater storage capacity of the floodplain or increases flood height. Compensating floodwater storage area shall be provided for any obstruction which decreases flood storage. This compensating volume shall be equal to or greater than the total volume of the obstruction. Additional detail is provided in the City's floodplain ordinance.

Policy 2
A plan review by the City is required for any project that is within the 100-year floodplain or upland flood storage area. Refer to the City of Wyoming website at www.wyomingmn.org for more information regarding the City's State-Approved floodplain and shoreland ordinances.

7. Wetland Policies

Policy 1
Water quality treatment to NPDES standards is required prior to the discharge of water into a wetland, except for Manage 3 classified wetlands (refer to *Water Quality and Quantity Policy 5* for a description of the four classifications).

Policy 2
Wetland alterations must be in conformance with the Wetland Conservation Act (WCA) and will be administered by the City of Wyoming which is the Local Governing Unit (LGU) for WCA within its City limits.

8. Buffer Policies

Policy 1
Buffers are required at any lot containing land within the buffer zone of any General Development Lake, Recreational Development Lake, Natural Environment Lake, stream, or wetland that;

- results from new subdivision of land into two or more buildable lots; or
- is subject to land disturbance for the purpose of a new primary use for which a rezoning or a land use variance for lot hard surface percentage or structure setback has been approved.

The required buffer zones are as follows:

(a) Stream (measured from top of bank) - 75 feet
(b) Lakes (measured from delineated OHWL)
  (1) Natural environment lake - 100 feet
  (2) Recreational development lake - 50 feet
  (3) General development lake - 25 feet
(c) Wetlands: Based on the wetland function and value assessment the following will be buffer requirement (measured from delineated wetland edge)
  (1) Preserve - 100 feet
  (2) Manage 1 - 75 feet
  (3) Manage 2 - 50 feet
  (4) Manage 3 - 25 feet
(d) If a lake or wetland is a groundwater-dependent natural resource, the buffer will be one hundred (100) feet. If the stream is a groundwater-dependent natural resource, the streamside zone will be fifty (50) feet, and the middle zone one hundred (100) feet.

Policy 2
Access to a waterbody for private or public use may be created and maintained. The access area must not exceed thirty (30) feet or fifty (50) percent of the lot width along the shoreline or streambank, whichever is less. A trail no more than ten (10) feet in width is allowed within a buffer. The trail shall not count toward the buffer width.

Policy 3
Management of noxious weeds or invasive species is allowed within the buffer. Planting of non-native species is not allowed within the buffer.

9. Groundwater Policies

Policy 1

The City will cooperate with the Department of Health to insure that all unsealed or improperly abandoned wells within the City are properly sealed.

10. Erosion and Sediment Control Policies

Policy 1

All persons shall submit an erosion control plan to the City and secure a permit from the City approving the erosion control plan for any grading, filling, or other land disturbing activity that involves:

- Grading, filling, or other land alteration activity that involves movement of more than two hundred (200) cubic yards of earth or erodible material.
- Surface disturbance or removal of vegetative cover on one quarter (1/4) acre or more of land within one thousand (1000) feet of a public water or one (1) acre or more of disturbance elsewhere.

Policy 2
The erosion control measures should be in conformance with MPCA's NPDES permit as well as the specifications outlined in the MPCA's manual "Protecting Water Quality in Urban Areas."

Policy 3
Erosion control measures are not required for agricultural land provided that a grass or natural vegetation buffer zone extending 16 feet or the width of an applicable shore impact zone, whichever is wider, is maintained along any water body and that no fertilizer is used in the zone.

Policy 4
The City will conduct regular erosion control inspections of all projects that require an erosion and sediment control plan. See City ordinance for information regarding failed erosion control at www.wyomingmn.org.

Policy 5
Development activities must minimize disturbed areas, runoff velocities, and erosion potential. Disturbed areas must be stabilized and protected as soon as possible.

Policy 6
Construction guidelines for turf restoration as outlined by the MPCA NPDES construction permit shall be the minimum standard for restoration.

Policy 7
New development and redevelopment projects will be encouraged to reduce the amount of impervious surface and use Low Impact Development (LID) techniques to the greatest extent reasonable taking into consideration land use, zoning, topography, previous site uses, and site constraints. LID techniques may include but are not limited to those presented on the MPCA-Low Impact Development website, http://www.pca.state.mn.us/water/stormwater/stormwater-lid.html.

D. INTERNAL OPERATIONS

The City's internal operations can have a significant impact on water resource management. This strategy is targeted primarily at the City and secondarly at the public and/or another agency. These policies are aimed at operation and maintenance activities associated with water resource management within the City. It is important to note that the City will be required to complete many of these activities to be in compliance with its MS4 Permit Program (anticipated to be added to the MS4 list in 2012).

1. Internal Operations Policies

Policy 1
The City will sweep the streets at least twice annually and record the lane miles swept. Areas that need more frequent sweeping will be swept as needed.

Policy 2
The City will clean out sump catch basins and manholes annually. The City will maintain records that contain the date that this work was completed and the number of sumps that were cleaned.

Policy 3
The City will conduct regular erosion control inspections of all projects that require an erosion and sediment control plan.

Policy 4
The City prefers to use regional retention, detention, and stormwater treatment facilities rather than site specific areas, where feasible. The City recognizes that construction of regional treatment facilities will likely be incorporated into development activities. The City may initiate the construction of regional facilities as desired to meet the goals of this document. If no regional system is available, development and redevelopment will be required to provide on-site systems.

Policy 5
The City requires as-builts of all ponding areas and designated emergency overflows.

Policy 6
The City will review its erosion control ordinance and make revisions as needed to address the SWMP and other regulations as needed. Ordinances can be found on the City's website at www.wyomingmn.org.

Policy 7
The City will review and update its natural resource management ordinances as needed. Ordinances can be found on the City's website at www.wyomingmn.org.

Policy 8
The City will develop and implement a City ordinance related to Illicit Discharge Detection and Elimination consistent with the City SWMP and MPCA NPDES rules.

Policy 9
The City will maintain and update its storm sewer map, including storm sewer pipes, outfalls, ponds, conveyances, water bodies, and structural BMPs on an annual basis.

Policy 10
The City will annually conduct visual inspections of stormwater discharges on City-owned land and record results of inspections in conformance with the City's MS4 SWMP and MPCA NPDES rules.

Policy 11
The City will contact the MPCA State Duty Officer at 1-800-422-0798 to report any hazardous material spills or discharges in conformance with the MPCA rules.

Policy 12
The City will annually inspect and maintain any exposed stockpiles and storage areas on City property to prevent erosion and discharge into the storm sewer system or water body in conformance with the City's MS4 SWMP.

Policy 13
The City will perform standard maintenance of the stormwater management system as needed (e.g. jetting, cleaning, repair/replacement).

Policy 14
The City will maintain and submit annual inspection reports, maintenance reports, and other needed documentation in conformance with the NPDES permit.

Policy 15
The City Staff will annually review and adjust as necessary mowing, fertilizing, and herbicide application practices to reduce organic and pollutant discharges to the storm sewer and water bodies.

Policy 16
The City will review road salt application practices and consider alternative products as they become available.

Policy 17
The City will work with neighboring cities and townships to develop stormwater related agreements that address volume reduction, rate control, and water quality of runoff generated from any new development that discharges to Wyoming.

Policy 18
The City will explore regional locations to implement water quality BMPs to reduce the negative effects of stormwater on area lake, rivers, and wetlands.

Policy 19
The City will work with the MPCA to address impairments, develop TMDLs, and implement TMDL plans.

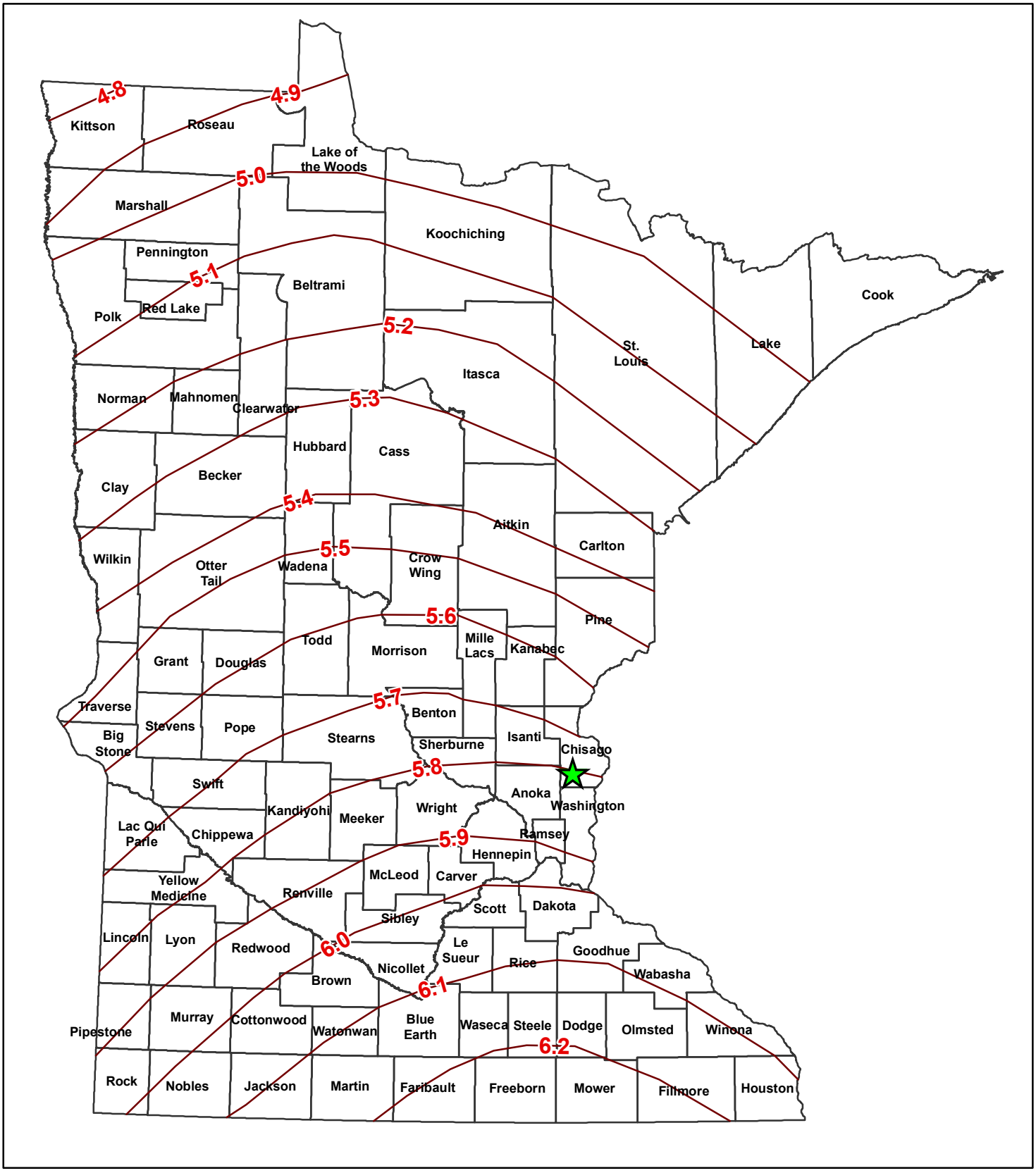
SECTION V

V. GLOSSARY OF ACRONYMS

BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
CAC	Citizen Advisory Committee
CAMP	Citizen Assisted Monitoring Program – MCES
CIP	Capital Improvement Project
CLFLWD	Comfort Lake Forest Lake Watershed District
CSMP	Citizen Stream Monitoring Program - MPCA
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GIS	Geographic Information System
HWL	High Water Level
IDDE	Illicit Discharge Detection and Elimination
LGU	Local Governing Unit
LID	Low Impact Development
LMC	League of Minnesota Cities
MCES	Metropolitan Council Environmental Services
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MNDNR	Minnesota Department of Natural Resources
MNDOT	Minnesota Department of Transportation
MNRAM	Minnesota Routine Assessment Method for Wetlands
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MUSA	Metropolitan Urban Service Area
NPDES	National Pollutant Discharge Elimination System
NURP	National Urban Runoff Program
NRCS	Natural Resource Conservation Service
NWL	Normal Water Level
OHW	Ordinary High Water Elevation
PAHs	Polycyclic Aromatic Hydrocarbons
P8	Program for Predicting Pollutant Particle Passage through Pits, Puddles, and Ponds
SWCD	Soil and Water Conservation District
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WCA	Wetland Conservation Act
WD	Watershed District
WHEP	Wetland Health Evaluation Program
WMO	Watershed Management Organization

APPENDIX A

FIGURES



City of Wyoming

City of Wyoming
Water Resource Guidance Document

Source: National Oceanic and Atmospheric Administration, Natural Resources Conservation Service, U.S. Department of Agriculture, 2003

1% Chance Rainfall Event in 24-hours

Values in Inches

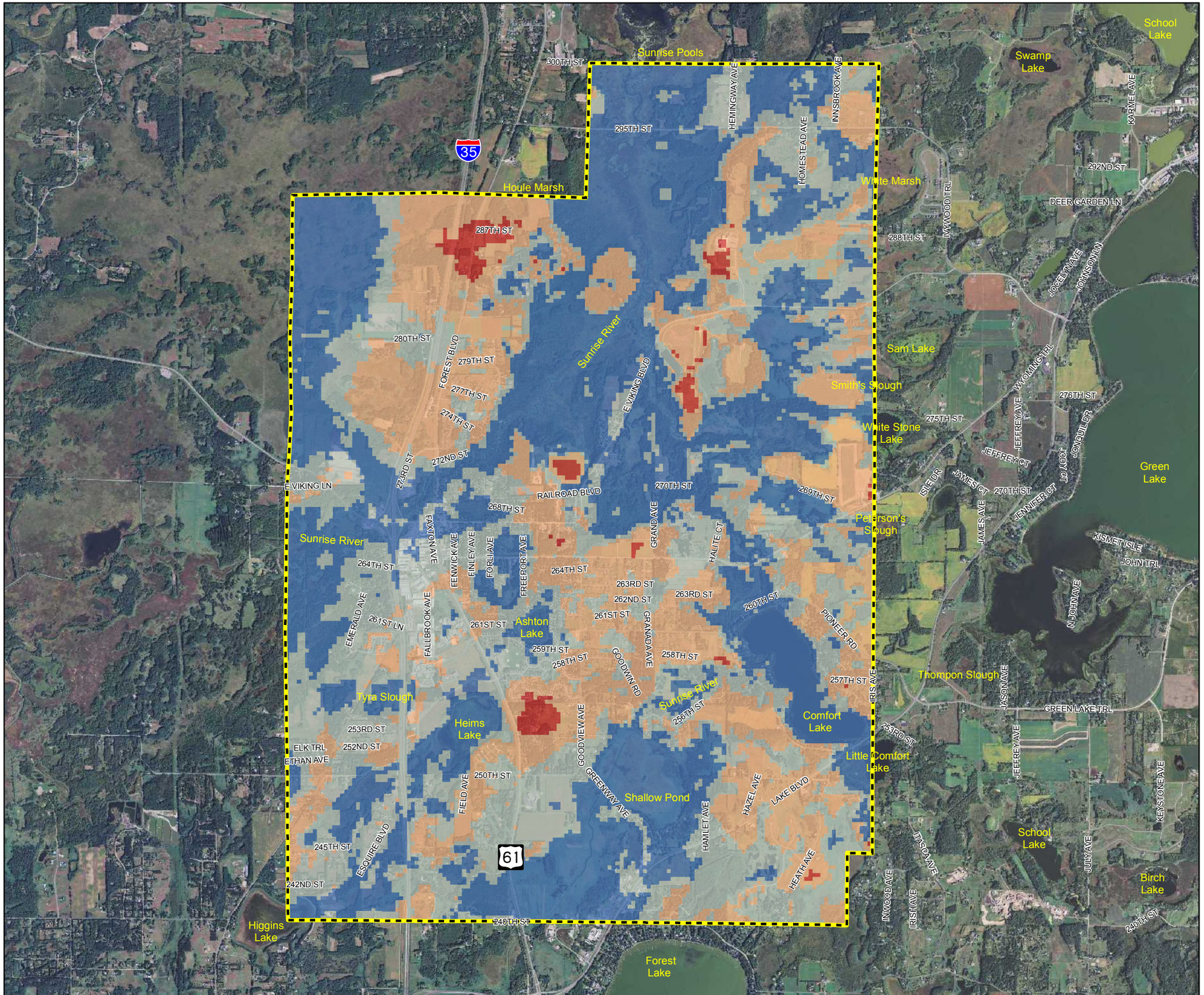
Figure 1

0 50 100 Miles

N S

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-1_100YearRainfallEvent.mxd, Jan 28, 2011 2:35:24 PM



City of Wyoming
Water Resource Guidance Document

Depth (ft) to Groundwater Map

Figure III-10

NORTH

0 1,750 3,500 7,000 Feet

Legend

City Boundary

Depth to Groundwater (ft)

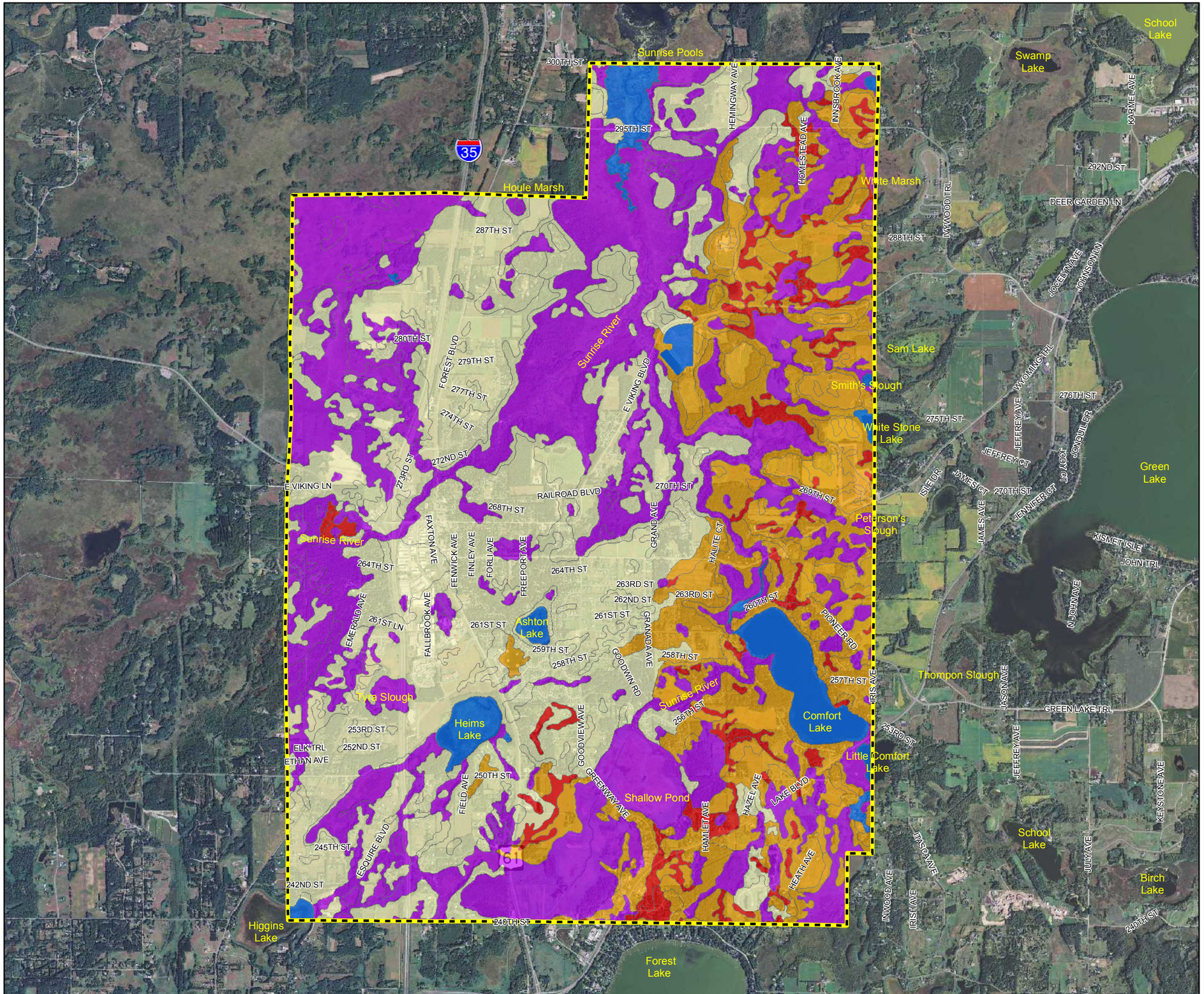
- 0-10
- 10-20
- 20-40
- 40-60

Note: The Depth to Groundwater shown on this map is an interpolation. A groundwater elevation raster was created using known lake, wetland, and soil boring information. The depth to groundwater was then calculated by subtracting the groundwater elevations from ground elevations throughout the City. Groundwater elevations were then verified using known soil boring information. For exact groundwater information it is suggested that soil borings be performed at the desired location

Source: WBS and Associates, 2011

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-10_Depth to Groundwater.mxd, Jan 28, 2011 3:07:11 PM



File: K:\01688-69\GIS\Maps\Figures\Figure III-11_Soils.mxd, Jan 28, 2011 3:08:17 PM

Source: Natural Resources Conservation Service, 2009

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Hydrologic Soils Map

Figure III-11

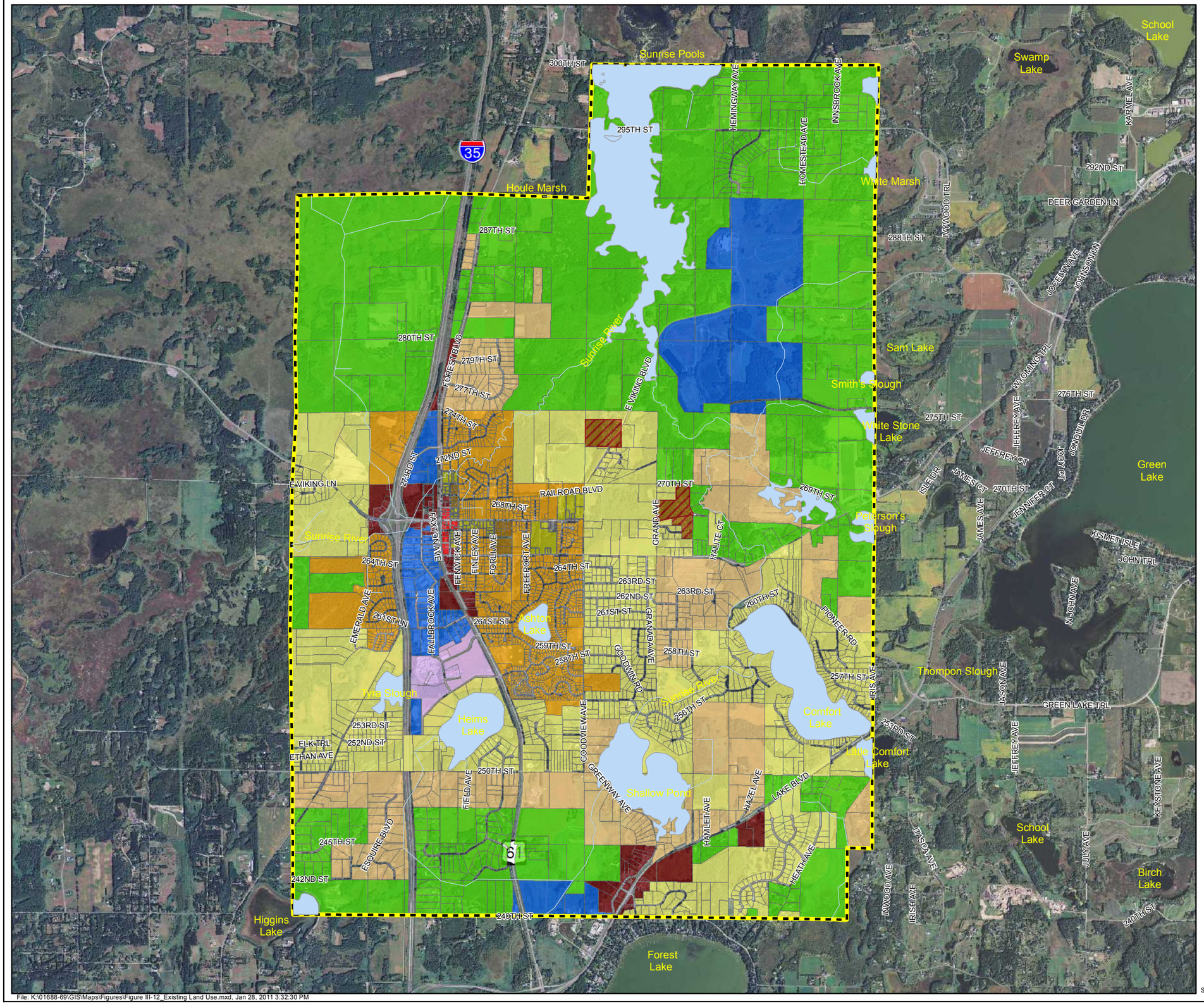
NORTH

0 1,750 3,500 7,000 Feet

Legend

- City Boundary
- Group A - These soils have high infiltration rates even when thoroughly wetted. These soils consist chiefly of deep, well drained to excessively drained sands and gravel. Group A soils have a high rate of water transmission, therefore resulting in a low runoff potential.
- Group B - These soils have moderate infiltration rates. Group B soils consist of deep moderately well to well drained soils with moderately fine to moderately coarse textures.
- Group A/D – These soils function as Group A soils in a drained condition, Group D soils (low infiltration rates) in an undrained condition. Water table is typically within two feet of the surface. Infiltration rates will vary based on the depth to water table.
- Group B/D – These soils function as Group B soils in a drained condition, Group D soils (low infiltration rates) in an undrained condition. Water table is typically within two feet of the surface. Infiltration rates will vary based on the depth to water table.
- Water

WSB & Associates, Inc.



City of Wyoming
Water Resource Guidance Document

Existing Land Use Map

Figure III-12

NORTH

0 1,750 3,500 7,000 Feet

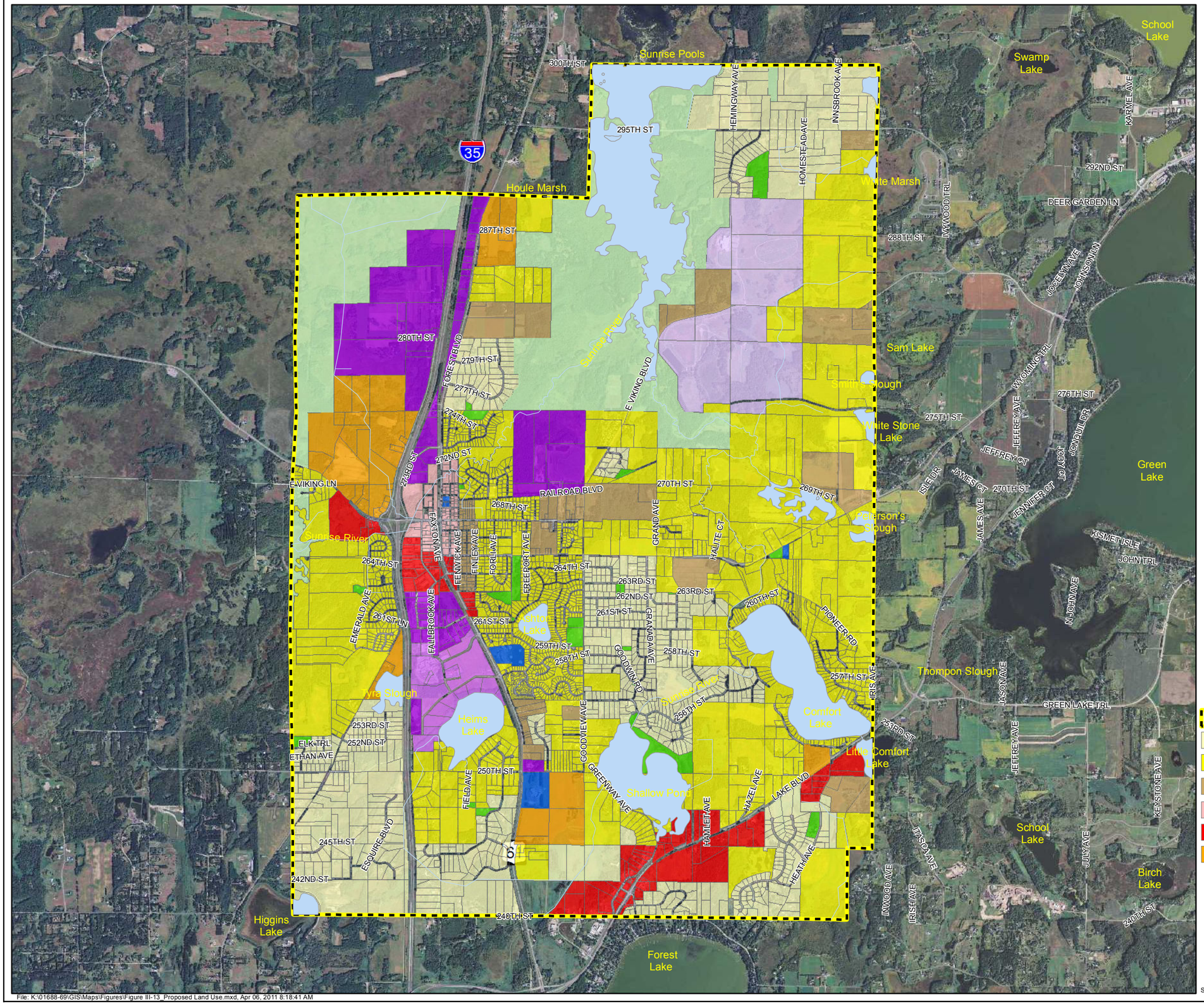
Legend

- City Boundary
- Agriculture
- Rural Residential I
- Rural Residential II
- Single Family Residential
- One and Two Family Residential
- Manufactured Homes
- Limited Multiple Dwellings
- Commercial
- Central Business
- Office and Health Care
- Industrial
- Water

Source: City of Wyoming Comprehensive Plan, 2008

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-12_Existing Land Use.mxd, Jan 28, 2011 3:32:30 PM



City of Wyoming
Water Resource Guidance Document

Proposed Land Use Map

Figure III-13

NORTH

0 1,750 3,500 7,000 Feet

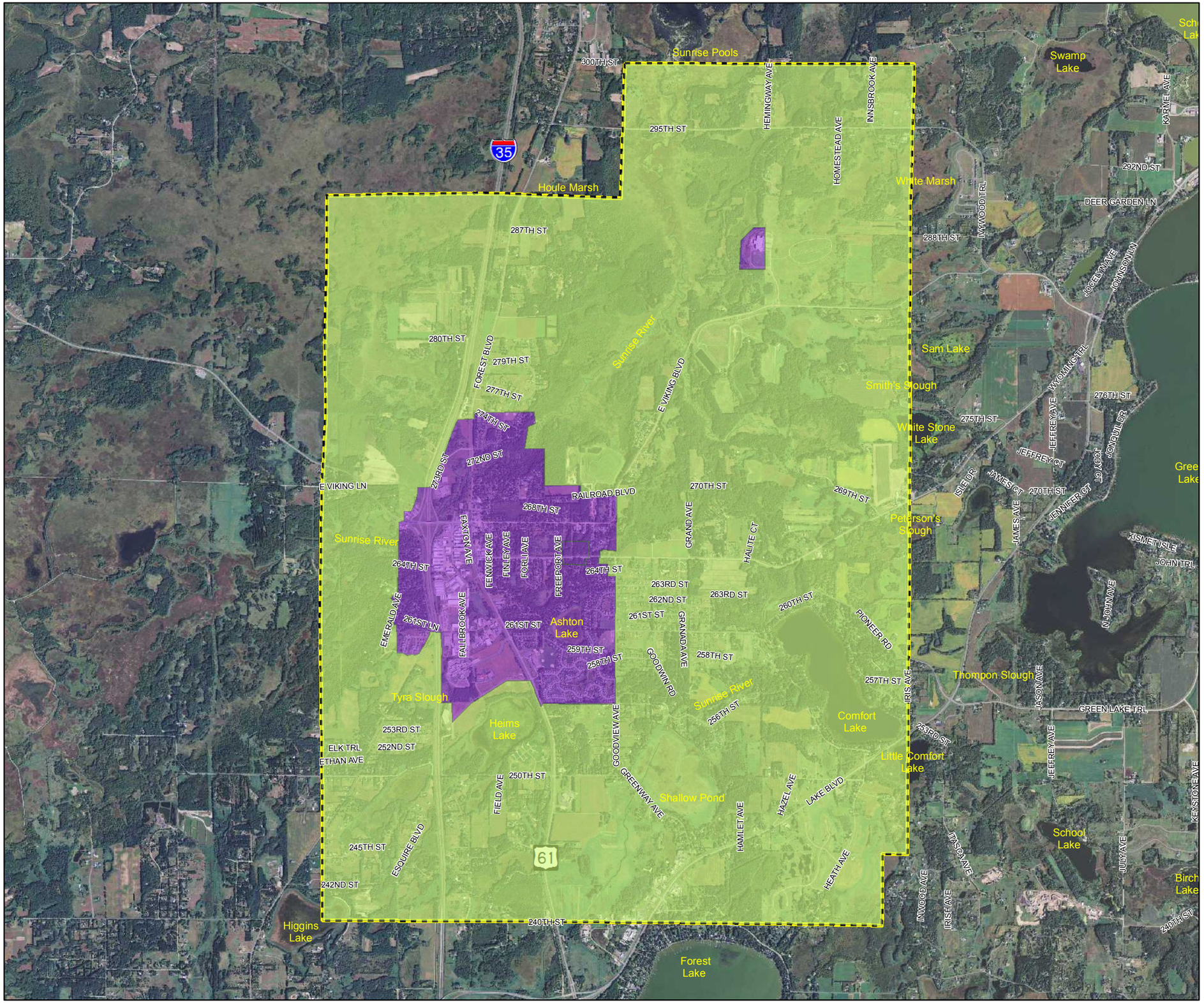
Legend

- City Boundary
- Semi-Rural Housing
- Lower-Density Suburban Neighborhoods
- Medium-and Higher-Density Suburban Neighborhoods
- City Center
- Commercial
- Mixed Use
- Rural Research and Development
- Office and Health Care Business
- Light Industry and General Business
- Parks
- Public and Semi Public
- Conservation and Open Space
- Water

Source: City of Wyoming Comprehensive Plan, 2008

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-13_Proposed Land Use.mxd, Apr 06, 2011 8:18:41 AM



CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Subsurface Sanitary Treatment System (SSTS) Map

Figure III-14

NORTH

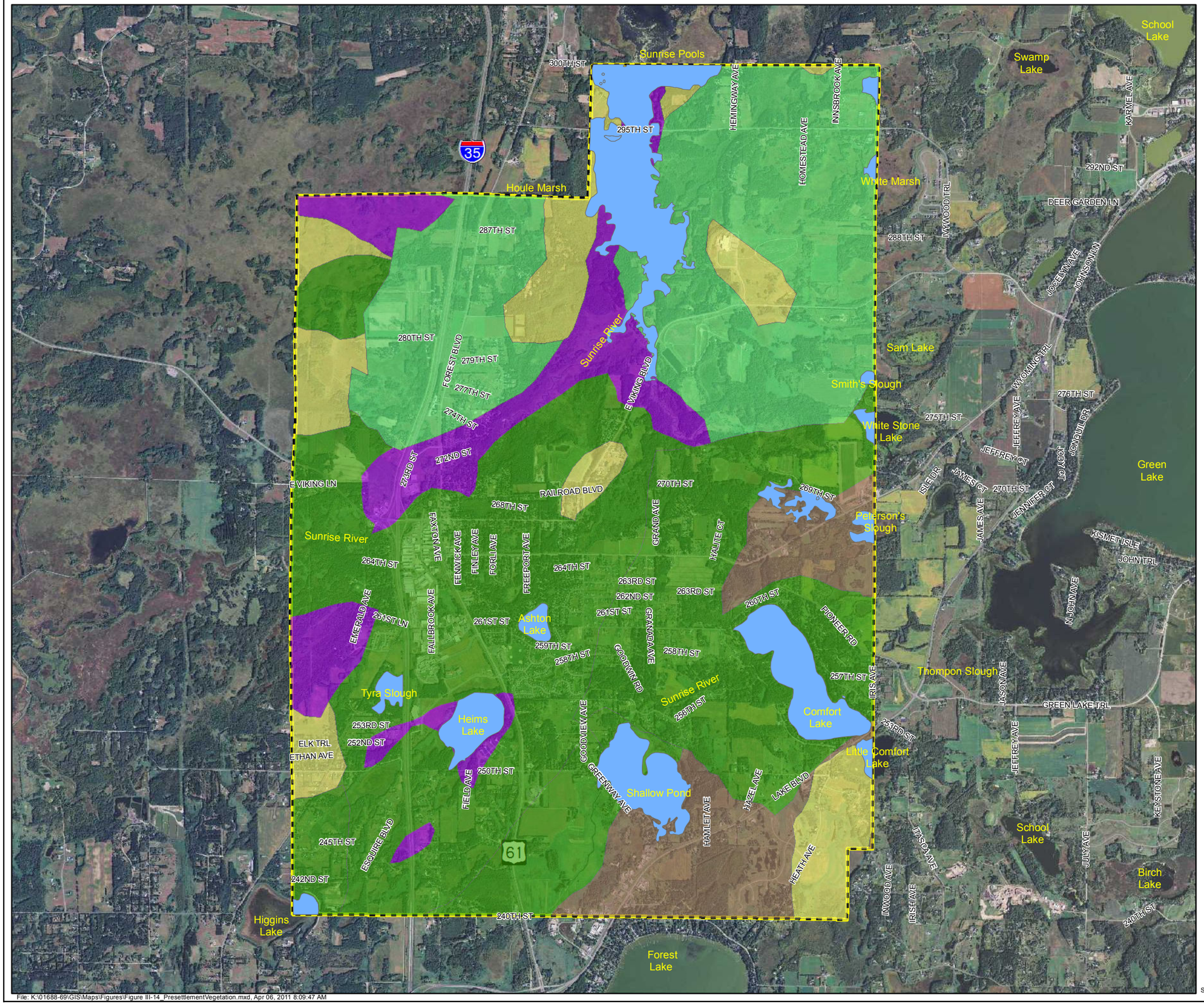
0 1,750 3,500 7,000 Feet

Legend

- Area Served by SSTS
- Area Served by City's Sanitary System
- City Boundary

Source: City of Wyoming - Wastewater System Plan, 2010

WSB & Associates, Inc.



File: K:\01688-69\GIS\Maps\Figures\Figure III-14_PresettlementVegetation.mxd, Apr 06, 2011 8:09:47 AM

Source: Minnesota Department of Natural Resources, 1994

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Presettlement Vegetation Map

Figure III-15

NORTH

0 1,750 3,500 7,000 Feet

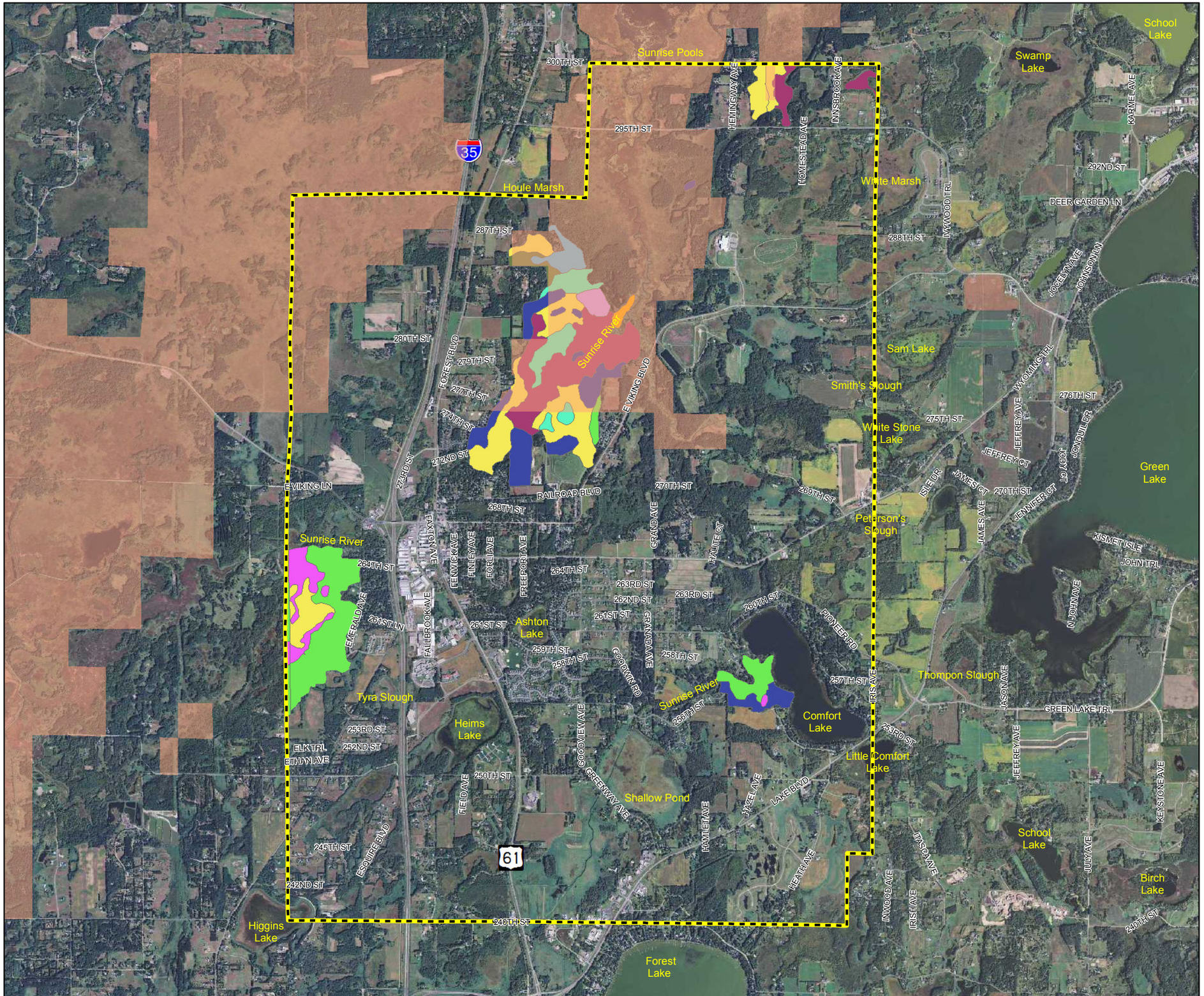
Legend

City Boundary

Presettlement Vegetation

- Aspen-Oak Land
- Big Woods (oak, maple, basswood, hickory)
- Conifer Bogs and Swamps
- Oak openings and barrens
- Wet Prairie
- Lakes (Open Water)

WSB & Associates, Inc.



City of Wyoming
Water Resource Guidance Document

Native Plant Communities and Scenic Areas

Figure III-16

NORTH

0 1,750 3,500 7,000 Feet

Legend

- City Boundary
- Carlos Avery Wildlife Management Area

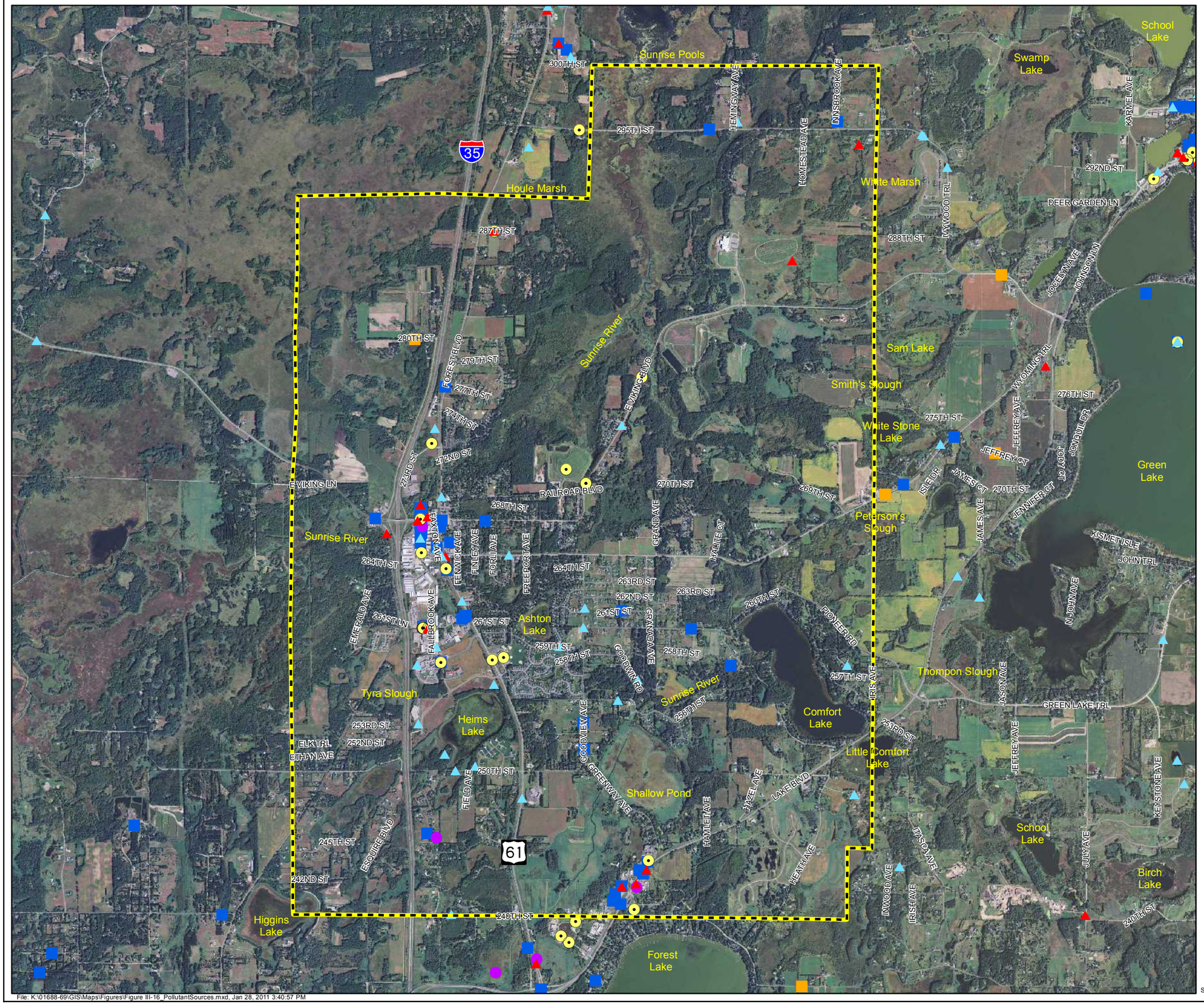
Natural Plant Communities

- DRY OAK SAVANNA
- EMERGENT MARSH
- HARDWOOD SWAMP FOREST
- OAK FOREST
- OAK WOODLAND-BRUSHLAND
- SHRUB SWAMP
- TAMARACK SWAMP
- WET MEADOW
- WHITE PINE-HARDWOOD FOREST
- WILLOW SWAMP

Source: Minnesota Department of Natural Resources, 2010

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-15_MCBS.mxd, Apr 06, 2011 8:08:35 AM



City of Wyoming
Water Resource Guidance Document

Pollutant Sources

Figure III-17

NORTH

0 1,750 3,500 7,000 Feet

Legend

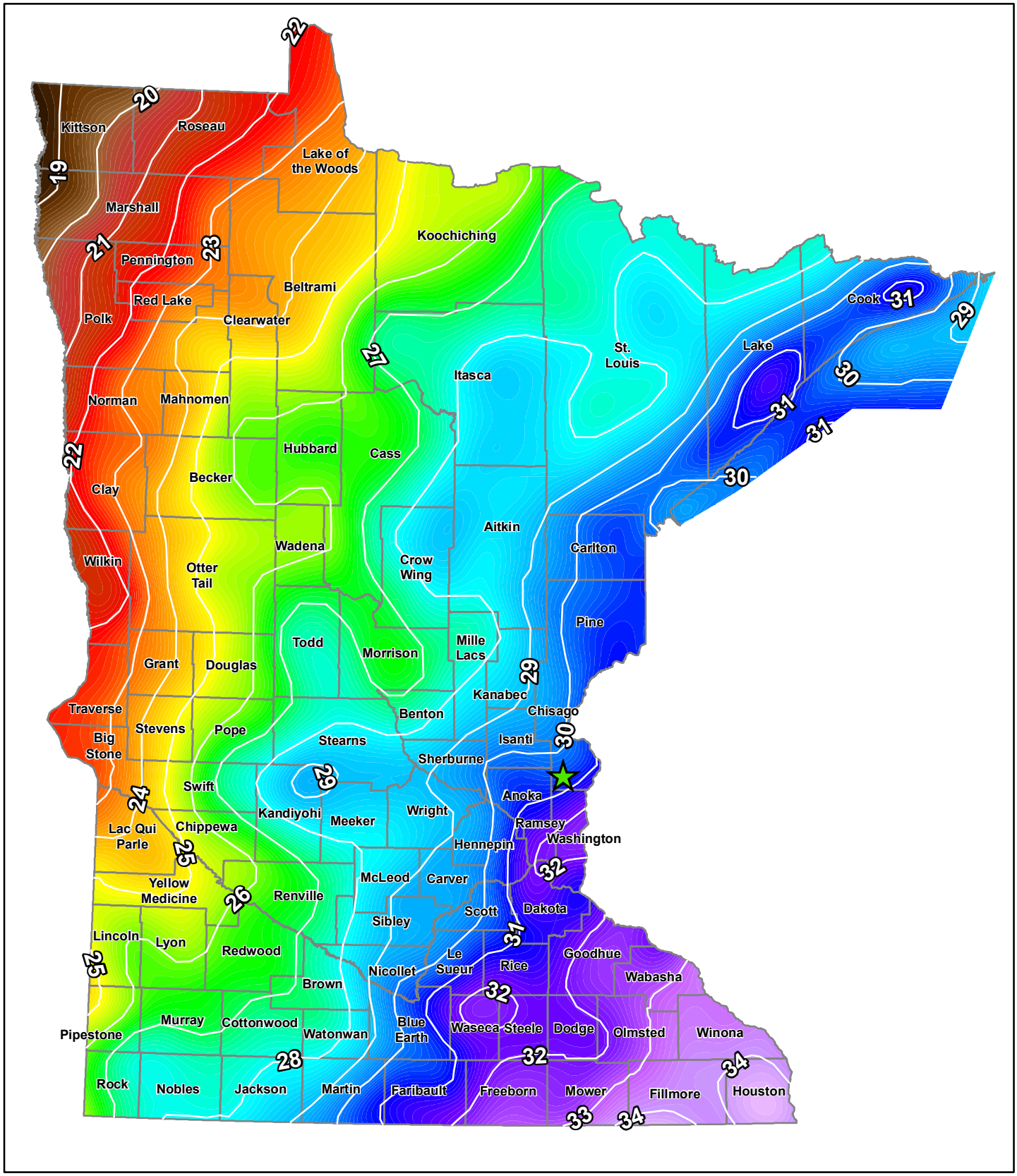
- City Boundary
- Air
- Investigation and Cleanup
- Water
- Feedlot
- Hazardous Waste
- Tanks and Leaks
- Multiple Activities

The status of these sites varies, some may be active and some have been cleaned up. Contact the MPCA or go to "What's In My Neighborhood" at www.pca.state.mn.us for more information.

Source: Minnesota Pollution Control Agency, 2009

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-16_PollutantSources.mxd, Jan 28, 2011 3:40:57 PM



City of Wyoming

City of Wyoming
Water Resource Guidance Document

Source: National Oceanic and Atmospheric Administration, Natural Resources Conservation Service, U.S. Department of Agriculture, 2003

N
S

Annual Normal Precipitation

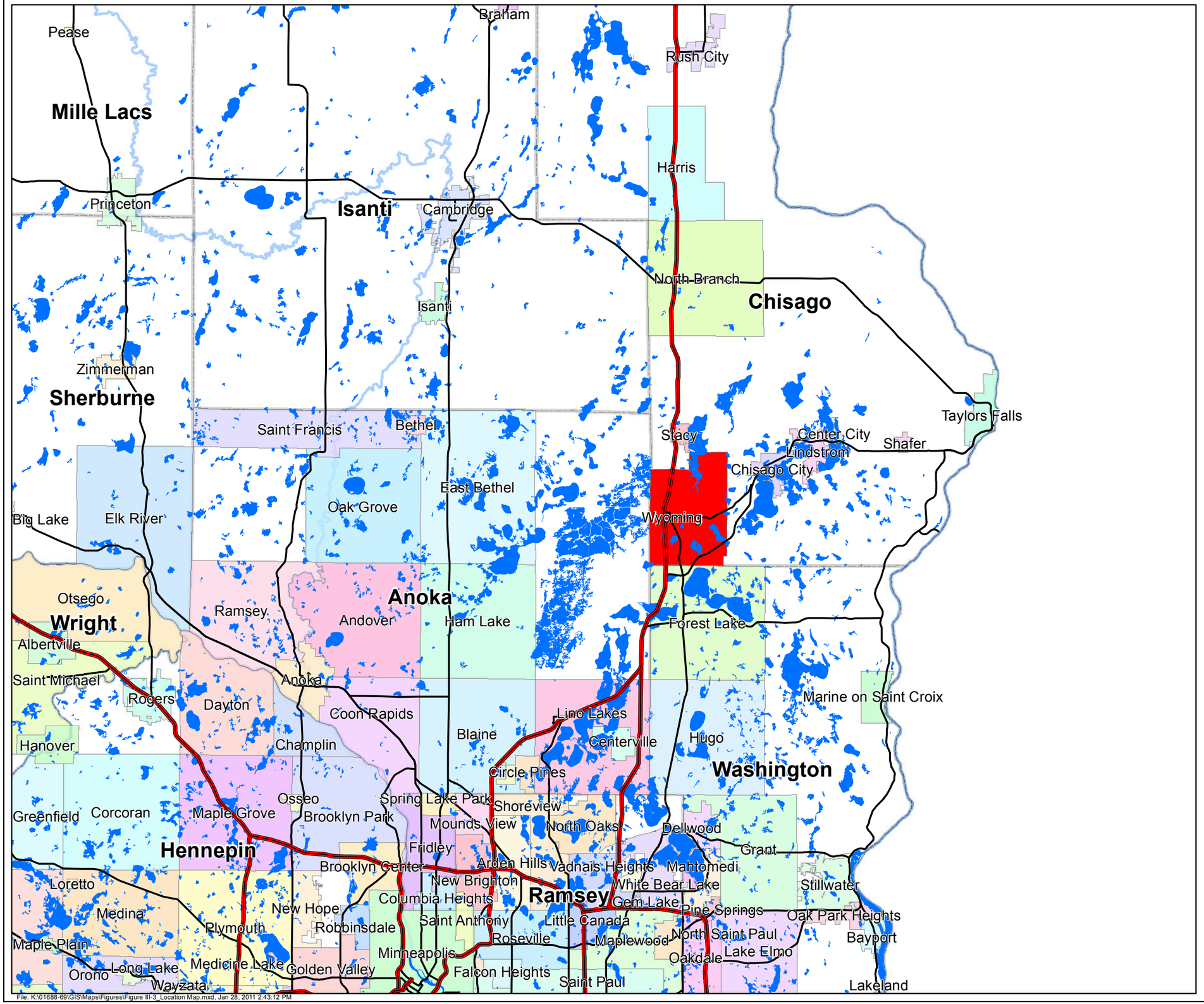
Values in Inches

Figure 2

0 50 100 Miles

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-2_AnnualPrecipitation.mxd, Jan 28, 2011 2:41:36 PM



City of Wyoming
Water Resource Guidance Document

City Location Map

Figure III-3

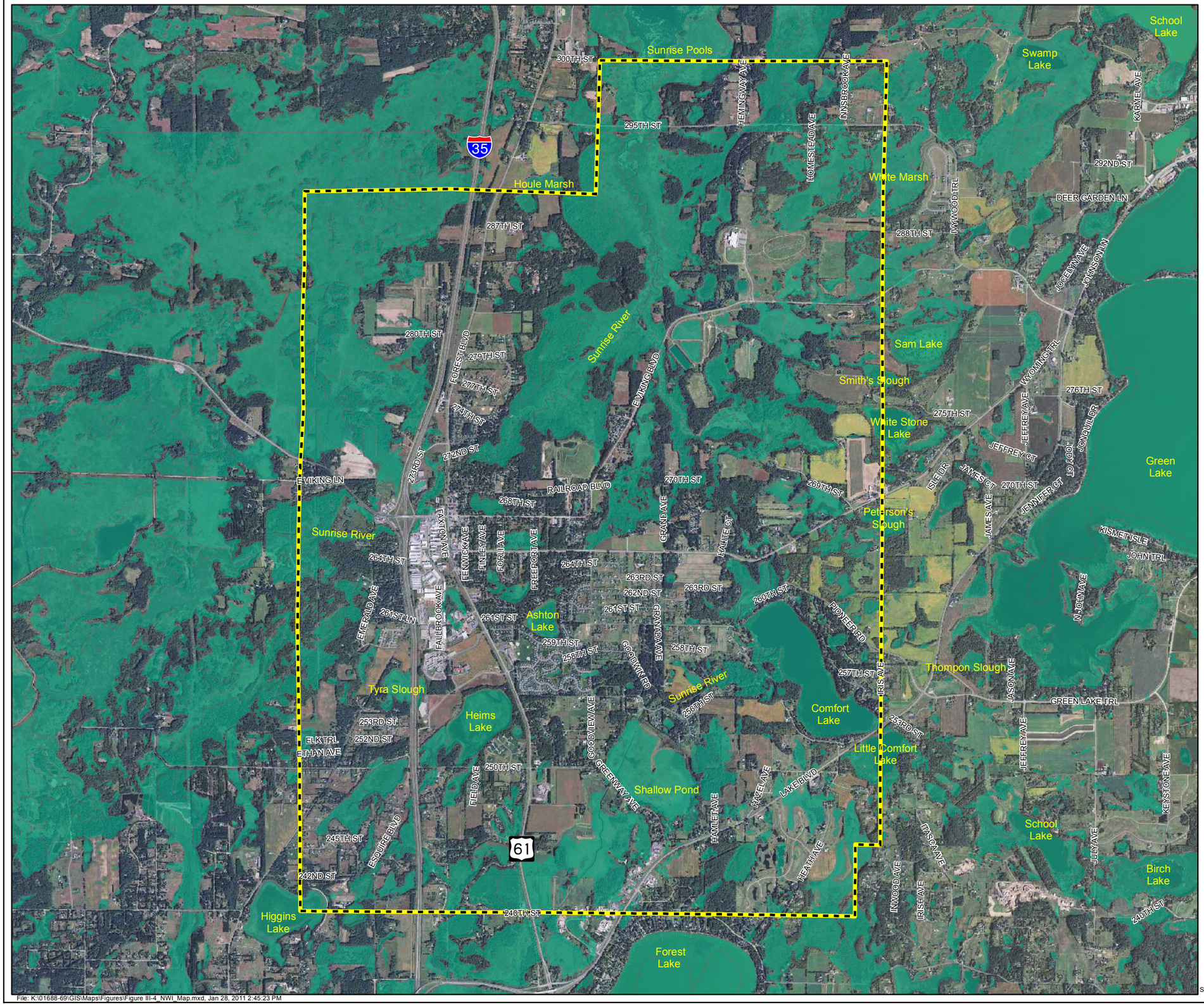
NORTH

0 2.5 5 10 Miles

Legend

City Boundary

WSB & Associates, Inc.



City of Wyoming
Water Resource Guidance Document

National Wetland Inventory (NWI) Map

Figure III-4

NORTH

0 1,750 3,500 7,000 Feet

Legend

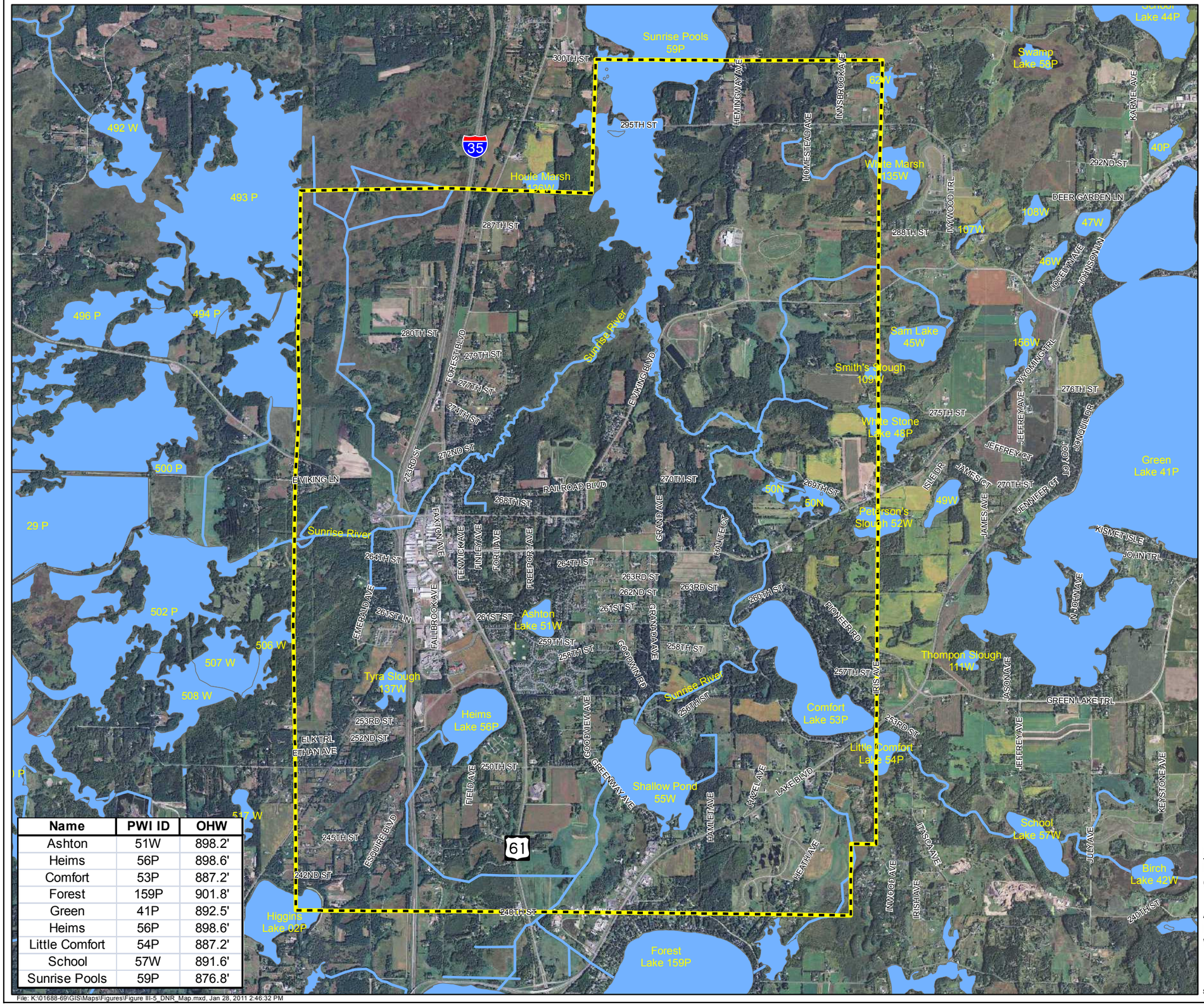
City Boundary

Wetlands

Source: U.S. Fish and Wildlife Service, 2010

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-4_NWI_Map.mxd, Jan 28, 2011 2:45:23 PM



Name	PWI ID	OHW
Ashton	51W	898.2'
Heims	56P	898.6'
Comfort	53P	887.2'
Forest	159P	901.8'
Green	41P	892.5'
Heims	56P	898.6'
Little Comfort	54P	887.2'
School	57W	891.6'
Sunrise Pools	59P	876.8'

File: K:\01688-69\GIS\Maps\Figures\Figure III-5_DNR_Map.mxd, Jan 28, 2011 2:46:32 PM

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

DNR Public Waters and Wetlands

Figure III-5

NORTH

0 1,750 3,500 7,000 Feet

Legend

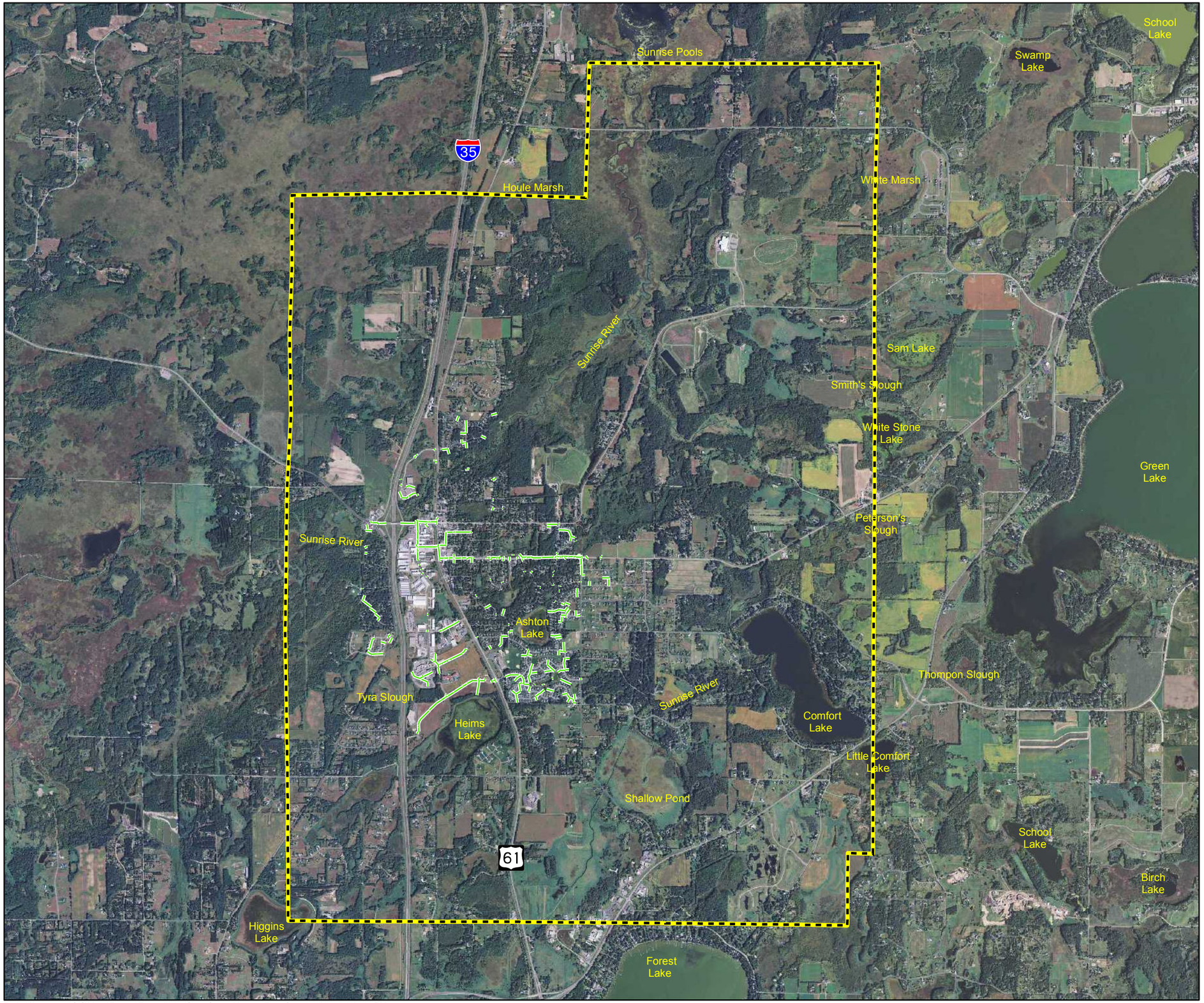
- City Boundary
- DNR Water/Wetland
- DNR Waterway

Definitions:
PWI - Public Water Inventory
OHW - Ordinary High Water

According to State Statute 103G
P- Public Waterbasins and Watercourses
W- Public Waters Wetlands

Source: Minnesota Department of Natural Resource, 2008

WSB & Associates, Inc.



Path: K:\01688-69\GIS\Maps\Figures\Figure III-6a_StormSewer Map.mxdDate Saved: 9/8/2011 2:26:08 PM

Source: City of Wyoming, 2011

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Storm Sewer Map

Figure III-6a

NORTH

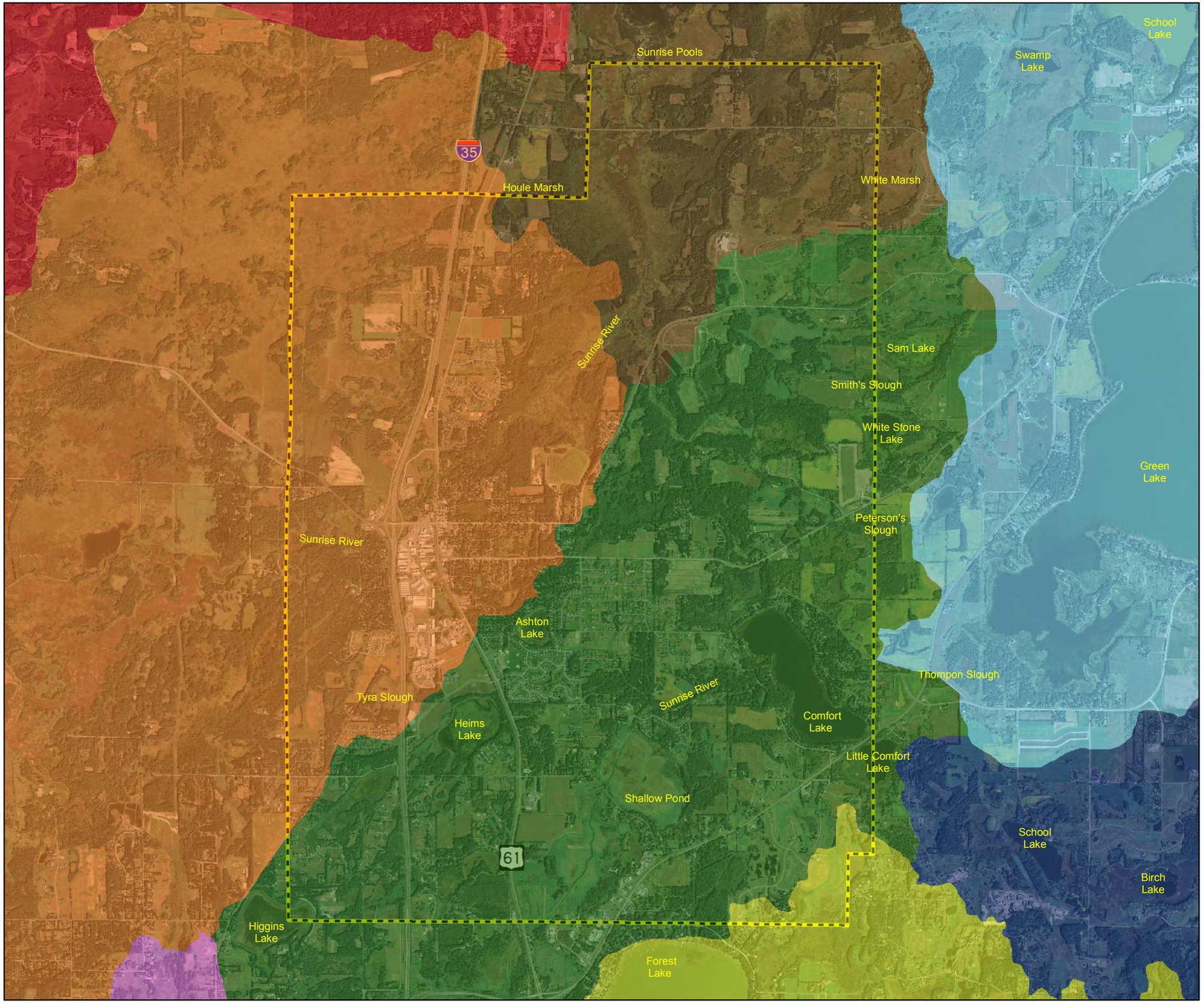
0 1,750 3,500 7,000 Feet

Legend

City Boundary

Stormwater Conveyance System

WSB & Associates, Inc.



Path: K:\01688-69\GIS\Maps\Figures\Figure III-6b_Subwatershed Map.mxdDate Saved: 9/8/2011 2:28:24 PM

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Subwatershed Map

Figure III-6b

NORTH

0 1,750 3,500 7,000 Feet

Legend

City Boundary

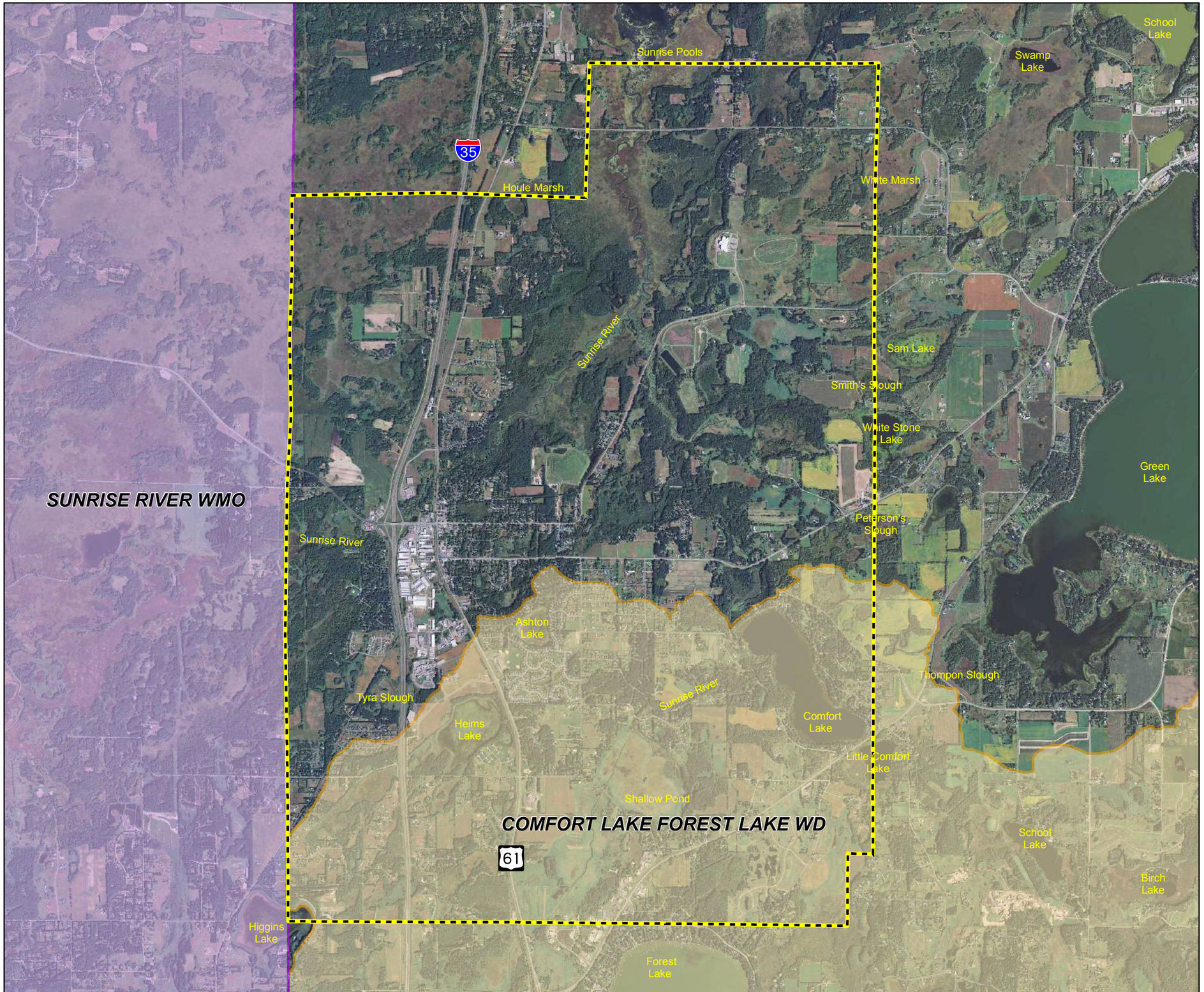
Subwatershed

- Bone Lake
- Chisago Chain of Lakes
- Comfort Lake-Sunrise River
- Forest Lake
- Headwaters Rice Creek
- Mud Lake-Sunrise River
- South Branch Sunrise River
- West Branch Sunrise River

Catchments were delineated by the DNR using GIS technology and modern delineation techniques.

Source: Minnesota Department of Natural Resources, 2009

WSB & Associates, Inc.



Path: K:\01688-69\GIS\Maps\Figures\Figure III-6c_Watershed Map.mxdDate Saved: 9/8/2011 2:29:30 PM

Source: Minnesota Department of Natural Resources, 2003

City of Wyoming, Minnesota — Wyoming — Established, 1855

City of Wyoming
Water Resource Guidance Document

Watershed Map

Figure III-6c

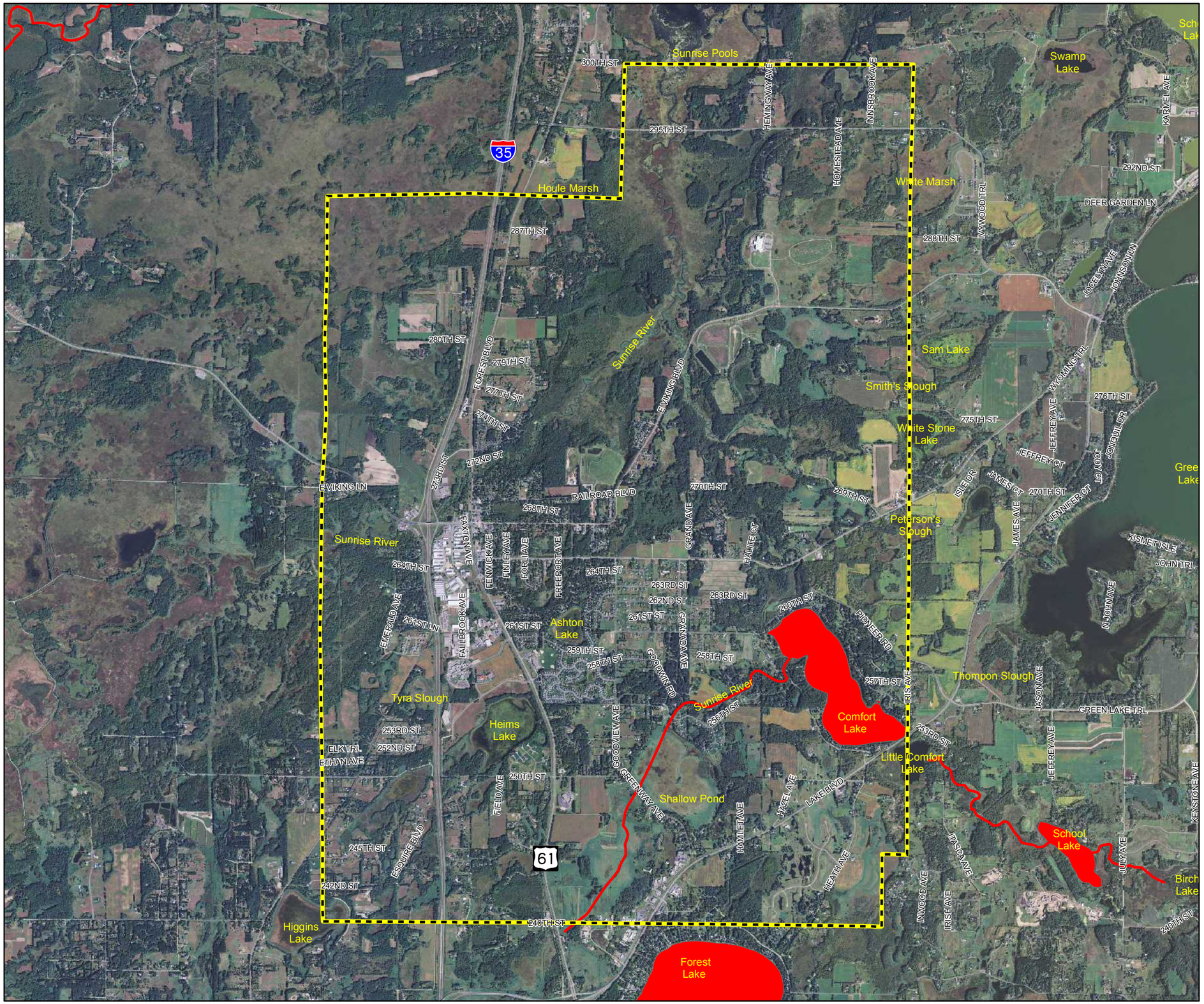
NORTH

0 1,750 3,500 7,000 Feet

Legend

- City Boundary
- COMFORT LAKE FOREST LAKE WD
- SUNRISE RIVER WMO

WSB & Associates, Inc.



CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Impaired Waters Map

Figure III-7

NORTH

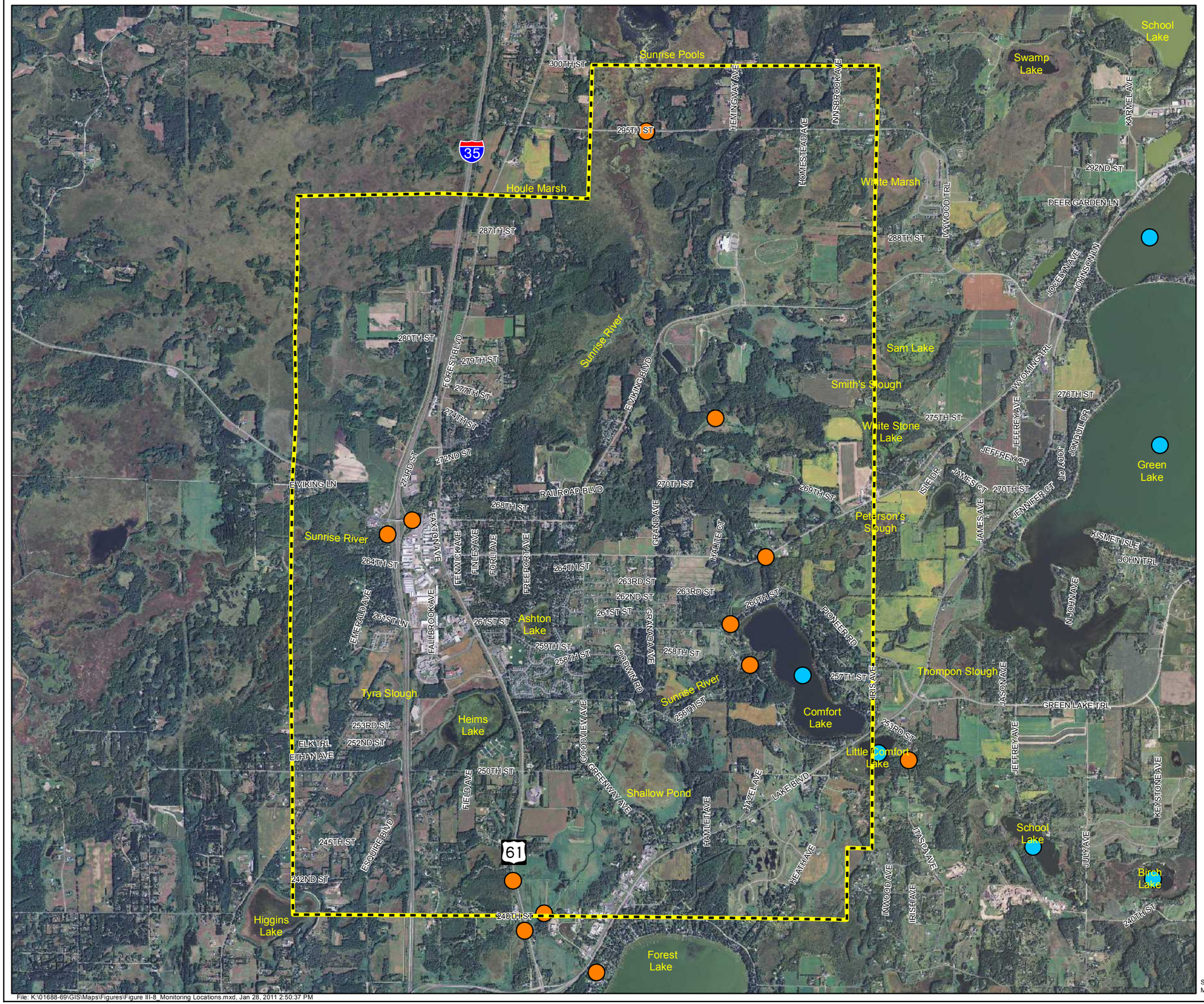
0 1,750 3,500 7,000 Feet

Legend

- City Boundary
- Impaired Waters

Source: Minnesota Pollution Control Agency, 2011

WSB & Associates, Inc.



File: K:\01688-69\GIS\Maps\Figures\Figure III-8_Monitoring Locations.mxd, Jan 28, 2011 2:50:37 PM

CITY OF WYOMING, MINNESOTA
Wyoming
ESTABLISHED, 1855

City of Wyoming
Water Resource Guidance Document

Water Quality Monitoring Locations

Figure III-8

NORTH

0 1,750 3,500 7,000 Feet

Legend

City Boundary

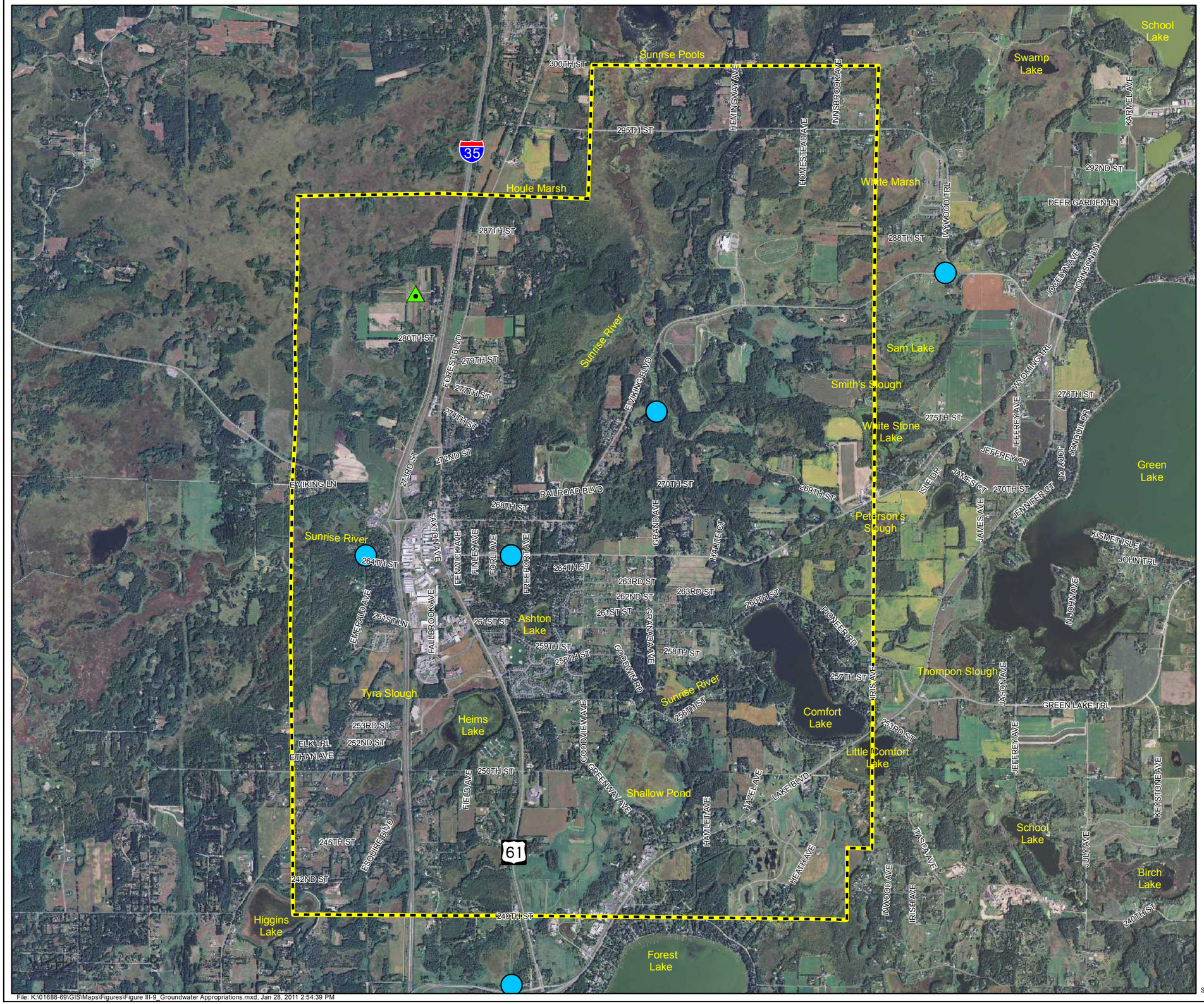
Monitoring Type

STREAM

LAKE

Source: Minnesota Pollution Control Agency:
Monitoring Locations-2006, Impaired Waters-2010

WSB & Associates, Inc.



City of Wyoming
Water Resource Guidance Document

Groundwater Appropriations

Figure III-9

NORTH

0 1,750 3,500 7,000 Feet

Legend

- City Boundary
- Major Crop Irrigation
- Municipal Wells

Source: Minnesota Department of Natural Resources, 2010

WSB & Associates, Inc.

File: K:\01688-69\GIS\Maps\Figures\Figure III-9_Groundwater Appropriations.mxd, Jan 28, 2011 2:54:39 PM

APPENDIX B

HYDRAULIC CAPACITY AND MODEL CALIBRATION REPORT

COMFORT LAKE-FOREST LAKE WATERSHED DISTRICT

Comfort Lake-Forest Lake Watershed District

HYDRAULIC CAPACITY

and

MODEL CALIBRATION REPORT

May 2005

Prepared for

Comfort Lake-Forest Lake Watershed District
Board of Managers

Prepared by

SRF CONSULTING GROUP, INC.
One Carlson Parkway, Suite 150
Plymouth, MN 55447-4443
www.srfconsulting.com

Comfort Lake – Forest Lake Watershed District
Hydraulic Capacity
and
Model Calibration Report

Table of Contents

1. Introduction/Purpose 1

2. Background 1

3. Data Collection 2

   A. Sources 2
      1) Air Photos 2
      2) Contour data/TIN file 2
      3) Soils data 2
      4) Watershed Management Plan (12/2000 – Houston Engineering) 2
      5) Field Surveying 3
      6) Existing Land Use Data 3
      7) Ultimate Land Use Data 3
      8) Flow Monitoring 3

   B. Reconciliation of Conflicting Data 3

4. Structures Inventory 3

5. Analysis Methodology 4

   A. Model Selection 4
   B. Model Parameters 4
   C. Critical Storm Event 5

6. Calibration 5

   A. Data Review and Processing 5
   B. Model Calibration Development 6

7. Modeling Results/Mapping 7

   A. Hydraulic Capacity 7
      1. Existing Conditions 7
      2. Proposed Structures 8

Table of Contents continued

B. Critical Storm Event 8
C. Profile Plots 8
D. Flood Mapping 9
E. Bounce Analysis 9

8. Regional Projects 9

A. Criteria 9
B. Potential Projects 10

9. Conclusions/Recommendations 11

10. Appendices

A. Metadata Information
B. Figures
(1) Major and Minor Hydrologic Boundaries
(2) Existing Structures
(3) Existing Land Use
(4) Ultimate Land Use
(5) Existing 100-Year Flood Levels
(6) Critical 100-Year Flood Levels
(7) Shoreland Protection Zones
(8) Sunrise River Flood Profiles
(9) Comfort Lake to Bone Lake Channel Profiles
(10) Existing Condition TIN Model
(11) 2003 Discharge Records
(12) Calibration Discharge Comparison - Bone Lake Outlet
(13) Calibration Discharge Comparison - Comfort Lake Outlet
(14) Calibration Discharge Comparison - Forest Lake Outlet
(15) Calibration Stage Comparison - Forest Lake Outlet
(16) Calibration Stage Comparison - Comfort Lake Outlet

C. Cross Sections
Sunrise River Cross Sections
Bone Lake-Little Comfort Lake Channel Cross Sections

D. Tables
(1) Structures Inventory
(2) Subwatershed Drainage Areas
(3) 100-Year Surface Water Elevations – Creek Profiles
(4) 100-Year Discharges – Creek Profiles
(5) Base Flood Levels – Existing and Critical Event
(6) Critical Storm Event Bounce
(7) Shoreland Protection Criteria

Table of Contents continued

(8) Soil and Infiltration Data Summary
(9) Calibration Comparison

E. Misc. XP-SWMM Long Plots

F. XP-SWMM Diagram

G. Photo Log

H. CD Files

Disk 1 – Report/Figures
Disk 2 – XP-SWMM Models

H:\Projects\4743\WR\final report\report text\CLFLWD Final Report.doc

1. Introduction/Purpose

The Comfort Lake-Forest Lake Watershed District Board of Managers retained SRF Consulting Group, Inc., to complete a floodplain delineation of the 49 square-mile watershed. The project was embarked upon to accomplish the following objectives:

- Accurately delineate existing and future floodplain boundaries.
- Map floodplains to permit control of land use and development.
- Identify regional flood control projects to manage future floodwaters.
- Provide technical tools and sound scientific basis for restoring water quality.

To accomplish this goal, the following tasks were completed:

- Collect and evaluate data from a variety of sources.
- Field survey critical hydraulic structures and other conveyance systems, including ditches and creeks.
- Construct an existing and ultimate conditions XP-SWMM hydrologic/hydraulic model.
- Map the floodplains identified in the modeling effort using Arc-GIS.

Calibration of the models was added to the effort under a separate work order. Flow data collected by the Washington Conservation District (WCD) was used for this effort and is documented in this report.

2. Background

The Sunrise River begins its trek to the confluent with the St. Croix River at the Forest Lake outlet. There is moderate fall in the stream profile as it crosses Highway 8, but, only a few thousand feet from the start, the Sunrise River flattens and follows a lazy flow path, as do many creeks and channels in the Anoka Sand Plain region. At the District's boundary, the outlet to Comfort Lake, the Sunrise has a very flat profile and, as such, tends to influence the discharge that leaves the watershed. This phenomenon is evident through a comparison of the discharge verses the elevation in the lake, as the measured peak elevation in the lake typically trails the peak discharge. The delayed peak indicates that the river is filling and backing up, which causes the lake to store the water until the river can accept the additional water. This is part of a natural cycle that will slowly cause peaks in the lakes to increase as further development occurs, likely with longer durations as more volume is generated.

Floodplain mapping exists for two lakes within the District (Forest Lake and Sylvan Lake), as well as a wetland complex along Highway 8, as found in the FIRM mapping for Forest Lake. This floodplain mapping project will provide updated hydrologic and hydraulic data for all of the lakes and the two primary streams within the District.

The primary technical component for the floodplain delineation is a hydrologic and hydraulic modeling effort, also referred to as the "H&H" study. The study fits with the District's mission statement as described in the Watershed Management Plan:

> "The mission of the Comfort Lake-Forest Lake Watershed District is to protect and conserve its water resources. The District encourages the use of sound scientific water management approaches, technologies and methods. The District intends to develop a uniform, integrated approach to water management within a rapidly changing and urbanizing area."

The floodplain delineation, incorporating the H&H study, is a building block that the Managers have completed to accomplish the mission statement. The study uses data collected by the District and provides a technical foundation to make informed decisions on projects that will proactively address future flooding concerns by active managing the systems that anticipate future development.

3. Data Collection

A. Data was collected from a variety of sources to complete the study, including the following:

1) Air Photos – Aerial photos obtained from The National Agricultural Imagery Program (NAIP)

2) Contour Data/TIN File – Surveying was completed by GRW Inc. under two separate contracts: one with Washington County and the other with the District. The Washington County data was purchased from the County, and the data for Chisago County was collected under the contract between GRW and the District.

3) Soils Data – Soils data is from the Soil Survey of Chisago County, Minnesota and the Soil Survey of Washington and Ramsey Counties, Minnesota.

4) Watershed Management Plan (12/2000 – Houston Engineering) – The Management Plan provided background of the area as well as direction for the monitoring program.

5) Field Surveying – Field surveying was performed to collect data on major culvert crossings within the District and streambed elevations for the Sunrise River and connection between Bone Lake and Little Comfort Lake. Data was used in the modeling effort, and is shown both in the Figure 2 and Table 1 and in the flood profiles and cross sections in the Appendix.

6) Existing Land Use Data – Existing land use information was taken from 2000 GIS information from both Washington and Chisago Counties. A number of developments were added that have occurred since the 2000 data was collected, and are noted on Figure 3.

7) Ultimate Land Use Data – The ultimate land use was compiled after a Manager's workshop in June 2004. Results of the workshop are shown on Figure 4 and reflect the Managers' desire to set floodplain limits that allow for growth similar to that seen in the metro area.

8) Flow Monitoring – SRF staff worked with the Manager's and WCD staff to establish a monitoring program for the District in 2003. Five sites were monitored in 2003 for flow and a variety of water quality parameters. A portion of this data was used for the calibration effort discussed in a later section. Metadata for the four locations is presented in the Appendix.

Available metadata files are found in the Appendix.

B. Reconciliation of Conflicting Data – There were a few instances where there was a discrepancy between data sets, or difficulties in determining drainage boundaries. Once instance was with drainage areas north of Forest Lake along Trunk Highway 8. After discussions with the Managers, SRF performed additional investigation using the TIN model as shown on Figure 10. Using the TIN and further field investigation, the model was adjusted to reflect the proper boundaries and confirm the observations by the Managers and local residents.

4. Structures Inventory

Hydraulic structures within the District, consisting of culverts and outlet weirs for Forest and Comfort Lake, were surveyed for use in the hydrologic model. Figure 2 shows all of the structures used in the modeling effort, while Table 1 contains the complete list, including location and condition data. The records also include culverts that were not surveyed but whose sizes and types were identified in the field for modeling purposes. Inverts for these structures were estimated using the TIN model and found sufficient for modeling purposes due to their location within the model. Photos taken of the culverts are listed in the photo log in the Appendix and on the attached CD.

5. Analysis Methodology

A. Model Selection

The XP-SWMM hydrologic and hydraulic model was chosen to perform the H&H study for a number of reasons:

- It is sophisticated hydrologic and hydraulic software, using complex algorithms to evaluate the hydraulics throughout the system at any time step.
- It is approved by Federal Emergency Management Agency (FEMA) for floodplain mapping.
- XP-SWMM can evaluate small storm events and multiple events.
- It can generate pollutant loading for future water quality studies.

B. Model Parameters

Model parameters were established prior to model assembly and demonstrated during the Pilot Study (North Bone Lake area). The key parameters are:

- Subwatershed Boundaries – The Managers set the subwatershed boundaries at an average 100-acre size to define subwatersheds for future use in water quality modeling and allow changes to the model as development occurred on a parcel-by-parcel basis. The model includes 286 subwatershed areas. The areas around wetland complexes and lakes are larger than 100 acres, and many of the subwatersheds in the developed areas are smaller. Existing culverts and roads often defined the size of the subwatershed.
- Runoff Method for Calculating Runoff – The runoff method allows for a very physically based method of defining hydrologic parameters, which allows for much greater flexibility than other methods of calculating runoff. Benefits to modeling of seasonal rainfall/pollutant loading
- Green-Ampt Methodology for Infiltration Parameters – This infiltration method relates the cumulative infiltration to the time at which infiltration begins, allowing for variable infiltration rates over time. The method also accounts for the variability in soil parameters.
- Flood Storage in Subwatersheds – Storage was included in the models for wetland complexes in each node, which were typically sized to one acre and larger to account for attenuation within the subwatershed.
- Hot Start Method – The calibration model was primed to match measured outflow from the Comfort, Forest, and Bone Lake gages. Using this method, also referred to as the Hot Start method by XP-SWMM, the storage in various nodes would be full at the start of the event, replicating a wetter seasonal condition.

C. Critical Storm Event

The critical event was determined by running the models in two different runoff events. Each model was then evaluated to identify which storm created the highest water surface elevation. The two events are described as follows:

- 100-year/24-hour Type II Rainfall Pattern – This is a typical design event for the Twin Cities area and assumes that 5.9 inches of rain falls in a 24-hour period. Roughly 80 percent of the rain falls in an intense two-hour period in the middle of the 24-hour event.

- 100-year/10-day Snowmelt Event – This event is modeled assuming 7.2 inches of runoff occurs in a 10-day period over frozen conditions. The runoff event is often considered a mixture of rainfall and snowmelt and typically yields a significant amount of runoff.

6. Calibration

There are three primary pieces of information that the H&H model can provide and are of concern when calibrating a model: volume of runoff, rate of discharge, and peak elevations of various lakes. Each is connected with a different, sometimes competing goal. Volume is typically connected with the water quality and, to a lesser extent, flooding. Discharge and elevations typically connected with flooding. The calibration effort is intended to balance the modeled results, which were generated with the observed rainfall to the observed discharge rates, volumes, and stages. Calibration of the H&H model involved the following steps:

A. Data Review and Processing

Rainfall and discharge data received from WCD was reviewed to find suitable data for calibration. Due to the large amount of storage available in the lakes and wetlands within the system, a period of rainfall from June 23 to July 30, 2003, was selected for analysis, which included both large and small storm events. Figure 11 shows the corresponding rainfall and discharge for the time period selected, as well as the other rainfall and discharge responses during the 2003 period. During the selected period, 7.39 inches of rain fell over the District, which was taken from the Bone Lake gage.

This data was formatted for use in the SWMM model and placed in the "BLout23JunetoJuly" rainfall file in the global database. The rainfall file was employed to obtain the initial SWMM model results and complete the calibration process.

B. Model Calibration Development

The model results were compared to measured discharge data, differences related to peak discharge timing and volumes, and lake levels found in the MnDNR Lakefinder website.

The model was then tested for sensitivity to a variety of hydrologic and hydraulic parameters based on given watershed characteristics and results obtained from the initial model run. The model was most sensitive to two parameters; soil parameters for the Green-Ampt Method (the most sensitive parameter is available water capacity) and Manning's roughness coefficient for the various channels. Adjustment of the Green-Ampt parameters were made to account for differences in the volume and peak discharges and the peak elevations observed in the lakes. The Manning's coefficient was adjusted up to help with the timing of the peak discharges within the system and was justified given the debris and bog found in many of the major channels.

Table 8 shows the ranges used to adjust the Green-Ampt parameters for the various soil types and characteristics. The various comparisons of calibrated models and measured flow graphs are presented in Figures 11 through 13. Figures 14 and 15 compare elevation information available for Forest and Comfort Lakes. Table 9 compares the calibrated and measured parameters for the peak discharge, volume, and stage. Elevation data was only available for Comfort and Forest Lakes through the MnDNR website.

Observations from the results include:

- Modeled peak flows were slightly underestimated for the Forest and Bone Lake outfalls and were slightly overestimated for the observed measurement at the Comfort Lake outlet.

- Runoff volumes for the watershed outfall (Comfort Lake outlet) are within eight percent of the observed measurement.

- Modeled water elevations, also referred to as stage, are within 0.1 foot of those found in the Lake Finder website (MnDNR) for Forest Lake and are approximately 0.4 foot overestimated at the Comfort Lake outlet.

While the predicted stage in Comfort Lake is higher than observed, the overall correlation with the three gages is good for both volume and discharge. Some difference from the observed values is expected given the need to balance the three components. It is highly unlikely that all three records can be matched simultaneously in a watershed of this complexity. It is usually best to be slightly high when dealing with stage calibration because of the safety and financial impacts associated with flooding. A low estimate could result in more frequent damages and safety risks.

The slightly elevated stage on Comfort Lake is likely due to a number of things, including:

- The outlet weir is in the model as currently constructed, which is slightly higher than that found in 2003.
- Tailwater at the outlet to the model was affected by Sunrise River hydraulics.
- Groundwater has an impact on the water elevations and flow rates within the District that are difficult to simulate without additional monitoring and model calibration.

As previously mentioned, runoff volume is typically considered one of the key elements of water quality computations, as the total loading to a water body is equal to the total volume multiplied by the concentration of pollutant in the water. The discharge rates are typically measured and converted to volumes by looking at the rate over a period of time. The model uses this data to compute flood elevations, which is the main focus of this study. The chosen calibration parameters balanced these three elements to provide a model that will provide the required data and a tool to evaluate both water quantity and quality.

7. Modeling Results/Mapping

The XP-SWMM models contain literally thousands of pieces of input data and the output contains tenfold the input quantity of data. The appendices include numerous figures and tables that provide the data requested in the contract as well as specific data that applies to a number of day-to-day issues addressed by the District.

Each XP-SWMM model produces approximately 300 pages of output tables for each run. All the output documents are included on the attached CD.

A. Hydraulic Capacity

1) Existing Conditions

After reviewing the model results, it is evident that a few of the culvert crossings along the main channels are undersized, as there is considerable difference between the upstream and downstream water surface elevation. This difference, also referred to as stage increase, results in higher flood elevation upstream, high velocities through the structure, and potential failure of the embankment. Examples of this are the culvert crossing at Trunk Highway 8 between Little Comfort Lake and Comfort Lake and the outlet to Birch Lake. See Tables 3 and 4 and Figures 8 and 9 for this information.

2) Proposed Structures

Many of the existing structures will require replacement in the near future due to their condition. Sizing can be performed based on a number of criteria, including:

- Stage and discharges found in Tables 3 and 4, respectively for the main channels
- Stage and discharge information in the model
- Typically sized at least as large as the upstream culvert
- MnDNR typical sizing recommendations allow for 0.5 foot of stage increase in MnDNR protected waters, unless other restrictions apply
- Federal Highway Administration typical sizing recommendations allow for the headwater to be 1.5 times the size of the culvert

There are a number of culverts that do not meet these criteria, such as the Highway 8 culvert. However, the water that this culvert is holding back in Little Comfort Lake may be limiting the bounce in Comfort Lake. Therefore, the regional ponding facilities should be identified and modeled prior to sizing new crossings.

B. Critical Storm Event

As outlined above, two critical storm events were modeled. It was determined that the 100-year/24-hour Type II rainfall event produced the most consistent stage increase in the channels and several of the lakes. However, six of the lakes mapped had greater stage increases caused by the 100-year/10-day snowmelt event. For these six lakes the stage produced by the snowmelt event was used for the Critical Event mapping (Figure 6).

The stages caused by the various events for each lake are presented in Table 5, and the critical events used for floodplain mapping are presented in Table 6. All river flooding was completed using the 100-year/24-hour Type II rainfall event.

C. Profile Plots

Figures 8 and 9 are profile plots along the Sunrise River from Forest Lake to the outlet to Comfort Lake and Bone Lake to the outlet to Comfort Lake, respectively. The plots show the surveyed streambed, existing structures, cross section locations, and both the 100-year existing and proposed water surface elevations. In addition, Tables 3 and 4 provide elevations and flows at various locations for both the existing and critical conditions. This information can be used to size new structures, or may be updated when regional projects are inserted in the model. Cross sections identified on the profiles are also presented in the Appendix.

D. Flood Mapping

Table 5 includes the 100-year flood elevation for the existing conditions, ultimate land use, 100-year 10-day snowmelt, and 100-year back-to-back storms for the landlocked lakes. Other data in Table 5 is from the MnDNR Lake Finder website, which provides context for the numbers. Floodplain mapping is found on Figures 5 and 6 for the existing and critical storm events. Flood elevations are mapped using the TIN, with adjustments based on the field survey information. The critical flood level map uses either the ultimate land use or the snowmelt condition, whichever condition generated the highest flood level.

E. Bounce Analysis

Table 6 compares the flood bounce for the existing and critical storm events. Bounce is measured from starting water surface (from the Hot Start model) of each lake to the flood elevation. A number of the lakes have significant bounce occurring in the critical storm condition, including Bone, Little Comfort and Comfort Lakes. The critical storm event for all of these lakes is the 10-day snowmelt condition, which could happen in the existing condition. However, this would be more probable in a developed condition as the conveyance systems to the channels and lakes would be better developed. Bounce is associated with saturated banks, which leads to additional shoreland erosion.

8. Regional Projects

A. Criteria

SRF staff reviewed the topography and model results to identify a list of potential regional projects that the Managers could consider to meet the long-term vision for the Watershed. Potential projects were identified based on the following criteria:

- Address both future (ultimate) and current concerns.
- Address flooding and water quality.
- Maximize benefit within the Watershed.
- Fit within logical physical parameters.
- Be physically contained within a specific site.
- Be upstream of one of the three major water bodies (Forest/Comfort/Bone).
- Be within currently undeveloped property.

It should be noted that any potential project should be screened for feasibility based numerous factors, including, but not limited to, ecological and endangered species. Based on the above criteria, potential regional projects that may be investigated are discussed in the next section.

B. Potential Projects

Forest Lake

1) FL44 Wetland

- This wetland is approximately 300 acres of the 497-acre drainage area. Roughly 1,000 acres drain through the wetland prior to entering Forest Lake through a 36-inch culvert.
- An additional 400 acres could potentially be redirected from water that currently flows to Little Comfort Lake directly as well as small landlocked areas on the north end of the Forest Lake system.
- This may require the North Shore Trail to be raised to allow additional flood storage.

2) FL63 Wetland (Outlet to Shields Lake)

- Water level changes in this wetland would directly affect Shields Lake water levels. Therefore, it is not a good candidate for flood control.
- The wetland could be managed for water quality.

Bone Lake – North

1) NBL17 Wetland

- This wetland is approximately 40 acres. Most of NBL drains through the wetland prior to entering Bone Lake through a 36-inch culvert.
- This may require 238th Street North to be raised to allow additional flood storage.

2) NBL 23

- This partial wetland/wooded upland could also provide additional flood protection, upstream of Moody Lake.

Bone Lake – South

1) SB11 and SB13 Wetlands

- Most of the SBL area drains through these two wetland complexes. Both could be managed for additional flood control and water quality.

Little Comfort Lake

1) LCL11 (Birch Lake)

2) LCL04 (School Lake)

- Both lakes could be managed for both flood control and water quality benefits.

Comfort Lake

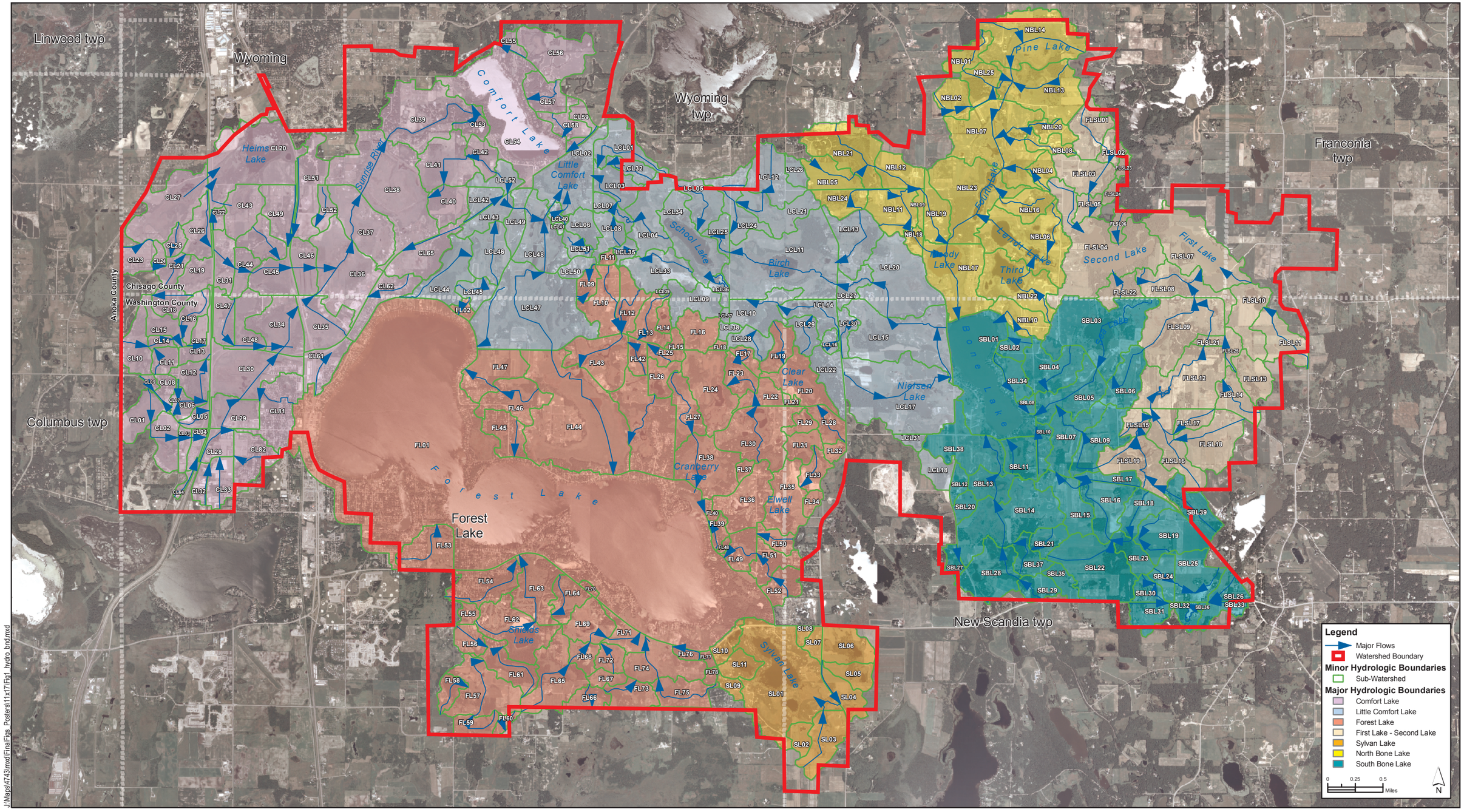
1) CL36/37/38

- Sunrise River runs through these drainage areas. From mapping, it appears a large water feature could be constructed that could be both an amenity and beneficial for flood storage and water quality for the District.
- Removal of some of the existing material may also reduce soluble phosphorus loading to the lake (from previous studies).

9. Conclusions/Recommendations

The floodplain mapping and corresponding H&H models provide the Managers with a powerful technical tool to evaluate potential projects and ensure that regional projects have the greatest chance for success. The following conclusions identify some of the things that this 'leathermen' of hydrologic models can evaluate:

- Lake 'bounce' can be exasperated by development. Historical data should be studied to identify the acceptable bounce based on predevelopment levels.
- Regional projects strategically placed could have significant benefit for both flood control and potentially water quality.
- A refined ultimate land use scenario that included regional projects would likely result in better flood control.
- The model can be used to assess water quality loading to the various water bodies.
- Refine the model/calibration with flow data at additional locations and accounting for groundwater by measuring landlocked basin elevation and reassigning infiltration to the various lakes.
- The model should be refined as the District develops to continue to assess impacts of changed land uses.



J:\Maps\4743\mxd\FinalFigs_Posters\11x17\Fig1_hydro_bnd.mxd

SRF Consulting Group, Inc.

0024743 05/25/05

MAJOR AND MINOR HYDROLOGIC BOUNDARIES

FLOODPLAIN DELINEATION

Comfort Lake - Forest Lake Watershed District

Figure 1

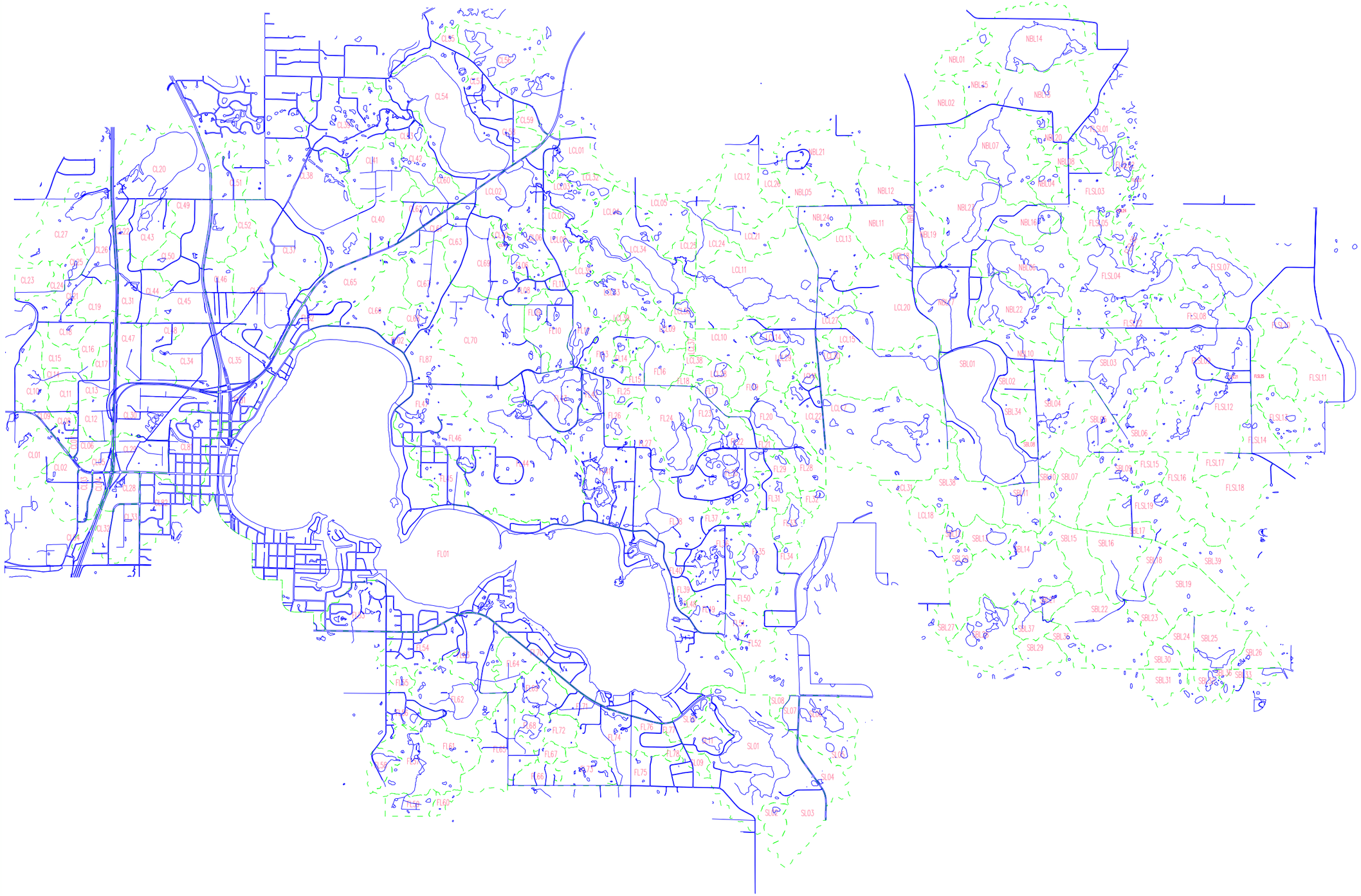


TABLE 1
STRUCTURE INVENTORY

Structure ID	Upstream SWMM Node	Existing Structure Type	Location Description	Upstream Y Coordinate	Upstream X Coordinate	Upstream Invert Elevation	Downstream Invert Elevation	Existing Condition Rating	Existing Length (ft)	County	City Township	Notes
1	CL34	60" RCP	Crossing Forest Blvd. east of Hwy 61	300415.49	460515.76	888.34	887.75	FAIR	62	Washington	Forest Lake	
2	CL34 B	8' X 6' BOX	Crossing Hwy 61 south of 240th St.	300451.37	460609.18	884.27	885.11	VERY POOR	63	Washington	Forest Lake	
3	CL34 B	8' X 6' BOX	Crossing Hwy 61 south of 240th St.	300461.53	460672.33	884.27	885.11	VERY POOR	63	Washington	Forest Lake	
4	FL44	36" CSP	Crossing North Shore Trail west of Iverson Ln.	292331.67	475518.02	901.03	901.15	FAIR	50	Washington	Forest Lake	
5	FL71	48" CSP	Crossing Hwy 97 east of Imperial Ave.	284795.43	476760.56	897.66	897.73	GOOD	84	Washington	Forest Lake	
6	FL65-1	15" CSP	Crossing Ingersoll Ave. south of 210th St.	283258.71	473058.84	915.83	915.42	VERY POOR	49	Washington	Forest Lake	
7	FL63-B	48" RCP	Crossing Hwy 97 west of Imperial Ave.	288513.10	470999.85	899.85	899.88	GOOD	68	Washington	Forest Lake	
8	CL04	48" RCP	Crossing SW ramp at I-35 and Broadway Ave.	294175.85	455870.15	891.79	890.46	GOOD	561	Washington	Forest Lake	
9	CL12A	36" RCP	Crossing I-35 south of Hwy 8	296888.03	456188.60	888.39	888.31	GOOD	230	Washington	Forest Lake	
10	CL35	54" RCP	Crossing driveway north of Hwy 8	299426.42	462422.44	887.08	887.02	GOOD	29	Washington	Forest Lake	
11	N520	60" CSP	Crossing Hwy 8 east of Hwy 61	299074.62	462739.01	897.30	894.92	FAIR	173	Washington	Forest Lake	
12	CL34A	66" CSP	Crossing bike trail west of Hwy 61	300426.53	460546.64	887.18	886.93	FAIR	40	Washington	Forest Lake	
13	N518	54" RCP ARCH	Crossing North Shore Trail (Forest Lake outlet)	298786.65	463282.76	899.17	897.85	FAIR	102	Washington	Forest Lake	(A)
14	CL30	60" RCP	Crossing Hwy 8 west of Hwy 61	298111.39	459488.01	888.74	888.53	GOOD	195	Washington	Forest Lake	
15	FL47	18" CSP	Crossing North Shore Trail south of 235th St.			903.99	903.89	FAIR	51	Washington	Forest Lake	(C)
16	FL45	24" CSP	Crossing North Shore Trail east of North Shore Ct.			900.72	900.45	FAIR	54	Washington	Forest Lake	(C)
17	FL38	36" CSP	Crossing North Shore Trail east of Jeffery Ave.					FAIR		Washington	Forest Lake	(C)
18	FL49	18" RCP	Crossing North Shore Trail west of Keather Tr.			914.51	914.19	FAIR	65	Washington	Forest Lake	(C)
19	FL51	24" CSP	Crossing Keather Tr. south of 217th St.			918.00	917.70	GOOD	60	Washington	Forest Lake	(C)
20	NBL20	18" CSP	Crossing Morgan Ave. north of 256th St.	308797.80	496983.70	936.74	936.66	GOOD	51	Chisago	Wyoming twp	
21	FLSL03	24" CSP	Crossing Morgan Ave. north of 250th St.	307172.40	496986.10	936.19	935.66	GOOD	60	Chisago	Wyoming twp	
22	NBL09	36"CSP	Crossing Lofton Ave. south of 250th St.	305811.80	490328.20	912.81	912.14	GOOD	158	Chisago	Wyoming twp	
23	NBL113	30" CSP	Crossing driveway south of 256th St.	309771.70	493995.80	915.18	915.09	FAIR	23	Chisago	Wyoming twp	
24	NBL113	24" CSP	Crossing driveway south of 256th St.	309794.70	494001.60	915.24	915.19	POOR	23	Chisago	Wyoming twp	
25	NBL19	36" CSP	Crossing 245th St. (Moody Lake inlet)	303354.00	491474.80	909.71	910.20	GOOD	40	Chisago	Wyoming twp	
26	NBL19	36" CSP	Crossing 245th St. (Moody Lake inlet)	303352.42	491315.80	909.98	910.81	GOOD	41	Chisago	Wyoming twp	
27	NBL13A	48" CSP	Crossing 256th St.	310221.82	494172.76	918.27	917.92	GOOD	62	Chisago	Wyoming twp	
28	NBL12	24" CSP	Crossing driveway on north side of 250th St.	306003.60	489934.32	913.54	913.81	GOOD	237	Chisago	Wyoming twp	
29	LCL03	45" RCP ARCH	Crossing Itasca Ave. (Little Comfort Lake inlet)	306586.70	474624.55	885.44	885.20	GOOD	65	Chisago	Wyoming twp	
30	LCL02	42" CSP	Crossing Hwy 8 (Little Comfort Lake Outlet)	307404.40	472931.58	883.68	883.61	FAIR	59	Chisago	Wyoming twp	
31	LCL48A	24" CSP	Crossing Heath Ave. south of Hwy 8	305060.17	471338.20	898.94	898.60	VERY POOR	51	Chisago	Wyoming twp	
32	CL54	84" RCP ARCH	Crossing W. Comfort Dr. (Comfort Lake outlet)	311446.44	468118.00	884.29	884.01	GOOD	40	Chisago	Wyoming twp	
33	CL54	84" RCP ARCH	Crossing W. Comfort Dr. (Comfort Lake outlet)	311461.51	468124.14	884.22	883.98	GOOD	40	Chisago	Wyoming twp	
34	LCL11A	48" HDPE	Crossing July Ave. north of 240th St.	302952.68	481117.15	894.00	893.44	GOOD	60	Chisago	Wyoming twp	
35	LCL24	42" CSP	Crossing July Ave. north of 240th St.	303823.79	481069.41	901.75	900.54	FAIR	66	Chisago	Wyoming twp	
36	LCL24	18" CSP	Crossing July Ave. south of Green Lake Tr.	305533.43	481090.95	910.26	909.29	FAIR	51	Chisago	Wyoming twp	
37	CL31	24" CSP	Crossing Falcon Ave. north of 240th St.	302254.05	457460.98	895.88	895.85	GOOD	45	Chisago	Wyoming twp	
38	CL31	24" RCP	Crossing driveway west of Falcon Ave.	302347.34	457349.39	897.89	896.35	VERY POOR	26	Chisago	Wyoming twp	
39	CL35	60" CSP	Crossing driveway east of Hwy 61	300919.45	461256.95	887.08	887.07	GOOD	29	Chisago	Wyoming twp	
40	CL45A	8' X 6' BOX	Crossing Hwy 61 north of 240th St.	302255.30	460193.80	886.25	884.52	VERY POOR	55	Chisago	Wyoming twp	
41	CL45A	8' X 6' BOX	Crossing Hwy 61 north of 240th St.	302240.35	460197.29	886.25	884.52	VERY POOR	55	Chisago	Wyoming twp	
42	CL45	24" CSP	Crossing bike trail north of 240th St.	302247.12	460108.35	889.96	889.65	FAIR	61	Chisago	Wyoming twp	
43	CL37	96" RCP ARCH	Crossing Greenway Ave. west of Goodview Ave.	305809.11	463529.37	886.52	886.14	GOOD	70	Chisago	Wyoming twp	
44	LCL27	48" CSP	Crossing Manning Tr. north of 240th St.	301414.91	486181.09	899.45	899.43	FAIR	59	Chisago	Wyoming twp	
45	CL38	72" CSP	Crossing 256th St. west of Gramford Ave.	308386.78	464773.19	885.35	885.28	GOOD	90	Chisago	Wyoming twp	
46	CL22A	54" RCP	Crossing I-35 south of Heims Lake	305107.66	456223.31	893.17	892.50	GOOD	312	Chisago	Wyoming twp	
47	CL26	54" RCP	Crossing I-35 north of 240th St.	303261.83	456341.60	894.32	893.94	GOOD	270	Chisago	Wyoming twp	
48	CL38	60" CSP	Crossing driveway south of 256th St.	308078.83	464600.68	885.32	885.54	GOOD	30	Chisago	Wyoming twp	
49	NBL12	24" CSP	Crossing 250th St. west of Lofton Ave.	305949.95	490212.68	913.82	913.19	GOOD	65	Chisago	Wyoming twp	

TABLE 1 CONTINUED
STRUCTURE INVENTORY

Structure ID	Upstream SWMM Node	Existing Structure Type	Location Description	Upstream End (D) Y Coordinate	Upstream End (D) X Coordinate	Upstream End (D) Invert Elevation	Downstream (D) Invert Elevation	Existing Condition Rating	Existing Length (ft)	County	City Township	Notes
50	LCL43A	48" CSP	Crossing Hwy 8 south of 250th St.	305840.23	470505.09	897.88	897.78	POOR	139	Chisago	Wyoming twp	
51	CL39	96" CSP	Crossing W. Comfort Dr. (Comfort Lake inlet)	310042.13	468797.13	884.03	884.07	POOR	50	Chisago	Wyoming twp	
52	LCL52	21" CSP	Crossing 250th Street west of Hwy 8			900.66	900.41	FAIR	62	Chisago	Wyoming twp	(C)
53	CL19	24" RCP	Crossing I-35 north of 240th St.			898.32	897.62	GOOD	140	Chisago	Wyoming twp	(B)
54	LCL13	36" CSP	Crossing Manning Tr. south of 240th St.			912.00	911.70	FAIR	60	Chisago	Wyoming twp	(C)
55	CL43	24" CSP	Crossing 250th St. west of Fondant Ave.			895.00	894.66	FAIR	68	Chisago	Wyoming twp	(C)
56	CL20B	36" CSP	Crossing 250th St. west of 245th St.			893.66	893.36	FAIR	60	Chisago	Wyoming twp	(C)
57	N288	36" CSP	Crossing 238th St. (Bone Lake inlet)	299812.30	491991.80	907.75	907.58	FAIR	43	Washington	New Scandia twp	
58	NBL10	24" CSP	Crossing 238th St. west of Melanie Trail	299927.30	494069.70	913.97	913.39	VERY POOR	61	Washington	New Scandia twp	
59	SBL38	18" CSP	Crossing 228th St. west of Meadowbrook Ave.	294154.20	493280.18	909.16	909.00	FAIR	64	Washington	New Scandia twp	(A)
60	SBL15	36" CSP ARCH	Crossing Oakhill Rd. west of Meadowbrook Ave.	292377.09	496638.57	939.20	939.10	POOR	50	Washington	New Scandia twp	
61	SBL05	84" CSP	Crossing Meadowbrook Ave. south of Melanie Tr.	295161.49	495705.67	910.14	909.62	GOOD	60	Washington	New Scandia twp	
62	SBL03	18" RCP	Crossing Nolan Ave. south of 236th St.	297324.70	498646.59	927.56	927.32	GOOD	38	Washington	New Scandia twp	
63	SBL03	12" HDPE	Crossing driveway northeast of Nolan Ave.	297379.03	498622.91	927.82	928.57	GOOD	38	Washington	New Scandia twp	
64	LCL30	24" RCP	Crossing Manning Tr. south of 240th St.	299609.80	486314.34	926.85	926.39	FAIR	115	Washington	New Scandia twp	
65	SBL25	24" CSP	Crossing Hwy 97 east of Novak Ave.	286253.08	503237.33	985.49	984.83	POOR	74	Washington	New Scandia twp	
66	FLSL16	48" CSP	Crossing 230th St. east of Nolan Ave.	295440.55	501174.40	933.04	932.23	GOOD	58	Washington	New Scandia twp	
67	FLSL16	48" CSP	Crossing 230th St. east of Nolan Ave.	295439.19	501169.22	932.41	932.34	GOOD	58	Washington	New Scandia twp	
68	SBL39	24" CSP	Crossing Oakhill Rd. east of Nolan Ave.	291536.92	501064.02	981.59	980.93	GOOD	53	Washington	New Scandia twp	
69	FLSL09	48" CSP	Crossing 240th St. east of Oldfield Ave.	300703.99	503239.99	915.21	914.65	GOOD	48	Washington	New Scandia twp	
70	FLSL09	48" CSP	Crossing 240th St. east of Oldfield Ave.	300704.54	503245.13	915.26	914.78	GOOD	48	Washington	New Scandia twp	
71	FLSL09	15" CSP	Crossing 240th St. east of Oldfield Ave.	300706.67	503728.59	920.13	919.45	GOOD	41	Washington	New Scandia twp	
72	FLSL21	24" RCP	Crossing 237th St. east of Oldfield Ave.	298896.00	503950.88	923.02	922.83	GOOD	44	Washington	New Scandia twp	
73	SBL11	18" CSP	Crossing 228th St. west of Meadowbrook Ave.	294061.46	494246.29	909.67	911.21	VERY POOR	69	Washington	New Scandia twp	
74	FLSL12	24" RCP	Crossing 236th St. east of Oldfield Ave.	298387.87	503681.64	925.12	924.99	GOOD	44	Washington	New Scandia twp	
75	SBL01	36" CSP ARCH	Crossing Lofton Ave. (Bone Lake outlet)	299340.52	491471.86	907.79	906.95	FAIR	98	Washington	New Scandia twp	
76	SBL10	12" CSP	Crossing Meadowbrook Ave. north of Melanie Tr.			913.00	912.70	POOR	60	Washington	New Scandia twp	(C)
77	SBL08	15" CSP	Crossing Melanie Tr. north of 228th St.			914.00	913.70	VERY POOR	60	Washington	New Scandia twp	(C)
78	SBL02	15" CSP	Crossing Melanie Tr. south of 238th St.			913.00	912.70	VERY POOR	60	Washington	New Scandia twp	(C)
79	FL21	15" CSP	Crossing 230th St. east of Kirk Ave.					POOR		Washington	New Scandia twp	(C)
Weir Data												
32	CL54	43' Long Weir	Comfort Lake Rock Weir Outfall			885.40	883.97	Good		Chisago	Wyoming twp	
13	FL01	23' Long Weir	Forest Lake Concrete Weir Outfall			901.35	899.00	Good		Washington	Forest Lake	

NOTES:

(A) UPSTREAM END OF CULVERT WAS SURVEYED. DOWNSTREAM INVERT APPROXIMATED AS FIELD OBSTRUCTIONS PREVENTED SURVEY OF INVERT.

(B) DOWNSTREAM END OF CULVERT WAS SURVEYED. UPSTREAM INVERT APPROXIMATED AS FIELD OBSTRUCTIONS PREVENTED SURVEY OF INVERT.

(C) CULVERT WAS VISUALLY INSPECTED IN THE FIELD BUT NO SURVEY DATA WAS OBTAINED.
MODELED INVERT ELEVATIONS WERE OBTAINED FROM TIN MODEL CREATED FOR THE WATERSHED.

TABLE 2
SUBWATERSHED DRAINAGE AREAS

XP-SWMM Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
CL01	68.3	0.0
CL02	71.7	0.0
CL03	25.3	0.0
CL04	25.9	0.0
CL05	27.9	0.0
CL06	24.0	0.0
CL07	10.3	0.0
CL08	26.7	0.0
CL09	9.1	0.0
CL10	74.9	0.0
CL11	34.7	0.0
CL12	62.1	0.0
CL13	36.0	0.0
CL14	16.2	0.0
CL15	50.8	0.0
CL16	48.7	0.0
CL17	23.1	0.0
CL18	44.3	0.0
CL19	57.7	0.0
CL20	198.4	89.5
CL21	37.9	0.0
CL22-L	14.9	0.0
CL23	47.8	0.0
CL24	14.6	0.0
CL25	25.8	0.0
CL26	68.5	0.0
CL27	152.6	27.6
CL28	45.3	0.0
CL29	79.5	0.0
CL30	191.6	0.0
CL31	62.1	0.0
CL32	26.4	0.0
CL33	63.8	0.0
CL34	126.2	0.0
CL35	111.7	0.0
CL36	217.5	0.0
CL37	155.5	0.0
CL38	362.3	0.0
CL39	233.8	0.0
CL40	71.3	0.0
CL41	129.9	0.0
CL42	47.7	0.0
CL43	85.0	0.0
CL44	45.2	0.0
CL45	87.7	0.0

Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
CL46	68.2	0.0
CL47	59.1	0.0
CL48	77.5	0.0
CL49	81.7	0.0
CL50	67.4	0.0
CL51	120.7	0.0
CL52	34.3	0.0
CL53	29.7	0.0
CL54	189.1	219.3
CL55	20.8	0.0
CL56	141.6	0.0
CL57	69.5	0.0
CL58	51.0	0.0
CL59	30.7	0.0
CL61	134.2	0.0
CL62	74.3	0.0
CL64	11.3	0.0
CL65	105.9	0.0
CL82	97.1	0.0
FL01	1350.6	2282.9
FL02	16.4	0.0
FL09-L	30.4	0.0
FL10	97.6	0.0
FL12	59.5	7.4
FL13	62.2	0.0
FL14	19.2	1.4
FL15	14.6	0.0
FL16	68.5	0.0
FL17	24.8	0.0
FL18	7.5	0.0
FL19	57.1	0.0
FL20-L	66.8	39.0
FL21-L	8.8	0.0
FL22	39.5	6.5
FL23	30.9	21.2
FL24	129.0	29.3
FL25	28.8	0.0
FL26-L	41.9	3.8
FL27	81.8	0.0
FL28	45.5	4.9
FL29-L	25.7	1.8
FL30	155.3	29.8
FL31-L	46.9	0.0
FL32-L	17.5	1.9
FL33	19.5	0.0

TABLE 2 CONTINUED
SUBWATERSHED DRAINAGE AREAS

XP-SWMM Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
FL33A	26.1	0.0
FL34-L	19.5	0.0
FL35-L	102.6	18.1
FL36-L	114.8	13.4
FL37	15.6	0.0
FL38	136.8	20.7
FL39	24.3	0.0
FL40	12.8	0.0
FL41	216.5	15.8
FL42	25.4	10.2
FL43	81.6	51.2
FL44	497.6	0.0
FL45	77.7	0.0
FL46	105.8	0.0
FL47	116.8	0.0
FL48	6.4	0.0
FL49	56.0	1.6
FL50	35.1	0.0
FL51	64.9	0.0
FL52	55.8	0.0
FL53	108.5	0.0
FL54	115.2	0.0
FL55-L	19.6	0.0
FL56	39.8	1.9
FL57	147.0	7.6
FL58	24.8	11.9
FL59	44.0	0.0
FL61	10.1	0.0
FL61A	75.0	0.0
FL62	148.4	7.6
FL63	128.8	0.0
FL64	62.6	0.0
FL65-1	111.7	0.0
FL65-2	44.4	0.0
FL67-L	20.4	0.0
FL68	28.4	12.6
FL69	83.7	0.0
FL70-L	8.2	0.0
FL71	49.6	0.0
FL72	38.3	0.0
FL73	69.3	0.0
FL74	123.0	0.0
FL75	80.8	0.0
FL76	14.5	0.0
FL77-L	9.9	0.0

Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
FL78-L	9.1	0.0
FL81	74.9	0.0
FL87	99.1	0.0
FLSL01	70.8	17.4
FLSL02	23.3	10.2
FLSL03	96.7	0.0
FLSL04	254.3	87.1
FLSL05	32.5	0.0
FLSL06-L	26.3	0.0
FLSL07	181.9	51.4
FLSL08	122.3	0.0
FLSL09	224.0	0.0
FLSL10-L	108.7	0.0
FLSL11	93.4	0.0
FLSL12	219.5	0.0
FLSL13-L	69.1	0.0
FLSL14	69.7	0.0
FLSL15	35.6	0.0
FLSL16	114.4	0.0
FLSL17	38.3	0.0
FLSL18	135.6	0.0
FLSL19	122.1	0.0
FLSL21	17.0	0.0
FLSL22	51.8	0.0
FLSL23-L	12.5	0.0
FLSL24	15.1	0.0
FLSL25	26.7	0.0
LCL01	89.2	0.0
LCL02	130.6	38.8
LCL03	70.2	0.0
LCL04	127.4	0.0
LCL05	80.4	0.0
LCL06-L	44.9	0.0
LCL07	36.3	0.0
LCL08	52.5	0.0
LCL09-L	79.6	0.0
LCL10	94.6	0.0
LCL11	388.7	0.0
LCL12	112.2	0.0
LCL13	123.0	0.0
LCL14	71.3	0.0
LCL15	265.5	0.0
LCL16	17.7	0.0
LCL17-L	374.9	0.0
LCL18-L	49.0	0.0

TABLE 2 CONTINUED
SUBWATERSHED DRAINAGE AREAS

XP-SWMM Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
LCL20	233.3	0.0
LCL21	102.7	0.0
LCL22-L	76.0	0.0
LCL24	96.9	0.0
LCL25	35.0	0.0
LCL26-L	28.0	0.0
LCL27	45.2	0.0
LCL28	47.8	0.0
LCL29-L	46.4	0.0
LCL30	31.2	0.0
LCL31-L	18.2	0.0
LCL32-L	39.1	0.0
LCL33	112.8	0.0
LCL34	154.9	0.0
LCL35	20.3	0.0
LCL36	22.6	0.0
LCL37-L	6.7	0.0
LCL38-L	15.3	0.0
LCL39-L	4.1	0.0
LCL40-L	15.4	0.0
LCL41-L	5.5	0.0
LCL42	40.5	0.0
LCL43	53.5	0.0
LCL44	115.1	0.0
LCL45	42.2	0.0
LCL46	98.2	0.0
LCL47	306.3	0.0
LCL48	140.4	0.0
LCL49	53.8	0.0
LCL50-L	28.9	0.0
LCL51-L	23.6	0.0
LCL52	47.9	0.0
NBL01	53.2	0.0
NBL02	62.3	0.0
NBL04	35.7	0.0
NBL05	76.4	0.0
NBL06	158.8	66.4
NBL07	217.9	60.0
NBL08	37.7	0.0
NBL09	15.7	0.0
NBL10	71.1	0.0
NBL11	101.6	0.0
NBL12	72.1	0.0
NBL13	162.1	32.9
NBL14	153.5	93.6

Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
NBL16	64.3	0.0
NBL17	148.5	44.7
NBL18	23.7	0.0
NBL19	71.5	0.0
NBL20	37.8	0.0
NBL21	167.1	0.0
NBL22	99.2	64.8
NBL23	205.6	27.8
NBL24	60.5	0.0
NBL25	63.3	0.0
SBL01	138.1	222.1
SBL02	37.2	0.0
SBL03	238.9	50.7
SBL04	119.1	0.0
SBL05	119.8	0.0
SBL06	88.6	0.0
SBL07	109.8	0.0
SBL08	11.8	0.0
SBL09	106.9	0.0
SBL10	35.4	0.0
SBL11	68.4	0.0
SBL12-L	26.2	0.0
SBL13	61.1	0.0
SBL14	246.8	0.0
SBL15	98.6	0.0
SBL16	107.5	0.0
SBL17	32.6	0.0
SBL18	70.3	0.0
SBL19	127.4	0.0
SBL20-L	27.7	0.0
SBL21	43.1	0.0
SBL22	207.5	0.0
SBL23	49.7	0.0
SBL24	42.8	0.0
SBL25	104.3	0.0
SBL26	43.6	0.0
SBL27	23.6	0.0
SBL28	135.9	0.0
SBL29	45.2	0.0
SBL30	34.8	0.0
SBL31	52.0	0.0
SBL32	32.7	0.0
SBL33	36.5	0.0
SBL34	47.2	0.0
SBL35-L	37.3	0.0
SBL36-L	3.6	0.0

TABLE 2 CONTINUED
SUBWATERSHED DRAINAGE AREAS

XP-SWMM Name	Land Area - Subcatch 1 (acres)	Water Area - Subcatch 2 (acres)
SBL37	51.2	0.0
SBL38	152.5	0.0
SBL39	97.9	0.0
SL01	275.9	122.8
SL02-L	32.1	0.0
SL03	101.1	0.0
SL04	60.0	0.0
SL05-L	48.3	0.0
SL06	73.2	0.0
SL07	38.9	0.0
SL08	13.1	0.0
SL09	21.4	0.0
SL10-L	36.5	0.0
SL11-L	45.3	0.0

Drainage Area Summary

XP-SWMM Name	Drainage Area Covered	Area (acres)	Area (sq mi)
CL	Comfort Lake	5241	8.2
FL	Forest Lake	8730	13.6
FLSL	First Lake/Second Lake	2328	3.6
LCL	Little Comfort Lake	4355	6.8
NBL	North Bone Lake	2550	4.0
SBL	South Bone Lake	3386	5.3
SL	Sylvan Lake	869	1.4
Sum		**27458**	**42.9**

TABLE 3
100-YEAR SURFACE WATER ELEVATIONS - CREEK PROFILES

XP-SWMM Node	Existing Max Water Elevation (ft)	Ultimate Water Elevation (ft)	NODETYPE
CL20	898.4	898.6	LAKE
CL35	894.2	894.9	REACH
CL38	891.3	891.8	REACH
CL38B	890.2	891.7	REACH
CL39	890.7	893.3	REACH
CL54	888.5	888.9	LAKE
FL01	902.4	902.5	LAKE
FL20-L	912.1	912.3	LAKE
FL35-L	923.0	924.8	LAKE
FL38	903.3	903.5	LAKE
FL62	902.9	903.4	LAKE
LCL17-L	932.6	933.9	LAKE
FLSL04	908.9	909.5	LAKE
FLSL07	908.5	908.5	LAKE
SBL03	927.2	907.3	LAKE
NBL22	925.9	926.0	LAKE
NBL17	914.3	914.7	LAKE
SBL01	910.6	911.3	LAKE
LCL15	906.8	907.5	REACH
BRL7	906.4	907.0	REACH
BRL8	905.6	906.5	REACH
LCL27	905.5	906.5	REACH
LCL11	896.9	897.2	LAKE
LCL11B	894.0	894.2	REACH
LCL25	892.6	893.0	REACH
LCL34	891.1	891.6	LAKE
LCL07	890.9	892.1	REACH
LCL03	890.8	892.1	REACH
LCL02	889.3	890.3	LAKE
SL01	939.4	939.9	LAKE

TABLE 4
100-YEAR DISCHARGES - CREEK PROFILES

XP-SWMM Link	Scenario	Upstream XP-SWMM Node	Max Flow (cfs)[a]
Sunrise River			
CL35A out	Existing 100-yr	CL35A	144
	10-day Snow Event	CL35A	140
	Ultimate 100-yr	CL35A	-347
CL36 out	Existing 100-yr	CL36	140
	10-day Snow Event	CL36	137
	Ultimate 100-yr	CL36	-199
CL36A out	Existing 100-yr	CL36A	-186
	10-day Snow Event	CL36A	135
	Ultimate 100-yr	CL36A	-369
L232	Existing 100-yr	CL37	143
	10-day Snow Event	CL37	136
	Ultimate 100-yr	CL37	294
L233	Existing 100-yr	CL37A	126
	10-day Snow Event	CL37A	139
	Ultimate 100-yr	CL37A	-159
CL38 out	Existing 100-yr	CL38	117
	10-day Snow Event	CL38	137
	Ultimate 100-yr	CL38	-135
CL38A out	Existing 100-yr	CL38A	117
	10-day Snow Event	CL38A	137
	Ultimate 100-yr	CL38A	-158
CL38B out	Existing 100-yr	CL38B	-117
	10-day Snow Event	CL38B	137
	Ultimate 100-yr	CL38B	-271
CL38C out	Existing 100-yr	CL38C	-251
	10-day Snow Event	CL38C	137
	Ultimate 100-yr	CL38C	-710
CL39 out	Existing 100-yr	CL39	344
	10-day Snow Event	CL39	202
	Ultimate 100-yr	CL39	536
CL54 out	Existing 100-yr	CL54	147
	10-day Snow Event	CL54	211
	Ultimate 100-yr	CL54	175
CL54A out	Existing 100-yr	CL54A	147
	10-day Snow Event	CL54A	211
	Ultimate 100-yr	CL54A	175
CL54C out	Existing 100-yr	CL54C	147
	10-day Snow Event	CL54C	211
	Ultimate 100-yr	CL54C	175
L271	Existing 100-yr	N518	77
	10-day Snow Event	N518	102
	Ultimate 100-yr	N518	86
L272	Existing 100-yr	N519	77
	10-day Snow Event	N519	102
	Ultimate 100-yr	N519	86

TABLE 4 CONTINUED
100-YEAR DISCHARGES - CREEK PROFILES

XP-SWMM Link	Scenario	Upstream XP-SWMM Node	Max Flow (cfs)[a]
L273	Existing 100-yr	N520	77
	10-day Snow Event	N520	102
	Ultimate 100-yr	N520	86
L274	Existing 100-yr	N521	77
	10-day Snow Event	N521	102
	Ultimate 100-yr	N521	86
CL35 out	Existing 100-yr	CL35	190
	10-day Snow Event	CL35	159
	Ultimate 100-yr	CL35	213
Comfort Lake to Bone Lake			
L115	Existing 100-yr	SBL01	34
	10-day Snow Event	SBL01	57
	Ultimate 100-yr	SBL01	41
BONELKWEIR	Existing 100-yr	NBL106	34
	10-day Snow Event	NBL106	57
	Ultimate 100-yr	NBL106	41
L222	Existing 100-yr	NBL106A	34
	10-day Snow Event	NBL106A	57
	Ultimate 100-yr	NBL106A	-46
LBRL-1	Existing 100-yr	BRL-1	-97
	10-day Snow Event	BRL-1	57
	Ultimate 100-yr	BRL-1	-219
LBRL-2	Existing 100-yr	BRL-2	-194
	10-day Snow Event	BRL-2	57
	Ultimate 100-yr	BRL-2	-409
LBRL-3	Existing 100-yr	BRL-3	-243
	10-day Snow Event	BRL-3	58
	Ultimate 100-yr	BRL-3	-495
LBRL-4	Existing 100-yr	LCL15	226
	10-day Snow Event	LCL15	103
	Ultimate 100-yr	LCL15	396
LBRL-5	Existing 100-yr	BRL-5	106
	10-day Snow Event	BRL-5	83
	Ultimate 100-yr	BRL-5	160
L223	Existing 100-yr	LCL20	174
	10-day Snow Event	LCL20	128
	Ultimate 100-yr	LCL20	321
LBRL-7	Existing 100-yr	BRL-7	105
	10-day Snow Event	BRL-7	104
	Ultimate 100-yr	BRL-7	116
LBRL-8	Existing 100-yr	BRL-8	104
	10-day Snow Event	BRL-8	105
	Ultimate 100-yr	BRL-8	116
LCL27 out	Existing 100-yr	LCL27	104
	10-day Snow Event	LCL27	109
	Ultimate 100-yr	LCL27	119

TABLE 4 CONTINUED
100-YEAR DISCHARGES - CREEK PROFILES

XP-SWMM Link	Scenario	Upstream XP-SWMM Node	Max Flow (cfs)[a]
L225	Existing 100-yr	BRL-10	104
	10-day Snow Event	BRL-10	108
	Ultimate 100-yr	BRL-10	118
LCL11 out	Existing Snow	LCL11	47
	10-day Snow Event	LCL11	75
	Ultimate 100-yr	LCL11	57
LCL11A out	Existing 100-yr	LCL11A	47
	10-day Snow Event	LCL11A	75
	Ultimate 100-yr	LCL11A	57
LCL11B out	Existing 100-yr	LCL11B	47
	10-day Snow Event	LCL11B	75
	Ultimate 100-yr	LCL11B	57
LCL25 out	Existing 100-yr	LCL25	333
	10-day Snow Event	LCL25	209
	Ultimate 100-yr	LCL25	449
LCL34 out	Existing 100-yr	LCL34	-76
	10-day Snow Event	LCL34	85
	Ultimate 100-yr	LCL34	-250
L231	Existing 100-yr	LCL04	236
	10-day Snow Event	LCL04	147
	Ultimate 100-yr	LCL04	553
LLCL-1	Existing 100-yr	LCL-1	214
	10-day Snow Event	LCL-1	141
	Ultimate 100-yr	LCL-1	484
LLCL-2	Existing 100-yr	LCL-2	187
	10-day Snow Event	LCL-2	132
	Ultimate 100-yr	LCL-2	396
LLCL-3	Existing 100-yr	LCL-3	206
	10-day Snow Event	LCL-3	141
	Ultimate 100-yr	LCL-3	387
LLCL-4	Existing 100-yr	LCL-4	183
	10-day Snow Event	LCL-4	132
	Ultimate 100-yr	LCL-4	332
LLCL-5	Existing 100-yr	LCL-5	141
	10-day Snow Event	LCL-5	117
	Ultimate 100-yr	LCL-5	238
LLCL-6	Existing 100-yr	LCL07	135
	10-day Snow Event	LCL07	117
	Ultimate 100-yr	LCL07	183
LLCL-7	Existing 100-yr	LCL-7	116
	10-day Snow Event	LCL-7	115
	Ultimate 100-yr	LCL-7	-304
LLCL-8	Existing 100-yr	LCL-8	-211
	10-day Snow Event	LCL-8	116
	Ultimate 100-yr	LCL-8	-520

TABLE 4 CONTINUED
100-YEAR DISCHARGES - CREEK PROFILES

XP-SWMM Link	Scenario	Upstream XP-SWMM Node	Max Flow (cfs)[a]
LLCL-9	Existing 100-yr	LCL-9	-250
	10-day Snow Event	LCL-9	116
	Ultimate 100-yr	LCL-9	-583
LCL03 out	Existing 100-yr	LCL03	147
	10-day Snow Event	LCL03	145
	Ultimate 100-yr	LCL03	178
LCL02 out	Existing 100-yr	LCL02	51
	10-day Snow Event	LCL02	77
	Ultimate 100-yr	LCL02	68

(a) Negative flow values are caused by back-flow conditions or reaches/pipes at adverse grades.

TABLE 5
BASE FLOOD LEVELS – EXISTING AND CRITICAL EVENT
(100-Year / 24-Hour SCS Type II Storm, Back-to-back 100-Year / 24-Hour SCS Type II Storm, and 100-Year / 10-Day Snowmelt)

				MnDNR Lake Finder Data		100-Year	100-Year Critical Event		
Name	Node Name	Landlocked	Approximate Outlet/Overflow Elevation (ft)	OHW (ft)	Recorded High (ft)	Existing Conditions[a]	Ultimate Conditions[a]	10-day Snowmelt 100% Impervious	Change (Critical–Existing)
COMFORT LAKE WATERSHED									
Heims Lake	CL20		896.8			898.4	898.6	898.6	0.2
Comfort Lake	CL54		885.4	887.20	888.32	888.5	888.9	889.5	1.0
Wetland	CL34		888.4			893.9	894.4	893.9	0.4
Wetland	CL30		888.7			894.8	895.2	894.4	0.4
LITTLE COMFORT LAKE WATERSHED									
Little Comfort Lake	LCL02		885.7	887.20	887.81	889.3	890.3	892.1	2.8
Nielsen Lake	LCL17-L	X	941.0			932.6	933.9	933.4	1.3
Birch Lake	LCL11		894.5			896.9	897.2	897.9	1.0
Clear Lake	FL20-L	X	939.0			912.1	912.3	911.5	0.3
School Lake	LCL34		889.5			891.1	891.6	892.8	1.7
FOREST LAKE WATERSHED									
Elwell Lake	FL35-L	X	924.0			923.0	924.8	923.2	1.7
Shields Lake	FL62		901.4	902.50	903.99	902.9	903.4	903.3	0.5
Cranberry Lake	FL38		901.9	903.00	903.30	903.3	903.5	903.1	0.2
Sylvan Lake	SL01	X	948.0	937.10	938.00	939.4	939.9	939.2	0.5
Forest Lake	FL01		901.4	901.80	902.60	902.4	902.5	902.7	0.3
BONE LAKE WATERSHED									
First Lake	FLSL07	X	914.0			908.5	908.8	908.5	0.3
Moody Lake	NBL17		912.3			914.3	914.7	915.0	0.7
Second Lake	FLSL04		906.6			908.9	909.5	909.7	0.8
Bone Lake	SBL01		907.3	909.10	910.97	910.6	911.3	913.7	3.2
Sea Lake	SBL03	X	927.6			927.1	927.3	926.8	0.2
Third Lake	NBL22		925.3	923.60		925.9	926.0	925.9	0.1
Pine Lake	NBL14		925.5			926.5	926.7	926.7	0.3

(a) Elevations for the land-locked basins are from the back-to-back 100-yr, 24-hour event and the elevations for the other basins are from the 100-yr, 24-hr event.

TABLE 6
CRITICAL STORM EVENT AND BOUNCE
(100-Year / 24-Hour SCS Type II Storm, Back-to-back 100-Year / 24-Hour SCS Type II Storm, and 100-Year / 10-Day Snowmelt)

Name	Node Name	Critical Storm Event	Starting Water Surface Modeled (ft)	Critical 100-yr Flood Elevations	Bounce (100-yr Critical–Starting Water Surface)
COMFORT LAKE WATERSHED					
Heims Lake	CL20	100-yr, 10-day Snow	897.0	898.6	1.6
Comfort Lake	CL54	100-yr, 10-day Snow	886.0	889.5	3.5
Wetland	CL34	100-yr, 24-hr	889.2	893.9	4.7
Wetland	CL30	100-yr, 24-hr	889.7	894.8	5.1
LITTLE COMFORT LAKE WATERSHED					
Little Comfort Lake	LCL02	100-yr, 10-day Snow	886.0	892.1	6.1
Nielsen Lake	LCL17-L	100-yr, 10-day Snow	930.0	933.4	3.4
Birch Lake	LCL11	100-yr, 10-day Snow	895.0	897.9	2.9
Clear Lake	FL20-L	100-yr, BTB	909.5	912.1	2.6
School Lake	LCL34	100-yr, 10-day Snow	890.0	892.8	2.8
FOREST LAKE WATERSHED					
Elwell Lake	FL35-L	100-yr, 10-day Snow	917.8	923.2	5.4
Shields Lake	FL62	100-yr, 10-day Snow	901.7	903.3	1.6
Cranberry Lake	FL38	100-yr, 24-hr	902.1	903.3	1.2
ylvan Lake	SL01	100-yr, BTB	937.4	939.4	2.0
Forest Lake	FL01	100-yr, 10-day Snow	901.7	902.7	1.0
BONE LAKE WATERSHED					
First Lake	FLSL07	100-yr, BTB	903.2	908.5	5.3
Moody Lake	NBL17	100-yr, 10-day Snow	913.3	915.0	1.7
Second Lake	FLSL04	100-yr, 10-day Snow	907.6	909.7	2.1
Bone Lake	SBL01	100-yr, 10-day Snow	908.4	913.7	5.3
Sea Lake	SBL03	100-yr, BTB	924.0	927.1	3.1
Third Lake	NBL22	100-yr, 24-hr	925.4	925.9	0.5
Pine Lake	NBL14	100-yr, 10-day Snow	925.8	926.7	0.9

TABLE 7
SHORELAND PROTECTION

Lake Name	OHW Elevation (ft)	OHW Source	Unsewered Setback	Sewer Setback	Lake Class	Setback Source	Setback Date
Elwell Lake	917.8	GRW	200	150	Natural Env	Washington Co	1998
Nielsen Lake	928.5	GRW	200	150	Natural Env	Washington Co	1998
Clear Lake	909.5	GRW	200	150	Natural Env	Washington Co	1998
Bone Lake	911.5	GRW	100	75	Recreational	Washington Co	1998
Sea Lake	923.5	GRW	200	150	Natural Env	Washington Co	1998
Third Lake	925.3	GRW	150	150	Natural Env	Chisago Co	1992
Moody Lake	911.1	GRW	150	150	Natural Env	Chisago Co	1992
First Lake	903.2	GRW	150	150	Natural Env	Chisago Co	1992
Second Lake	907.5	GRW	150	150	Natural Env	Chisago Co	1992
Heims Lake	896.8	GRW	100	75	Recreational	Chisago Co	1992
School Lake	891.4	GRW	150	150	Natural Env	Chisago Co	1992
Birch Lake	895.4	GRW	150	150	Natural Env	Chisago Co	1992
Sylvan Lake	937.1	DNR	100	75	Recreational	Washington Co	1998
Shields Lake	902.5	DNR	200	150	Natural Env	Washington Co	1998
Cranberry Lake	903.0	DNR	200	150	Natural Env	Washington Co	1998
Forest Lake	901.8	DNR	75	50	Gen Development	Washington Co	1998
Little Comfort Lake	887.2	DNR	75	50	Gen Development	Chisago Co	1992
Comfort Lake	887.2	DNR	75	50	Gen Development	Chisago Co	1992
Pine Lake	925.4	GRW	150	150	Natural Env	Chisago Co	1992
Fourth Lake	913.4	GRW	150	150	Natural Env	Chisago Co	1992
Lendt Lake	923.2	GRW	150	150	Natural Env	Chisago Co	1992
River Reaches							
Birch Lake to School Lake	Varies**	GRW	100	75	Tributary River	Wyoming	1992*
School Lake to Little Comfort Lake	Varies**	GRW	100	75	Tributary River	Wyoming	1992*
Sunrise River-Forest Lake to Comfort Lake	Varies**	GRW	100	75	Tributary River	Wyoming	1992*

*Date not found, assumed same as Chisago County
**Surface water elevation changes over the different stretches of the river

TABLE 8
SOIL AND INFILTRATION DATA SUMMARY

						Green-Ampt Inviltration Ranges			
General Chisago Co. Soils	**Hydrologic Soil Type**	**Taxonomic Class**	**EOR Defined Regions**	**Hydrologic Soil Type To Use**	**XP Name**	**Low Water Table (Higher Hydraulic Conductivity)**	**High Water Table (Lower Hydraulic Conductivity)**	**IMD**	**Suction (in)**
Zimmerman-Isanti	A, A/D	Fine sand, fine sandy loam	Discharge	D	SndLmDschrgD	0.05	0	0.33	8
Seeleyville-Markey	A/D, A/D	Sandy, muck	Discharge	D	SndDschrgD	0.05	0	0.34	4
Braham-Blomford-Eckvoll	B, B/D, B	Fine loamy sand	Discharge	B	SndLmDschrgB	0.3	0.15	0.33	8
Nebish-Talmoon	B, B/D	Fine sandy loam	Recharge	B	SndLmRchrgB	0.3	0.15	0.33	8
Mahtomedi-Pomroy	A, A/D	Loamy coarse sand	Recharge/ Discharge	D	SndDschrgD, SndRchrgD	0.05	0	0.34	4
General Washington Co. Soils									
Zimmerman-Isanti-Lino	A, A/D, B	Fine sand, fine sandy loam	Discharge	D	SndLmDschrgD	0.05	0	0.33	8
Braham-Blomford-Urban Land	B, B/D	Fine loamy sand	Recharge	B	SndLmDschrgB	0.3	0.15	0.33	8
Hayden-Nessel-Dundas	B, B, B/D	Fine loamy sand	Recharge/ Discharge	B	SndLmDschrgB, SndLmRchrgB	0.3	0.15	0.33	8
Demontreville-Kingsley	B, B	Coarse loamy sand	Discharge	B	SndDschrgB	0.3	0.15	0.34	4
Antigo-Comstock	B, B	Fine silty sand	Recharge	B	SltLmRchrgB	0.3	0.15	0.32	12
Antigo-Chetek-Mahtomedi	B, B	Fine silty sand	Recharge	B	SltLmRchrgB	0.3	0.15	0.32	12
Santiago-Kingsley	B, B	Fine loamy sand	Recharge	B	SndLmRchrgB	0.3	0.15	0.33	8
Nessel-Dundas-Webster	B, B/D	Fine loamy sand	Discharge	D	SndLmDschrgD	0.05	0	0.33	8

TABLE 9
CALIBRATION COMPARISON

Peak Discaharge

	Measured Peak Flow (cfs)	Calibrated Peak Flow (cfs)	Calibrated Flow as % of Measured
Bone Lake	28.1	25.8	92%
Comfort Lake	97.3	107.6	111%
Forest Lake	56.0	50.9	91%

Discharge Volume

	Measured Volume (ac-ft)	Calibrated Volume (ac-ft)	Calibrated Volume as % of Measured
Bone Lake	748	914	122%
Comfort Lake	4964	5345	108%
Forest Lake	2233	2191	98%

Peak Stage

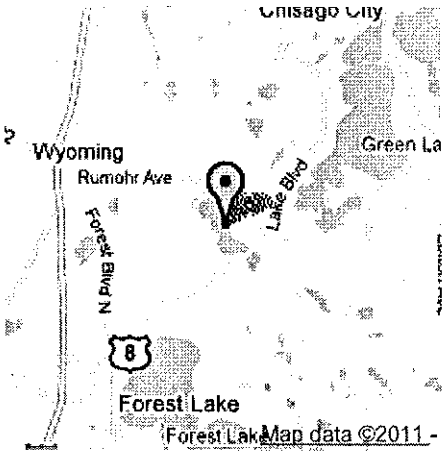
	Measured Stage (ft)	Calibrated Stage (ft)	Variance (ft)
Bone Lake	N/A[(a)]	910.59	N/A
Comfort Lake	887.31	887.74	0.43
Forest Lake	902.08	902.02	-0.06

(a) No Lake Finder data for Bone Lake available for the calibration event

APPENDIX C

MPCA WATER QUALITY MONITORING DATA

COMFORT LAKE – FOREST LAKE WATERSHED DISTRICT 2010 WATER MONITORING REPORT



Physical Information

Name: Comfort
DNR Lake ID number: 13-0053
County: CHISAGO
Location from nearest town: 3 MI SW O CHISAGO CITY
Ecoregion: NCHF
Basin: SC
Hydrologic Unit Code: 7030005
Surface Area: 212 (acres)
Maximum depth: 47 (feet)
Water Body Type: P

Latitude/Longitude: 45.32083333/-92.94713889
UTMx/UTMy: 504142/5018589

Lake Water Quality Assessment

This summary is based on available summer (June through September) data in STORET (STORET is the national water quality data repository developed by the United States Environmental Protection Agency. All water quality data collected by MPCA or received from external groups is placed in STORET.) collected between 1999 and 2008.

Data Quality: excellent
Aquatic Recreation Use Support:

Lake Water Quality Data Summary

Total Phosphorus Mean: 35.0 ppb (parts per billion)
Total Phosphorus Standard Error: 2.0 ppb
Total Phosphorus # of Observations: 82

Chlorophyll-a Mean: 16.3 ppb
Chlorophyll-a Standard Error: 0.7 ppb
Chlorophyll-a # of Observations: 140

Secchi Disk Mean: 1.6 meters
Secchi Disk Standard Error: 0.0 meters
Secchi Disk # of Observations: 133
www.pca.state.mn.us/water/clmp.html

Alkalinity Mean: 0.0 ppm (parts per million)
Color Mean: 0.00 Platinum-cobalt Units

Carlson Trophic Status for Total Phosphorus: 56.0
Carlson Trophic Status for Chlorophyll-a: 58.0
Carlson Trophic Status for Secchi Disk: 53.0
Overall Trophic Status: E
(O=oligotrophic, M=mesotrophic, E=eutrophic, H=hypereutrophic)

See the Difference! **Oligotrophic** vs. **Hypereutrophic**

Watch how lakes change over the summer.

Compare this lake to reference lakes or all assessed lakes.

Transparency ***Chlorophyll-a*** ***Total Phosphorus***

Citizen Lake Monitoring Program

Other Searches

Based on your search, there is data available from other programs about this lake as well. Click on the link(s) below to display the other data we have available.
Lake Water Quality Program
MPCA Electronic Data Access

Below is the Secchi data from the Citizen Lake Monitoring Program for lake COMFORT (13-0053).

Data shown in the table below is from STORET, the U.S. Environmental Protection Agency's national water quality database. **All data in this table are in units of meters.** To convert meters to feet, multiply values shown by 3.28 (e.g. 1.2 meters = 3.9 feet).

Year	Average Secchi Reading (meters)
1987	2.6
1988	2.4
1989	2.8
1994	2.1
1995	1.3
1997	1.9
1998	1.4
1999	1.4
2000	1.5
2001	1.9
2002	1.3
2003	1.3
2004	1.7
2005	1.9
2006	1.8
2007	1.7
2008	1.6
2009	1.9

Click on the year at the left to get full information about the data samples for that year.

Average is computed by the months June-Sept.

Heims Lake (13-0056) *Comfort Lake - Forest Lake Watershed District*

Heims Lake is located in Wyoming Township (Chisago County). There are known bathymetric data available for this lake. This was the first year this lake was part of the CAMP.

On each sampling day the lake was monitored for total phosphorus (TP), chlorophyll-a (CLA), total kjeldahl nitrogen (TKN), and secchi transparency, as well as the lake's perceived physical condition and recreational suitability. The resulting data are summarized in tables and figures on the following page.

2009 summer (May-September) data summary

Parameter	*Mean*	*Minimum*	*Maximum*	*Grade*
TP (µg/l)	41.4	24.0	82.0	C
CLA (µg/l)	16.9	3.0	82.0	B
Secchi (m)	0.5	0.4	0.6	F
TKN (mg/l)	1.61	1.00	2.10	
			Lake Grade	C

The lake received a lake grade of C for 2009. Continued monitoring is suggested build the baseline water quality database for this lake.

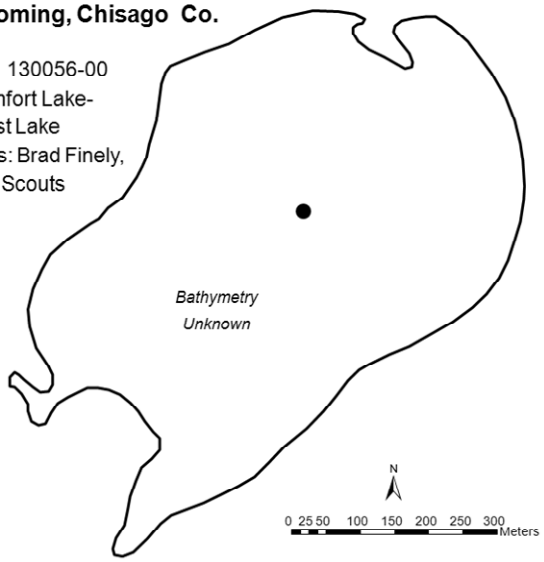
Throughout the monitoring period, the volunteer's opinions of the lake's physical condition and recreational suitability were ranked on a 1-to-5 scale. These user perception rankings are shown on the following page.

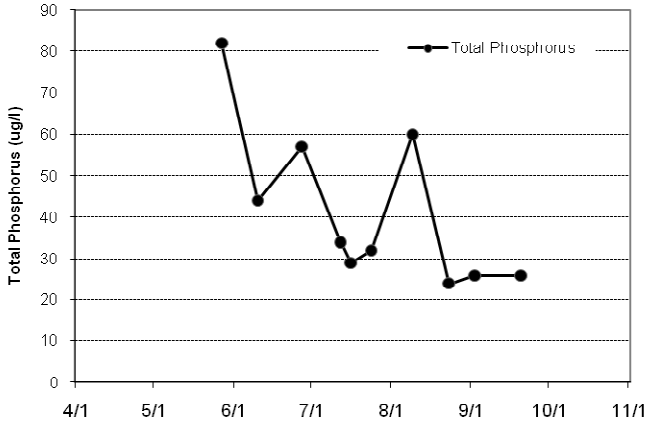
If you notice any errors in the lake's data or physical information, or are aware of any additional or missing information, please contact Brian Johnson of the Metropolitan Council at (651) 602-8743 or brian.johnson@metc.state.mn.us.

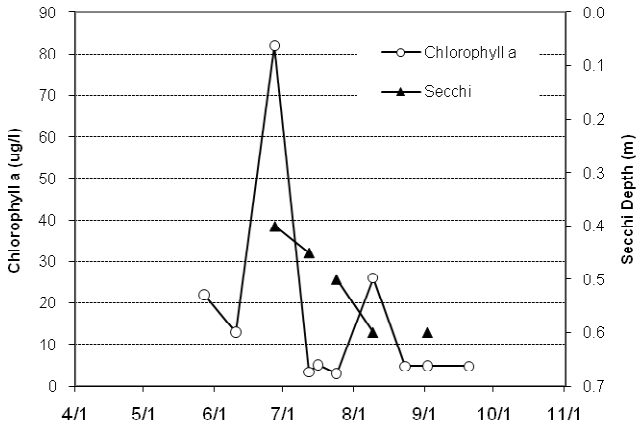
Heims Lake

City of Wyoming, Chisago Co.

LAKE ID: 130056-00
WD: Comfort Lake-Forest Lake
Volunteers: Brad Finely, Boy Scouts

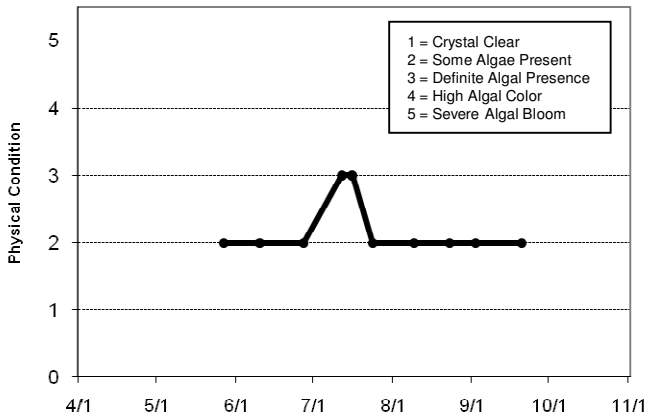






2009 Data

DATE	Surf Tmp (ºC)	Bot Tmp (ºC)	Surf DO (mg/L)	Bot DO (mg/L)	CLA (µg/L)	Surf TP (µg/L)	Bot TP (µg/L)	Secchi (m)	PC	RS
5/27					22	82			2	5
6/10	21				13	44			2	5
6/27	21				82	57		0.4	2	5
7/12	21				3.4	34		0.5	3	5
7/16	20				5.1	29			3	5
7/24	24				3	32		0.5	2	4
8/9	25				26	60		0.6	2	4
8/23	25.8				4.8	24			2	4
9/2	21.9				4.9	26		0.6	2	5
9/20	21.4				4.8	26			2	4



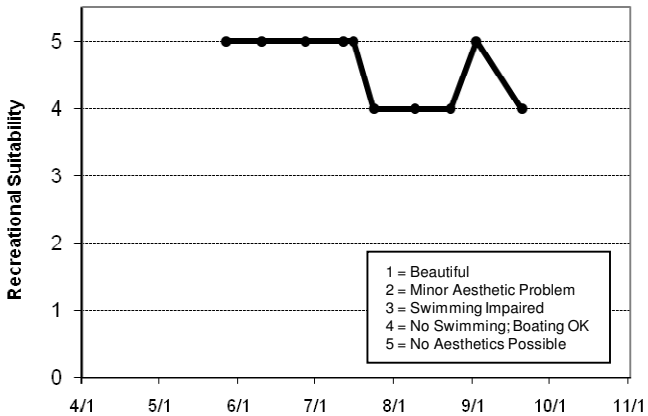
Lake Water Quality Grades Based on Summertime Averages

Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total Phosphorus												
Chlorophyll a												
Secchi Depth												
Lake Grade												

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total Phosphorus												
Chlorophyll a												
Secchi Depth												
Lake Grade												

Year	2004	2005	2006	2007	2008	2009
Total Phosphorus						C
Chlorophyll a						B
Secchi Depth						F
Lake Grade						**C**

Source: Metropolitan Council and STORET data



Little Comfort Lake (13-0054) *Comfort Lake - Forest Lake Watershed District*

Little Comfort Lake is located near the City of Wyoming (Chisago County). The lake has a maximum depth of 17.0 m (56 feet).

On each sampling day the lake was monitored for total phosphorus (TP), chlorophyll-a (CLA), total kjeldahl nitrogen (TKN), and secchi transparency, as well as the lake's perceived physical condition and recreational suitability. The resulting data are summarized in tables and figures on the following page.

2009 summer (May-September) data summary

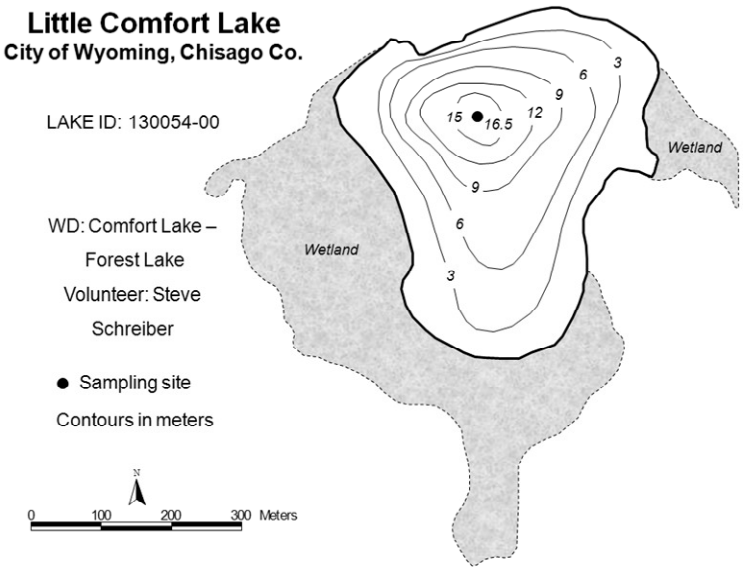
Parameter	*Mean*	*Minimum*	*Maximum*	*Grade*
TP (µg/l)	20.6	14.0	30.0	A
CLA (µg/l)	8.1	3.5	11.0	A
Secchi (m)	1.9	1.0	3.0	C
TKN (mg/l)	0.82	0.74	0.92	
			Lake Grade	B

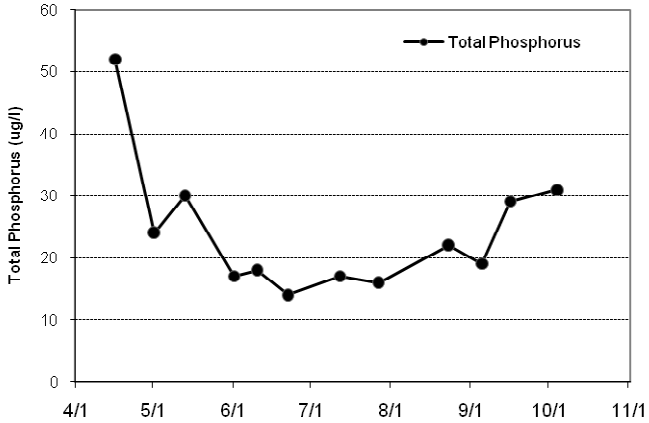
The lake received a lake grade of C for 2009. The TP grade of A was the best grade received for this parameter in the lake's water quality database.

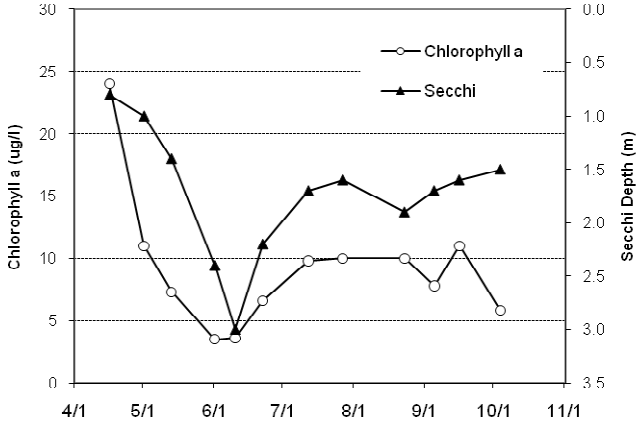
Throughout the monitoring period, the volunteer's opinions of the lake's physical condition and recreational suitability were ranked on a 1-to-5 scale. These user perception rankings are shown on the following page.

The Fisheries Section of the Minnesota Department of Natural Resources (MDNR) conducted a fisheries survey on the lake. Information on the survey can be obtained through the MDNR Fisheries Section by calling (651) 259-5831 or by downloading the information off the Internet at http://www.dnr.state.mn.us/lakefind/.

If you notice any errors in the lake's data or physical information, or are aware of any additional or missing information, please contact Brian Johnson of the Metropolitan Council at (651) 602-8743 or brian.johnson@metc.state.mn.us.

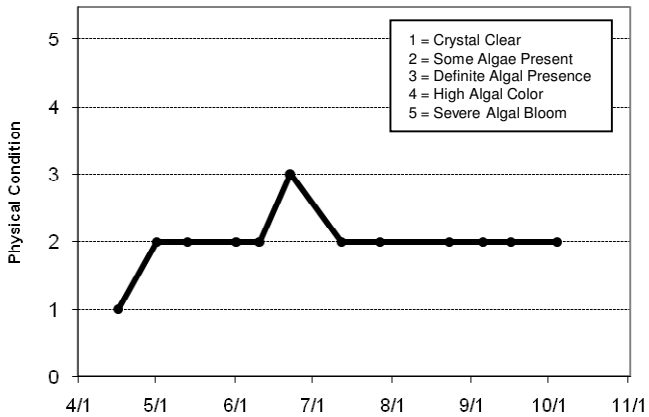






2009 Data

DATE	Surf Tmp (ºC)	Bot Tmp (ºC)	Surf DO (mg/L)	Bot DO (mg/L)	CLA (µg/L)	Surf TP (µg/L)	Bot TP (µg/L)	Secchi (m)	PC	RS
4/16	15.2				24	52		0.8	1	1
5/1	15.6				11	24		1.0	2	2
5/13	16				7.3	30		1.4	2	2
6/1	20.3				3.5	17		2.4	2	2
6/10	22.3				3.6	18		3.0	2	2
6/22	28.1				6.6	14		2.2	3	3
7/12					9.8	17		1.7	2	2
7/27					10	16		1.6	2	3
8/23					10	22		1.9	2	3
9/5	25.6				7.8	19		1.7	2	3
9/16	24				11	29		1.6	2	3
10/4	14.6				5.8	31		1.5	2	3



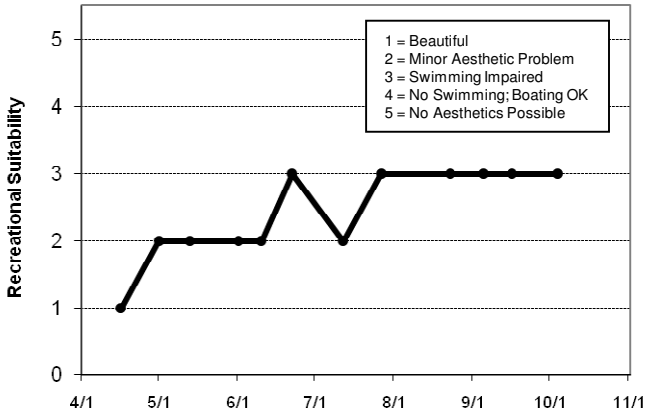
Lake Water Quality Grades Based on Summertime Averages

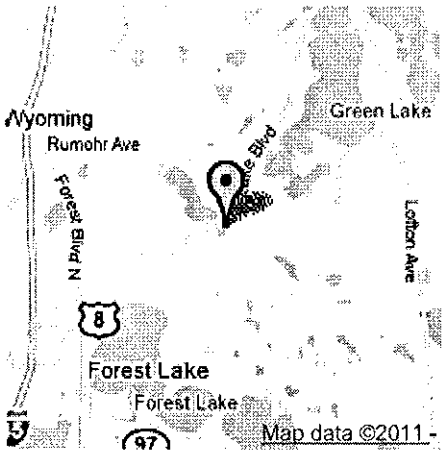
Year	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total Phosphorus												
Chlorophyll a												
Secchi Depth												
Lake Grade												

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total Phosphorus			C									
Chlorophyll a			C									
Secchi Depth			C									
Lake Grade			**C**									

Year	2004	2005	2006	2007	2008	2009
Total Phosphorus			D	C	C	A
Chlorophyll a			C	A	B	A
Secchi Depth			C	C	C	C
Lake Grade			**C**	**B**	**C**	**B**

Source: Metropolitan Council and STORET data





Physical Information

Name: Little Comfort
DNR Lake ID number: 13-0054
County: CHISAGO
Location from nearest town: 3 MI SE OF WYOMING
Ecoregion: NCHF
Basin: SC
Hydrologic Unit Code: 7030005
Surface Area: 35 (acres)
Maximum depth: 54 (feet)
Water Body Type: P

Latitude/Longitude: 45.31305556/-92.93633333
UTMx/UTMy: 504991/5017727

Lake Water Quality Assessment

This summary is based on available summer (June through September) data in STORET (STORET is the national water quality data repository developed by the United States Environmental Protection Agency. All water quality data collected by MPCA or received from external groups is placed in STORET.) collected between 1999 and 2008.

Data Quality: excellent
Aquatic Recreation Use Support:

Comments: Sufficient data exists to review this basin for assessment. TP exceeds the standard, while chl-a and Secchi are just within the standard. Recommend continued monitoring to determine if TP is declining or if chl-a and Secchi are exceeding the thresholds.

Lake Water Quality Data Summary

Total Phosphorus Mean: 51.0 ppb (parts per billion)
Total Phosphorus Standard Error: 6.0 ppb
Total Phosphorus # of Observations: 25

Chlorophyll-a Mean: 12.7 ppb
Chlorophyll-a Standard Error: 1.1 ppb
Chlorophyll-a # of Observations: 41

Secchi Disk Mean: 1.5 meters
Secchi Disk Standard Error: 0.1 meters
Secchi Disk # of Observations: 25

www.pca.state.mn.us/water/clmp.html

Alkalinity Mean: 0.0 ppm (parts per million)
Color Mean: 0.00 Platinum-cobalt Units
Carlson Trophic Status for Total Phosphorus: 61.0
Carlson Trophic Status for Chlorophyll-a: 56.0
Carlson Trophic Status for Secchi Disk: 54.0
Overall Trophic Status: E
(O=oligotrophic, M=mesotrophic, E=eutrophic, H=hypereutrophic)

See the Difference! **Oligotrophic** vs. **Hypereutrophic**

Watch how lakes change over the summer.

Compare this lake to reference lakes or all assessed lakes.

—*Transparency* —*Chlorophyll-a* —*Total Phosphorus*

Citizen Lake Monitoring Program

Other Searches

Based on your search, there is data available from other programs about this lake as well. Click on the link(s) below to display the other data we have available.
Lake Water Quality Program
MPCA Electronic Data Access

Below is the Secchi data from the Citizen Lake Monitoring Program for lake LITTLE COMFORT (13-0054).

Data shown in the table below is from STORET, the U.S. Environmental Protection Agency's national water quality database. **All data in this table are in units of meters.** To convert meters to feet, multiply values shown by 3.28 (e.g. 1.2 meters = 3.9 feet).

Year	Average Secchi Reading (meters)
1994	1.8
2006	1.4
2007	1.4
2008	1.8

Click on the year at the left to get full information about the data samples for that year.

Average is computed by the months June-Sept.

Photo not available

Connection Failure

Lat/Lon: 45.3219/-92.9546
Datum: NAD83
County: Chisago

Stream Station Information

Station Name	SUNRISE R RD CULVERT 400' UP INLET BIG COMFORT
Alternate IDs:	SU-28 Sunrise R @ B Cmft L SC132 Trib to Big Comfort SSGWJ-1409
Waterbody Name:	SUNRISE R
Data Steward Org:	MPCA
Station ID:	S001-223
Hydrologic Unit Code (HUC):	07030005
Assessment Unit:	
Period of Record:	1994 through 2009

Projects Associated with this Station

Project	Purpose
CLFLWD Water Monitoring Assessment Project	Condition Monitoring. CWLA SWAG. 2008 Contract #B12601. 2009 Contract #B25247.
Washington Conservation District	Condition-baseline monitoring program
Ambient Trace Metals	The Ambient Trace Metals Program is a condition monitoring program that began in 1996 to assess total and dissolved fraction concentrations of arsenic, cadmium, chromium (added in 2003), copper, lead, mercury, nickel and zinc (added in 1997) in Minnesota's river basins using improved sampling and analysis techniques.
MPCA Stream Monitoring Program Project	This is an inclusive ?project? created to migrate data to modernized STORET from the 21MINN Agency Code in Legacy STORET where project information was not stored on the sample or result level. Specific purposes for Legacy STORET data collection may be available in the station descriptions.

Station Data Collection Years

2009 2008 2007 2006 2005 2004 1996 1994

Station Data

Sample Date:	Sample Type	BOD mg/L	Chl-a µg/L	Stream Transp cm	DO mg/L	TKN mg/L	NO2NO3 mg/L	pH	Pheo µg/L	TP mg/L	TSS mg/L	Ter Deg C
10/06/2009	Routine Sample/Observation			> 100	8.52	1.4		8.1		0.011	3	9.3
10/02/2009	Routine Sample/Observation			> 100	7.48	1		7.9		0.041	3	9.3
09/30/2009	Routine Sample/Observation											
09/28/2009	Routine Sample/Observation				3.65	1.3		8.0		0.047	2	12.'
09/08/2009	Routine Sample/Observation			> 100	3.67	1.8		7.68		0.063	2	17.:
08/27/2009	Routine Sample/Observation											
08/20/2009	Routine Sample/Observation			> 100	3.99	1.3		7.7		0.1	5	18.(
08/10/2009	Trip Blank					< 0.03				< 0.01	< 1	
08/10/2009	Routine Sample/Observation			> 100		2.2				0.094	2	
08/05/2009	Routine Sample/Observation			> 100	3.53	1.7		8.1		0.154	2	16.!
07/29/2009	Routine Sample/Observation			> 120	3.32							16.(
07/21/2009	Routine Sample/Observation			50	4.81	1.3		8.1		0.082	7	17.'
06/25/2009	Routine Sample/Observation			79.5	1.73							20.(
06/24/2009	Routine Sample/Observation			> 100	1.30	2.1				0.124	3	21.!
06/08/2009	Routine Sample/Observation			90	5.02	2.9				0.097	5	11.:
05/28/2009	Routine Sample/Observation			> 100	2.01							10.:
05/14/2009	Routine Sample/Observation			> 120	10.00	1.7				0.04	4	11.!
03/24/2009	Routine Sample/Observation			72	12.21	1.8		8.0		0.122	4	3.2

Station Dataset Download

Download Standard Parameter Data (Same format as above)

Photo not available

Connection Failure

Lat/Lon: 45.3108/-92.9310
Datum: NAD83
County: Chisago

Biological Station Information

Stream Name	TRIB. TO COMFORT LAKE
Waterbody Name:	Trib. to Comfort Lake
Data Steward Org:	MPCA
Station ID:	09SC036
Hydrologic Unit Code (HUC):	07030005
Assessment Unit:	07030005-522
Period of Record:	2009 through 2009
Predominant substrate:	
Mean Depth (cm):	
Mean Width (meters):	
Drainage Area (square miles)	20.4

Land Use	Agricultural	21.9 %
	Forest	20.8 %
	Range	38.5 %
	Urban	5.0 %
	Water	5.9 %
	Wetland	7.9 %
	Other	0.0 %

Projects Associated with this Station

Project	Purpose
Phase1	Sites selected for watershed monitoring.

Site Index of Biological Integrity (IBI)

Category	IBI/Rating
Fish IBI	35
Fish Rating	
Invertebrate IBI	No Visit
Invertebrate Rating	

Chemical Data

Date	Jun 15 2009
Water Temperature °C	27.00
Conductivity □mhos/cm	345.0
Field Turbidity NTU	
Dissolved Oxygen mg/L	8.15
pH	7.60
Flow m^3/sec	
Nitrogen mg/L	< 0.05
Total Phosphorus mg/L	0.073
Total Suspended Solids mg/L	8.4
Ammonia mg/L	0.06

Fish Found at this Site

Species	Count	Min. Length (mm)	Max. Length (mm)
Central Mudminnow	42	51	72
Johnny Darter	1	66	66
Pumpkinseed	3	75	98
Tadpole Madtom	6	52	77
Yellow Perch	1	87	87

Fish Attributes

Attribute	Value
DELT (abnormalities)	0
Darter species	1
Exotic species	0
Fish per 100 m	35.3
Game fish species	2
Gravel spawning species	0
Piscivore species	0
Pollution intolerant species	0
Special concern species	0
Total species	5

Invertebrates Found at Site

Common Name

Sorry, there was no data collected this year.

Invertebrate Attributes

Attribute	Value

Sorry, there was no data collected this year.

Photo not available

Connection Failure

Lat/Lon: 45.3101/-92.9752
Datum: NAD83
County: Chisago

Stream Station Information

Station Name SUNRISE R AT GREENWAY RD IN WYOMING
Alternate IDs: Sunrise R - Greenway
Greenway Ave.
Waterbody Name:
Data Steward Org: MPCA
Station ID: S004-926
Hydrologic Unit Code (HUC): 07030005
Assessment Unit:
Period of Record: 2008 through 2008

Projects Associated with this Station

Project	Purpose
Comfort Lake/Forest Lake Watershed District TMDL (CWLA)	Condition Monitoring
CLFLWD Water Monitoring Assessment Project	Condition Monitoring. CWLA SWAG. 2008 Contract #B12601. 2009 Contract #B25247.

Station Data Collection Years

- 2008

Station Data

Sample Date:	Sample Type	BOD mg/L	Chl-a µg/L	Stream Transp cm	DO mg/L	TKN mg/L	NO2NO3 mg/L	pH	Pheo µg/L	TP mg/L	TSS mg/L	Temp Degrees C	Turb	FC #/100ml	ECOLI #/100ml
08/28/2008	Routine Sample/Observation					2.4				0.229	87				
08/27/2008	Routine Sample/Observation			> 100	5.56							18.9			104
08/07/2008	Routine Sample/Observation														326
07/31/2008	Routine Sample/Observation			81	2.40	0.97				0.090	5	22.7			
07/17/2008	Routine Sample/Observation			> 120	1.80							24.3			147
07/13/2008	Routine Sample/Observation			83.5											
07/05/2008	Routine Sample/Observation			41.5											
06/28/2008	Routine Sample/Observation			61.5		4.6				0.523	422				
06/26/2008	Routine Sample/Observation														126
06/23/2008	Routine Sample/Observation			81	5.29	0.91				0.056	9	20.5			
06/20/2008	Routine Sample/Observation			73											
06/12/2008	Routine Sample/Observation			39		2.3				0.173	76				
06/12/2008	Field Replicate/Duplicate					2.2				0.158	81				
06/11/2008	Routine Sample/Observation			42											
06/05/2008	Routine Sample/Observation														31

05/21/2008	Routine Sample/Observation	> 100	8.80	1.1		0.047 17	13.0
05/03/2008	Routine Sample/Observation			1.8		0.166 103	
04/25/2008	Routine Sample/Observation			2.3		0.146 97	
04/22/2008	Routine Sample/Observation	95	11.11	1.5		0.026 5	11.5
04/02/2008	Routine Sample/Observation			2.6		0.081 6	

Station Dataset Download

Download Standard Parameter Data (Same format as above)

Download All Monitoring Data (Including all Parameters)

Photo not available

Connection Failure

Lat/Lon: 45.3350/-93.0061
Datum: NAD83
County: Chisago

Stream Station Information

Station Name	SUNRISE R, S BR, AT KETTLE R RD, IN WYOMING, MN
Alternate IDs:	CSMP0825
Waterbody Name:	SUNRISE R
Data Steward Org:	MPCA
Station ID:	S003-481
Hydrologic Unit Code (HUC):	07030005
Assessment Unit:	
Period of Record:	2004 through 2009

Projects Associated with this Station

Project	Purpose
Citizen Stream Monitoring Program	Monitor stream status.

Station Data Collection Years

2009 2008 2007 2006 2005 2004

Station Data

Sample Date:	Sample Type	BOD mg/L	Chl-a µg/L	Stream Transp cm	DO mg/L	TKN mg/L	NO2NO3 mg/L	pH	Pheo µg/L	TP mg/L	TSS mg/L	Temp Degrees C	Turb	FC #/100ml	ECOLI #/100ml
09/09/2009	Routine Sample/Observation			> 60								21.1			
07/22/2009	Routine Sample/Observation			44								23.3			
07/14/2009	Routine Sample/Observation			> 60								20			
06/24/2009	Routine Sample/Observation			> 60								27.8			
06/17/2009	Routine Sample/Observation			> 60								23.3			
05/31/2009	Routine Sample/Observation			> 60								21.1			
05/20/2009	Routine Sample/Observation			> 60								22.2			
05/13/2009	Routine Sample/Observation			> 60								17.8			
05/06/2009	Routine Sample/Observation			> 60								18.9			
04/29/2009	Routine Sample/Observation			> 60								10			
04/23/2009	Routine Sample/Observation			39								11.1			

Station Dataset Download

Download Standard Parameter Data (Same format as above)

Download All Monitoring Data (Including all Parameters)

Photo not available

Connection Failure

Lat/Lon: 45.3364/-93.0026
Datum: NAD83
County: Chisago

Stream Station Information

Station Name	SUNRISE R, S BR, AT US-61 IN WYOMING, MN
Alternate IDs:	CSMP0816
Waterbody Name:	SUNRISE R
Data Steward Org:	MPCA
Station ID:	S003-473
Hydrologic Unit Code (HUC):	07030005
Assessment Unit:	
Period of Record:	2004 through 2009

Projects Associated with this Station

Project	Purpose
Citizen Stream Monitoring Program	Monitor stream status.

Station Data Collection Years

2009 2008 2007 2006 2005 2004

Station Data

Sample Date:	Sample Type	BOD mg/L	Chl-a µg/L	Stream Transp cm	DO mg/L	TKN mg/L	NO2NO3 mg/L	pH	Pheo µg/L	TP mg/L	TSS mg/L	Temp Degrees C	Turb	FC #/100ml	ECOLI #/100ml
10/14/2009	Routine Sample/Observation			> 60								15.6			
09/28/2009	Routine Sample/Observation			> 60								16.7			
09/22/2009	Routine Sample/Observation			> 60								21.1			
09/13/2009	Routine Sample/Observation			> 60								18.9			
08/13/2009	Routine Sample/Observation			> 60								25.6			
08/09/2009	Routine Sample/Observation			> 60								23.3			
08/02/2009	Routine Sample/Observation			> 60								23.3			
07/24/2009	Routine Sample/Observation			> 60								23.3			
07/11/2009	Routine Sample/Observation			> 60								25.6			
06/26/2009	Routine Sample/Observation			> 60											
06/14/2009	Routine Sample/Observation			> 60								24.4			
05/31/2009	Routine Sample/Observation			> 60								24.4			
05/25/2009	Routine Sample/Observation			> 60								17.8			
05/17/2009	Routine Sample/Observation			> 60								16.7			
05/10/2009	Routine Sample/Observation			> 60								13.3			
05/03/2009	Routine Sample/Observation			> 60								12.8			

04/25/2009	Routine Sample/Observation	> 60	12.8
04/12/2009	Routine Sample/Observation	50	7.8
04/05/2009	Routine Sample/Observation	51	1.1
03/29/2009	Routine Sample/Observation	49	1.1

Station Dataset Download

Download Standard Parameter Data (Same format as above)

Download All Monitoring Data (Including all Parameters)

Photo not available

Connection Failure

Lat/Lon: 45.3407/-92.9985
Datum: NAD83
County: Chisago

Stream Station Information

Station Name SUNRISE R, SB AT CSAH-30 IN WYOMING
Alternate IDs: 09SC007
Waterbody Name:
Data Steward Org: MPCA
Station ID: S005-530
Hydrologic Unit Code (HUC): 07030005
Assessment Unit:
Period of Record: 2009 through 2009

Projects Associated with this Station

Project	Purpose
Lower St. Croix Watershed Monitoring	Condition. Water chemistry sampling will take place at 10 locations throughout the Lower St. Croix Watershed to coincide to biological monitoring at 44 additional sites.`

Station Data Collection Years

- 2009

Station Data

Sample Date:	Sample Type	BOD mg/L	Chl-a µg/L	Stream Transp cm	DO mg/L	TKN mg/L	NO2NO3 mg/L	pH	Pheo µg/L	TP mg/L	TSS mg/L	Temp Degrees C	Turb	FC #/100ml	ECOLI #/100ml
09/23/2009	Routine Sample/Observation			> 100	8.7	0.58	0.27	7.66		0.027	1.2	18.2			
09/09/2009	Routine Sample/Observation			> 100	8.36	0.94	*Present	7.61		0.038	*Present	18.5			
08/26/2009	Routine Sample/Observation			> 100	5.4	1.19	*Present	7.31		0.064	1.2	20.2			50
08/12/2009	Routine Sample/Observation			> 100	9.23	0.47	*Present	8.24		0.030	1.6	23.6			19
07/22/2009	Routine Sample/Observation			> 100	6.12	0.65	*Present	7.77		0.034	3.6	21.1			17
07/22/2009	Field Replicate/Duplicate					0.63	*Present			0.040	32				25
07/09/2009	Routine Sample/Observation			> 100	4.63	0.45	*Present	7.47		0.017	1.2	18.9			18
06/24/2009	Routine Sample/Observation			> 100	10.83	0.79	0.20	7.65		0.029	3.3	21.5			45
06/10/2009	Routine Sample/Observation			92	7.84	1.05	*Present	7		0.044	2.4	13.8			54
05/28/2009	Routine Sample/Observation			> 100	10.63	1.20	*Present	7.7		0.056	2.6	18.8			
05/04/2009	Routine Sample/Observation			> 100	11.27	0.99	*Present	7.71		0.034	1.6	14.5			

Station Dataset Download

Download Standard Parameter Data (Same format as above)

Download All Monitoring Data (Including all Parameters)

Picture: School Lake near outlet, July 30, 2007

COMFORT LAKE-FOREST LAKE WATERSHED DISTRICT 2010 WATER MONITORING REPORT

Prepared for:

Comfort Lake-Forest Lake Watershed District

Prepared By:

Washington Conservation District

Comfort Lake-Forest Lake Watershed District

Memorandum

To: Comfort Lake-Forest Lake Watershed District Managers
From: Erik Anderson, Matt Downing, Wendy Griffin, Adam King, and Jessica Thiel --Washington Conservation District
Date: March 22, 2011
Re: CLFLWD 2010 Monitoring: Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Forest Lake Outlet, Sunrise River at Comfort Lake Inlet, Sunrise River at Comfort Lake Outlet, Sunrise River at County Line Ditch, Sunrise River at Bixby Park, Tributary to Bone Lake at Bone Lake North Inlet, and Moody Lake Outlet.

At the request of the Comfort Lake-Forest Lake Watershed District (CLFLWD), the Washington Conservation District (WCD) conducted:

Continuous discharge and stream water quality monitoring at:

- Tributary to Sunrise River at Little Comfort Lake Inlet (Grab Samples only)
- Sunrise River at Forest Lake Outlet (Flow only)
- Sunrise River at Comfort Lake Inlet (Grab Samples only)
- Sunrise River at Comfort Lake Outlet (Flow only)
- Sunrise River at County Line Ditch (Grab Samples only)
- Sunrise River at Bixby Park (Grab Samples only)
- Tributary to Bone Lake at Bone Lake North Inlet (Grab Samples only)
- Moody Lake Outlet (Grab Samples only)

A table of the locations and monitoring types can be found in Table 1. The locations of the monitoring sites can be found in Figure 1. The following report briefly summarizes our methods and results for monitoring conducted from January 1 - December 31, 2010. A complete list of detailed Washington Conservation District water monitoring methods and standard operating procedures can be found at http://www.mnwcd.org/water_monitoring_standards.php. This report and the accompanying data will also be provided in an electronic format. Please contact the Washington Conservation District at (651) 275-1136 to obtain historical data.

Continuous Stream Monitoring Sites: Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Forest Lake Outlet, Sunrise River at Comfort Lake Inlet, Sunrise River at Comfort Lake Outlet, Sunrise River at County Line Ditch, Sunrise River at Bixby Park, Tributary to Bone Lake at Bone Lake North Inlet, and Moody Lake Outlet.

Continuous stage, velocity, and discharge measurements were recorded every 15 minutes at the Tributary to Sunrise River at Little Comfort Lake Inlet from March 30-October 15, 2010, at Sunrise River at Forest Lake Outlet from March 30-November 2, 2010, at Sunrise River at Comfort Lake Inlet from March 30-October 30, 2010, at Sunrise River at Comfort Lake Outlet from April 5-November 2, 2010, at Sunrise River at County Line Ditch from March 31-November 1, 2010, at Sunrise River at Bixby Park from March 30-November 1, 2010, at Tributary to Bone Lake at Bone Lake North Inlet from April 5-November 1, 2010, and at Moody Lake Outlet from March 31-November 1, 2010 (measurements recorded every hour). Precipitation data was also continuously collected at Tributary to Sunrise River at Little Comfort Lake Inlet, Sunrise River at Comfort Lake Inlet, Sunrise River at Comfort Lake Outlet, Sunrise River at County Line Ditch, and at Tributary to Bone Lake at Bone Lake North Inlet.

Staff gages were installed and read at each site. Field stage measurements were taken in the stream channels. Temperature, dissolved oxygen, specific conductivity, pH, and transparency tube measurements were also taken. Stage-discharge relationships were developed at all stream sites and an area-velocity relationship was used to determine discharge during certain time periods, with the exception of Moody Lake Outlet due to lack of samples and flow measurements. Storm event and baseflow grab samples were collected at all continuous stream monitoring sites, as well as snowmelt grab samples at most sites. The exception to this is the Forest Lake Outlet and Comfort Lake Outlet sites, where no samples were collected. *E. coli* grab samples were also collected at all sampled monitoring sites. The Metropolitan Council Environmental Services Laboratory in St. Paul analyzed the samples.

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

BMP	Best Management Practice
cfs	cubic feet per second
cf	cubic feet
Cl-*a* or CLA	Chlorophyll-*a*
CLFLWD	Comfort Lake-Forest Lake Watershed District
COD	Total Chemical Oxygen Demand
Composite Sample	Many samples at various flow points taken by an automated device
DO	Dissolved Oxygen
Grab Sample	Manually taken discrete water sample
E. Coli	*Escherichia coli*
mg/L	milligram per liter
MN DNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
MPN	most probable number
OHW	Ordinary High Water level
Ortho-P	Ortho-phosphate
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TP	Total Phosphorus
TSS	Total Suspended Solids
μg/L	microgram per liter
VSS	Volatile Suspended Solids
WCD	Washington Conservation District

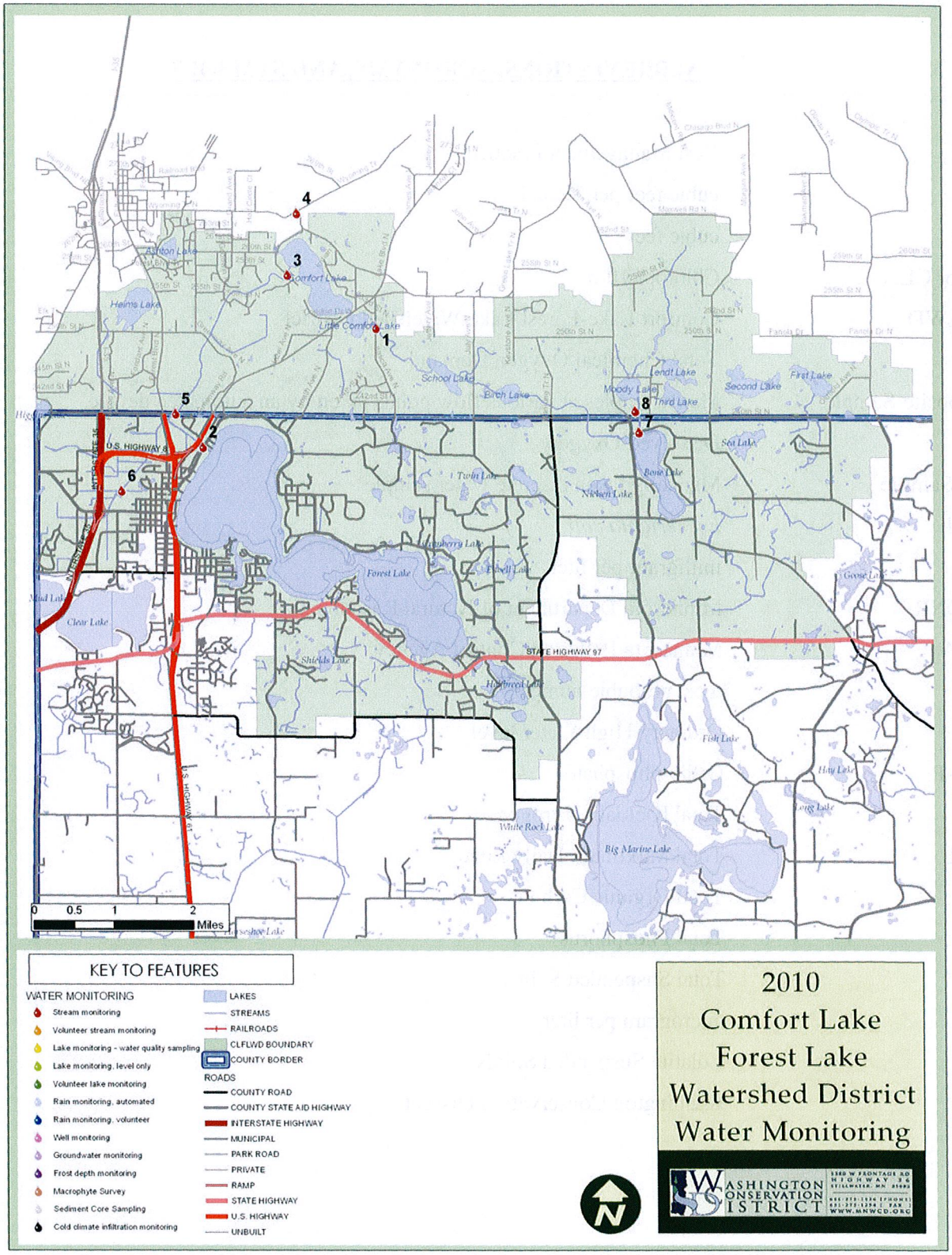


Figure 1. CLFLWD Monitoring Locations

Table 1. Monitoring Site Location and Description Summary

Site Description	Map Site ID#	Full Site Name	Summarized Site Name	General Site Location	Monitoring Site Description	Monitored Parameters
Stream Monitoring	1	Tributary to Sunrise River at Little Comfort Lake Inlet	Little Comfort Lake Inlet	Itasca Avenue	Flow Monitoring in Natural Cross-Section	Discharge and Water Quality Grab Samples*
Stream Monitoring	2	Sunrise River at Forest Lake Outlet	Forest Lake Outlet	North Shore Drive	Flow Monitoring in Natural Cross-Section	Discharge Only
Stream Monitoring	3	Sunrise River at Comfort Lake Inlet	Comfort Lake Inlet	West Comfort Drive	Flow Monitoring Through Culvert	Discharge and Water Quality Grab Samples*
Stream Monitoring	4	Sunrise River at Comfort Lake Outlet	Comfort Lake Outlet	Wyoming Trail	Flow Monitoring in Natural Cross-Section	Discharge Only
Stream Monitoring	5	Sunrise River at County Line Ditch	County Line Ditch	¼ Mile East of Hwy 61	Flow Monitoring in Natural Cross-Section	Discharge and Water Quality Grab Samples*
Stream Monitoring	6	Sunrise River at Bixby Park	Bixby Park	Bixby Park Compost Site	Flow Monitoring in Natural Cross-Section	Discharge and Water Quality Grab Samples*
Stream Monitoring	7	Bone Lake North Inlet	Bone Lake North	238th Street North	Flow Monitoring in Natural Cross-Section	Discharge and Water Quality Grab Samples*
Stream Monitoring	8	Moody Lake Outlet	Moody Lake Outlet	24045 Lofton Ave	Flow Monitoring in Natural Cross-Section	Discharge and Water Quality Grab Samples*

*Stream Monitoring Water Quality Sample Parameters Include: Total Phosphorus, Dissolved Phosphorus, Total Kjeldahl Nitrogen, Nitrate, Nitrite, Ammonia Nitrogen, Total Suspended Solids, Volatile Suspended Solids, Total Chlorides, E. Coli Bacteria

Sections Within Report

1)Bone Lake Subwatershed

- Stream Monitoring
  a. Bone Lake North Inlet
  b. Moody Lake Outlet

2) Little Comfort Lake Subwatershed

- Stream Monitoring
  a. Little Comfort Lake Inlet

3) Forest Lake Subwatershed

- Stream Monitoring
  a. Forest Lake Outlet

4) Comfort Lake Subwatershed

- Stream Monitoring
  a. Bixby Park
  b. County Line Ditch
  c. Comfort Lake Inlet
  d. Comfort Lake Outlet

5) Watershed Phosphorus Flow Chart

6) Historical Stream Loading, Discharge, and E. coli Summary

7) Appendices and References

1) Bone Lake Subwatershed

Bone Lake North Inlet

Monitoring at the north inlet to Bone Lake resumed in 2010 after a four-year hiatus. The station recorded flow and rainfall from April -November 1, 2010 (Figure 2). Total discharge during this period was 3,546,401 cf or 81 acre-ft. Total rainfall recorded during the monitoring season was 19.33 inches. Peak discharge of 2.943 cfs was recorded on September 23rd, resulting from a 1.69-inch rainfall event that occurred September 22nd-23rd.

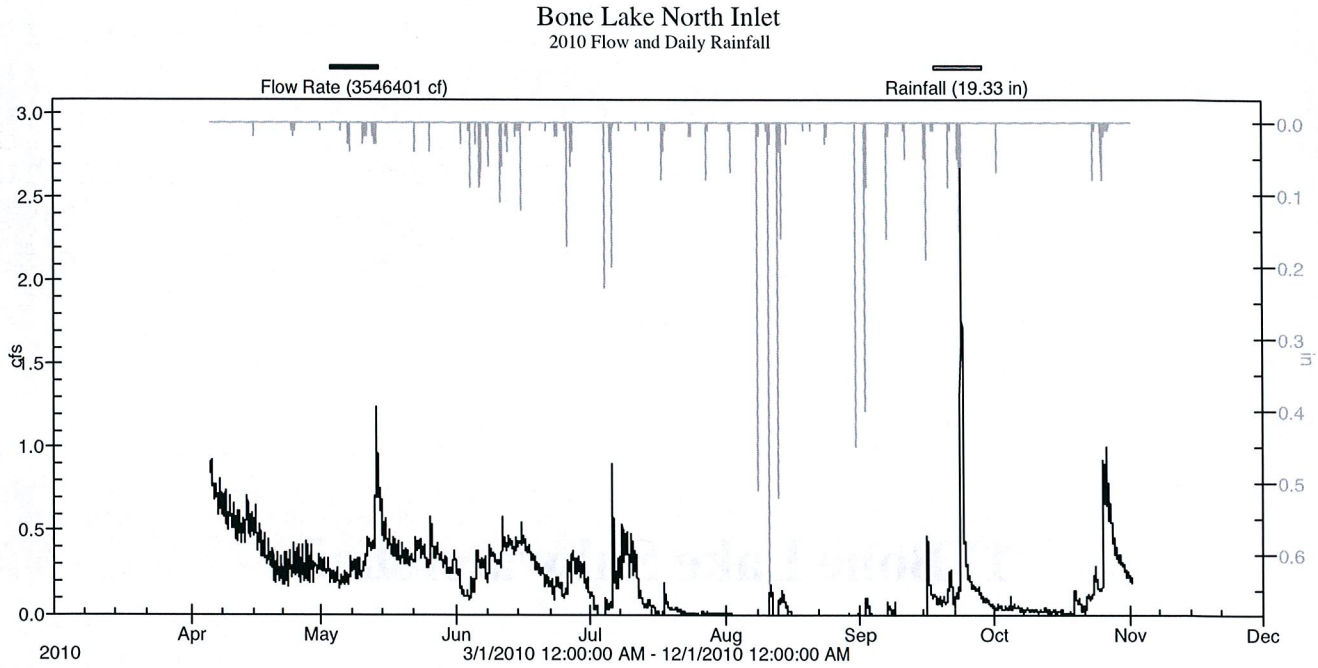


Figure 2. Bone Lake North Inlet 2010 Flow and Daily Rainfall

Grab samples were taken at the Bone North Inlet site in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride, and *E. coli* results from all collected samples are listed in Table 2 and field water quality results are listed in Table 3. The highest TKN and TP results of 2.8 mg/L and 0.693 mg/L, respectively, came from an August 11th storm grab sample. The highest TSS result of 37 mg/L also came from this sample.

Table 2. Bone Lake North Inlet 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	E. Coli (mpn/100ml)
Snowmelt Grab	3/10/2010 15:34	3/10/2010 15:34	7	5	1.7	0.425	0.401	10	<0.03	0.44	0.54	
Base Grab	4/29/2010 10:05	4/29/2010 10:05	7	~4	1.3	0.131	0.078	17	<0.03	<0.05	<0.02	
Storm Grab	5/12/2010 10:30	5/12/2010 10:30	6	5	2	0.185	~0.040	11	<0.03	<0.05	~0.04	
Storm Grab	7/6/2010 9:51	7/6/2010 9:51	4	3	1.8	0.186	0.092	8	<0.03	<0.05	0.13	
Storm Grab	8/11/2010 10:37	8/11/2010 10:37	37	~23	2.8	0.693	0.142	9	<0.03	<0.05	0.49	
Storm Grab	9/24/2010 10:14	9/24/2010 10:14	~1	~2	2	0.100	0.090	14	<0.03	<0.05	~0.04	
E. Coli Grab	5/25/2010 9:26	5/25/2010 9:26										17
E. Coli Grab	6/24/2010 9:35	6/24/2010 9:35										74

Exceeds Water Quality Standard

Table 3. Bone Lake North Inlet 2010 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/29/2010 10:05	>120	11.4	3.47		
5/12/2010 10:30	>120	8.7	6.12	179	7.8
8/11/2010 10:37	34	22.4	0.60	222	6.1
9/24/2010 10:14	>120	13.6	2.66	167	6.8

Exceeds Water Quality Standard

Table 4. Bone Lake North Inlet 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	**Start**	**End**	**TSS (mg/L)**	**TP (mg/L)**	**Start**	**End**	**Interval Volume (cf)**	**Interval Volume (ac-ft)**	**Interval TSS (lb)**	**Interval TP (lb)**
*Base**			*7*	*0.131*	*1/1/10 0:00*	*3/10/10 6:30*	*471,888*	*10.84*	*206.2*	*3.86*
Snowmelt Grab*	3/10/2010 15:34	3/10/2010 15:34	7	0.425	3/10/10 6:30	3/11/10 16:30	*30,600*	0.70	13.4	0.81
*Base**			*7*	*0.131*	*3/11/10 16:30*	*4/5/10 10:30*	*722,801*	*16.60*	*315.9*	*5.91*
Base			*7*	*0.131*	*4/5/10 10:30*	*4/28/10 6:30*	*877,892*	*20.16*	*383.6*	*7.18*
Base Grab	4/29/2010 10:05	4/29/2010 10:05	7	0.131	4/28/10 6:30	5/7/10 9:30	196,750	4.52	86.0	1.61
Storm			*12*	*0.291*	*5/7/10 9:30*	*5/8/10 22:30*	*38,838*	*0.89*	*29.1*	*0.71*
Base			*7*	*0.131*	*5/8/10 22:30*	*5/11/10 12:30*	*62,039*	*1.42*	*27.1*	*0.51*
Storm Grab	5/12/2010 10:30	5/12/2010 10:30	6	0.185	5/11/10 12:30	5/13/10 2:30	56,472	1.30	21.2	0.65
Storm			*12*	*0.291*	*5/13/10 2:30*	*5/14/10 22:30*	*121,224*	*2.78*	*90.8*	*2.20*
Base			*7*	*0.131*	*5/14/10 22:30*	*5/25/10 17:30*	*353,878*	*8.13*	*154.6*	*2.89*
Storm			*12*	*0.291*	*5/25/10 17:30*	*5/26/10 15:30*	*36,920*	*0.85*	*27.7*	*0.67*
Base			*7*	*0.131*	*5/26/10 15:30*	*6/5/10 6:30*	*205,137*	*4.71*	*89.6*	*1.68*
Storm			*12*	*0.291*	*6/5/10 6:30*	*6/8/10 3:30*	*72,978*	*1.68*	*54.7*	*1.33*
Storm			*12*	*0.291*	*6/8/10 3:30*	*6/11/10 3:30*	*84,851*	*1.95*	*63.6*	*1.54*
Storm			*12*	*0.291*	*6/11/10 3:30*	*6/12/10 7:30*	*44,711*	*1.03*	*33.5*	*0.81*
Base			*7*	*0.131*	*6/12/10 7:30*	*6/25/10 17:30*	*342,482*	*7.87*	*149.7*	*2.80*
Storm			*12*	*0.291*	*6/25/10 17:30*	*6/27/10 14:30*	*47,022*	*1.08*	*35.2*	*0.85*
Base			*7*	*0.131*	*6/27/10 14:30*	*7/4/10 9:30*	*80,823*	*1.86*	*35.3*	*0.66*
Storm			*12*	*0.291*	*7/4/10 9:30*	*7/4/10 18:30*	*2,562*	*0.06*	*1.9*	*0.05*
Base			*7*	*0.131*	*7/4/10 18:30*	*7/5/10 21:30*	*4,289*	*0.10*	*1.9*	*0.04*
Storm Grab	7/6/2010 9:51	7/6/2010 9:51	4	0.186	7/5/10 21:30	7/6/10 10:30	26,930	0.62	6.7	0.31
Base			*7*	*0.131*	*7/6/10 10:30*	*7/9/10 2:30*	*73,190*	*1.68*	*32.0*	*0.60*
Storm			*12*	*0.291*	*7/9/10 2:30*	*7/11/10 20:30*	*83,836*	*1.93*	*62.8*	*1.52*
Base			*7*	*0.131*	*7/11/10 20:30*	*7/17/10 20:30*	*24,422*	*0.56*	*10.7*	*0.20*
Storm			*12*	*0.291*	*7/17/10 20:30*	*7/18/10 10:30*	*6,277*	*0.14*	*4.7*	*0.11*
Base			*7*	*0.131*	*7/18/10 10:30*	*8/10/10 18:30*	*15,584*	*0.36*	*6.8*	*0.13*
Storm Grab	8/11/2010 10:37	8/11/2010 10:37	37	0.693	8/10/10 18:30	8/11/10 12:30	7,757	0.18	17.9	0.34
Base			*7*	*0.131*	*8/11/10 12:30*	*8/12/10 20:30*	*0*	*0.00*	*0.0*	*0.00*
Storm			*12*	*0.291*	*8/12/10 20:30*	*8/14/10 20:30*	*14,031*	*0.32*	*10.5*	*0.25*
Base			*7*	*0.131*	*8/14/10 20:30*	*9/2/10 3:30*	*1,770*	*0.04*	*0.8*	*0.01*
Storm			*12*	*0.291*	*9/2/10 3:30*	*9/3/10 3:30*	*5,583*	*0.13*	*4.2*	*0.10*
Base			*7*	*0.131*	*9/3/10 3:30*	*9/6/10 19:30*	*223*	*0.01*	*0.1*	*0.00*
Storm			*12*	*0.291*	*9/6/10 19:30*	*9/7/10 17:30*	*3,155*	*0.07*	*2.4*	*0.06*
Base			*7*	*0.131*	*9/7/10 17:30*	*9/15/10 18:30*	*177*	*0.00*	*0.1*	*0.00*
Storm			*12*	*0.291*	*9/15/10 18:30*	*9/16/10 11:30*	*18,341*	*0.42*	*13.7*	*0.33*
Base			*7*	*0.131*	*9/16/10 11:30*	*9/20/10 6:30*	*30,685*	*0.70*	*13.4*	*0.25*
Storm			*12*	*0.291*	*9/20/10 6:30*	*9/21/10 18:30*	*20,002*	*0.46*	*15.0*	*0.36*
Base			*7*	*0.131*	*9/21/10 18:30*	*9/23/10 9:30*	*15,127*	*0.35*	*6.6*	*0.12*
Storm Grab	9/24/2010 10:14	9/24/2010 10:14	1	0.100	9/23/10 9:30	9/25/10 2:30	154,138	3.54	9.6	0.96
Base			*7*	*0.131*	*9/25/10 2:30*	*10/24/10 3:30*	*133,100*	*3.06*	*58.2*	*1.09*
Storm			*12*	*0.291*	*10/24/10 3:30*	*10/25/10 21:30*	*28,160*	*0.65*	*21.1*	*0.51*
Storm			*12*	*0.291*	*10/25/10 21:30*	*10/28/10 19:30*	*161,647*	*3.71*	*121.1*	*2.94*
Base			*7*	*0.131*	*10/28/10 19:30*	*11/1/10 14:30*	*93,400*	*2.15*	*40.8*	*0.76*
*Base**			*7*	*0.131*	*11/1/10 14:30*	*1/1/11 0:00*	*703,880*	*16.17*	*307.6*	*5.76*
Snowmelt Average			7	0.425						
Storm Average			12	0.291						
Base Average			7	0.131						
All Average			10	0.287						
Total							**5,475,569**	**126**	**2,588**	**53**
CLFLWD Major Subwatershed Total Acres							2,479			
Total Load										
Total TP/TSS (lb/ac/yr)									1.04	0.02
Total TP/TSS (kg/ha/yr)									1.17	0.02

Italics indicate estimated concentrations based on average base and storm flow concentrations.

* Interval volumes from 1/1/10 to 4/5/10 and 11/1/10 to 1/1/11 were estimated based upon base and storm flow.

Total phosphorus loading at the Bone Inlet site for 2010 was estimated at 0.02 lbs/ac (53 lbs.) (Table 4). Monitoring should continue at this site to observe a current trend of loading entering Bone Lake.

Moody Lake Outlet

A monitoring station was established at the outlet of Moody Lake in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride, and *E. coli* results from all collected samples are listed in Table 5. Due to very little flow occurring at this site, difficulty arose while attempting to establish a level to flow relationship. This made developing loading estimations for 2010 impossible.

Table 5. Moody Lake Outlet 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	E. Coli (mpn/100ml)
Base Grab	4/29/2010 9:45	4/29/2010 9:45	6	~3	1.5	0.124	0.062	14	<0.03	<0.05	<0.02	
Base Grab	5/24/2010 11:41	5/24/2010 11:41	~25	~25	2.5	0.526	0.199	11	<0.03	<0.05	<0.02	
Storm Grab	5/12/2010 11:56	5/12/2010 11:56	~1	~1	1.1	~0.041	~0.026	13	<0.03	<0.05	<0.02	
Storm Grab	7/6/2010 10:13	7/6/2010 10:13	17	12	2.2	0.237	0.075	7	<0.03	<0.05	0.08	
E. Coli Grab	5/25/2010 9:13	5/25/2010 9:13										1204
E. Coli Grab	6/24/2010 9:22	6/24/2010 9:22										387

Exceeds Water Quality Standard

2) Little Comfort Lake Subwatershed

Little Comfort Lake Inlet

Flow was recorded at the Little Comfort Lake Inlet site between March 30-October 15, 2010 and rainfall was recorded through November 1, 2010 (Figure 3). Total discharge during this period was 103,234,147 cf or 2,371 acre-ft. Total rainfall recorded during the monitoring season was 23.58 inches. Peak discharge of 16.71 cfs occurred on July 10th. This high flow occurred after large rain events on July 4th and 5th totaling 3.51 inches.

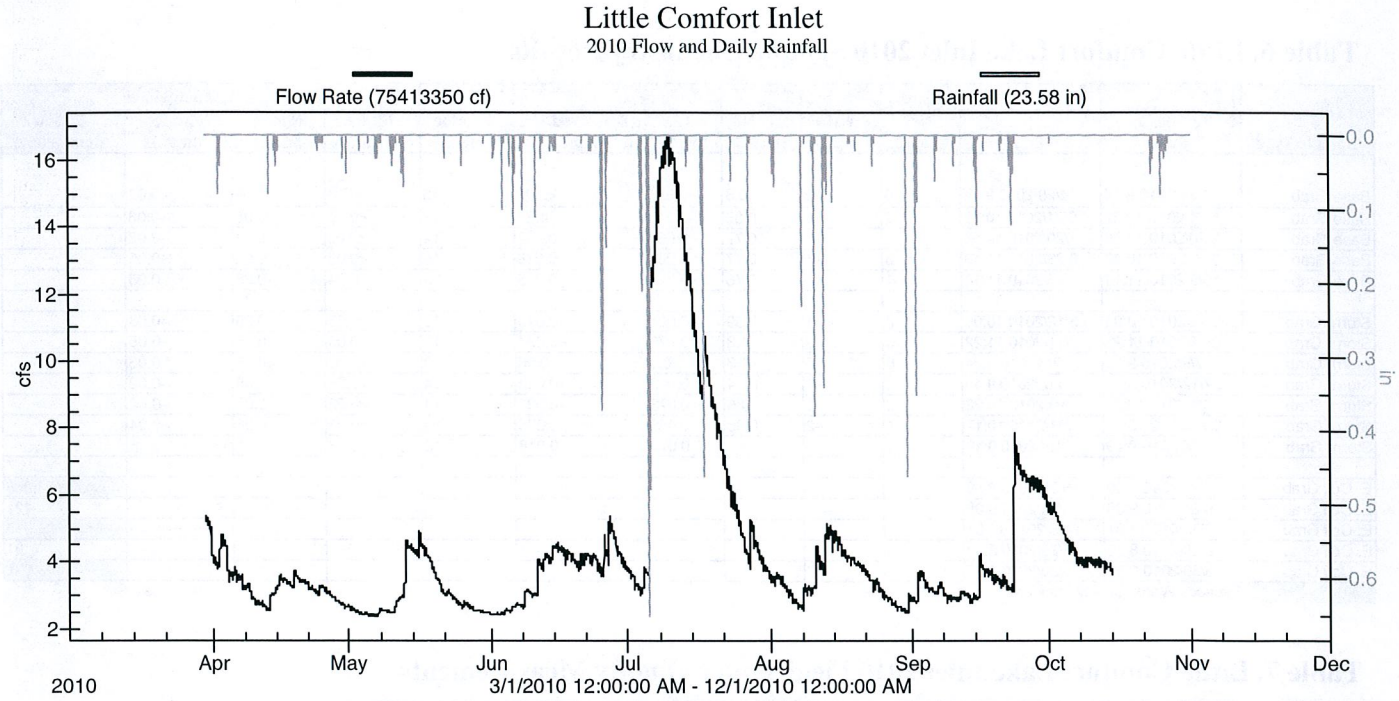


Figure 3. Little Comfort Lake Inlet 2010 Flow and Daily Rainfall

Grab samples were collected at the Little Comfort Lake Inlet site in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride, and *E. coli* results from all collected samples are listed in Table 6 and field water quality measurements are listed in Table 7. The highest concentrations of TKN and TP were 1.30 mg/L (June 11th storm grab, July 6th storm grab) and 0.10 mg/L (July 6th storm grab). The TSS maximum concentration of 11 mg/L was from a September 24th storm grab sample.

Table 6. Little Comfort Lake Inlet 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	E. Coli (mpn/100ml)
Base Grab	4/29/2010 9:14	4/29/2010 9:14	5	~2	0.8	~0.034	<0.01	16	<0.03	<0.05	<0.02	
Base Grab	5/24/2010 10:32	5/24/2010 10:32	~2	~2	0.86	~0.048	4.25	15	<0.03	<0.05	~0.06	
Base Grab	7/20/2010 14:56	7/20/2010 14:56	~2	~2	0.77	0.058	~0.037	14	<0.03	0.07	~0.02	
Base Grab	8/23/2010 10:40	8/23/2010 10:40	3	~1	0.77	0.063	~0.038	15	<0.03	<0.05	~0.05	
Base Grab	10/5/2010 11:14	10/5/2010 11:14	~1	~1	0.76	~0.025	~0.016	15	0.04	0.28	0.08	
Storm Grab	5/12/2010 10:05	5/12/2010 10:05	3	~1	0.69	~0.028	~0.019	15	<0.03	<0.05	~0.03	
Storm Grab	6/11/2010 11:22	6/11/2010 11:22	5	3	1.3	0.075	~0.034	12	<0.03	0.06	~0.05	
Storm Grab	7/6/2010 9:24	7/6/2010 9:24	6	3	1.3	0.1	0.06	9	<0.03	<0.05	0.06	
Storm Grab	7/12/2010 9:49	7/12/2010 9:49	~2	~1	0.74	0.063	~0.039	14	<0.03	<0.05	~0.02	
Storm Grab	8/9/2010 10:22	8/9/2010 10:22	~2	~1	0.86	0.073	~0.025	14	<0.03	0.07	~0.02	
Storm Grab	8/11/2010 10:17	8/11/2010 10:17	4	~2	0.88	0.089	~0.035	13	<0.03	0.06	~0.04	
Storm Grab	9/24/2010 9:49	9/24/2010 9:49	11	6	1.1	0.077	~0.018	12	<0.03	0.11	0.18	
E. Coli Grab	5/25/2010 8:59	5/25/2010 8:59										866
E. Coli Grab	6/24/2010 9:08	6/24/2010 9:08										121
E. Coli Grab	7/28/2010 11:01	7/28/2010 11:01										210
E. Coli Grab	8/26/2010 8:30	8/26/2010 8:30										91
E. Coli Grab	9/30/2010 9:05	9/30/2010 9:05										201

Exceeds Water Quality Standard

Table 7. Little Comfort Lake Inlet 2010 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/29/2010 9:14	>120	13.1	7.44		
5/12/2010 10:05	>120	9.9	9.39	355	8.3
5/24/2010 10:32	>120	25.3	7.45	370	7.7
6/11/2010 11:22	>100	18.2	5.88	281	7.3
7/12/2010 9:49	>120	21.9	3.16	350	7.3
7/20/2010 14:56	>120	26.3	7.45		
8/9/2010 10:22	>120	24.6	3.20	448	6.8
8/11/2010 10:17	>120	24.5	2.83	340	6.7
8/23/2010 10:40	>120	23.7	4.69	375	7.3
8/26/2010 8:30	>120	15.7	5.63	339	8.6
9/24/2010 9:49	>120	14.6	4.69	324	7
10/5/2010 11:14	>120	12.0	7.78	389	7.9

Exceeds Water Quality Standard

Table 8. Little Comfort Lake Inlet 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*3*	*0.046*	*1/1/10 0:00*	*3/30/2010 9:00*	*7,635,600*	*175.38*	*1239*	*21.7*
Base			*3*	*0.046*	*3/30/10 9:00*	*4/2/2010 5:00*	*1,117,784*	*25.67*	*181*	*3.2*
Storm			*5*	*0.072*	*4/2/10 5:00*	*4/4/10 3:00*	*738,562*	*16.96*	*217*	*3.3*
Base			*3*	*0.046*	*4/4/10 3:00*	*4/13/10 4:00*	*2,452,385*	*56.33*	*398*	*7.0*
Storm			*5*	*0.072*	*4/13/10 4:00*	*4/18/10 14:00*	*1,534,847*	*35.25*	*452*	*6.9*
Storm			*5*	*0.072*	*4/18/10 14:00*	*4/24/10 8:00*	*1,650,504*	*37.91*	*486*	*7.4*
Storm			*5*	*0.072*	*4/24/10 8:00*	*4/27/10 10:00*	*836,066*	*19.20*	*246*	*3.8*
Base Grab	4/29/2010 9:14	4/29/2010 9:14	5	0.034	4/27/10 10:00	5/7/10 8:00	2,212,306	50.81	691	4.7
Storm			*5*	*0.072*	*5/7/10 8:00*	*5/10/10 18:00*	*745,280*	*17.12*	*219*	*3.4*
Storm Grab	5/12/2010 10:05	5/12/2010 10:05	3	0.028	5/10/10 18:00	5/12/10 23:00	537,140	12.34	101	0.9
Storm			*5*	*0.072*	*5/12/10 23:00*	*5/19/10 15:00*	*2,448,637*	*56.24*	*721*	*11.0*
Base Grab	5/24/2010 10:32	5/24/2010 10:32	2	0.048	5/19/10 15:00	5/26/10 8:00	1,769,978	40.65	221	5.3
Base			*3*	*0.046*	*5/26/10 8:00*	*6/8/10 11:00*	*2,908,813*	*66.81*	*472*	*8.3*
Storm			*5*	*0.072*	*6/8/10 11:00*	*6/9/10 14:00*	*303,341*	*6.97*	*89*	*1.4*
Base			*3*	*0.046*	*6/9/10 14:00*	*6/11/10 4:00*	*416,712*	*9.57*	*68*	*1.2*
Storm Grab	6/11/2010 11:22	6/11/2010 11:22	5	0.075	6/11/10 4:00	6/11/10 23:00	261,235	6.00	82	1.2
Base			*3*	*0.046*	*6/11/10 23:00*	*6/25/10 17:00*	*4,923,655*	*113.09*	*799*	*14.0*
Storm			*5*	*0.072*	*6/25/10 17:00*	*6/26/10 20:00*	*416,897*	*9.58*	*123*	*1.9*
Storm			*5*	*0.072*	*6/26/10 20:00*	*6/28/10 1:00*	*518,867*	*11.92*	*153*	*2.3*
Base			*3*	*0.046*	*6/28/10 1:00*	*7/4/10 7:00*	*2,052,606*	*47.15*	*333*	*5.8*
Storm			*5*	*0.072*	*7/4/10 7:00*	*7/5/10 15:00*	*427,543*	*9.82*	*126*	*1.9*
Storm Grab	7/6/2010 9:24	7/6/2010 9:24	6	0.1	7/5/10 15:00	7/6/10 10:00	684,595	15.72	256	4.3
Storm Grab	7/12/2010 9:49	7/12/2010 9:49	2	0.063	7/6/10 10:00	7/13/10 12:00	9,290,515	213.39	1160	36.5
Base			*3*	*0.046*	*7/13/10 12:00*	*7/17/10 20:00*	*4,248,509*	*97.58*	*690*	*12.1*
Storm			*5*	*0.072*	*7/17/10 20:00*	*7/18/10 16:00*	*753,236*	*17.30*	*222*	*3.4*
Base Grab	7/20/2010 14:56	7/20/2010 14:56	2	0.058	7/18/10 16:00	7/27/10 19:00	5,199,017	119.42	649	18.8
Storm			*5*	*0.072*	*7/27/10 19:00*	*7/28/10 14:00*	*345,869*	*7.94*	*102*	*1.6*
Base			*3*	*0.046*	*7/28/10 14:00*	*8/8/10 0:00*	*3,123,850*	*71.75*	*507*	*8.9*
Storm Grab	8/9/2010 10:22	8/9/2010 10:22	2	0.073	8/8/10 0:00	8/10/10 18:00	757,695	17.40	95	3.5
Storm Grab	8/11/2010 10:17	8/11/2010 10:17	4	0.089	8/10/10 18:00	8/12/10 20:00	729,401	16.75	182	4.1
Storm			*5*	*0.072*	*8/12/10 20:00*	*8/13/10 16:00*	*338,051*	*7.76*	*99*	*1.5*
Base Grab	8/23/2010 10:40	8/23/2010 10:40	3	0.063	8/13/10 16:00	8/31/10 3:00	5,466,254	125.55	1024	21.5
Storm			*5*	*0.072*	*8/31/10 3:00*	*9/2/10 3:00*	*498,989*	*11.46*	*147*	*2.2*
Storm			*5*	*0.072*	*9/2/10 3:00*	*9/3/10 16:00*	*477,383*	*10.96*	*140*	*2.1*
Base			*3*	*0.046*	*9/3/10 16:00*	*9/15/10 17:00*	*3,182,216*	*73.09*	*516*	*9.1*
Storm			*5*	*0.072*	*9/15/10 17:00*	*9/16/10 8:00*	*211,119*	*4.85*	*62*	*1.0*
Base			*3*	*0.046*	*9/16/10 8:00*	*9/23/10 10:00*	*2,152,966*	*49.45*	*349*	*6.1*
Storm Grab	9/24/2010 9:49	9/24/2010 9:49	11	0.077	9/23/10 10:00	9/24/10 11:00	607,163	13.95	417	2.9
Base Grab	10/5/2010 11:14	10/5/2010 11:14	1	0.025	9/24/10 11:00	10/7/10 7:00	6,370,097	146.31	398	9.9
Base			*3*	*0.046*	*10/7/10 7:00*	*10/15/10 3:00*	*2,703,265*	*62.09*	*439*	*7.7*
*Base**			*3*	*0.046*	*10/15/10 3:00*	*1/1/11 0:00*	*20,185,200*	*463.63*	*3276*	*57.5*
Storm Average			5	0.072						
Base Average			3	0.046						
All Average			4	0.061						
Total							**103,234,147**	**2,371**	**18,146**	**331**
CLFLWD Major Subwatershed Total Acres							10,513			
Total TP/TSS (lb/ac/yr)									1.73	0.03
Total TP/TSS (kg/ha/yr)									1.93	0.04

Italics indicate estimated concentrations based on average base and storm flow concentrations.

* Interval volumes from 1/1/10 to 3/30/10 and 10/15/10 to 1/1/11 were estimated based upon base and storm flow.

Total phosphorus loading for Little Comfort Lake Inlet for 2010 was estimated at 0.03 lb/ac (331 lbs.) (Table 8). Nearly the same estimated total discharge occurred in 2010 when compared to 2009, but a reduction of 87 pounds of phosphorus exported into the lake was observed. Further monitoring is needed to establish if this is a positive trend in load reductions going into Little Comfort Lake.

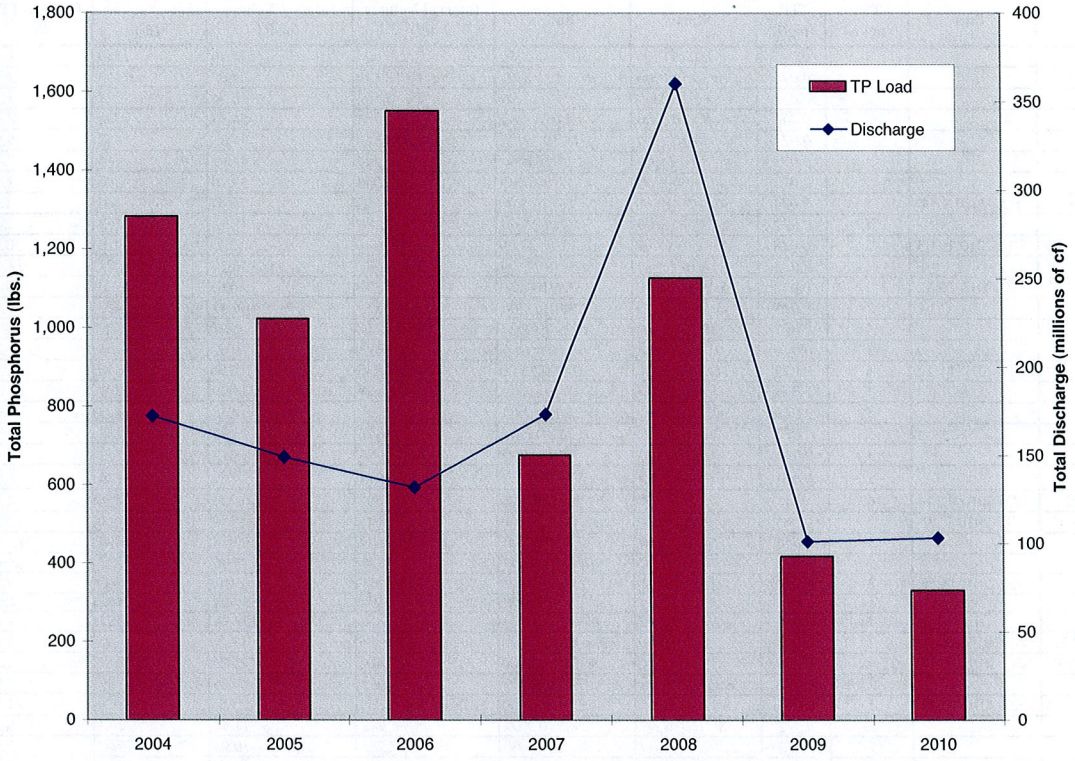


Figure 4. Little Comfort Inlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Little Comfort Inlet site since 2004. Total estimated annual discharge and phosphorus loads can be found in Figure 4. When comparing year-to-year loading numbers it should be noted is that the sampling technique changed between 2006 and 2007. In 2006 and earlier, water chemistry data was collected using composite samples. Since 2007 this data has been collected with grab samples. The apparent drop in total phosphorus export between 2006 and 2007 may be due to this switch in techniques. Composite samples generally capture more of the rising limb and peak of a storm event, whereas grab samples typically are taken near the peak or on the falling limb of a storm event. This is important to note because typically the majority of the load that is present is concentrated in the rising limb.

3) Forest Lake Subwatershed

Forest Lake Outlet

The station at the Forest Lake Outlet site recorded stage, velocity, and flow from March 30 - November 2, 2010 (Figure 5). Total discharge during the recorded period was 110,853,500 cf or 2545 acre-ft. No automated rain gage was installed at this site to determine total seasonal rainfall. The highest discharge recorded of 54.327 cfs occurred on July 5th. This peak is a result of a large rain event of 2.57 inches (recorded at the County Line Ditch Site) occurring over July 4th and 5th.

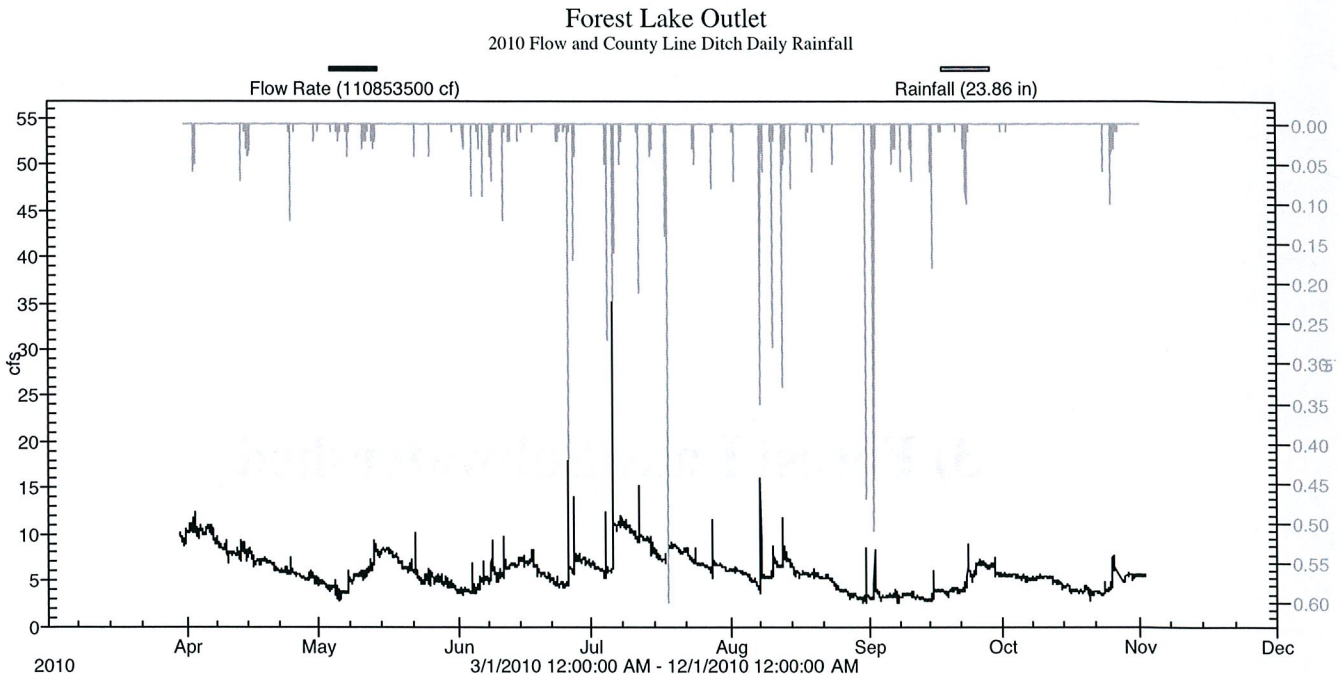


Figure 5. Forest Lake Outlet 2010 Flow and County Line Ditch Daily Rainfall

Table 9. Forest Lake Outlet 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base***			*N/A*	*0.029*	*1/1/10 0:00*	*4/5/10 11:45*	*28,573,650*	*656.30*	*N/A*	*51.73*
Base Grab	4/16/10 13:00	4/16/10 13:00	N/A	0.028	4/5/10 11:45	4/22/10 12:45	15,360,320	352.81	N/A	26.85
Base Grab	4/30/10 12:01	4/30/10 12:01	N/A	0.041	4/22/10 12:45	5/7/10 7:45	9,409,851	216.13	N/A	24.08
Storm			*N/A*	*0.029*	*5/7/10 7:45*	*5/7/10 15:45*	*158,452*	*3.64*	*N/A*	*0.29*
Base			*N/A*	*0.029*	*5/7/10 15:45*	*5/11/10 6:45*	*2,068,887*	*47.52*	*N/A*	*3.75*
Storm			*N/A*	*0.029*	*5/11/10 6:45*	*5/13/10 20:45*	*2,019,792*	*46.39*	*N/A*	*3.66*
Base Grab	5/14/10 13:10	5/14/10 13:10	N/A	0.028	5/13/10 20:45	6/8/10 4:45	18,877,520	433.59	N/A	33.00
Storm			*N/A*	*0.029*	*6/8/10 4:45*	*6/8/10 14:45*	*192,323*	*4.42*	*N/A*	*0.35*
Base Grab	6/10/10 12:10	6/10/10 12:10	N/A	0.020	6/8/10 14:45	6/11/10 3:45	1,402,819	32.22	N/A	1.75
Storm			*N/A*	*0.029*	*6/11/10 3:45*	*6/11/10 8:45*	*138,298*	*3.18*	*N/A*	*0.25*
Base			*N/A*	*0.029*	*6/11/10 8:45*	*6/25/10 17:45*	*13,724,080*	*315.23*	*N/A*	*24.85*
Storm			*N/A*	*0.029*	*6/25/10 17:45*	*6/25/10 18:45*	*36,357*	*0.84*	*N/A*	*0.07*
Base			*N/A*	*0.029*	*6/25/10 18:45*	*6/26/10 20:45*	*938,387*	*21.55*	*N/A*	*1.70*
Storm			*N/A*	*0.029*	*6/26/10 20:45*	*6/27/10 0:45*	*157,028*	*3.61*	*N/A*	*0.28*
Base Grab	6/29/10 11:00	6/29/10 11:00	N/A	0.022	6/27/10 0:45	7/4/10 6:45	6,634,632	152.39	N/A	9.11
Storm			*N/A*	*0.029*	*7/4/10 6:45*	*7/4/10 9:45*	*112,009*	*2.57*	*N/A*	*0.20*
Base			*N/A*	*0.029*	*7/4/10 9:45*	*7/5/10 15:45*	*1,075,453*	*24.70*	*N/A*	*1.95*
Storm			*N/A*	*0.029*	*7/5/10 15:45*	*7/6/10 0:45*	*476,168*	*10.94*	*N/A*	*0.86*
Base Grab	7/15/10 10:20	7/15/10 10:20	N/A	0.036	7/6/10 0:45	7/20/10 0:45	30,592,870	702.68	N/A	68.75
Base Grab	7/28/10 13:45	7/28/10 13:45	N/A	0.031	7/20/10 0:45	8/1/10 0:45	15,767,170	362.15	N/A	30.51
Base Grab	8/8/10 12:00	8/8/10 12:00	N/A	0.036	8/1/10 0:45	8/10/10 16:45	7,127,017	163.70	N/A	16.02
Storm			*N/A*	*0.029*	*8/10/10 16:45*	*8/10/10 23:45*	*242,681*	*5.57*	*N/A*	*0.44*
Base			*N/A*	*0.029*	*8/10/10 23:45*	*8/12/10 19:45*	*1,646,939*	*37.83*	*N/A*	*2.98*
Storm			*N/A*	*0.029*	*8/12/10 19:45*	*8/13/10 6:45*	*486,015*	*11.16*	*N/A*	*0.88*
Base Grab	8/16/10 15:10	8/16/10 15:10	N/A	0.027	8/13/10 6:45	8/31/10 2:45	18,211,310	418.29	N/A	30.70
Storm			*N/A*	*0.029*	*8/31/10 2:45*	*8/31/10 5:45*	*81,571*	*1.87*	*N/A*	*0.15*
Base Grab	9/1/10 11:45	9/1/10 11:45	N/A	0.026	8/31/10 5:45	9/2/10 2:45	1,184,856	27.21	N/A	1.92
Storm			*N/A*	*0.029*	*9/2/10 2:45*	*9/2/10 7:45*	*152,549*	*3.50*	*N/A*	*0.28*
Base			*N/A*	*0.029*	*9/2/10 7:45*	*9/15/10 16:45*	*8,761,730*	*201.25*	*N/A*	*15.86*
Storm			*N/A*	*0.029*	*9/15/10 16:45*	*9/15/10 23:45*	*181,335*	*4.17*	*N/A*	*0.33*
Base Grab	9/17/10 11:50	9/17/10 11:50	N/A	0.026	9/15/10 23:45	9/18/10 10:45	1,622,584	37.27	N/A	2.63
Storm			*N/A*	*0.029*	*9/18/10 10:45*	*9/18/10 13:45*	*98,983*	*2.27*	*N/A*	*0.18*
Base			*N/A*	*0.029*	*9/18/10 13:45*	*9/23/10 8:45*	*3,540,125*	*81.31*	*N/A*	*6.41*
Storm			*N/A*	*0.029*	*9/23/10 8:45*	*9/23/10 17:45*	*295,110*	*6.78*	*N/A*	*0.53*
Base			*N/A*	*0.029*	*9/23/10 17:45*	*10/2/10 12:45*	*11,143,400*	*255.95*	*N/A*	*20.17*
Storm			*N/A*	*0.029*	*10/2/10 12:45*	*10/2/10 15:45*	*156,123*	*3.59*	*N/A*	*0.28*
Base Grab	10/3/10 15:00	10/3/10 15:00	N/A	0.025	10/2/10 15:45	10/10/10 15:45	7,164,614	164.56	N/A	11.18
Base Grab	10/15/10 12:20	10/15/10 12:20	N/A	0.029	10/10/10 15:45	10/25/10 20:45	5,509,432	126.55	N/A	9.97
Storm			*N/A*	*0.029*	*10/25/10 20:45*	*10/26/10 4:45*	*139,566*	*3.21*	*N/A*	*0.25*
Base			*N/A*	*0.029*	*10/26/10 4:45*	*11/2/10 9:45*	*4,382,486*	*100.66*	*N/A*	*7.93*
*Base***			*N/A*	*0.029*	*11/2/10 9:45*	*11/20/10 9:45*	*7,776,000*	*178.61*	*N/A*	*14.08*
*Base***			*N/A*	*0.029*	*11/20/10 9:45*	*1/1/11 0:00*	*12,577,950*	*288.90*	*N/A*	*22.77*
Storm Average			N/A	N/A						
Base Average			N/A	0.029						
All Average			N/A	0.029						
Total							**240,198,442**	**5,517**	**N/A**	**450**
CLFLWD Major Subwatershed Total Acres							24,558			
Total TP/TSS (lb/ac/yr)									N/A	0.018
Total TP/TSS (kg/ha/yr)									N/A	0.021

*Italics indicate estimated concentrations based on average base and storm flow concentrations

** Interval volumes from 1/1/10 to 4/5/10 and 11/2/10 to 1/1/11 where estimated using base flow averages

Although no samples were collected at the Forest Lake Outlet site in 2010, the WCD used in-lake concentrations from samples collected by a volunteer to estimate a total phosphorus load at this location. Total phosphorus loading for Forest Lake Outlet for 2010 was estimated at 0.025 lb/ac (221 lbs.) (Table 9). This is greatly increased from last year, likely due to the overall higher flow. Unlike 2009, the site was continuously flowing the entire monitoring season. Utilizing this data and the loading data from the County Line Ditch location will allow the CLFLWD to quantify the load originating from the City of Forest Lake that drains through the Bixby Park area. The monitoring station at Bixby Park that was installed in 2009 will help to verify the contribution from the city.

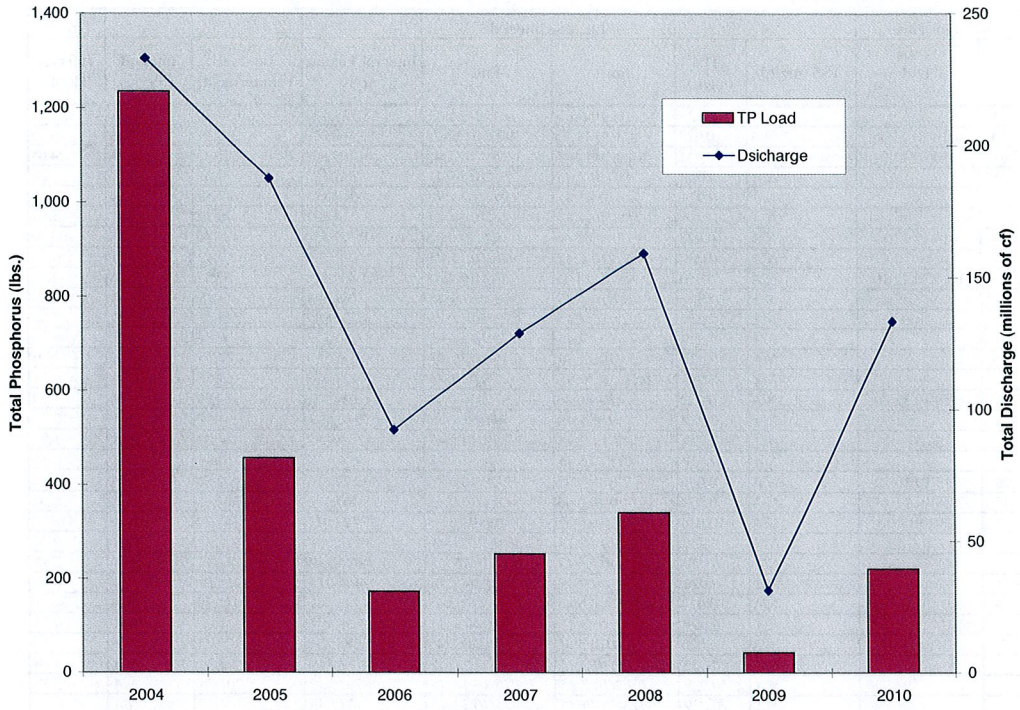


Figure 6. Forest Lake Outlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Forest Lake Outlet site since 2004. Total estimated annual phosphorus loading and discharge can be found in Figure 6. It should be noted that when comparing year to year loading estimates, the sampling technique utilized at this site has changed a number of times. Composite sampling was used in the 2004-2005 monitoring seasons, and was switched to grab sampling only for the 2006 season. Sampling at the site ceased in 2007, and all estimates since then have been made using in-lake sample concentrations. These changes partially explain the reduction in load versus discharge, due to the refinement level of each technique. Composite sampling typically does the best job of characterizing nutrient levels, as it is able to capture the rising limb of a storm event. Grab sampling usually occurs near the peak or falling limb of storm events, where the nutrient concentration is normally much lower. In lake concentrations are generally much lower than the results of either of the other two sampling methods.

4) Comfort Lake Subwatershed

Bixby Park

2010 was the second year that data was collected at the Bixby Park site. The primary purpose of this site was to quantify the loads to the Comfort Lake Subwatershed coming from the City of Forest Lake. Flow was recorded from March 30-November 1, 2010 (Figure 7). Total discharge for this period was 18,842,000 cf, or 433 acre-feet. No automated rain gage was installed at this site to record daily rainfall. A peak discharge of 43.48 cfs occurred on July 6, 2010 caused by a large precipitation event in the area. 2.57 inches of rain fell at the County Line Ditch site from July 4th-5th.

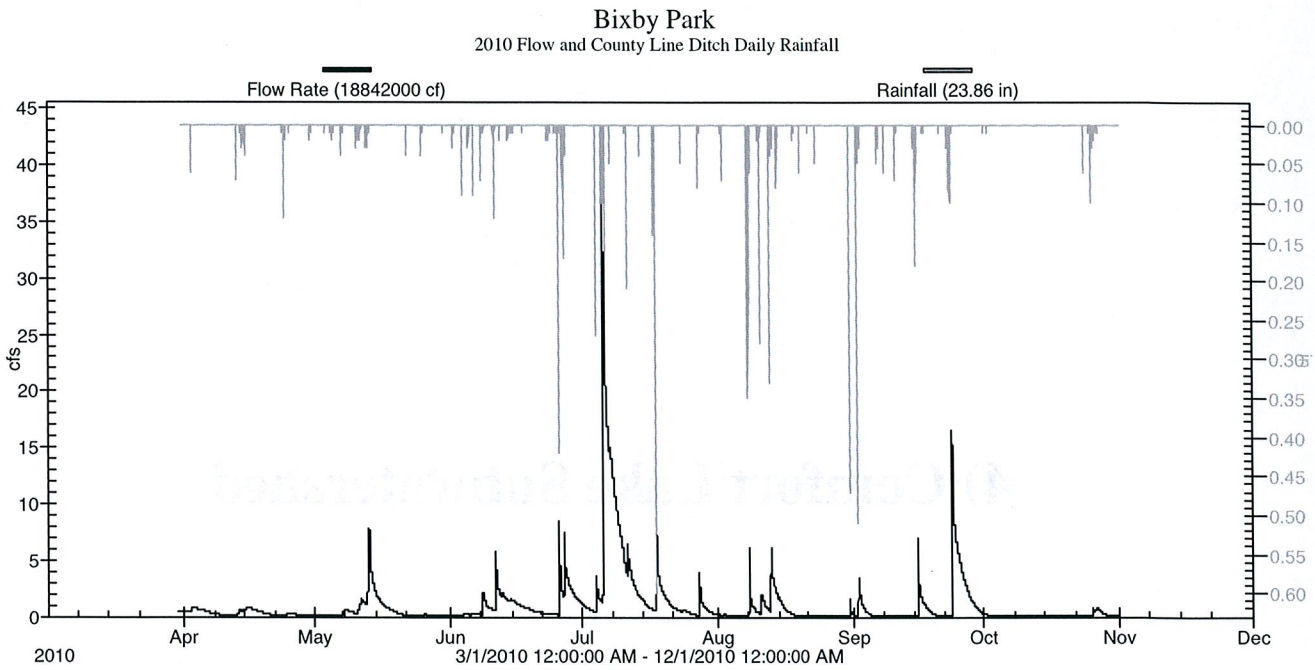


Figure 7. Bixby Park 2010 Flow and County Line Ditch Daily Rainfall

Grab samples were taken at the Bixby Park site in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride and *E. Coli* results from all collected samples are listed in Table 10 and field water quality measurements are listed in Table 11. The highest TSS and TP results of 28 mg\L and 0.196 mg/L, respectively, were from a March 10th snowmelt grab sample. The greatest TKN result of 3.3 mg/L was from a base grab sample on May 24th.

Table 10. Bixby Park 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen	E. Coli (mpn/100ml)
Snowmelt Grab	3/8/2010 10:51	3/8/2010 10:51	4	~2	2.50	0.137	0.073	400	<0.03	0.57	0.54	
Snowmelt Grab	3/10/2010 14:21	3/10/2010 14:21	28	~12	2.30	0.196	0.100	234	<0.03	0.62	0.36	
Base Grab	5/24/2010 11:07	5/24/2010 11:07	~8	~6	3.30	0.147	~0.021	281	<0.03	<0.05	0.40	
Base Grab	8/23/2010 9:42	8/23/2010 9:42	9	~4	2.70	0.122	~0.029	150	<0.03	<0.05	0.60	
Base Grab	10/5/2010 10:19	10/5/2010 10:19	4	~2	2.00	0.053	~0.010	195	0.03	0.14	0.38	
Storm Grab	5/12/2010 8:46	5/12/2010 8:46	4	3	1.70	0.071	0.058	196	<0.03	0.09	~0.04	
Storm Grab (duplicate)	5/12/2010 12:00	5/12/2010 12:00	3	~2	1.80	~0.047	~0.037	191	<0.03	0.09	~0.05	
Storm Grab	6/11/2010 13:20	6/11/2010 13:20	9	3	0.69	0.146	0.062	87	<0.03	0.20	0.11	
Storm Grab	7/6/2010 8:13	7/6/2010 8:13	14	4	1.30	0.175	0.096	43	<0.03	<0.05	0.17	
Storm Grab	8/9/2010 9:09	8/9/2010 9:09	4	3	1.50	0.141	0.089	94	<0.03	0.08	0.18	
Storm Grab	8/11/2010 9:36	8/11/2010 9:36	4	~2	1.60	0.185	0.128	81	<0.03	0.06	0.12	
Storm Grab	9/2/2010 10:50	9/2/2010 10:50	5	~2	0.94	0.145	0.090	46	<0.03	0.15	0.06	
Storm Grab	9/16/2010 9:40	9/16/2010 9:40	4	~2	1.20	0.094	~0.044	79	<0.03	0.17	~0.05	
Storm Grab	9/24/2010 8:59	9/24/2010 8:59	3	~2	1.50	0.074	~0.038	74	<0.03	0.22	~0.04	
E. Coli Grab	5/25/2010 8:17	5/25/2010 8:17										125
E. Coli Grab	7/28/2010 10:04	7/28/2010 10:04										1300

Exceeds Water Quality Standard
Exceeds Chronic Standard
Exceeds Max Standard
Exceeds Final Acute Standard
Exceeds Water Quality Standard for Turbidity(TSS Value used to calculate)

Table 11. Bixby Park 2010 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/8/2010 10:51	57	0.08	8.07	1621	7.9
5/12/2010 8:46	>120	7.6	6.07	1014	7.7
5/24/2010 11:07	27	22.2	1.32	1464	7.3
6/11/2010 13:20	45	17.3	4.04	420	7
8/9/2010 9:09	85	22.8		771	6.5
8/11/2010 9:36	95	23.1	1.06	572	6.8
8/23/2010 9:42	75	22.0	0.73	1020	6.7
9/2/2010 10:50	53	18.8	4.45	362	8
9/16/2010 9:40		13.7	4.46	461	8.3
9/24/2010 8:59	106	14.6	3.67	453	7.7
10/5/2010 10:19	95	8.9	4.09	1240	6.2

Exceeds Water Quality Standard

Table 12. Bixby Park 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*7*	*0.107*	*1/1/10 0:00*	*3/8/10 6:00*	*457,920*	*10.5*	*200*	*3.1*
Snowmelt Grab*	3/8/2010 10:51	3/8/2010 10:51	4	0.137	3/8/10 6:00	3/9/10 15:00	35,640	0.8	9	0.3
*Base**			*7*	*0.129*	*3/9/10 15:00*	*3/10/10 7:00*	*9,695*	*0.2*	*4*	*0.1*
Snowmelt Grab*	3/10/2010 14:21	3/10/2010 14:21	28	0.196	3/10/10 7:00	3/11/10 17:00	42,840	1.0	75	0.5
*Base**			*7*	*0.107*	*3/11/10 17:00*	*3/30/10 12:45*	*273,737*	*6.3*	*120*	*1.8*
Base			*7*	*0.107*	*3/30/10 12:45*	*4/13/10 4:45*	*401,452*	*9.2*	*175*	*2.7*
Storm			*6*	*0.129*	*4/13/10 4:45*	*4/20/10 15:45*	*314,363*	*7.2*	*115*	*2.5*
Base			*7*	*0.107*	*4/20/10 15:45*	*4/24/10 8:45*	*31,648*	*0.7*	*14*	*0.2*
Storm			*6*	*0.129*	*4/24/10 8:45*	*5/1/10 8:45*	*85,536*	*2.0*	*31*	*0.7*
Base			*7*	*0.107*	*5/1/10 8:45*	*5/7/10 9:45*	*8,154*	*0.2*	*4*	*0.1*
Storm			*6*	*0.129*	*5/7/10 9:45*	*5/10/10 13:45*	*123,134*	*2.8*	*45*	*1.0*
Storm Grab	5/12/2010 8:46	5/12/2010 8:46	4	0.071	5/10/10 13:45	5/12/10 20:45	202,598	4.7	51	0.9
Storm			*6*	*0.129*	*5/12/10 20:45*	*5/18/10 0:45*	*955,261*	*21.9*	*350*	*7.7*
Base Grab	5/24/2010 11:07	5/24/2010 11:07	8	0.147	5/18/10 0:45	5/26/10 11:45	159,969	3.7	80	1.5
Base			*7*	*0.107*	*5/26/10 11:45*	*6/4/10 2:45*	*46,136*	1.1	20	0.3
Storm			*6*	*0.129*	*6/4/10 2:45*	*6/8/10 6:45*	*75,028*	*1.7*	*28*	*0.6*
Storm			*6*	*0.129*	*6/8/10 6:45*	*6/11/10 4:45*	*238,334*	*5.5*	*87*	*1.9*
Storm Grab	6/11/2010 13:20	6/11/2010 13:20	9	0.146	6/11/10 4:45	6/12/10 14:45	336,897	7.7	189	3.1
Base			*7*	*0.107*	*6/12/10 14:45*	*6/25/10 17:45*	*887,423*	*20.4*	*388*	*5.9*
Storm			*6*	*0.129*	*6/25/10 17:45*	*6/26/10 20:45*	*327,595*	*7.5*	*120*	*2.6*
Storm			*6*	*0.129*	*6/26/10 20:45*	*6/28/10 19:45*	*588,174*	*13.5*	*216*	*4.7*
Base			*7*	*0.107*	*6/28/10 19:45*	*7/4/10 6:45*	*488,639*	*11.2*	*214*	*3.3*
Storm			*6*	*0.129*	*7/4/10 6:45*	*7/5/10 15:45*	*218,028*	*5.0*	*80*	*1.8*
Storm Grab	7/6/2010 8:13	7/6/2010 8:13	14	0.175	7/5/10 15:45	7/7/10 13:45	3,295,116	75.7	2,880	36.0
Base			*7*	*0.107*	*7/7/10 13:45*	*7/17/10 20:45*	*4,112,728*	*94.5*	*1,797*	*27.6*
Base			*7*	*0.107*	*7/18/10 13:45*	*7/27/10 19:45*	*747,594*	*17.2*	*327*	*5.0*
Storm			*6*	*0.129*	*7/27/10 19:45*	*7/29/10 4:45*	*167,627*	*3.9*	*61*	*1.3*
Base			*7*	*0.107*	*7/29/10 4:45*	*8/7/10 23:45*	*156,686*	*3.6*	*68*	*1.0*
Storm Grab	8/9/2010 9:09	8/9/2010 9:09	4	0.141	8/7/10 23:45	8/10/10 17:45	241,759	5.6	60	2.1
Storm Grab	8/11/2010 9:36	8/11/2010 9:36	4	0.185	8/10/10 17:45	8/12/10 20:45	192,859	4.4	48	2.2
Storm			*6*	*0.129*	*8/12/10 20:45*	*8/15/10 4:45*	*550,043*	*12.6*	*202*	*4.4*
Base Grab	8/23/2010 9:42	8/23/2010 9:42	9	0.122	8/15/10 4:45	8/24/10 16:45	212,864	4.9	120	1.6
Base			*7*	*0.107*	*8/24/10 16:45*	*8/31/10 2:45*	*5,193*	*0.1*	*2*	*0.0*
Storm			*6*	*0.129*	*8/31/10 2:45*	*9/2/10 2:45*	*44,770*	*1.0*	*16*	*0.4*
Storm Grab	9/2/2010 10:50	9/2/2010 10:50	5	0.145	9/2/10 2:45	9/4/10 9:45	228,398	5.2	71	2.1
Base			*7*	*0.107*	*9/4/10 9:45*	*9/15/10 12:45*	*47,123*	*1.1*	*21*	*0.3*
Storm Grab	9/16/2010 9:40	9/16/2010 9:40	4	0.094	9/15/10 12:45	9/17/10 6:45	312,819	7.2	78	1.8
Base			*7*	*0.107*	*9/17/10 6:45*	*9/23/10 7:45*	*144,408*	*3.3*	*63*	*1.0*
Storm Grab	9/24/2010 8:59	9/24/2010 8:59	3	0.074	9/23/10 7:45	9/25/10 20:45	1,596,947	36.7	299	7.4
Base Grab	10/5/2010 10:19	10/5/2010 10:19	4	0.053	9/25/10 20:45	10/7/10 20:45	734,447	16.9	183	2.4
Base			*7*	*0.107*	*10/7/10 20:45*	*10/25/10 21:45*	*3,295*	*0.1*	*1*	*0.0*
Storm			*6*	*0.129*	*10/25/10 21:45*	*10/28/10 8:45*	*107,882*	*2.5*	*40*	*0.9*
Base			*7*	*0.107*	*10/28/10 8:45*	*11/1/10 2:30*	*27,599*	*0.6*	*12*	*0.2*
*Base**			*7*	*0.107*	*11/1/10 2:30*	*1/1/11 0:00*	*1,410,787*	*32.4*	*616*	*9.5*
Snowmelt Average			16	0.167						
Storm Average			6	0.129						
Base Average			7	0.107						
All Average			8	0.130						
Total							**21,072,618**	**484**	**9,737**	**158**
CLFLWD Major Subwatershed Total Acres							747			
Total TP/TSS (lb/ac/yr)									13.04	0.212
Total TP/TSS (kg/ha/yr)									14.61	0.237

Italics indicate estimated concentrations based on average base and storm flow concentrations.

* Interval volumes from 1/1/10 to 3/30/10 and 11/1/10 to 1/1/11 were estimated based upon base and storm flow.

Total phosphorus loading for the Bixby Park Site for 2010 was estimated at 0.212 lb/ac (158 lbs.) (Table 12). When compared to the County Line Ditch site, the TP and TSS loadings per acre are higher at Bixby Park, possibly leading to the conclusion that the wetlands downstream of this site are acting as a sink for nutrients. Water quality monitoring should continue at this site to better assess the affect on the downstream watershed.

County Line Ditch

The station at the County Line Ditch recorded flow and rainfall from March 31, 2010 to November 1, 2010 (Figure 8). Total discharge during this period was 127,396,700 cf or 2,925 acre-ft. Total rainfall for the monitoring season was 23.86 inches. A peak flow of 43.32 cfs occurred on July 6th from a cumulative rainfall of 2.57 inches that fell from July 5th – 6th. One note about this location is that observed channel conditions were drastically different from the previous year. Difficulty has arisen in making yearly comparisons at this site due to fluctuations in the channel characteristics between monitoring seasons. In past monitoring seasons the deepest point within the channel would change frequently, thereby either burying the sensor in sediment or having the deep point (thalweg) in the channel getting rerouted around the sensor. 2010 was a departure from this trend, with the channel maintaining a high flow and depth for the majority of the season. The variations in flow characteristics seem to be closely tied to the frequency and quantity of discharge from Forest Lake.

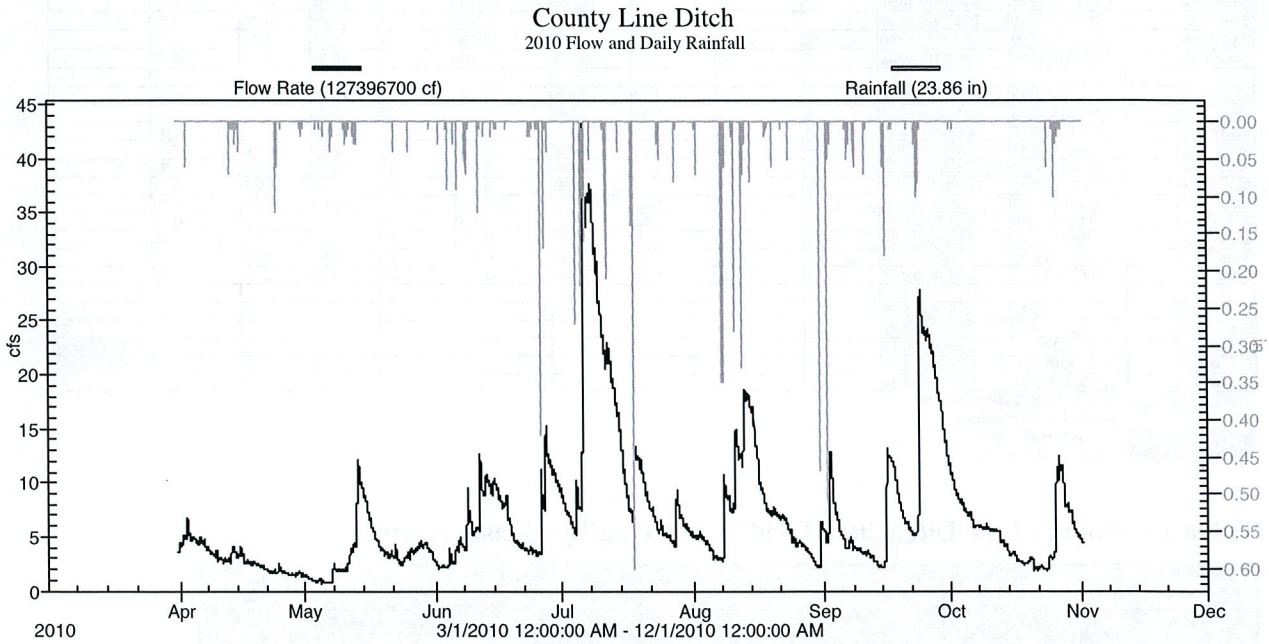


Figure 8. County Line Ditch 2010 Flow and Daily Rainfall

Grab samples were taken at the County Line Ditch site in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride and *E. Coli* results from all collected samples are listed in Table 13 and field water quality measurements are listed in Table 14. The highest TSS concentration of 12 mg/L was collected in an August 11th storm grab sample and an August 23rd base grab sample. The highest TKN concentration of 1.70 mg/L was collected in a March 10th snowmelt grab sample, a July 12th storm grab sample, and a August 23rd base grab sample. The highest TP concentration of 0.179 mg/L was also collected in the July 12th storm sample.

Table 13. County Line Ditch 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	E. Coli (mpn/100ml)
Snowmelt Grab	3/8/2010 11:12	3/8/2010 11:12	11	6	2.00	0.064	<0.010	156	<0.03	0.12	0.21	
Snowmelt Grab	3/10/2010 14:44	3/10/2010 14:44	9	4	1.70	0.060	0.051	169	<0.03	0.38	0.32	
Base Grab	4/29/2010 8:41	4/29/2010 8:41	5	~2	0.90	~0.028	<0.010	81	<0.03	<0.05	<0.02	
Base Grab	5/24/2010 10:55	5/24/2010 10:55	~1	~1	1.10	~0.036	~0.016	76	<0.03	<0.05	~0.04	
Base Grab	7/20/2010 15:40	7/20/2010 15:40	7	4	1.80	0.083	~0.038	58	<0.03	<0.05	~0.04	
Base Grab	8/23/2010 10:00	8/23/2010 10:00	12	9	1.70	0.087	~0.040	15	<0.03	<0.05	~0.06	
Base Grab	10/5/2010 10:35	10/5/2010 10:35	3	~2	0.90	~0.032	<0.010	51	<0.03	0.06	~0.04	
Storm Grab	5/12/2010 9:16	5/12/2010 9:16	~2	~2	1.10	~0.025	<0.010	80	<0.03	0.18	<0.02	
Storm Grab	6/11/2010 12:28	6/11/2010 12:28	5	~2	0.86	0.088	~0.039	79	<0.03	0.08	~0.06	
Storm Grab	6/28/2010 9:16	6/28/2010 9:16	4	~2	1.10	0.103	~0.037	66	<0.03	<0.05	<0.02	
Storm Grab	7/6/2010 8:44	7/6/2010 8:44	8	3	1.20	0.095	~0.038	42	<0.03	0.06	0.06	
Storm Grab	7/12/2010 8:58	7/12/2010 8:58	11	6	1.70	0.179	0.072	40	<0.03	<0.05	<0.02	
Storm Grab	7/28/2010 10:18	7/28/2010 10:18	6	3	1.10	0.088	~0.032	70	<0.03	<0.05	0.09	
Storm Grab	8/9/2010 9:32	8/9/2010 9:32	6	~5	1.20	0.092	<0.010	55	<0.03	<0.05	0.06	
Storm Grab	8/11/2010 9:49	8/11/2010 9:49	12	8	1.40	0.121	~0.032	66	<0.03	0.06	~0.03	
Storm Grab	9/2/2010 11:00	9/2/2010 11:00	11	~5	1.10	0.104	~0.016	50	<0.03	0.14	0.06	
Storm Grab	9/16/2010 9:30	9/16/2010 9:30	4	~2	1.20	0.130	~0.021	86	<0.03	0.15	0.12	
Storm Grab	9/24/2010 9:14	9/24/2010 9:14	4	3	1.20	0.073	~0.011	60	<0.03	0.16	~0.05	
E. Coli Grab	5/25/2010 8:32	5/25/2010 8:32										93
E. Coli Grab	6/24/2010 8:41	6/24/2010 8:41										31
E. Coli Grab	7/28/2010 10:18	7/28/2010 10:18										461
E. Coli Grab	8/26/2010 9:00	8/26/2010 9:00										135
E. Coli Grab	9/30/2010 8:34	9/30/2010 8:34										64

Exceeds Water Quality Standard
Exceeds Chronic Standard
Exceeds Max Standard
Exceeds Final Acute Standard

Table 14. County Line Ditch 2010 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
3/8/2010 11:12	>100	2.1	9.83	890	8.3
4/29/2010 8:41	>120	12.7	8.21		
5/12/2010 9:16	>120	8.6	8.58	635	8.1
5/24/2010 10:55	>120	23.8	9.42	519	8.1
6/11/2010 12:28	99	18.1	5.33	442	7.6
7/12/2010 8:58	55	22.0	2.07	427	6.7
7/20/2010 15:40	114	26.3	4.64		
7/28/2010 10:18	85	24.5	4.06	481	8.2
8/9/2010 9:32	85	25.3	2.23	503	6.6
8/11/2010 9:49	68	24.6	2.13	451	6.7
8/23/2010 10:00	59	24.4	1.50	432	6.9
8/26/2010 9:00	99	19.7	2.19	393	8
9/2/2010 11:00	52	19.8	3.94	334	8
9/16/2010 9:30		14.0	3.15	516	8.5
9/24/2010 9:14	108	15.0	3.00	421	7.4
10/5/2010 10:35	>120	11.6	7.49	450	7.8

Exceeds Water Quality Standard

Table 15. County Line Ditch 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*6*	*0.053*	*1/1/10 0:00*	*3/8/10 6:00*	*14,310,000*	*328.7*	*5,003*	*47.5*
Snowmelt Grab*	3/8/2010 11:12	3/8/2010 11:12	11	0.064	3/8/10 6:00	3/9/10 18:00	561,143	12.9	385	2.2
*Base**			*6*	*0.053*	*3/9/10 18:00*	*3/10/10 7:00*	*263,843*	*6.1*	*92*	*0.9*
Snowmelt Grab*	3/10/2010 14:44	3/10/2010 14:44	9	0.06	3/10/10 7:00	3/11/10 17:00	529,969	12.2	298	2.0
*Base**			*6*	*0.053*	*3/11/10 17:00*	*3/31/10 11:45*	*9,635,357*	*221.3*	*3,368*	*32.0*
Base			*6*	*0.053*	*3/31/10 11:45*	*4/13/10 5:45*	*4,438,547*	*101.9*	*1,552*	*14.7*
Storm			*7*	*0.100*	*4/13/10 5:45*	*4/16/10 5:45*	*931,652*	*21.4*	*386*	*5.8*
Base			*6*	*0.053*	*4/16/10 5:45*	*4/29/10 2:45*	*2,267,568*	*52.1*	*793*	*7.5*
Base Grab	4/29/2010 8:41	4/29/2010 8:41	5	0.028	4/29/10 2:45	5/7/10 9:45	776,867	17.8	242	1.4
Storm			*7*	*0.100*	*5/7/10 9:45*	*5/7/10 21:45*	*80,748*	*1.9*	*33*	*0.5*
Base			*6*	*0.053*	*5/7/10 21:45*	*5/11/10 4:45*	*566,353*	*13.0*	*198*	*1.9*
Storm Grab	5/12/2010 9:16	5/12/2010 9:16	2	0.025	5/11/10 4:45	5/13/10 1:45	603,893	13.9	75	0.9
Storm			*7*	*0.100*	*5/13/10 1:45*	*5/17/10 12:45*	*3,130,908*	*71.9*	*1,297*	*19.5*
Base Grab	5/24/2010 10:55	5/24/2010 10:55	1	0.036	5/17/10 12:45	6/4/10 1:45	5,080,383	116.7	317	11.4
Storm			*7*	*0.100*	*6/4/10 1:45*	*6/4/10 14:45*	*156,766*	*3.6*	*65*	*1.0*
Base			*6*	*0.053*	*6/4/10 14:45*	*6/5/10 14:45*	*223,110*	*5.1*	*78*	*0.7*
Storm			*7*	*0.100*	*6/5/10 14:45*	*6/8/10 5:45*	*910,899*	*20.9*	*377*	*5.7*
Storm			*7*	*0.100*	*6/8/10 5:45*	*6/9/10 9:45*	*708,524*	*16.3*	*294*	*4.4*
Base			*6*	*0.053*	*6/9/10 9:45*	*6/11/10 4:45*	*867,996*	*19.9*	*303*	*2.9*
Storm Grab	6/11/2010 12:28	6/11/2010 12:28	5	0.088	6/11/10 4:45	6/12/10 8:45	981,169	22.5	306	5.4
Storm			*7*	*0.100*	*6/12/10 8:45*	*6/16/10 7:45*	*3,280,269*	*75.3*	*1,359*	*20.4*
Base			*6*	*0.053*	*6/16/10 7:45*	*6/25/10 16:45*	*4,027,380*	*92.5*	*1,408*	*13.4*
Storm			*7*	*0.100*	*6/25/10 16:45*	*6/26/10 4:45*	*378,470*	*8.7*	*157*	*2.4*
Base			*6*	*0.053*	*6/26/10 4:45*	*6/26/10 21:45*	*478,816*	*11.0*	*167*	*1.6*
Storm Grab	6/28/2010 9:16	6/28/2010 9:16	4	0.103	6/26/10 21:45	6/28/10 9:45	1,605,106	36.9	401	10.3
Base			*6*	*0.053*	*6/28/10 9:45*	*7/4/10 6:45*	*4,230,875*	*97.2*	*1,479*	*14.1*
Storm			*7*	*0.100*	*7/4/10 6:45*	*7/4/10 16:45*	*314,700*	*7.2*	*130*	*2.0*
Base			*6*	*0.053*	*7/4/10 16:45*	*7/5/10 15:45*	*641,047*	*14.7*	*224*	*2.1*
Storm Grab	7/6/2010 8:44	7/6/2010 8:44	8	0.095	7/5/10 15:45	7/11/10 9:45	15,208,320	349.3	7,595	90.2
Storm Grab	7/12/2010 8:58	7/12/2010 8:58	11	0.179	7/11/10 9:45	7/15/10 1:45	5,940,755	136.5	4,079	66.4
Base			*6*	*0.053*	*7/15/10 1:45*	*7/17/10 20:45*	*2,193,325*	*50.4*	*767*	*7.3*
Storm			*7*	*0.100*	*7/17/10 20:45*	*7/19/10 14:45*	*1,889,155*	*43.4*	*783*	*11.8*
Base Grab	7/20/2010 15:40	7/20/2010 15:40	7	0.083	7/19/10 14:45	7/27/10 19:45	4,728,791	108.6	2,066	24.5
Storm Grab	7/28/2010 10:18	7/28/2010 10:18	6	0.088	7/27/10 19:45	7/28/10 12:45	498,395	11.4	187	2.7
Base			*6*	*0.053*	*7/28/10 12:45*	*8/7/10 23:45*	*4,261,973*	*97.9*	*1,490*	*14.2*
Storm Grab	8/9/2010 9:32	8/9/2010 9:32	6	0.092	8/7/10 23:45	8/9/10 10:45	1,085,862	24.9	407	6.2
Base			*6*	*0.053*	*8/9/10 10:45*	*8/10/10 17:45*	*840,874*	*19.3*	*294*	*2.8*
Storm Grab	8/11/2010 9:49	8/11/2010 9:49	12	0.121	8/10/10 17:45	8/11/10 15:45	1,044,588	24.0	783	7.9
Base			*6*	*0.053*	*8/11/10 15:45*	*8/12/10 20:45*	*1,284,600*	*29.5*	*449*	*4.3*
Storm			*7*	*0.100*	*8/12/10 20:45*	*8/16/10 10:45*	*5,025,195*	*115.4*	*2,082*	*31.3*
Base Grab	8/23/2010 10:00	8/23/2010 10:00	12	0.087	8/16/10 10:45	8/31/10 2:45	7,302,190	167.7	5,470	39.7
Storm			*7*	*0.100*	*8/31/10 2:45*	*9/2/10 2:45*	*900,097*	*20.7*	*373*	*5.6*
Storm Grab	9/2/2010 11:00	9/2/2010 11:00	11	0.104	9/2/10 2:45	9/4/10 11:45	1,815,032	41.7	1,246	11.8
Base			*6*	*0.053*	*9/4/10 11:45*	*9/15/10 7:45*	*3,413,574*	*78.4*	*1,193*	*11.3*
Storm Grab	9/16/2010 9:30	9/16/2010 9:30	4	0.13	9/15/10 7:45	9/18/10 18:45	2,996,985	68.8	748	24.3
Base			*6*	*0.053*	*9/18/10 18:45*	*9/23/10 6:45*	*2,435,099*	*55.9*	*851*	*8.1*
Storm Grab	9/24/2010 9:14	9/24/2010 9:14	4	0.073	9/23/10 6:45	9/30/10 7:45	12,331,670	283.2	3,079	56.2
Base Grab	10/5/2010 10:35	10/5/2010 10:35	3	0.032	9/30/10 7:45	10/7/10 16:45	5,340,098	122.7	1,000	10.7
Base			*6*	*0.053*	*10/7/10 16:45*	*10/24/10 3:45*	*5,358,806*	*123.1*	*1,873*	*17.8*
Storm			*7*	*0.100*	*10/24/10 3:45*	*10/25/10 5:45*	*279,003*	*6.4*	*116*	*1.7*
Storm			*7*	*0.100*	*10/25/10 5:45*	*10/28/10 1:45*	*2,152,388*	*49.4*	*892*	*13.4*
Base			*6*	*0.053*	*10/28/10 1:45*	*11/1/10 10:30*	*2,387,858*	*54.8*	*835*	*7.9*
*Base**			*6*	*0.053*	*11/1/10 10:30*	*1/1/11 0:00*	*29,499,719*	*677.6*	*10,313*	*98.0*
Snowmelt Average			10	0.062						
Storm Average			7	0.100						
Base Average			6	0.053						
All Average			7	0.083						
Total							**182,196,709**	**4,185**	**69,760**	**811**
CLFLWD Major Subwatershed Total Acres							9,806			
Total TP/TSS (lb/ac/yr)									7.11	0.083
Total TP/TSS (kg/ha/yr)									7.97	0.093

Italics indicate estimated concentrations based on average base and storm flow concentrations.

* Interval volumes from 1/1/10 to 3/31/10 and 11/1/10 to 1/1/11 were estimated based upon base and storm flow.

Total phosphorus loading for the County Line Ditch Site for 2010 was estimated at 0.083 lb/ac (811 lbs.) (Table 15). This load is substantially higher than the estimate from 2009, and more in line with what was observed in 2008. The likely cause of this is the overall increase of flow at this site in 2010, which was more than double the discharge observed in 2009. When compared to the Bixby Park site, the TP and TSS loadings per acre are lower at County Line Ditch, possibly leading to the conclusion that the wetland complex between these two sites is acting as a sink for nutrients. Another cause of this nutrient reduction may be from dilution by the lower nutrient concentrations from Forest Lake. The monitoring data suggests that the majority of the discharge observed at this site originates from the outlet of Forest Lake.

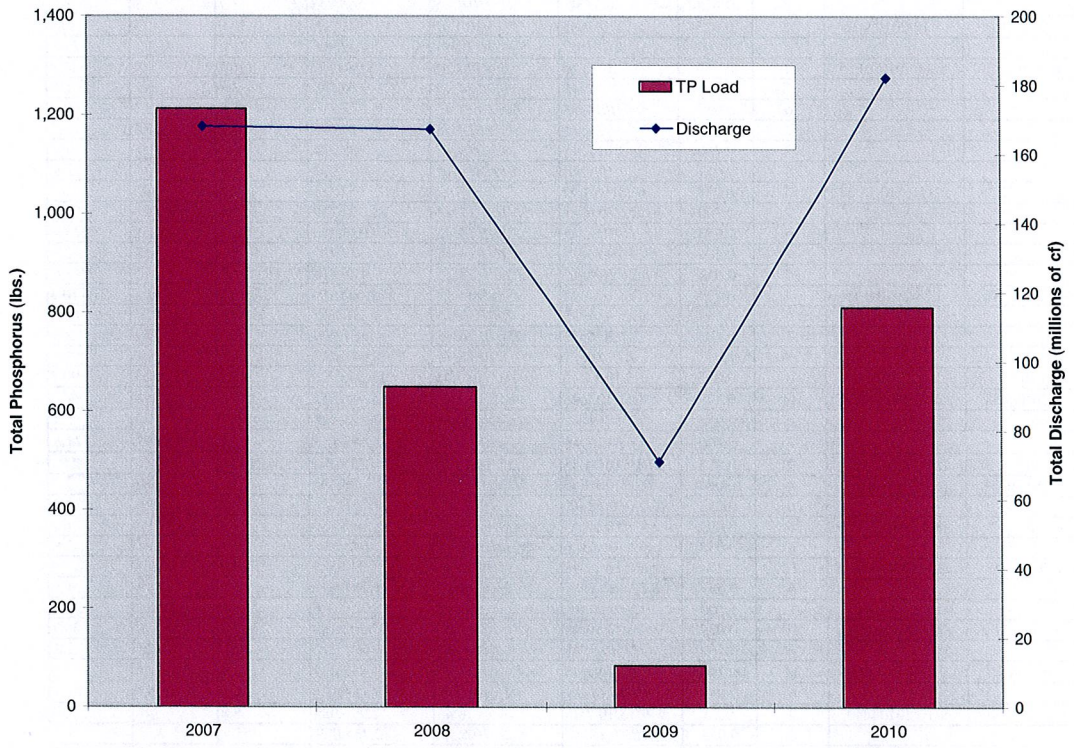


Figure 9. County Line Ditch Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the County Line Ditch site since 2007. Estimated annual total discharge and phosphorus export can be seen in Figure 9. When comparing year-to-year load estimations, the change in the sampling techniques used at this site should be noted. In 2007-2008, composite sampling was used, whereas grab samples only were taken in 2009-2010. Composite samples typically lead to higher load estimations, but it isn't clear if that is the case at this site. Further monitoring is needed to assess the loading trend present at this site.

Comfort Lake Inlet

The station for the Comfort Lake Inlet site recorded flow and rainfall between March 30-October 30, 2010 (Figure 10). Total discharge during this period was 175,493,200 cf or 4,029 acre-ft. Total rainfall for the monitoring season was 22.68 inches. A peak flow of 60.27 cfs occurred on July 5th. This peak was due to a 3.71-inch rain event occurring July 5th and 6th.

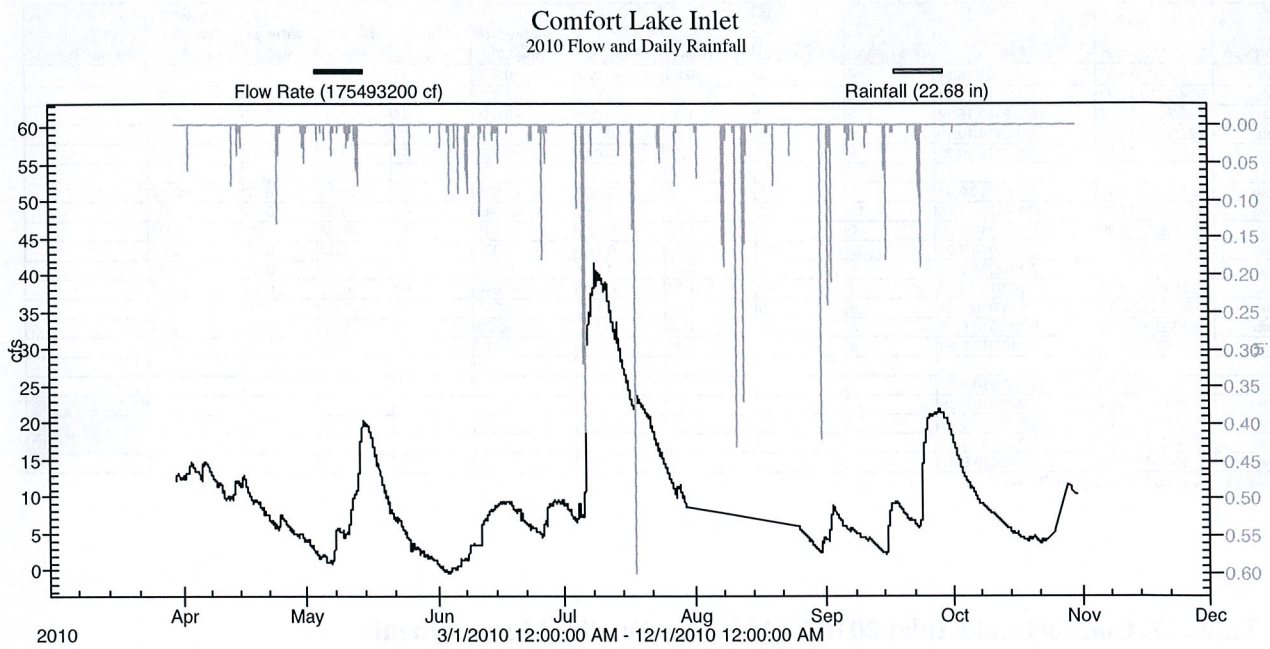


Figure 10. Comfort Lake Inlet 2010 Flow and Daily Rainfall

Grab samples were taken at the Comfort Lake Inlet site in 2010. The TSS, TKN, TP, VSS, Nitrate, Nitrite, Dissolved Phosphorus, Ammonia Nitrogen, Chloride and *E. Coli* results from all collected samples are listed in Table 16 and field water quality measurements are listed in Table 17. The highest TKN and TP concentrations were 2.00 mg/L, from a July 12th storm grab, and 0.673 mg/L, from a June 28th storm grab. The highest TSS concentration observed was 35 mg/L from a July 6th storm grab.

Table 16. Comfort Lake Inlet 2010 Sample Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved TP (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)	Ammonia Nitrogen (mg/L)	E. Coli (mpn/100ml)
Base Grab	4/29/2010 8:57	4/29/2010 8:57	4	~2	0.93	~0.023	~0.035	90	<0.03	0.10	<0.02	
Base Grab	5/24/2010 10:41	5/24/2010 10:41	~2	~2	1.50	0.081	~0.023	83	<0.03	0.16	0.22	
Base Grab	7/20/2010 15:17	7/20/2010 15:17	3	~2	1.30	0.086	~0.045	57	<0.03	0.07	<0.02	
Base Grab	8/23/2010 10:19	8/23/2010 10:19	6	~3	1.60	0.107	0.053	46	<0.03	0.08	0.30	
Base Grab	10/5/2010 10:52	10/5/2010 10:52	~1	~2	0.95	~0.032	~0.022	57	<0.03	0.19	~0.04	
Storm Grab	5/12/2010 9:41	5/12/2010 9:41	~1	~2	1.30	~0.032	~0.011	96	<0.03	0.07	<0.02	
Storm Grab	6/11/2010 11:45	6/11/2010 11:45	15	5	0.82	0.086	~0.040	61	<0.03	0.15	0.06	
Storm Grab	6/28/2010 9:00	6/28/2010 9:00	~2	~1	1.20	0.673	0.149	61	<0.03	0.09	0.06	
Storm Grab	7/6/2010 9:04	7/6/2010 9:04	35	10	1.70	0.135	0.060	29	<0.03	0.07	0.08	
Storm Grab	7/12/2010 9:26	7/12/2010 9:26	8	5	2.00	0.212	0.092	49	<0.03	<0.05	<0.02	
Storm Grab	7/28/2010 10:43	7/28/2010 10:43	3	~2	1.30	0.082	~0.040	50	<0.03	0.10	~0.03	
Storm Grab	8/9/2010 9:54	8/9/2010 9:54	6	3	1.40	0.115	0.051	72	<0.03	0.08	0.16	
Storm Grab	9/16/2010 9:13	9/16/2010 9:13	3	~1	1.30	~0.042	~0.02	71	0.07	0.25	0.18	
Storm Grab	9/24/2010 9:35	9/24/2010 9:35	5	3	1.40	0.054	~0.017	45	0.03	0.30	0.08	
E. Coli Grab	5/25/2010 8:45	5/25/2010 8:45										84
E. Coli Grab	6/24/2010 8:55	6/24/2010 8:55										206
E. Coli Grab	7/28/2010 10:43	7/28/2010 10:43										261
E. Coli Grab	8/26/2010 8:43	8/26/2010 8:43										161
E. Coli Grab	9/30/2010 8:51	9/30/2010 8:51										77

Exceeds Water Quality Standard

Table 17. Comfort Lake Inlet 2010 Field Water Quality Measurements

Date/Time	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/29/2010 8:57	>120	12.6	7.24		
5/12/2010 9:41	>120	8.1	7.53	689	7.9
5/24/2010 10:41	>120	22.1	2.87	597	7.5
6/11/2010 11:45	95	16.8	5.35	414	7
7/12/2010 9:26	41	21.0	0.56	413	6.6
7/20/2010 15:17	110	22.9	2.49		
7/28/2010 10:43	>120	23.1	3.71	437	7.6
8/9/2010 9:54	>120	24.4	2.65	621	6.8
8/23/2010 10:19	>120	23.5	2.49	474	7
8/26/2010 8:43	>120	18.0	4.09	491	8.2
9/16/2010 9:13		13.2	5.23	520	8.6
9/24/2010 9:35	110	14.8	4.42	386	7.3
10/5/2010 10:52	>120	10.8	6.29	507	7.5

Exceeds Water Quality Standard

Table 18. Comfort Lake Inlet 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac ft)	Interval TSS (lb)	Interval TP (lb)
*Base**			*3*	*0.066*	*1/1/10 0:00*	*3/30/10 9:45*	*15,276,600*	*350.9*	*3,052*	*62.8*
Base			*3*	*0.066*	*3/30/10 9:45*	*4/13/10 3:45*	*14,843,210*	*340.9*	*2,965*	*61.0*
Storm			*9*	*0.159*	*4/13/10 3:45*	*4/16/10 18:45*	*3,696,857*	*84.9*	*2,000*	*36.7*
Base Grab	4/29/2010 8:57	4/29/2010 8:57	4	0.023	4/16/10 18:45	5/7/10 10:45	9,728,228	223.4	2,429	14.0
Storm			*9*	*0.159*	*5/7/10 10:45*	*5/11/10 0:45*	*1,537,124*	*35.3*	*832*	*15.3*
Storm Grab	5/12/2010 9:41	5/12/2010 9:41	1	0.032	5/11/10 0:45	5/20/10 8:45	11,457,130	263.2	715	22.9
Base Grab	5/24/2010 10:41	5/24/2010 10:41	2	0.081	5/20/10 8:45	5/25/10 19:45	2,960,867	68.0	370	15.0
Base			*3*	*0.066*	*5/25/10 19:45*	*6/11/10 3:45*	*2,372,721*	*54.5*	*474*	*9.7*
Storm Grab	6/11/2010 11:45	6/11/2010 11:45	15	0.086	6/11/10 3:45	6/19/10 0:45	5,652,064	129.8	5,293	30.3
Base			*3*	*0.066*	*6/19/10 0:45*	*6/25/10 17:45*	*3,748,058*	*86.1*	*749*	*15.4*
Storm			*9*	*0.159*	*6/25/10 17:45*	*6/26/10 20:45*	*615,488*	*14.1*	*333*	*6.1*
Storm Grab	6/28/2010 9:00	6/28/2010 9:00	2	0.673	6/26/10 20:45	7/1/10 20:45	3,918,329	90.0	489	164.6
Base			*3*	*0.066*	*7/1/10 20:45*	*7/5/10 15:45*	*2,483,928*	*57.1*	*496*	*10.2*
Storm Grab	7/6/2010 9:04	7/6/2010 9:04	35	0.135	7/5/10 15:45	7/6/10 9:45	1,735,369	39.9	3,792	14.6
Storm Grab	7/12/2010 9:26	7/12/2010 9:26	8	0.212	7/6/10 9:45	7/12/10 10:45	19,537,090	448.7	9,757	258.6
Base Grab	7/20/2010 15:17	7/20/2010 15:17	3	0.086	7/12/10 10:45	7/27/10 18:45	28,003,120	643.2	5,244	150.3
Storm Grab	7/28/2010 10:43	7/28/2010 10:43	3	0.082	7/27/10 18:45	7/28/10 20:45	1,050,142	24.1	197	5.4
Base			*3*	*0.066*	*7/28/10 20:45*	*7/30/10 6:00*	*1,147,995*	*26.4*	*229*	*4.7*
*Base**			*3*	*0.066*	*7/30/10 6:00*	*8/9/10 3:45*	*5,135,400*	*118.0*	*1,026*	*21.1*
Storm Grab*	8/9/2010 9:54	8/9/2010 9:54	6	0.115	8/9/10 3:45	8/12/10 9:45	2,723,818	62.6	1,020	19.6
Base Grab*	8/23/2010 10:19	8/23/2010 10:19	6	0.107	8/12/10 9:45	8/25/10 14:45	6,847,200	157.3	2,565	45.7
Base			*3*	*0.066*	*8/25/10 14:45*	*8/31/10 2:45*	*1,967,780*	*45.2*	*393*	*8.1*
Storm			*9*	*0.159*	*8/31/10 2:45*	*9/2/10 2:45*	*713,675*	*16.4*	*386*	*7.1*
Storm			*9*	*0.159*	*9/2/10 2:45*	*9/4/10 21:45*	*1,775,198*	*40.8*	*960*	*17.6*
Base			*3*	*0.066*	*9/4/10 21:45*	*9/15/10 15:45*	*4,014,046*	*92.2*	*802*	*16.5*
Storm Grab	9/16/2010 9:13	9/16/2010 9:13	3	0.042	9/15/10 15:45	9/19/10 11:45	2,733,807	62.8	512	7.2
Base			*3*	*0.066*	*9/19/10 11:45*	*9/23/10 9:45*	*2,255,334*	*51.8*	*451*	*9.3*
Storm Grab	9/24/2010 9:35	9/24/2010 9:35	5	0.054	9/23/10 9:45	10/2/10 15:45	15,230,080	349.8	4,754	51.3
Base Grab	10/5/2010 10:52	10/5/2010 10:52	1	0.032	10/2/10 15:45	10/7/10 18:45	5,161,965	118.6	322	10.3
Base			*3*	*0.066*	*10/7/10 18:45*	*10/30/10 15:30*	*13,687,390*	*314.4*	*2,734*	*56.2*
*Base**			*3*	*0.066*	*10/30/10 15:30*	*1/1/11 0:00*	*26,937,000*	*618.7*	*5,381*	*110.6*
Storm Average			9	0.159						
Base Average			3	0.066						
All Average			7	0.126						
Total							**218,947,013**	**5,029**	**60,721**	**1,278**
CLFLWD Major Subwatershed Total Acres							13,732			
Total TP/TSS (lb/ac/yr)									4.42	0.09
Total TP/TSS (kg/ha/yr)									4.96	0.10

Italics indicate estimated concentrations based on average base and storm flow concentrations.

* Interval volumes from 1/1/10 to 3/30/10, 7/30/10 to 8/25/10 (no data), and 10/30/10 to 1/1/11 were estimated based upon base and storm flow.

Total phosphorus loading at the Comfort Lake Inlet for 2010 was estimated at 0.09 lb/ac (1,278 lbs.) (Table 18). Compared to the County Line Ditch site, the TP load at Big Comfort Inlet is higher. When looking at the last 3 years of data, it appears that roughly 50 percent of the load entering Comfort Lake originates from the County Line Ditch Site. Installing targeted BMP's in that subwatershed would help reduce the load entering Comfort Lake.

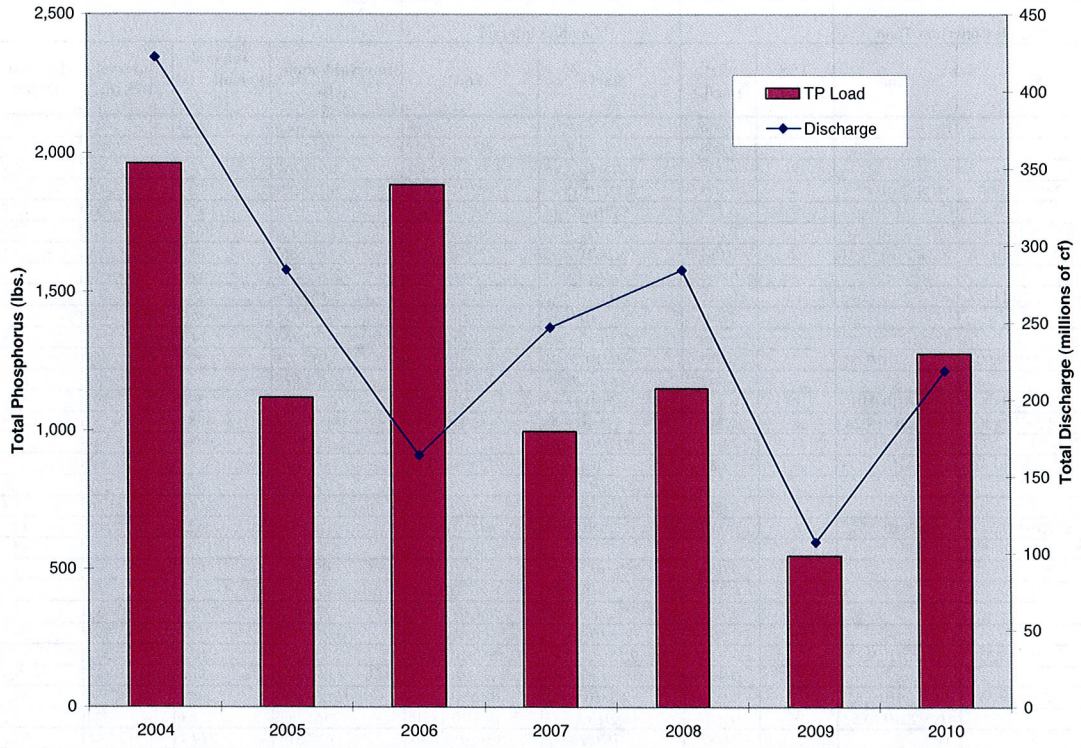


Figure 11. Comfort Lake Inlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Comfort Lake Inlet site since 2004. Estimated total annual phosphorus export and discharge can be seen in Figure 11. When making year-to-year comparisons of load estimates, it should be noted that the sampling technique changed from composite sampling in 2004-2006 to grab only sampling in 2007 –2010. Unlike the other sites with historic information available, there doesn't seem to be as great of an impact on the overall load estimation when switching between the two sampling methods. One potential cause of this could be that the Shallow Pond complex upstream of the site may be acting as a sink for nutrients, and settling them out before they reach this site.

Comfort Lake Outlet

The station for the Comfort Lake Outlet site recorded flow and rainfall from April 5-November 2, 2010 (Figure 12). Total flow for this period was 191,268,800 cf or 4,391 acre-ft. A rain gage was installed at this site in 2010, recording a total of 22.97 inches of precipitation. On July 10th, the highest flow was recorded for the monitoring season at 28.81 cfs. The cause of this high flow was a large rain event, totaling 3.00 inches, occurring July 5th and 6th. No water quality data was collected at the Comfort Lake Outlet site in 2010 by the WCD, but lake water quality samples were utilized to develop a loading estimate.

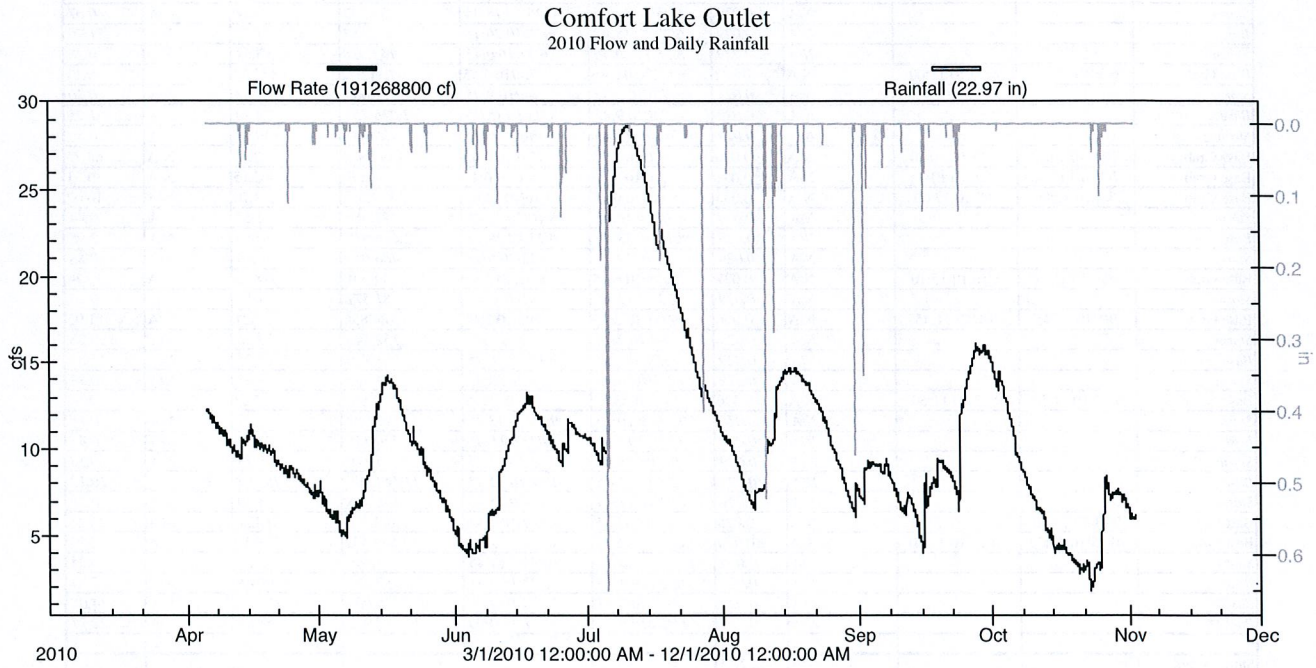


Figure 12. Comfort Lake Outlet 2010 Flow and Daily Rainfall

Table 19. Comfort Lake Outlet 2010 Total Phosphorus and Total Suspended Solids Loading

	Sample Collection Time				Loading Interval					
Sample Type	Start	End	TSS (mg/L)	TP (mg/L)	Start	End	Interval Volume (cf)	Interval Volume (ac-ft)	Interval TSS (lb)	Interval TP (lb)
*Base***			*N/A*	*0.029*	*1/1/10 0:00*	*4/5/10 11:45*	*28,573,650*	*656.30*	*N/A*	*51.73*
Base Grab	4/16/10 13:00	4/16/10 13:00	N/A	0.028	4/5/10 11:45	4/22/10 12:45	15,360,320	352.81	N/A	26.85
Base Grab	4/30/10 12:01	4/30/10 12:01	N/A	0.041	4/22/10 12:45	5/7/10 7:45	9,409,851	216.13	N/A	24.08
Storm			*N/A*	*0.029*	*5/7/10 7:45*	*5/7/10 15:45*	*158,452*	*3.64*	*N/A*	*0.29*
Base			*N/A*	*0.029*	*5/7/10 15:45*	*5/11/10 6:45*	*2,068,887*	*47.52*	*N/A*	*3.75*
Storm			*N/A*	*0.029*	*5/11/10 6:45*	*5/13/10 20:45*	*2,019,792*	*46.39*	*N/A*	*3.66*
Base Grab	5/14/10 13:10	5/14/10 13:10	N/A	0.028	5/13/10 20:45	6/8/10 4:45	18,877,520	433.59	N/A	33.00
Storm			*N/A*	*0.029*	*6/8/10 4:45*	*6/8/10 14:45*	*192,323*	*4.42*	*N/A*	*0.35*
Base Grab	6/10/10 12:10	6/10/10 12:10	N/A	0.020	6/8/10 14:45	6/11/10 3:45	1,402,819	32.22	N/A	1.75
Storm			*N/A*	*0.029*	*6/11/10 3:45*	*6/11/10 8:45*	*138,298*	*3.18*	*N/A*	*0.25*
Base			*N/A*	*0.029*	*6/11/10 8:45*	*6/25/10 17:45*	*13,724,080*	*315.23*	*N/A*	*24.85*
Storm			*N/A*	*0.029*	*6/25/10 17:45*	*6/25/10 18:45*	*36,357*	*0.84*	*N/A*	*0.07*
Base			*N/A*	*0.029*	*6/25/10 18:45*	*6/26/10 20:45*	*938,387*	*21.55*	*N/A*	*1.70*
Storm			*N/A*	*0.029*	*6/26/10 20:45*	*6/27/10 0:45*	*157,028*	*3.61*	*N/A*	*0.28*
Base Grab	6/29/10 11:00	6/29/10 11:00	N/A	0.022	6/27/10 0:45	7/4/10 6:45	6,634,632	152.39	N/A	9.11
Storm			*N/A*	*0.029*	*7/4/10 6:45*	*7/4/10 9:45*	*112,009*	*2.57*	*N/A*	*0.20*
Base			*N/A*	*0.029*	*7/4/10 9:45*	*7/5/10 15:45*	*1,075,453*	*24.70*	*N/A*	*1.95*
Storm			*N/A*	*0.029*	*7/5/10 15:45*	*7/6/10 0:45*	*476,168*	*10.94*	*N/A*	*0.86*
Base Grab	7/15/10 10:20	7/15/10 10:20	N/A	0.036	7/6/10 0:45	7/20/10 0:45	30,592,870	702.68	N/A	68.75
Base Grab	7/28/10 13:45	7/28/10 13:45	N/A	0.031	7/20/10 0:45	8/1/10 0:45	15,767,170	362.15	N/A	30.51
Base Grab	8/8/10 12:00	8/8/10 12:00	N/A	0.036	8/1/10 0:45	8/10/10 16:45	7,127,017	163.70	N/A	16.02
Storm			*N/A*	*0.029*	*8/10/10 16:45*	*8/10/10 23:45*	*242,681*	*5.57*	*N/A*	*0.44*
Base			*N/A*	*0.029*	*8/10/10 23:45*	*8/12/10 19:45*	*1,646,939*	*37.83*	*N/A*	*2.98*
Storm			*N/A*	*0.029*	*8/12/10 19:45*	*8/13/10 6:45*	*486,015*	*11.16*	*N/A*	*0.88*
Base Grab	8/16/10 15:10	8/16/10 15:10	N/A	0.027	8/13/10 6:45	8/31/10 2:45	18,211,310	418.29	N/A	30.70
Storm			*N/A*	*0.029*	*8/31/10 2:45*	*8/31/10 5:45*	*81,571*	*1.87*	*N/A*	*0.15*
Base Grab	9/1/10 11:45	9/1/10 11:45	N/A	0.026	8/31/10 5:45	9/2/10 2:45	1,184,856	27.21	N/A	1.92
Storm			*N/A*	*0.029*	*9/2/10 2:45*	*9/2/10 7:45*	*152,549*	*3.50*	*N/A*	*0.28*
Base			*N/A*	*0.029*	*9/2/10 7:45*	*9/15/10 16:45*	*8,761,730*	*201.25*	*N/A*	*15.86*
Storm			*N/A*	*0.029*	*9/15/10 16:45*	*9/15/10 23:45*	*181,335*	*4.17*	*N/A*	*0.33*
Base Grab	9/17/10 11:50	9/17/10 11:50	N/A	0.026	9/15/10 23:45	9/18/10 10:45	1,622,584	37.27	N/A	2.63
Storm			*N/A*	*0.029*	*9/18/10 10:45*	*9/18/10 13:45*	*98,983*	*2.27*	*N/A*	*0.18*
Base			*N/A*	*0.029*	*9/18/10 13:45*	*9/23/10 8:45*	*3,540,125*	*81.31*	*N/A*	*6.41*
Storm			*N/A*	*0.029*	*9/23/10 8:45*	*9/23/10 17:45*	*295,110*	*6.78*	*N/A*	*0.53*
Base			*N/A*	*0.029*	*9/23/10 17:45*	*10/2/10 12:45*	*11,143,400*	*255.95*	*N/A*	*20.17*
Storm			*N/A*	*0.029*	*10/2/10 12:45*	*10/2/10 15:45*	*156,123*	*3.59*	*N/A*	*0.28*
Base Grab	10/3/10 15:00	10/3/10 15:00	N/A	0.025	10/2/10 15:45	10/10/10 15:45	7,164,614	164.56	N/A	11.18
Base Grab	10/15/10 12:20	10/15/10 12:20	N/A	0.029	10/10/10 15:45	10/25/10 20:45	5,509,432	126.55	N/A	9.97
Storm			*N/A*	*0.029*	*10/25/10 20:45*	*10/26/10 4:45*	*139,566*	*3.21*	*N/A*	*0.25*
Base			*N/A*	*0.029*	*10/26/10 4:45*	*11/2/10 9:45*	*4,382,486*	*100.66*	*N/A*	*7.93*
*Base***			*N/A*	*0.029*	*11/2/10 9:45*	*11/20/10 9:45*	*7,776,000*	*178.61*	*N/A*	*14.08*
*Base***			*N/A*	*0.029*	*11/20/10 9:45*	*1/1/11 0:00*	*12,577,950*	*288.90*	*N/A*	*22.77*
Storm Average			N/A	N/A						
Base Average			N/A	0.029						
All Average			N/A	0.029						
Total							**240,198,442**	**5,517**	**N/A**	**450**
CLFLWD Major Subwatershed Total Acres							24,558			
Total TP/TSS (lb/ac/yr)									N/A	0.018
Total TP/TSS (kg/ha/yr)									N/A	0.021

*Italics indicate estimated concentrations based on average base and storm flow concentrations

** Interval volumes from 1/1/10 to 4/5/10 and 11/2/10 to 1/1/11 where estimated using base flow averages

Although no samples were collected at the Comfort Lake Outlet site in 2010, the WCD used in-lake concentrations from samples collected by a volunteer to estimate a total phosphorus load at this location. Total phosphorus loading at the Comfort Lake Outlet site and the entire Comfort Lake Forest Lake Watershed was estimated at 0.018 lbs./acre (450 lbs) (Table 19). This increase from 2009 is likely due to the overall increase in flow, and not necessarily due to increased nutrients entering the system. TP and TSS are captured in Big Comfort Lake and Little Comfort Lake resulting in lower load amounts leaving the watershed.

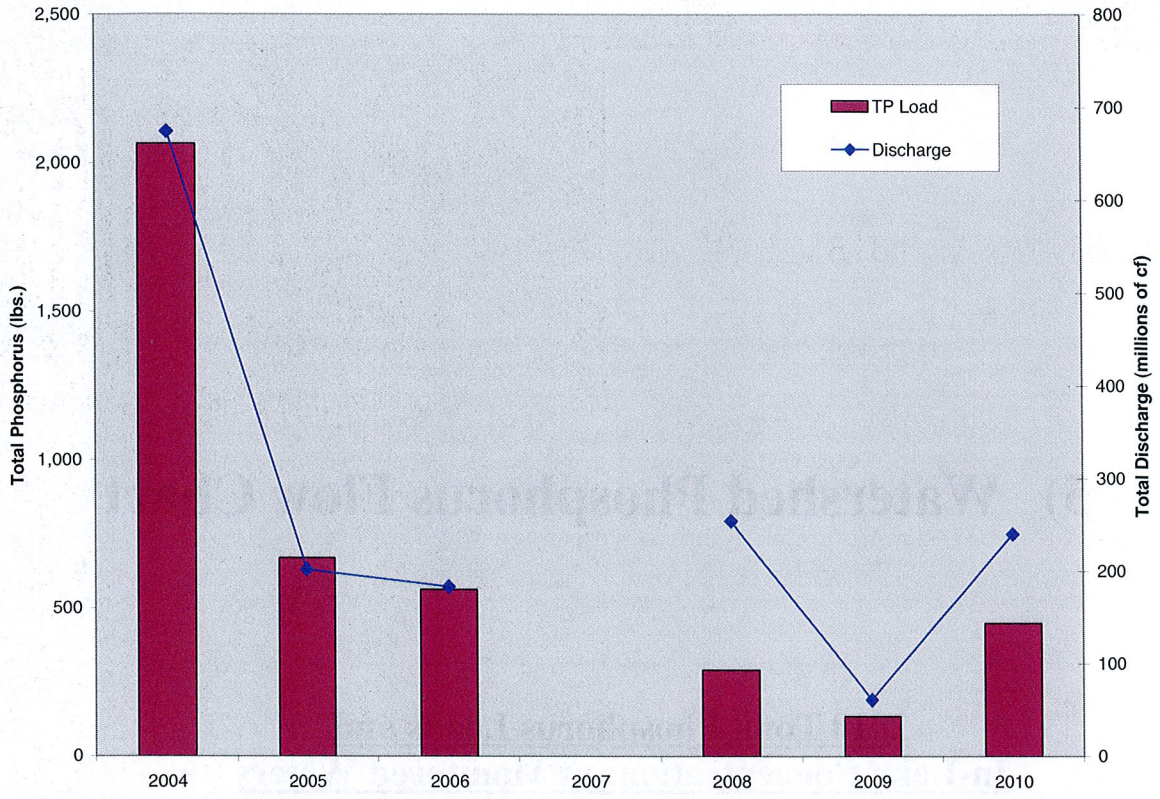


Figure 13. Comfort Lake Outlet Historic Annual Discharge and Total Phosphorus Load

Flow and water chemistry data has been collected at the Comfort Lake Outlet site since 2004. The equipment was installed but damaged in 2007, making no load or discharge data available from that year. Estimated total annual phosphorus export and discharge can be seen in Figure 13. When making year-to-year load comparisons, it should be noted that three different sampling methods have been employed at this site. Composite sampling was used in 2004-2005, and grab only sampling occurred in 2006. Grab samples were also taken in 2008, where sampling was on a set schedule and was not event based. In lake nutrient concentrations were used to develop an estimate of total phosphorus loads in 2009-2010. The sampling methods used in 2008-2010 do not necessarily characterize the full export accurately, as they do not represent the concentrations present during storm flow conditions. It is recommended that storm event weighted sampling resume at this site to better understand the load that is leaving the watershed.

5) Watershed Phosphorus Flow Chart

2010 Total Phosphorus Loads and In-Lake Concentrations at Monitored Waters

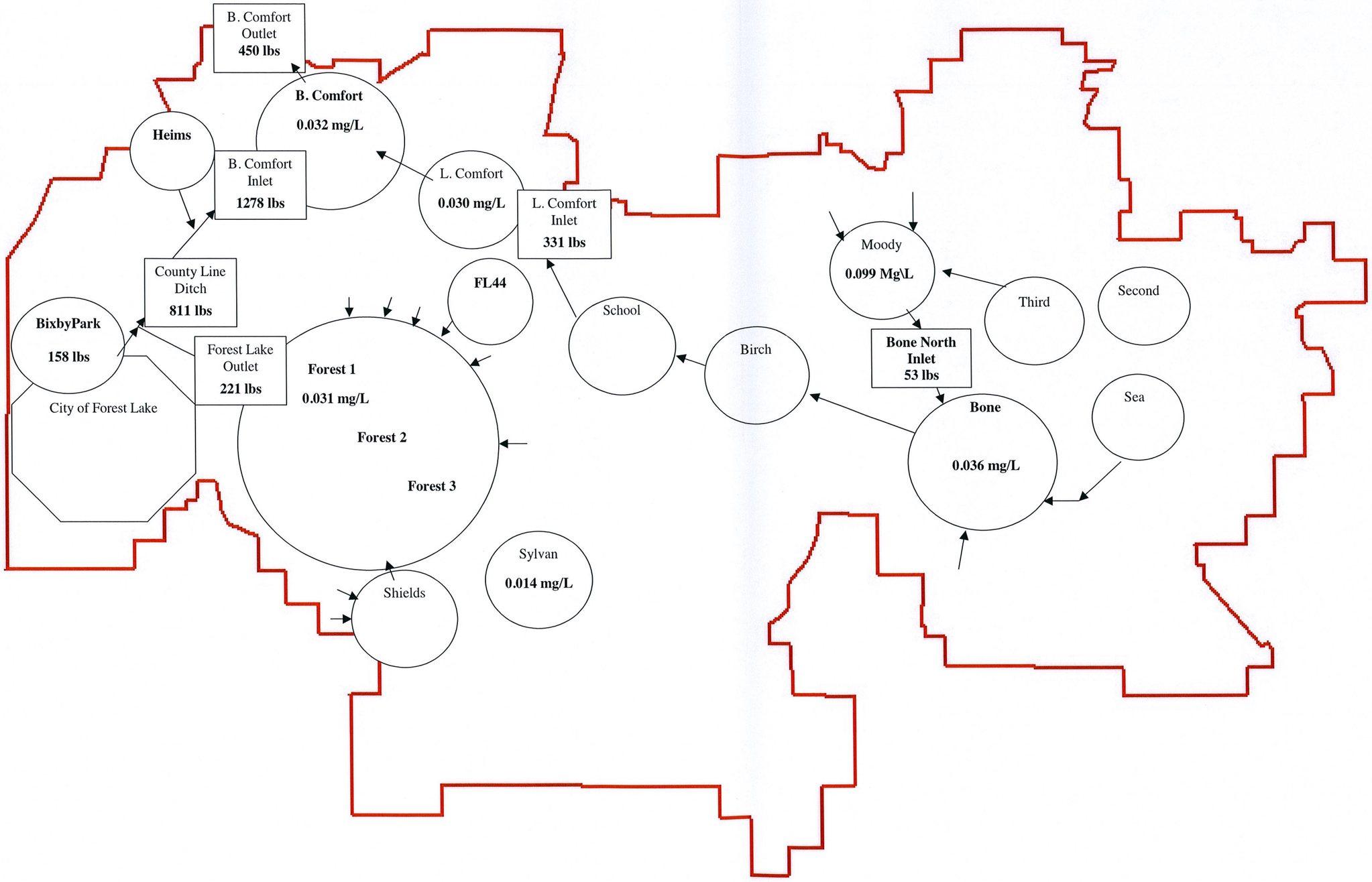


Figure 14. 2010 Watershed Summer Average Lake Phosphorus Concentrations and Total Phosphorus Load Water Quality Flow Chart

6) Historical Stream Loading, Discharge, and E. coli Summary

Table 20. CLFLWD Historical Stream Loading, Discharge and Rainfall Summary

			Growing Season (June 1-Sept 30) Discharge*		Yearly Estimated Discharge		Growing Season (June 1-Sept 30) Load*		Total Yearly Estimated Load		
Site	Year	Monitoring Season	Cubic Feet	Acre Feet	Cubic Feet	Acre Feet	TP (lbs.)	TSS (lbs.)	TP (lbs.)	TSS (lbs.)	Monitored Rainfall (inches)
Tributary to Sunrise River at Bone Lake North Inlet	2003	5/27/03-10/30/03	23,012,779	528	NA	NA	654	129,443	NA	NA	12.73
Tributary to Sunrise River at Bone Lake North Inlet	2005	3/29/05-11/1/05	3,370,684	77	14,075,577	323	89	14,745	226	24,817	20.73
Tributary to Sunrise River at Bone Lake North Inlet	2006	5/1/06-10/25/06	1,892,891	43	9,625,678	221	74	1,085	315	5,225	15.67
Tributary to Sunrise River at Bone Lake North Inlet	2010	4/5/10-11/1/10	1,519,181	35	5,475,569	126	17	742	53	2,588	19.33
Tributary to Sunrise River at Bone Lake Outlet	2003	5/27/03-10/30/03	45,627,921	1,047	NA	NA	297	66,763	NA	NA	12.35
Tributary to Sunrise River at Bone Lake Outlet	2004	3/24/04-11/2/04	27,081,226	622	66,316,511	1,522	146	14,138	339	35,283	18.03
Tributary to Sunrise River at Bone Lake Outlet	2005	3/29/05-11/1/05	7,753,089	178	26,115,815	600	36	30,343	97	38,776	18.27
Tributary to Sunrise River at Bone Lake Outlet	2006	5/1/06-10/30/06	6,821,497	157	23,460,532	539	14	1,018	49	3,158	14.08
Tributary to Sunrise River at Bone Lake South Inlet	2005	4/5/05-11/1/05	4,581,651	105	23,004,776	528	117	34,695	231	41,383	No Data Available at Site
Tributary to Sunrise River at Bone Lake South Inlet	2006	5/1/06-10/30/06	2,278,834	52	15,794,923	363	71	4,734	229	14,324	No Data Available at Site
Tributary to Sunrise River at Shields Outlet/Forest Inlet	2005	4/20/05-11/1/05	11,446,896	263	27,638,328	634	237	19,188	420	79,186	19.63
Tributary to Sunrise River at Shields Outlet/Forest Inlet	2006	5/2/06-10/30/06	4,119,142	95	17,784,049	408	92	3,372	332	8,620	13.18
Sunrise River at Forest Lake Outlet	2003	5/29/03-10/11/03	134,712,756	3,093	NA	NA	551	209,614	NA	NA	No Data Available at Site
Sunrise River at Forest Lake Outlet	2004	3/31/04-11/2/04	93,716,849	2,151	233,100,967	5,351	598	107,761	1,235	167,533	No Data Available at Site
Sunrise River at Forest Lake Outlet	2005	3/24/05-11/2/05	59,097,451	1,357	187,748,294	4,310	141	27,981	457	83,383	No Data Available at Site
Sunrise River at Forest Lake Outlet	2006	5/2/06-10/25/06	21,006,901	482	92,349,949	2,120	41	5,738	173	24,263	No Data Available at Site
Sunrise River at Forest Lake Outlet	2007	3/26/07-10/29/07	5,378,189	123	128,950,817	2,960	8	NA	253	NA	No Data Available at Site
Sunrise River at Forest Lake Outlet	2008	4/3/08-11/3/08	41,809,187	960	159,233,702	3,656	81	NA	341	NA	No Data Available at Site
Sunrise River at Forest Lake Outlet	2009	4/9/09-11/2/09	373,155	9	31,187,212	716	1	NA	43	NA	No Data Available at Site
Sunrise River at Forest Lake Outlet	2010	3/30/10-11/2/10	65,644,741	1,507	133,406,543	3,063	117	NA	221	NA	No Data Available at Site
Sunrise River at Bixby Park	2009	5/7/09-10/20/09	11,602,336	266	22,103,528	507	103	5,212	179	9,317	No Data Available at Site
Sunrise River at Bixby Park	2010	3/30/10-11/1/10	15,997,632	367	21,072,618	484	121	7,639	158	9,737	No Data Available at Site
Sunrise River at County Line Ditch	2007	3/27/07-10/29/07	13,265,950	305	168,125,270	3,860	420	35,317	1,212	109,981	20.65
Sunrise River at County Line Ditch	2008	4/3/08-11/4/08	46,128,347	1,059	167,318,507	3,841	216	67,304	650	144,481	16.85
Sunrise River at County Line Ditch	2009	4/3/09-11/3/09	15,225,062	350	71,188,173	1,634	45	2,364	85	5,403	17.52
Sunrise River at County Line Ditch	2010	3/31/10-11/1/10	104,422,088	2,397	182,196,709	4,183	524	41,009	811	69,760	23.86
Sunrise River at Greenway Avenue	2008	4/14/08-11/4/08	64,476,470	1,480	231,516,014	5,315	499	233,541	1,505	696,004	No Data Available at Site
Tributary to Sunrise River at Manning Trail	2008	4/21/08-11/3/08	7,613,182	175	63,196,487	1,451	41	1,232	508	7,421	No Data Available at Site
Tributary to Sunrise River at Manning Trail	2009	4/2/09-11/2/09	759,696	17	11,231,268	258	7	265	104	3,718	No Data Available at Site
Tributary to Sunrise River at July Avenue	2008	4/17/08-11/3/08	22,886,998	525	80,937,662	1,858	146	5,316	431	14,137	17.25
Tributary to Sunrise River at July Avenue	2009	4/2/09-11/2/09	3,759,027	86	27,127,126	623	23	1,295	151	9,112	17.92
Tributary to Sunrise River at Little Comfort Lake Inlet	2004	5/4/04-11/2/04	79,549,516	1,826	172,272,256	3,955	584	474,947	1,283	1,220,397	19.59
Tributary to Sunrise River at Little Comfort Lake Inlet	2005	3/29/05-11/2/05	56,782,372	1,304	149,011,733	3,421	461	211,373	1,023	697,890	21.99
Tributary to Sunrise River at Little Comfort Lake Inlet	2006	5/4/06-10/30/06	42,677,774	980	131,946,491	3,029	834	411,398	1,551	643,540	16.89
Tributary to Sunrise River at Little Comfort Lake Inlet	2007	4/26/07-10/30/07	54,709,030	1,256	173,218,653	3,977	202	13,620	676	43,113	23.65
Tributary to Sunrise River at Little Comfort Lake Inlet	2008	4/22/08-11/3/08	93,791,250	2,153	360,171,837	8,268	256	23,369	1,127	94,344	16.35
Tributary to Sunrise River at Little Comfort Lake Inlet	2009	4/9/09-11/2/09	26,119,773	600	101,219,564	2,324	119	12,439	418	34,444	17.34
Tributary to Sunrise River at Little Comfort Lake Inlet	2010	3/30/10-10/15/10	56,666,594	1,301	103,234,147	2,370	188	9,260	331	18,146	23.58
Sunrise River at Comfort Lake Inlet	2004	4/5/04-11/2/04	147,834,005	3,394	422,272,825	9,694	899	255,626	1,963	403,759	20.97
Sunrise River at Comfort Lake Inlet	2005	3/29/05-11/2/05	93,498,873	2,146	284,332,944	6,527	392	33,117	1,119	125,039	22.48
Sunrise River at Comfort Lake Inlet	2006	5/2/06-10/30/06	40,363,884	927	163,858,477	3,762	913	52,781	1,887	175,089	18.27
Sunrise River at Comfort Lake Inlet	2007	3/26/07-10/30/07	39,591,680	909	247,038,494	5,671	242	15,064	997	63,755	22.42
Sunrise River at Comfort Lake Inlet	2008	4/3/08-9/24/08	109,097,724	2,505	284,321,095	6,527	482	85,171	1,153	196,267	18.24
Sunrise River at Comfort Lake Inlet	2009	4/3/09-11/2/09	33,167,079	761	107,548,295	2,469	155	7,325	547	21,691	17.80
Sunrise River at Comfort Lake Inlet	2010	3/30/10-10/30/10	113,660,642	2,609	218,947,013	5,026	874	39,921	1,278	60,721	22.68
Sunrise River at Comfort Lake Outlet	2003	5/29/03-11/3/03	361,495,072	8,299	NA	NA	1,308	285,063	NA	NA	13.09
Sunrise River at Comfort Lake Outlet	2004	3/22/04-11/2/04	249,741,973	5,733	673,985,011	15,473	1,076	401,584	2,065	566,195	21.68
Sunrise River at Comfort Lake Outlet	2005	3/24/05-11/2/05	85,981,864	1,974	201,840,954	4,634	326	153,936	670	251,622	22.32
Sunrise River at Comfort Lake Outlet	2006	5/2/06-10/30/06	51,812,383	1,189	183,293,248	4,208	122	16,097	563	60,519	18.32
Sunrise River at Comfort Lake Outlet	2007	3/26/07-7/12/07	NA	NA	NA	NA	NA	NA	NA	NA	21.42
Sunrise River at Comfort Lake Outlet	2008	5/1/08-11/3/08	73,273,609	1,682	254,442,469	5,841	99	21,762	291	62,469	16.53
Sunrise River at Comfort Lake Outlet	2009	4/22/09-11/2/09	17,619,711	404	61,039,355	1,401	34	NA	134	NA	No Data Available at Site
Sunrise River at Comfort Lake Outlet	2010	4/5/10-11/2/10	144,901,319	3,326	240,198,442	5,514	273	NA	450	NA	22.97

*Growing season discharge and loads include quantities estimated from just previous to and including June 1, and just post and including Sept 30.

E. coli

The Minnesota Pollution Control Agency has set water quality standards for Class 2 Waters of the State for aquatic life and recreation (https://www.revisor.mn.gov/rules/?id=7050.0222). The following is the description for the Escherichia (E.) coli standard:

> "Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31."

Monthly Geometric Means for E. coli (#/100 mL)

Site	April	May	June	July	August	September	October
Bone Lake North Inlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bone Lake South Inlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bone Lake Outlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Shields Outlet/Forest Inlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Forest Lake Outlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bixby Park	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
County Line Ditch	Insufficient Data	Insufficient Data	59	102	141	Insufficient Data	Insufficient Data
Greenway Avenue	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Manning Trail	Insufficient Data	Insufficient Data	99	152	415	Insufficient Data	Insufficient Data
July Avenue	Insufficient Data	Insufficient Data	21	56	208	Insufficient Data	Insufficient Data
Little Comfort Inlet	Insufficient Data	Insufficient Data	66	175	209	Insufficient Data	Insufficient Data
Big Comfort Lake Inlet	Insufficient Data	Insufficient Data	176	159	241	Insufficient Data	Insufficient Data
Big Comfort Lake Outlet	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data

Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month

10% of samples taken in the last 10 years exceed 1260 #/100mL (Doesn't necessarily exceed geometric mean standard)

Site	Date	E. Coli (#/100ml)
Greenway Avenue	6/5/2008 9:50	31
	6/26/2008 10:00	126
	7/17/2008 7:38	147
	8/7/2008 8:45	326
	8/27/2008 9:40	104
Shields Outlet/Forest Inlet	5/5/2005 8:15	27
	7/13/2005 9:15	120
	10/19/2005 9:30	14
	6/14/2006 9:15	66
	10/10/2006 9:00	59
Forest Lake Outlet	7/22/2003 10:25	13
	6/8/2004 8:45	3
	7/15/2004 8:45	18
	5/5/2005 8:30	59
	7/13/2005 9:30	126
	10/19/2005 9:45	19
	6/14/2006 9:30	10
	8/10/2006 9:15	44
	9/6/2006 9:30	13
Bone Lake South Inlet	5/5/2005 8:30	13
	7/13/2005 10:45	567
	10/19/2005 10:45	95
	6/14/2006 10:30	345
	8/10/2006 8:30	96
	9/6/2006 8:15	250
	10/10/2006 10:00	115

Site	Date	E. Coli (#/100ml)
Bone Lake North Inlet	7/22/2003 9:40	69
	9/11/2003 8:45	1638
	10/7/2003 10:15	44
	10/28/2003 8:25	28
	5/5/2005 8:15	26
	7/13/2005 10:30	384
	10/19/2005 11:00	38
	6/14/2006 10:20	32
	8/10/2006 8:45	411
	9/6/2006 8:45	238
	5/25/2010 9:26	17
	6/24/2010 9:35	74
Bone Lake Outlet	7/22/2003 9:20	<1
	9/11/2003 8:55	265
	6/8/2004 10:00	3
	7/15/2004 10:00	2
	8/12/2004 9:15	139
	5/5/2005 8:15	1
	7/13/2005 10:30	<1
	10/19/2005 11:00	2
	6/14/2006 10:25	1
	7/24/2006 10:30	727
	8/10/2006 8:50	26
	9/6/2006 8:30	33

Site	Date	E. Coli (#/100ml)
Bixy Park	6/16/2009 9:15	7
	6/23/2009 8:15	30
	6/30/2009 9:09	63
	7/15/2009 8:54	>2420
	7/21/2009 8:45	>2420
	7/28/2009 8:00	579
	8/11/2009 8:30	43
	8/18/2009 8:30	41
	8/26/2009 8:34	192
	5/25/2010 8:17	125
	7/28/2010 10:04	1300
Big Comfort Lake Inlet	6/8/2004 9:00	19
	7/15/2004 9:15	50
	8/12/2004 8:30	176
	9/27/2004 9:30	22
	5/5/2005 8:45	302
	7/13/2005 9:45	158
	8/25/2005 8:45	435
	10/19/2005 10:00	32
	6/14/2006 9:45	128
	7/24/2006 9:45	387
	8/10/2006 9:00	291
	9/6/2006 10:00	261
	5/2/2007 11:00	31
	6/13/2007 9:43	115
	7/16/2007 10:23	127
	10/18/2007 9:48	649
	6/5/2008 10:35	86
	6/12/2008 9:07	365
	6/19/2008 9:00	150
	6/26/2008 9:45	249
	6/30/2008 9:28	206
	7/7/2009 9:30	115
	7/14/2008 10:00	160
	7/17/2008 7:50	238
	7/24/2008 8:40	172
	7/31/2008 9:30	167
	8/7/2008 9:00	649
	8/11/2008 9:30	179
	8/14/2008 9:08	387
	8/21/2008 9:10	150
	8/27/2008 9:25	326
	5/28/2009 9:15	41
	6/25/2009 9:00	>2420
	7/29/2009 8:54	118
	8/27/2009 10:25	84
	9/30/2009 9:13	152
	5/25/2010 8:45	84
	6/24/2010 8:55	206
	7/28/2010 10:43	261
	8/26/2010 8:43	161
	9/30/2010 8:51	77
Big Comfort Lake Outlet	7/22/2003 10:00	3
	9/11/2003 8:25	34
	10/7/2003 10:00	13
	10/28/2003 8:10	3
	6/8/2004 9:15	6
	7/15/2004 9:30	6
	8/12/2004 8:45	32
	9/27/2004 9:45	14
	5/5/2005 8:45	3
	7/13/2005 10:00	14
	10/19/2005 10:15	6
	6/14/2006 9:55	42
	7/24/2006 10:00	111
	8/10/2006 9:00	17
	9/6/2006 9:15	18
	10/10/2006 9:20	10

Site	Date	E. Coli (#/100ml)
County Line Ditch	5/2/2007 10:45	22
	6/13/2007 10:02	186
	7/16/2007 10:37	>2420
	10/18/2007 10:23	328
	6/5/2008 9:55	20
	6/12/2008 8:46	1300
	6/19/2008 8:50	28
	6/26/2008 10:15	18
	6/30/2008 9:07	34
	7/7/2008 9:45	66
	7/14/2008 9:45	45
	7/17/2008 7:22	162
	7/24/2008 8:25	140
	7/31/2008 10:00	129
	8/4/2008 9:20	131
	8/7/2008 8:30	142
	8/14/2008 8:43	218
	8/21/2008 9:25	210
	8/27/2008 9:50	>2420
	5/28/2009 9:30	1120
	6/25/2009 8:30	>2420
	7/29/2009 8:37	29
	8/27/2009 10:15	68
	9/30/2009 8:56	44
	5/25/2010 8:32	93
	6/24/2010 8:41	31
	7/28/2010 10:18	461
	8/26/2010 9:00	135
	9/30/2010 8:34	64
Manning Trail	6/5/2008 9:15	249
	6/12/2008 9:52	417
	6/19/2008 9:35	71
	6/26/2008 9:15	41
	6/30/2008 10:08	26
	7/7/2008 8:50	102
	7/14/2008 10:03	118
	7/17/2008 8:21	214
	7/24/2008 9:16	115
	7/31/2008 8:30	272
	8/4/2008 8:30	88
	8/7/2008 9:30	195
	8/14/2008 9:47	205
	8/21/2008 8:30	248
	8/27/2008 8:50	>2420
	5/28/2009 8:45	58
	6/10/2009 8:10	119
	8/26/2009 8:00	>2420
July Avenue	6/5/2008 9:18	23
	6/12/2008 9:37	52
	6/19/2008 9:25	10
	6/26/2008 9:20	15
	6/30/2008 9:56	12
	7/7/2008 9:05	11
	7/14/2008 9:10	19
	7/17/2008 8:12	125
	7/24/2008 9:04	56
	7/31/2008 9:00	38
	8/4/2008 8:45	46
	8/7/2008 9:20	88
	8/14/2008 9:36	144
	8/21/2008 8:45	411
	8/27/2008 9:00	980
	5/28/2009 9:00	126
	6/10/2009 8:20	37
	7/28/2009 8:00	579
	8/26/2009 8:11	345

Site	Date	E. Coli (#/100ml)
Little Comfort Inlet	6/8/2004 9:45	16
	7/15/2004 9:45	16
	8/12/2004 9:00	195
	9/27/2004 10:00	126
	5/5/2005 9:00	4
	7/13/2005 10:00	69
	10/19/2005 10:30	21
	6/14/2006 10:05	108
	7/24/2006 10:15	214
	8/10/2006 8:45	461
	9/6/2006 9:00	166
	10/10/2006 9:40	101
	5/2/2007 11:10	30
	6/13/2007 9:28	109
	7/16/2007 10:10	147
	10/18/2007 9:32	41
	6/5/2008 9:30	38
	6/12/2008 9:27	148
	6/19/2008 9:15	31
	6/26/2008 9:35	63
	6/30/2008 9:45	23
	7/7/2008 9:20	72
	7/14/2008 9:20	225
	7/17/2008 8:01	1733
	7/24/2008 8:53	365
	7/31/2008 9:15	145
	8/4/2008 9:00	261
	8/7/2008 9:10	687
	8/14/2008 9:22	172
	8/21/2008 9:00	56
	8/27/2008 9:15	261
	6/10/2009 8:30	548
	7/28/2009 8:10	201
	5/25/2010 8:59	866
	6/24/2010 9:08	121
	7/28/2010 11:01	210
	8/26/2010 8:30	91
	9/30/2010 9:05	201

Note: When fecal coliform samples were collected, results were converted to equivalent *E. coli* values.

7) Appendices and References

Appendix A – Individual Lake Summaries
References

COMFORT LAKE - FOREST LAKE WATERSHED DISTRICT LAKE WATER QUALITY SUMMARY

Lake	Acres	DNR ID	Most Recent Phosphorous Average (ug/L)	Year	Grade	Listed by MPCA as Impaired for Phosphorous	Water Qulaity Trend	
Bone	210	820054	37	2010	C	X	+	
Birch	33	130042	60	2007	C		N/A	
Comfort	218	130053	28	2010	B	X	=	
Forest (west)	2251	820156	31	2010	B		=	
Forest (center)	2251	820156	31	2006	B		N/A	
Forest (east)	2251	820156	32	2006	B		N/A	
Heims	90	130056	37	2009	C		N/A	
Little Comfort	36	130054	28	2010	B		N/A	
Moody	35	130023	81	2010	D	X	N/A	
Second	75	130025	54	2008	C		N/A	shallow Lake
School	47	130057	47	2009	C	X	+	
Sea	50	820053	122	2009	D		N/A	
Shields	26	820162	233	2007	F	X	N/A	
Sylvan	84	820080	14	2010	A		=	
Third Lake	42	130024	14	2008	A		N/A	

Grade

Grade is determinied by the most recetn summer-average for phosphorus. The scale used to assign grades is the same used by Metropolitan Council

A<23 B 23-32
C32-68 D68-152
F>152

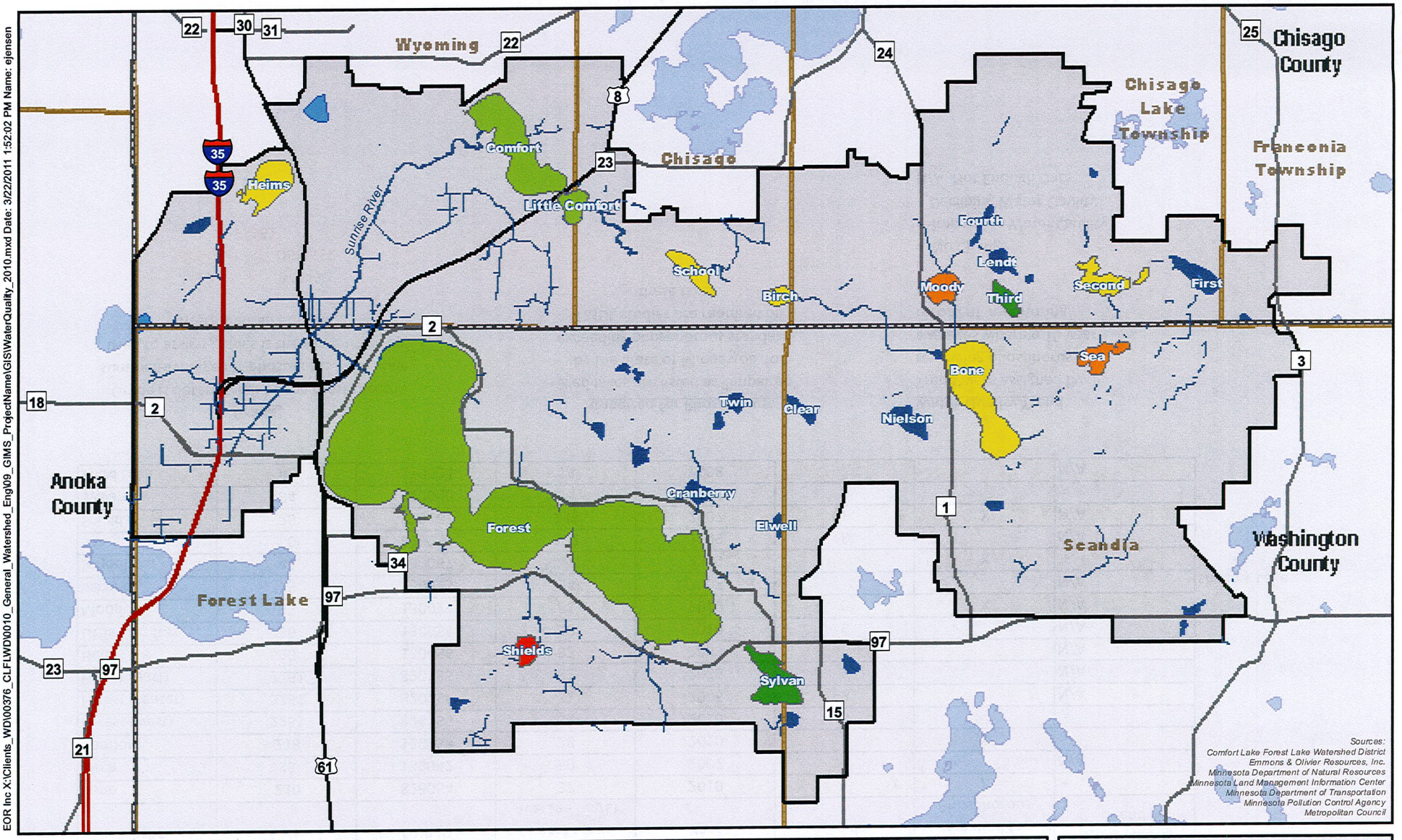
Impaired for Phosphorus

X'ed lakes are listed as "impaired" by the State of Minnestoa for exceeding phosphorous standards. TMDL studies are required on these lakes.

Water Quality Trend

Trend were assigned by reviewing phosphorus averages where a 10 year record of monitoring exists

= No Change
+ Improving Water Qaulity
- Declining Water Qaulity
N/A Not Enough Data



Sources:
Comfort Lake Forest Lake Watershed District
Emmons & Olivier Resources, Inc.
Minnesota Department of Natural Resources
Minnesota Land Management Information Center
Minnesota Department of Transportation
Minnesota Pollution Control Agency
Metropolitan Council

Political Boundary
County Boundary
Muncipal Boundary

2010 Lake Grade
- A
- B
- C
- D
- F

EOR
www.eorinc.com

N

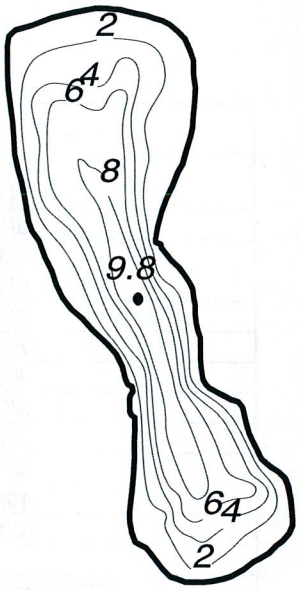
0 0.5 1 2 Miles

EOR Inc X:\Clients_WD\00376_CLFLWD\0010_General_Watershed_Eng\09_GIMS_ProjectName\GIS\WaterQuality_2010.mxd Date: 3/22/2011 1:52:02 PM Name: ejensen

Bone Lake

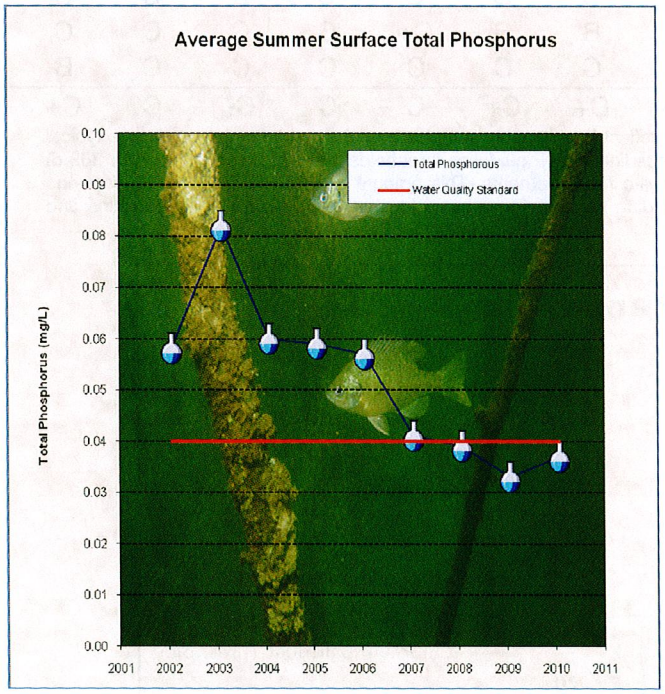
2010 Lake Grade: C+

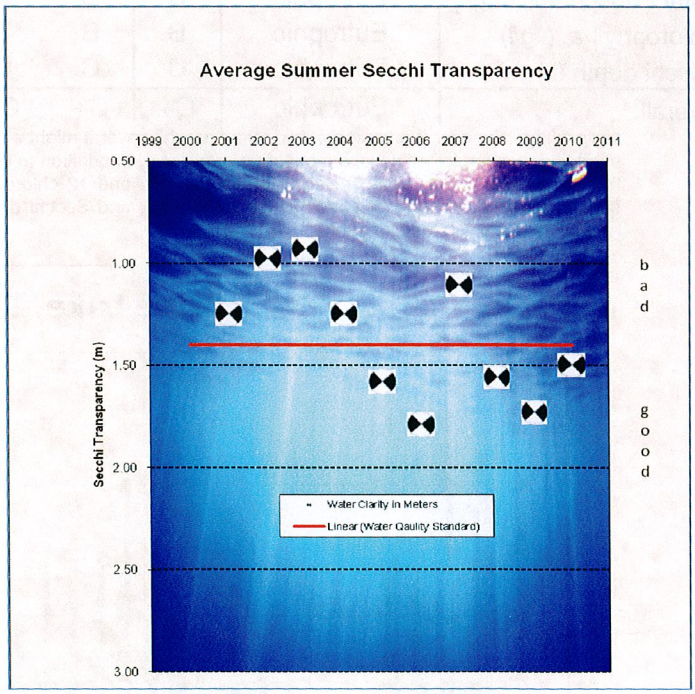
- DNR ID #: 820054
- Municipality: City of Scandia
- Location: Section 5 T32N-R20W
- Lake Size: 210 Acres
- Maximum Depth: 32 ft
- Ordinary High Water Mark: 909.1 ft
- 58% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Bone Lake was considered a eutrophic lake in 2010, based on the Carlson Trophic State Index (similar to 2006-2009).
- Bone Lake's summer phosphorus mean was lower than that experienced in 2003-2008.
- **Bone Lake is listed on the MPCA's Impaired Waters List for excessive nutrients.**
- **Eurasian Milfoil and Curly leaf pondweed (invasive aquatic plants) are extensive in this lake.**
- **Carp removal was done in winter of 2011.**
- The major land use is rural/agricultural.
- The lake does stratify throughout the summer months.





2010 WATER QAULITY READINGS

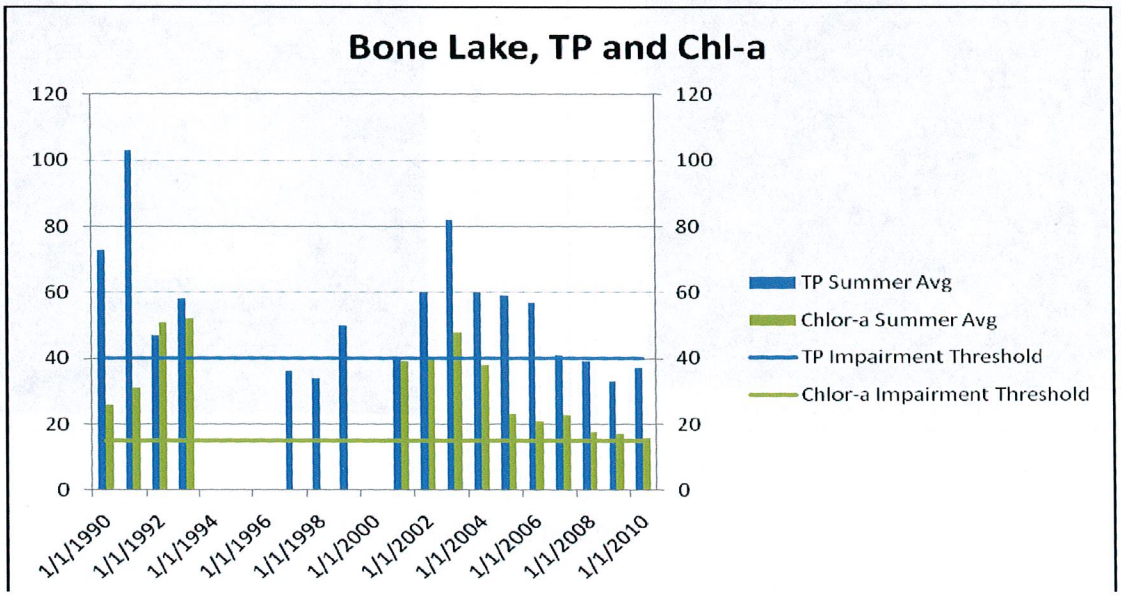
Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
5/16/10	0.024	20	0.99	2
5/31/10	0.017	4.5	0.89	2.1
6/15/10	0.024	14	0.91	2
6/20/10	0.028	12	1	1.8
7/19/10	0.02	5.7	0.88	1.7
8/6/10	0.029	6.4	1	2
8/28/10	0.077	10	0.94	1.5
9/8/10	0.043	9.8	1.3	1
9/19/10	0.03	26	1.1	1.4
10/1/10	0.034	34	1.1	1.4
10/15/10	0.035	24	1.3	1.2
2010 Summer Average	0.037	15.988	1.078	1.500
Water Quality threshold is 0.04 mg/L TP or higher*				

	High	High Date	Low	Low Date	Average
2010 Elevation (ft)	NA	NA	NA	NA	NA

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary

	Trophic Status	Lake Grades										
	2009	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Eutrophic	C	C	C	C	C	C	C	D	C	C	C
Chlorophyll-*a* (ug/l)	Eutrophic	B	B	B	B	B	C+	C	C	C	C	C
Secchi depth (ft)	Eutrophic	C	C	C	C	C	C	C	C	C	B	C
Overall	Eutrophic	C+	C+	C+	C+	C+	C	C	C-	C	C+	C



BONE LAKE
WATER SURFACE ELEVATION STATISTICS

Outlet Elevation (culvert) = 907.3

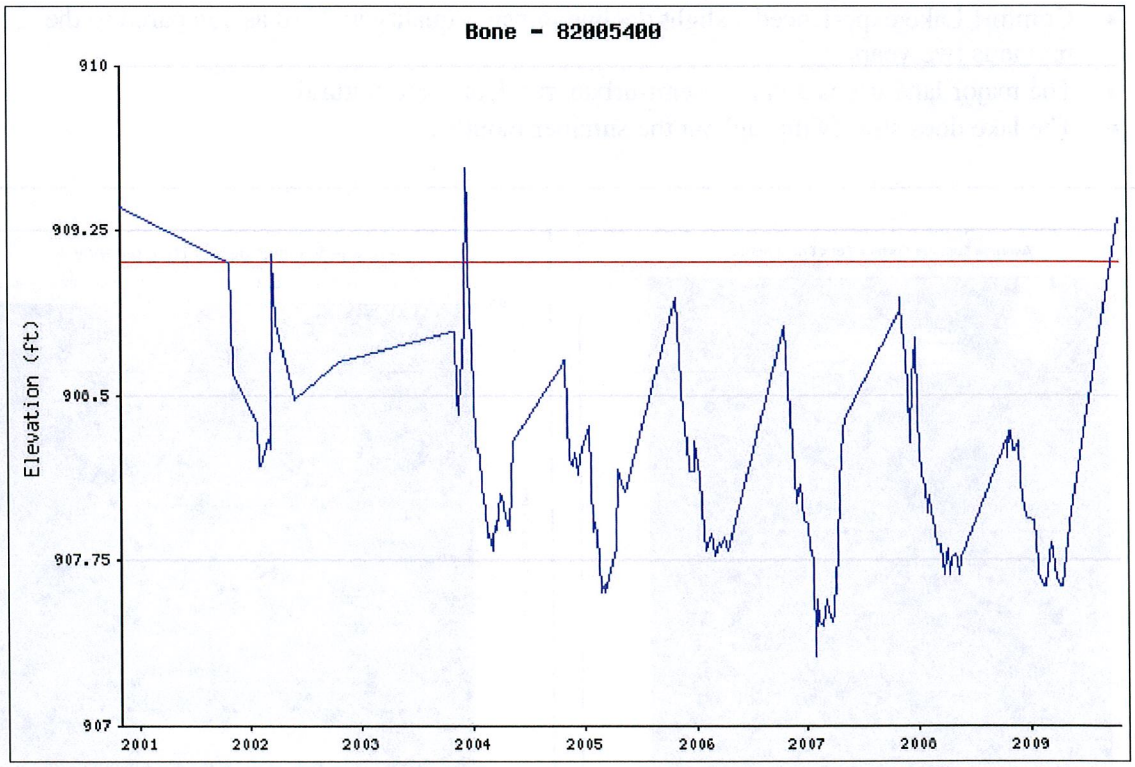
Ordinary High Water Level (OHW) elevation = 909.1

100 Year Flood Elevation (CLFLWD) = 910.6

Highest recorded: 910.97 ft (07/07/1975)

Lowest recorded: 906.7 ft (11/07/1966)

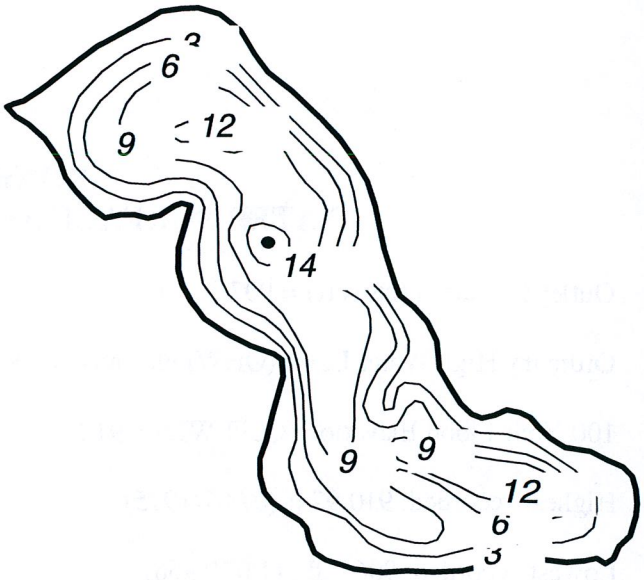
Datum: NGVD 29 (ft)



Comfort Lake

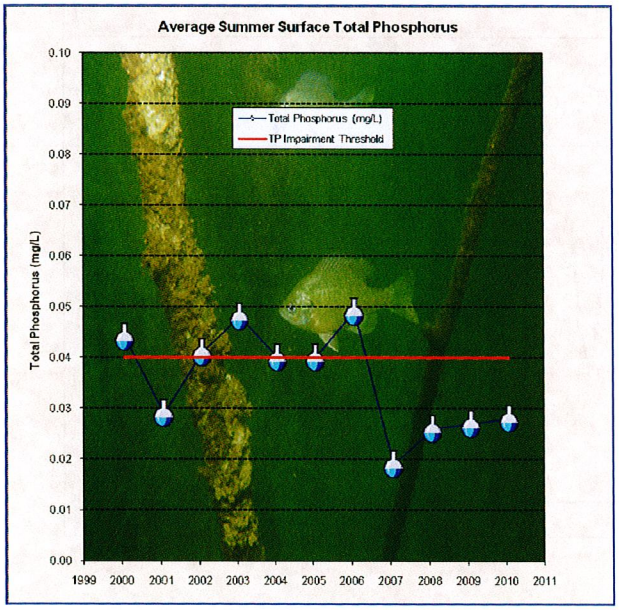
2010 Lake Grade: B-

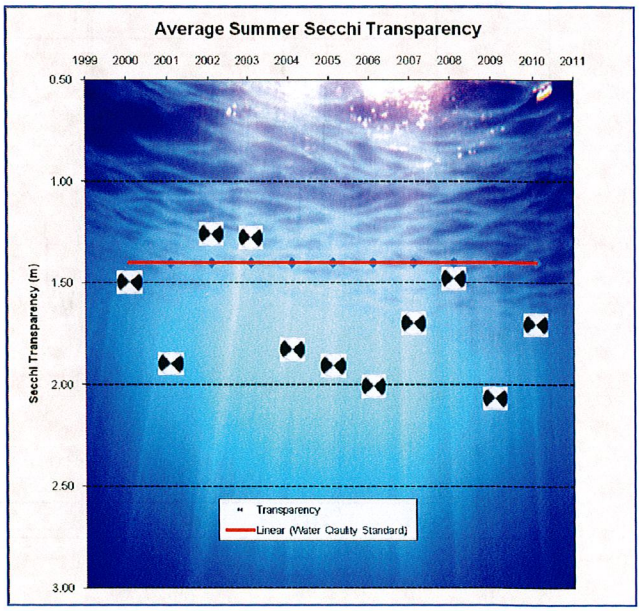
- DNR ID #: 130053
- Municipality: City of Wyoming
- Location: Section 27 T33N-R21W
- Lake Size: 218 Acres
- Maximum Depth: 47 ft
- Ordinary High Water Mark: 887.2 ft
- 41% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Comfort Lake was considered a mesotrophic lake in 2010, based on the Carlson Trophic State Index (similar to that experienced in 2007-2009 and better than 2002-2006).
- **Comfort Lake is listed on the MPCA's Impaired Waters List for excessive nutrients.**
- **Curly leaf pondweed (an invasive aquatic plant) is extensive in this lake.**
- Comfort Lake experienced a slight decline in water quality in 2010 as compared to the previous two years.
- The major land use is a mix of semi-urban, rural, and agricultural.
- The lake does stratify throughout the summer months.





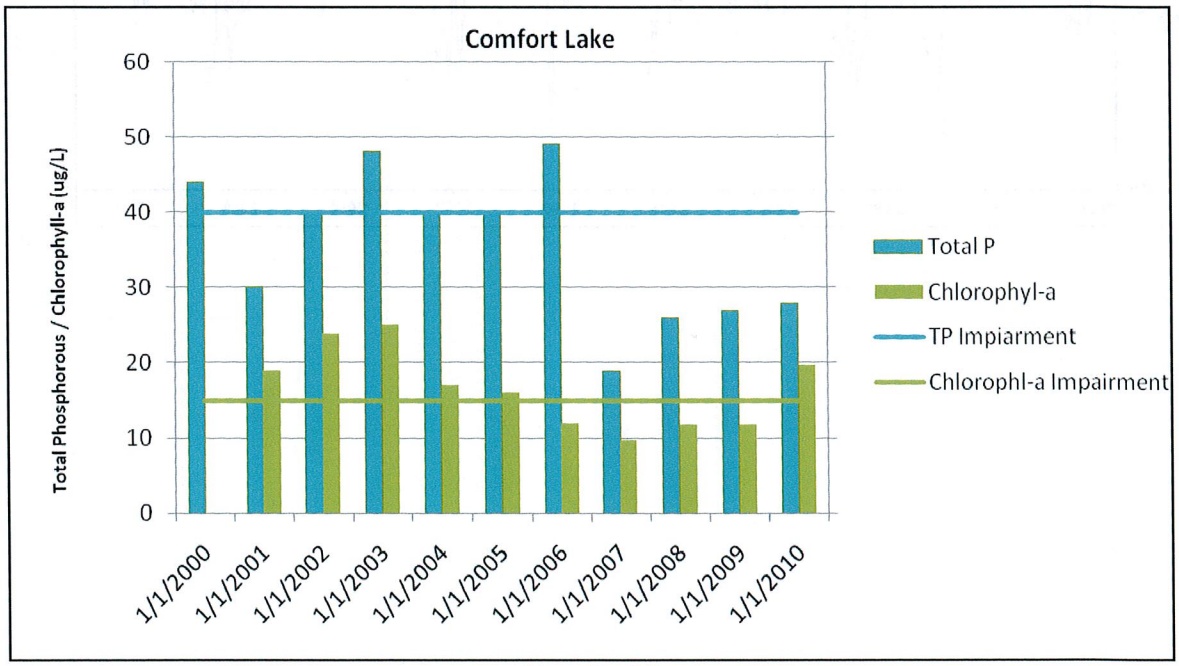
Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
4/16/10	0.028	15	0.86	1.65
4/30/10	0.041	11	0.9	2.4
5/14/10	0.028	13	0.88	2.1
5/29/10		4.7	0.91	2.45
6/10/10	0.02	6.5	0.86	2.5
6/29/10	0.022	6.4	1	2.4
7/15/10	0.036	24	1.2	1.7
7/28/10	0.031	31	1.4	1
8/8/10	0.036	34	1.5	1
8/16/10	0.027	27	1.3	1.1
9/1/10	0.026	16	0.85	1.5
9/17/10	0.026	27	1.2	1.7
10/3/10	0.025	21	1.1	1.7
10/15/10	0.029	26	1.4	1.35
2010 Summer Average	0.028	19.622	1.136	1.706

Water Quality threshold is 0.04 mg/L TP or higher*

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary

	Trophic Status	Lake Grades										
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Mesotrophic	B	B	B	A	C	C	C	C	C	B	C
Chlorophyll-*a* (ug/l)	Eutrophic	B-	B	A	A	B	B	B	C	C	B	C
Secchi depth (ft)	Mesotrophic	C	C	C	C	C	C	C	C	C	C	C
Overall	**Mesotrophic**	**B-**	B	B	B+	C+	C+	C+	C	C	B	C



COMFORT LAKE
SURFACE WATER ELEVATION STATISTICS

Outlet Elevation (rock weir) = 885.4

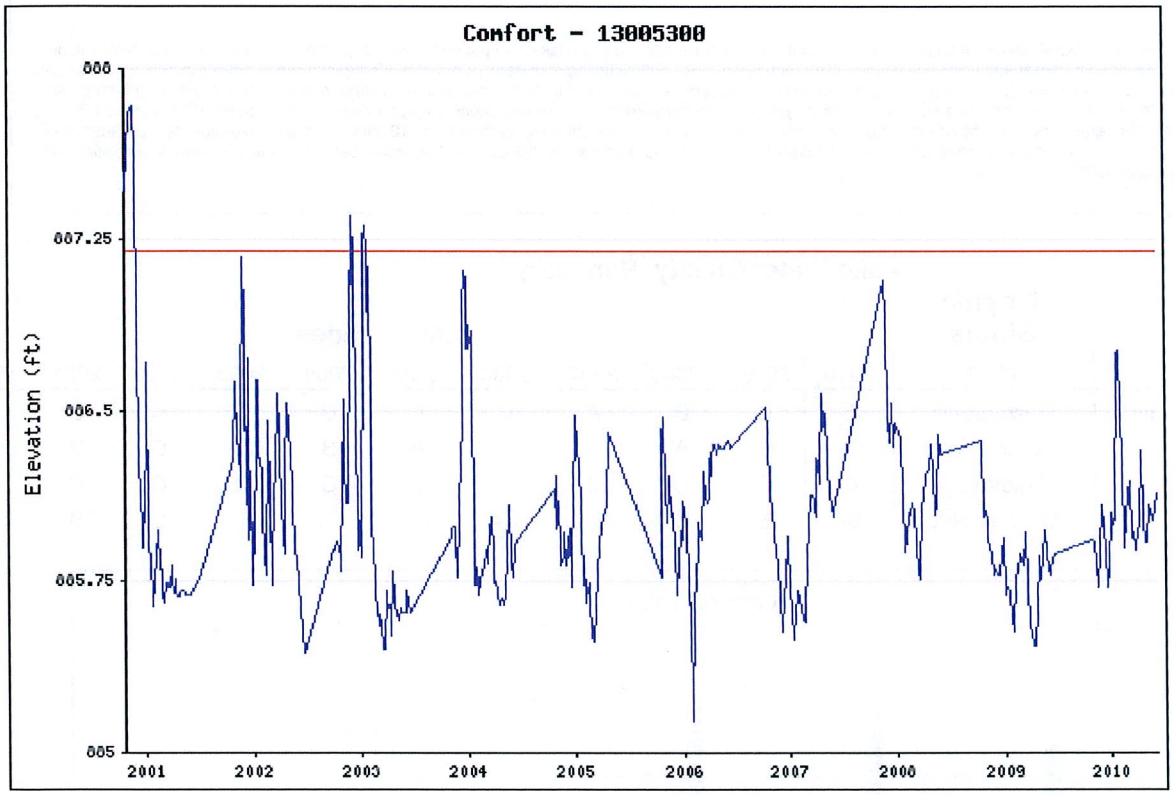
DNR Ordinary High Water (OHW) elevation = 887.2

100 Year Flood Elevation (CLFLWD) = 889.5

Highest recorded: 888.32 ft (07/02/1975)

Lowest recorded: 884.8 ft (10/08/1969)

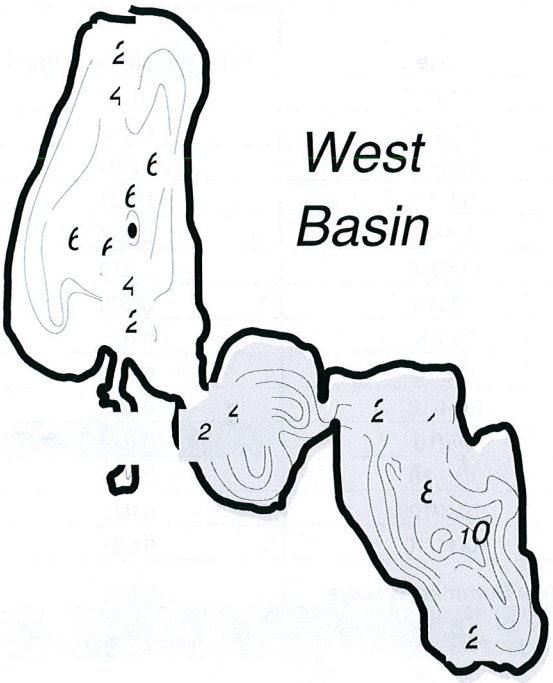
Datum: NGVD 29 (ft)



Forest Lake- Western Basin

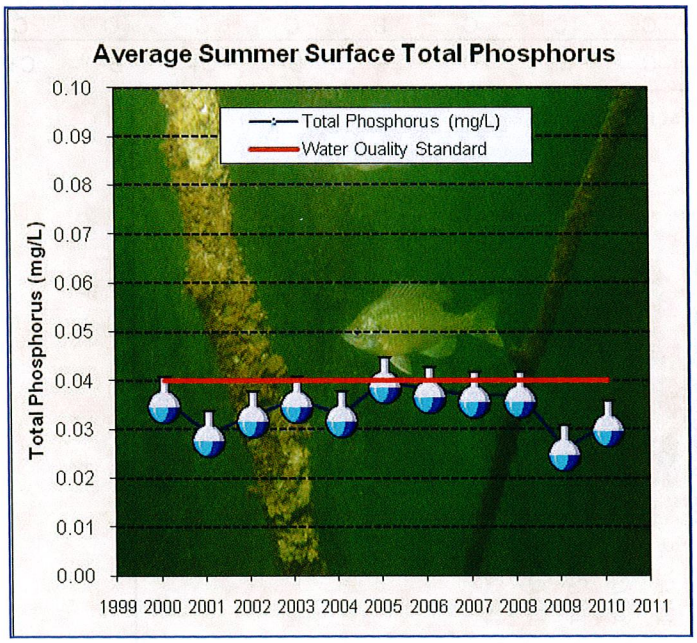
2010 Lake Grade: C+

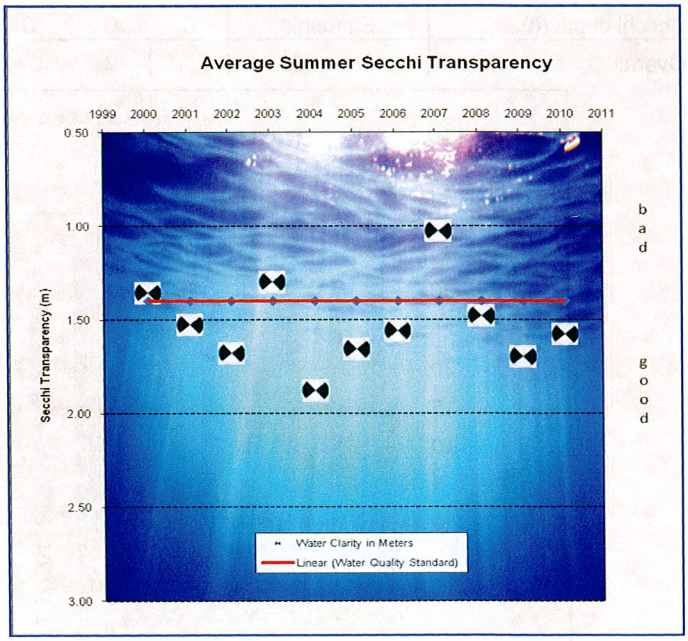
- DNR ID #: 820159
- Municipality: City of Forest Lake
- Location: Section 9 T32N-R21W
- Lake Size: 2,251 Acres
- Maximum Depth: 37 ft
- Ordinary High Water Mark: 901.8 ft
- 67% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Forest Lake was considered a eutrophic lake in 2010, based on the Carlson Trophic State Index.
- Forest Lake is not listed as impaired for excessive nutrients.
- **Curly leaf pondweed and Flowering rush (invasive aquatic plants) are present in this lake.**
- Forest Lake has a healthy diverse aquatic plant population.
- The major land use is semi-urban and rural/agricultural.
- The lake does stratify throughout the summer months.



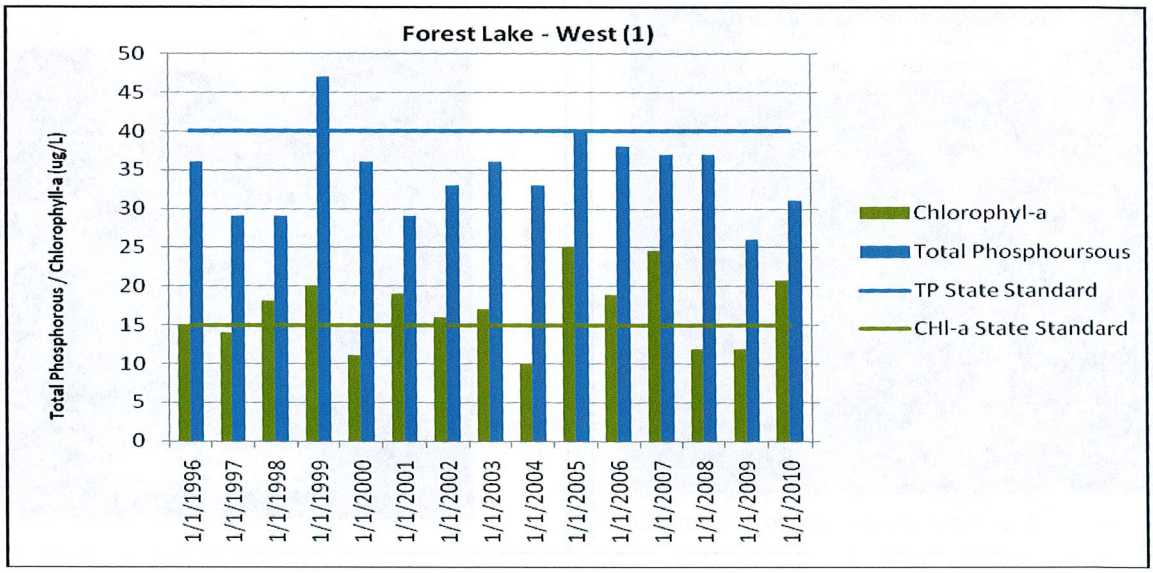


Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
4/12/10	0.02	3.5	0.62	2.5
4/28/10	0.022	3.1	0.65	2.5
5/25/10	0.024	3	0.64	3.5
5/31/10	0.021	2.7	0.63	2.9
6/4/10	0.032	3.7	0.65	2.6
6/22/10	0.019	4.2	0.72	2.2
7/9/10	0.023	8.2	0.86	1.9
7/23/10	0.027	15	0.91	1.5
8/8/10	0.035	30	1.1	1
8/14/10	0.035	35	1.2	0.8
9/5/10	0.049	53	1.4	0.5
9/19/10	0.038	40	1.3	0.9
10/3/10	0.027	15	0.87	1.5
10/11/10	0.021	9.2	0.88	1.9
2010 Summer Average	0.031	20.680	0.964	1.580
Water Quality threshold is	0.04 mg/L TP or higher*			

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary

	Trophic Status	Lake Grades										
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Eutrophic	B-	B	C	C	C	C	C+	B	C	B	C
Chlorophyll-*a* (ug/l)	Eutrophic	C+	B+	B	C	B	C+	A-	B	B	B	B
Secchi depth (ft)	Eutrophic	C	C	C	C	C	C	B	C	C	C	C
Overall	Eutrophic	C+	B	C+	C	C+	C	B	B-	C+	B-	C+



FOREST LAKE

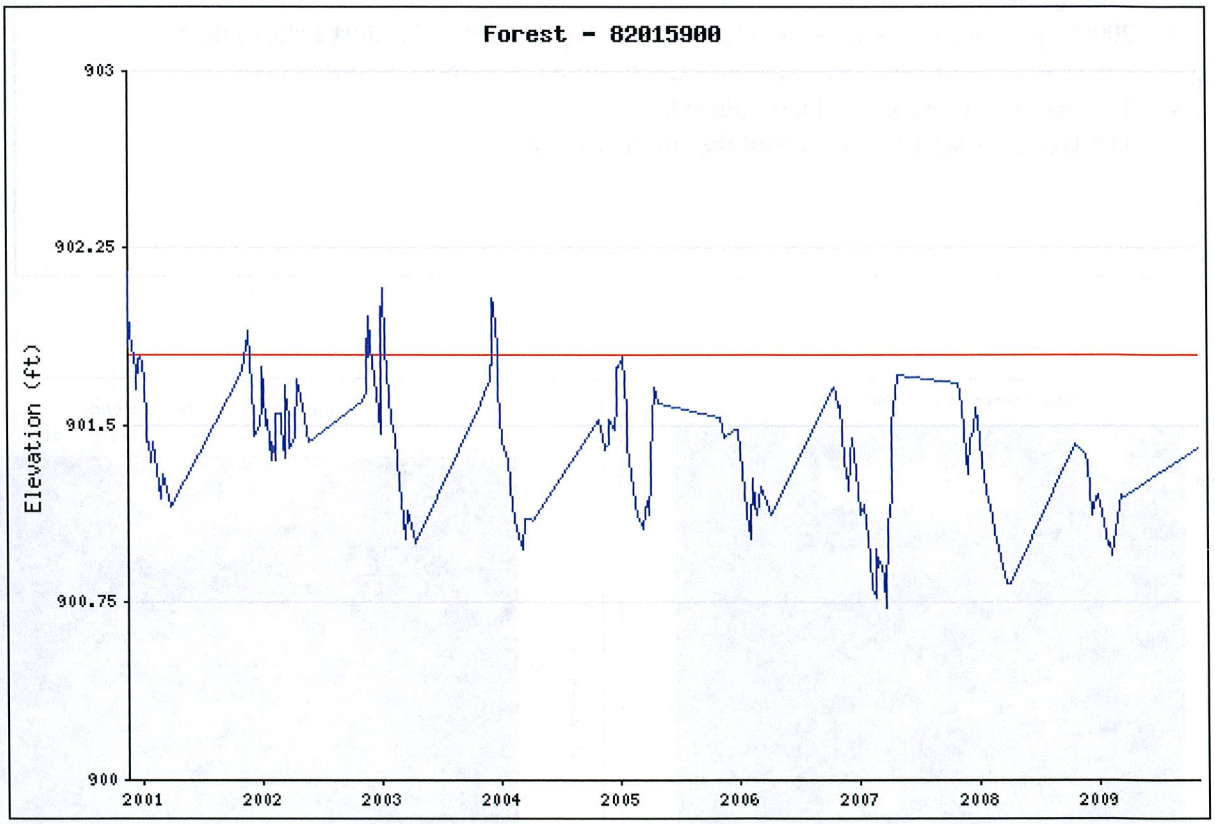
SURFACE WATER ELEVATION STATISTICS

Elevation of outlet/dam = 901.4

DNR Established Ordinary High Water (OHW) elevation = 901.8

100 Year Flood Elevation = 902.4

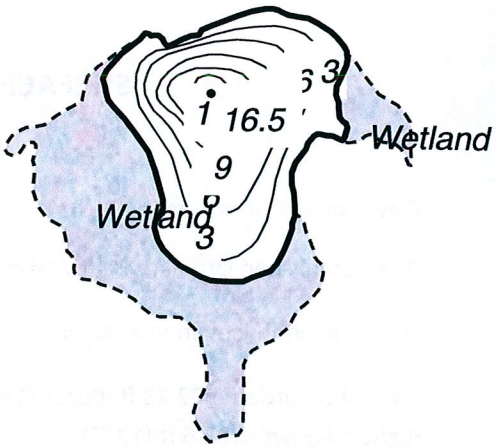
Highest recorded: 902.23 ft (06/25/1993)
Highest known: 902.6 ft (1975)
Lowest recorded: 899.45 ft (10/07/1969)
Recorded range: 2.78 ft
Last reading: 901.4 ft (04/20/2010)
Datum: NGVD 29 (ft)



Little Comfort Lake

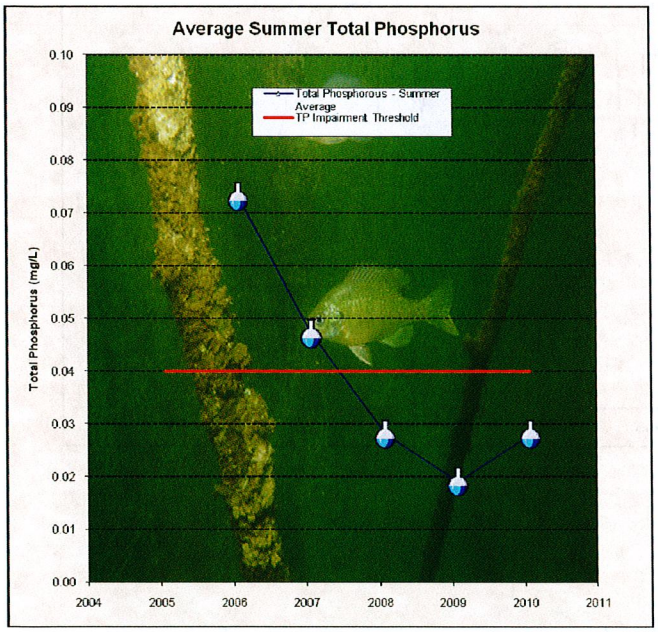
2010 Lake Grade: B+

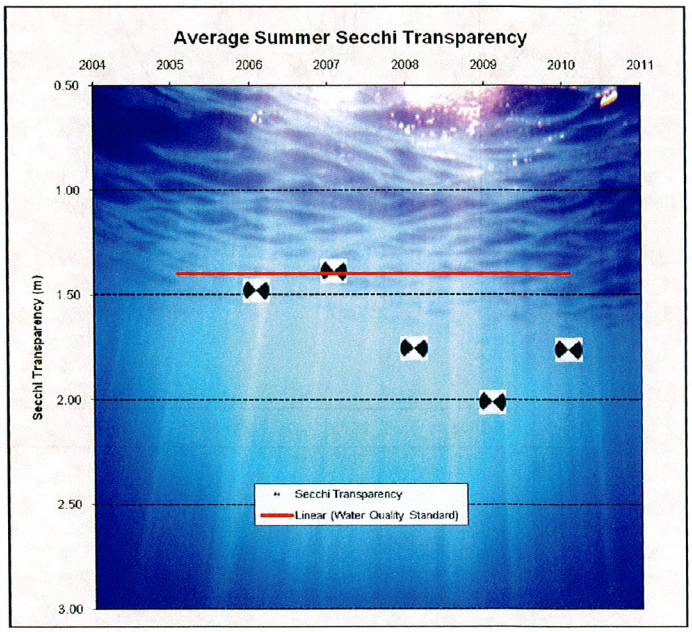
- DNR ID #: 130054
- Municipality: Chisago City
- Location: Section 27 T33N-R21W
- Lake Size: 36 Acres
- Maximum Depth: 56 ft
- Ordinary High Water Mark: 887.2 ft
- 49% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Little Comfort Lake was considered a mesotrophic lake in 2010, based on the Carlson Trophic State Index.
- 2009 represents the best monitored water quality for Little Comfort Lake to date.
- **Curly leaf pondweed (invasive aquatic plants) are extensive in this lake.**
- The major land use is rural/agricultural.
- The lake does stratify throughout the summer months.





2010 WATER QUALITY DATA

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
4/18/10	0.023	6.2	0.82	1.5
5/3/10	0.023	5.3	0.82	2.1
5/17/10	0.015	3.1	0.58	2.2
5/31/10	0.019	2.7	0.84	2.4
6/14/10	0.022	9.8	0.68	1.9
6/27/10	0.026	2.9	0.79	2.4
7/14/10	0.037	19	0.98	2
7/28/10	0.042	26	1.2	1
8/5/10	0.034	22	1.2	1
9/5/10	0.028	16	1	1.5
9/13/10	0.024	14	1	1.7
9/27/10	0.02	8.6	0.86	2
2010 Summer Average	0.028	14.050	0.950	1.767
Water Quality threshold is 0.04 mg/L TP or higher*				

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary

	Trophic Status	Lake Grades									
	2009	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Mesotrophic	A	B	C	D						
Chlorophyll-*a* (ug/l)	Mesotrophic	A	C	A	C						
Secchi depth (ft)	Mesotrophic	C	C	C	C						
Overall	Mesotrophic	B+	B-	B-	C						

LITTLE COMFORT LAKE
SURFACE WATER ELEVATION STATISTICS

Outlet Elevation (approx) = 885.7

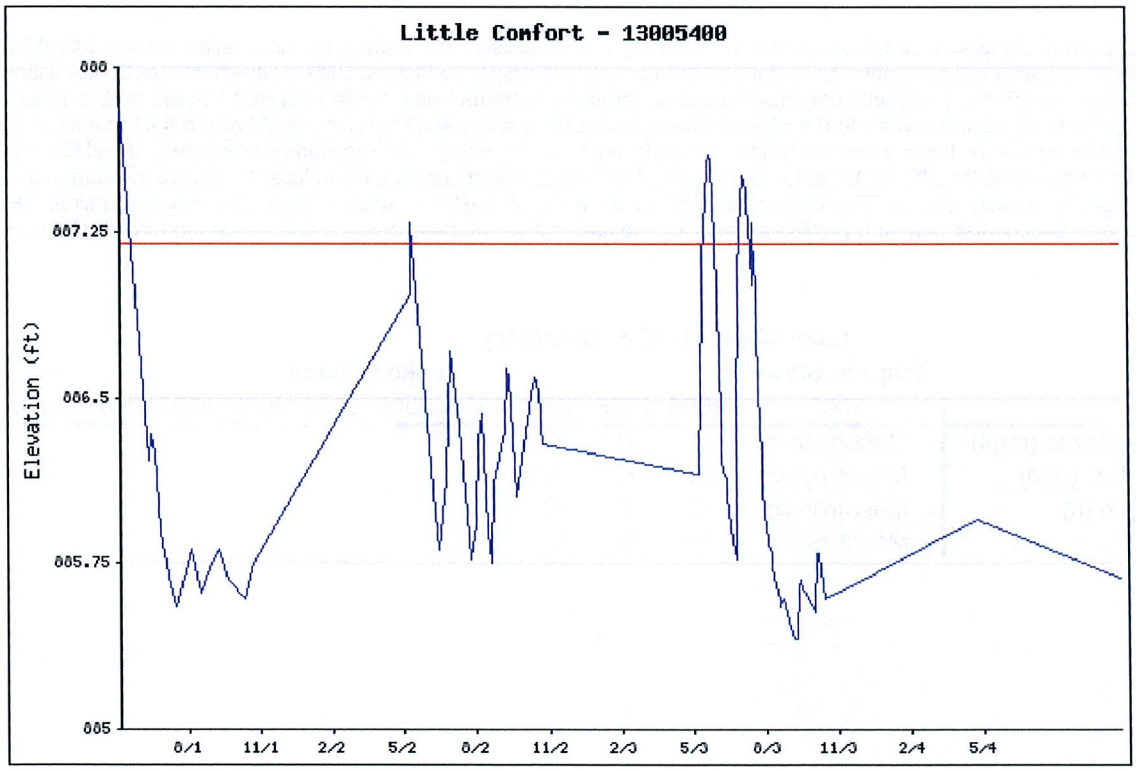
Ordinary High Water Level (OHW) elevation: 887.2 ft

100 year = 892.1

Highest recorded: 887.81 ft (05/08/2001)

Lowest recorded: 885.41 ft (09/10/2003)

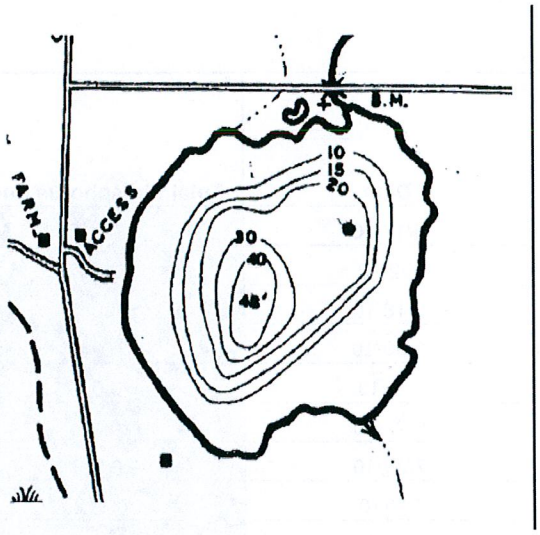
Datum: NGVD 29 (ft)



Moody Lake

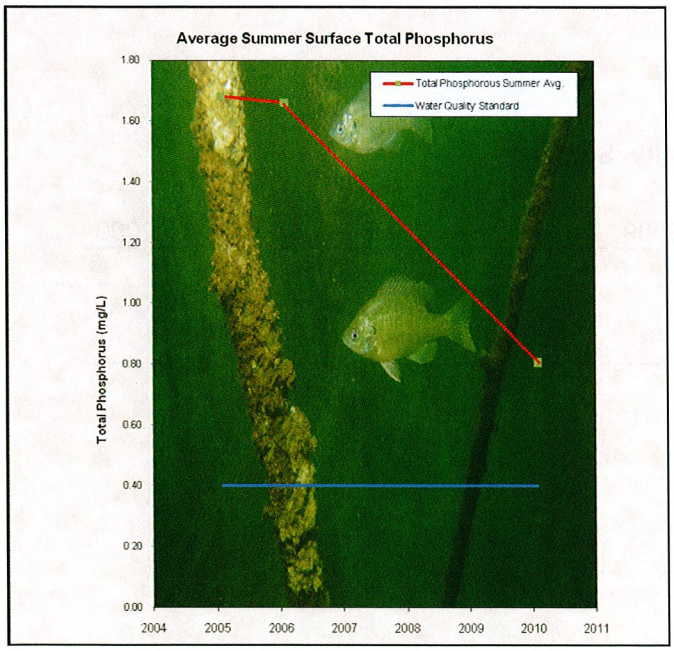
2010 Lake Grade:

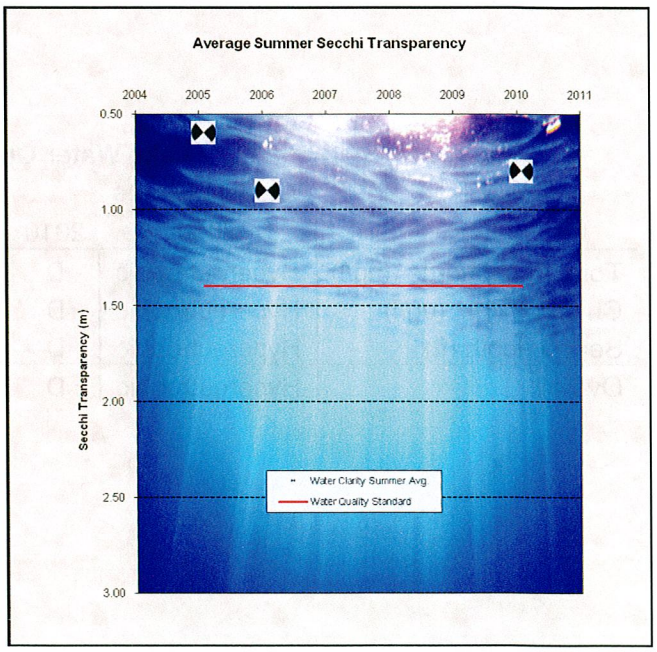
- DNR ID #: 13002300
- Municipality: Chisago Lakes Township
- Location: SW$^{1/4}$ Section 32 T33N-R20W
- Lake Size: 35 Acres
- Maximum Depth: 48 ft
- Ordinary High Water Mark: N/A
- 61% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- School Lake was considered a hypereutrophic lake in 2010, based on the Carlson Trophic State Index.
- **Curly Leaf Pondweed (An invasive aquatic plant) was dominant in a 2007 survey.**
- **Moody Lake is listed on the MPCA's Impaired Waters List for excessive nutrients.**
- At this time, there are not enough years of data to determine a statistically significant trend in overall water quality but the water quality appears to be improving slightly.
- The major land use is rural/agricultural.
- The lake does stratify throughout the summer months.





Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
4/17/10	0.065	27	1.4	1.300
5/2/10	0.057	18	1.2	1.600
5/16/10	0.082	9.7	1.4	2.900
5/30/10	0.045	20	1.2	1.800
6/6/10	0.049	20	1.2	1.900
6/27/10	0.071	70	1.8	0.800
7/25/10	0.127	130	2.5	0.400
8/8/10	0.12	100	2.5	0.300
8/22/10	0.129	65	2.2	0.350
9/5/10	0.115	90	2.2	0.400
9/19/10	0.079	70	1.9	0.500
10/3/10	0.061	44	1.6	0.900
2010 Summer Average	0.806	70.625	1.938	0.806
Water Quality threshold is 0.04 mg/L TP or higher*				

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

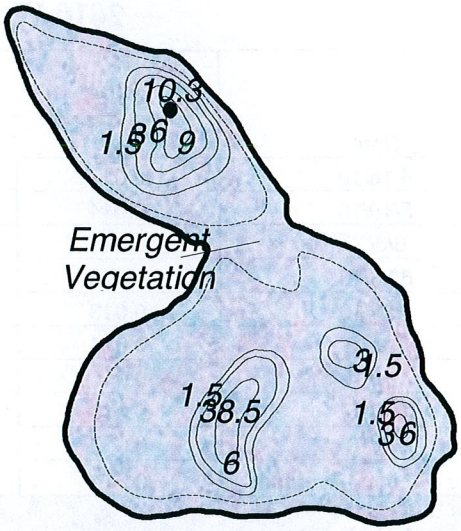
Lake Water Quality Summary

	Trophic Status	Lake Grades							
	2010	2010	2009	2008	2007	2006	2005	2004	2003
Total Phosphorus (mg/l)	Hypereutrophic	D				F	F		
Chlorophyll-*a* (ug/l)	Hypereutrophic	D				D	D		
Secchi depth (ft)	Hypereutrophic	D				D	F		
Overall	Hypereutrophic	D				D-	F		

Sylvan Lake

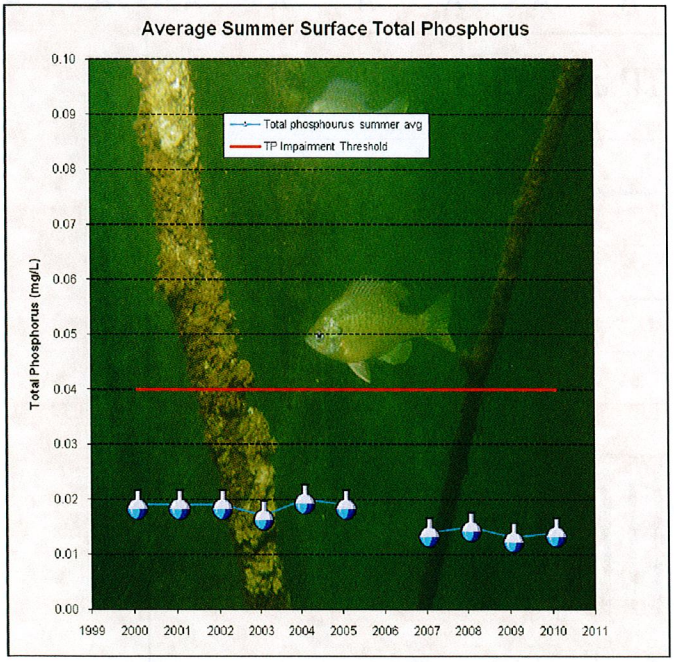
2010 Lake Grade: A

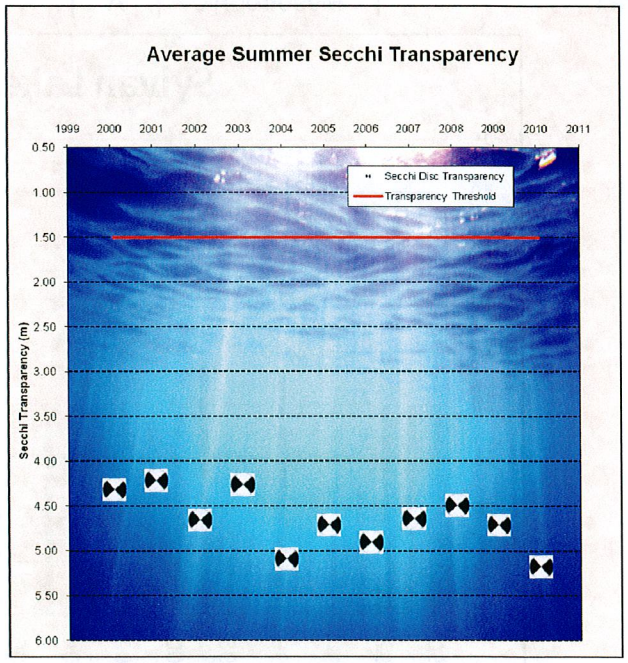
- DNR ID #: 820080
- Municipality: City of Forest Lake
- Location: Section 24 T32N-R21W
- Lake Size: 84 Acres
- Maximum Depth: 35 ft
- Ordinary High Water Mark: 937.1 ft
- 68% Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Sylvan Lake was considered a mesotrophic lake again in 2010, based on the Carlson Trophic State Index.
- The water quality of Sylvan Lake ranks among the top ten percent in the Twin Cities Metro Area.
- **Curly leaf pondweed (an invasive aquatic plant) is present in this lake.**
- Sylvan Lake has a healthy diverse aquatic plant population.
- The major land use is semi-urban and rural/agricultural.
- The lake does stratify throughout the summer months.





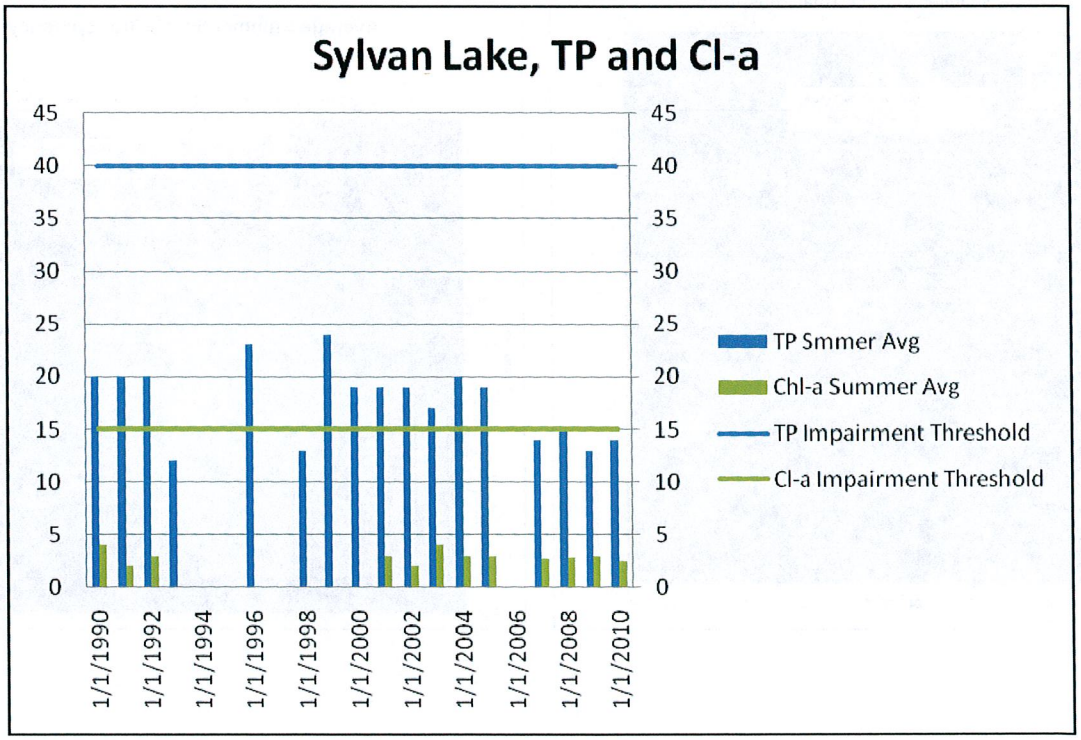
2010 Water Quality Readings

Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depth (m)
4/16/10	0.017	2.3	0.49	5.4
5/19/10	0.014	1.9	0.54	6.5
6/3/10	0.015	7.3	0.61	3.2
6/23/10	0.013	2	0.64	5.2
6/29/10	0.013	2	0.68	6.1
7/9/10	0.014	2.4	0.6	4.8
7/18/10	0.016	3	0.65	4.7
8/6/10	0.013	2.7	0.5	4.1
9/8/10	0.012	2.2	0.68	6.2
2010 Summer Average	0.014	2.460	0.622	5.180
Water Quality threshold is 0.04 mg/L TP or higher*				

*MPCA description of Impaired Lake's Listing criteria: "At a minimum, a decision that a given lake is impaired for the 303(d) list due to excessive nutrients will be supported by data for both causal and response factors. Data requirements for 303(d) listing consist of 12 or more TP measurements collected from June through September over the most recent 10-year period. Ideally this should represent 12 separate visits to the lake over the course of two summers; however it might also reflect four monthly samples over the course of three years (a typical sampling regimen for many lake monitoring programs). In addition to exceeding the TP guideline thresholds, lakes to be considered for 303(d) listing should have at least 12 Secchi measurements and 12 chlorophyll-a measurements. This amount of data will allow for at least one season (preferably more) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

Lake Water Quality Summary

	Trophic Status	Lake Grades									
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
Total Phosphorus (mg/l)	Mesotrophic	A	A	A	A	A	A	A	A	A	A
Chlorophyll-*a* (ug/l)	Oligitrophic	A	A	A	A	A	A	A	A	A	A
Secchi depth (ft)	Oligitrophic	A	A	A	A	A	A	A	A	A	A
Overall	Mesotrophic	A	A	A	A	A	A	A	A	A	A



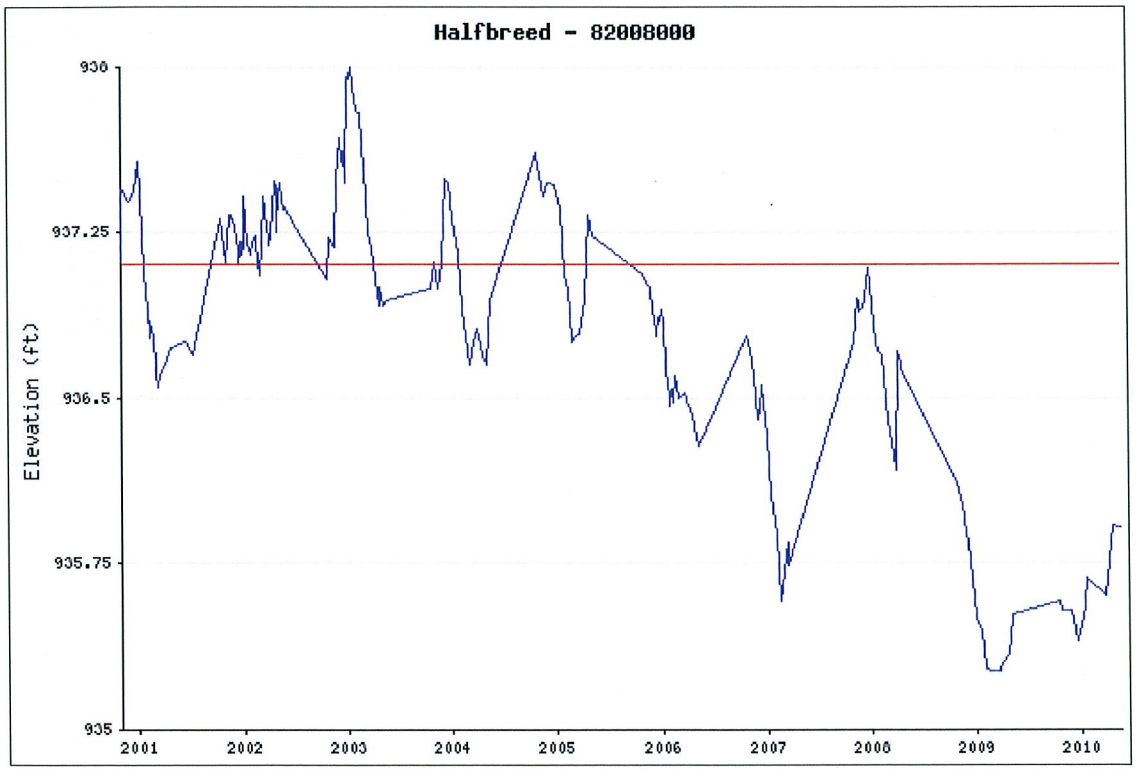
SYLVAN LAKE
WATER SYRFACE ELEVATION STATISTICS

Outlet Elevation = N/A landlocked

DNR Ordinary High Water Elevation = 937.1

Highest recorded elevation = 938 (07/03/2003)

Highest known elevation = 938 (07/03/03)

Lowest recorded elevation = 934.52 (11/22/1990)

Datum: NGVD 29