Cobblestone Lake Management Plan

REPORT

City of Apple Valley

July 2008

Project Number: 000068-06328-0

Bonestroo

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July 18, 2008

Mr. Jeff Kehrer
Natural Resources Coordinator
City of Apple Valley
6442 140th Street
Apple Valley, MN 55124

Re: Cobblestone Lake Management Plan
City of Apple Valley
Bonestroo File No.: 68-06328-0

Dear Jeff:

Please find attached the Cobblestone Lake Management Plan. This report contains a review and characterization of lake and watershed conditions followed by an assessment of pollutant loadings and in-lake water quality. Options for reducing watershed phosphorus loadings are proposed, including cost and effectiveness. The report concludes with recommendations for watershed and in-lake management measures.

We would be pleased to discuss the contents of the report with City staff or other parties. Please contact me at 651-604-4783 if you have any questions or need further information.

Thank you for the opportunity to assist you in this effort. We hope to provide continued guidance and support in the future.

Sincerely,

BONESTROO

Rich Brasch
Project Manager

cc. Colin Manson, City Engineer
Corey Markfort, Bonestroo

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Executive Summary

Cobblestone Lake is a man-made lake with a surface area of 37 acres and a maximum depth of about 20 feet. The lake is located in southeast Apple Valley, northeast of the intersection of Pilot Knob Road and County Road 46. Cobblestone Lake was created in 2001 through a grading operation in a former sand and gravel mining area. The lake was intended to provide a stormwater management function as well as create a recreational and aesthetic amenity for the surrounding mixed use development. Cobblestone Lake is at the southern end of the East Vermillion River drainage district, which comprises approximately 3,440 acres in the eastern third of the City of Apple Valley. Because of the large amount of infiltration that occurs in the lake and –to a lesser extent-in the lake's watershed, the lift station outlet for Cobblestone Lake has not operated since it was installed in 2002 (except for pump maintenance purposes). Water pumped through the lift station would discharge to the City of Lakeville. Both the City of Apple Valley and the City of Lakeville desire to maintain "zero discharge" under normal conditions.

In 2006, the City of Apple Valley expressed interest in developing a lake management plan for Cobblestone Lake to guide management of the lake and surrounding lake environment. The City's interest in managing the lake is based on four factors:

1. The lake is identified as a resource management priority in the City's recently adopted Surface Water Management Plan (2007).

2. The lake is viewed as a recreational resource of local importance with well-developed access that fosters public use. The classification of Cobblestone Lake as a Class II water body in the City's SWMP recognizes that its primary intended uses are for fishing, canoeing, and aesthetic enjoyment.

3. Cobblestone Lake is an important feature in the City's stormwater management system. Infiltration that occurs in the lake is essential in controlling discharges to Lakeville, and the City of Apple Valley is interested in protecting this infiltration capacity. To date, the lift station outlet for the lake has not operated (except for routine testing) because of the large amount of infiltration losses.

4. Cobblestone Lake could be evaluated by MPCA in the future to determine if it meets pending state water quality standards and whether it should be listed as an Impaired Water for which a Total Maximum Daily Load (TMDL) would need to be prepared. The City wants to take proactive management steps to protect the lake now and in the near future (when it is relatively easy and inexpensive) so that lake water quality is at least as good as or better than the standards. Consistent with City policy, protection of a good quality resource is preferred over restoration of a degraded resource.

Over the long term, the water level in Cobblestone Lake is largely a reflection of the elevation of the shallow groundwater table with which it is in contact. Under the current system configuration, the lift station outlet will not operate until the water level in the lake reaches over 4-feet above the long-term water elevation exhibited by the lake over the last several years. Based on historic lake water level behavior, the lake's normal water elevation fluctuates between 908 ft. Mean Sea Level (MSL) and 910 ft. MSL. Temporary "bounces" caused by runoff events cause the lake surface elevation to "bounce" temporarily to between 911 ft. MSL and 912 ft. MSL, and it may take from several days to perhaps 1-2 months to return to normal as accumulated water in the lake discharges to the groundwater system.

Below a water surface elevation of 909.5 ft. MSL, Cobblestone Lake would be considered a shallow lake, as defined by the MPCA, because over 80% of the lake area at this water elevation is less than 15 feet deep. If normal water elevations increase to above 910 ft. MSL, the lake could be considered deep. This distinction is important because different, more stringent water quality standards could be applied by MPCA based on their eutrophication standards if the lake is considered deep. The City's policy is to maintain infiltration capacity of the Cobblestone Lake system and to minimize surface discharges from the lake to Lakeville as much as possible. Thus, it is anticipated that the water elevation in Cobblestone Lake will continue to be reflective of the local groundwater surface elevation and that this elevation will over the long term remain largely unchanged from its recent historical levels.

The MPCA administers the Impaired Waters program in Minnesota and assesses lakes for listing based on in-lake water quality. A water quality data collection effort was initiated in 2005 by City staff through the Metropolitan Council's Citizen Assisted Monitoring Program (CAMP). Data from 2005 and 2006 for total phosphorus, chlorophyll-*a*, and water clarity are summarized below in Table E-1 and compared to the MPCA eutrophication standards for shallow lakes in the Western Corn Belt Plains (WCBP) Ecoregion within which Cobblestone Lake lies. The water quality criteria for Cobblestone Lake presented in the City's Surface Water Management Plan (2007) are the same as the MPCA criteria, pending completion of this Lake Management Plan.

Table E-1 – Monitored Water Quality in Cobblestone Lake

Parameter	MPCA Standard*	2005 Monitored Value[1,2]	2006 Monitored Value[1,2]
Total Phosphorus (μg/l)	< 90	85.0	61.0
Chlorophyll-*a* (μg/l)	< 30	58.3	24.2
Water Clarity (m)	> 0.7	0.51	1.0

* MPCA standards shown are for shallow lakes in the Western Corn Belt Ecoregion.
For comparison, the MPCA standards for deep lakes are, TP < 65, Chl-*a* < 22, Water Clarity > 0.9

[1] Values are based on approximately biweekly samples between June and September of each year

[2] Annual precipitation for 2005 and 2006 was 32.4" and 28.7", compared to a 30-year average of 34.76"

Guidance provided by MPCA indicates that to avoid listing a lake as impaired, one of the two following conditions must be met:

1. The monitored in-lake TP concentration and at least one of the other two parameters, chlorophyll-*a* or water clarity, must be better than or equal to the applicable standard.
2. The monitored value for both chlorophyll-*a* and water clarity must be equal or better than the applicable standard, even if the TP concentration is worse than the standard.

Based on knowledge of the lake's history, water quality monitoring data, an evaluation of the in-lake and near-shore biological community, and modeling of the system, the following are some important considerations concerning the current condition of the lake:

- Cobblestone Lake is an extremely young lake compared to natural lakes and has neither a stable watershed nor a stable in-lake biological community. It may take 5-10 years or more for the lake to stabilize.

- Based on 2005 data, which was a year with near-normal precipitation (within two inches of average annual precipitation depth), Cobblestone Lake did not meet either MPCA's eutrophication standards nor the in-lake water quality criteria adopted in the City's Surface Water Management Plan for either water clarity or chlorophyll-*a*. The total phosphorus value was just below the threshold. Thus, the lake would have been listed as Impaired on the basis of these data, so there is some urgency for action.

- Based on 2006 data, which was a year with well below normal precipitation (more than six inches less than the average annual precipitation depth), Cobblestone Lake met all three criteria. This could indicate that reduced surface runoff associated with below normal precipitation allowed groundwater (which is generally of much better quality than surface water runoff) to be the primary influence on the lake's water quality. It could also reflect to some degree the development of a more desirable but still young biological community dominated by native aquatic plants and a more balanced fish population containing predatory fish to control populations of roughfish and small panfish. (Too many rough fish and/or stunted panfish negatively impact water quality by their feeding behavior.)

- The watershed assessment indicates that under ultimate watershed development conditions, as much as 33% of the total phosphorus load to Cobblestone Lake could come from the 4.6% of the lake's watershed immediately around the lake that drains directly to it if nothing is done to treat the runoff. Most of this additional load would be generated by development that has yet to occur in the direct drainage area if stormwater treatment is not put in place.

- Minimizing pollutant loads to the lake generated by surface water runoff within the watershed and helping the lake establish a desirable biological community (including a balanced fish population, a rich aquatic plant community dominated by native species, and a natural lakeshore plant community) will be essential in achieving and maintaining relatively clear water conditions. A lake with clear water and a rich native submergent and emergent aquatic plant community is the goal for the Cobblestone Lake given the primary uses it is intended to support and based on current science, state and federal regulations, and City policy.

The proposed management strategy for Cobblestone Lake takes a phased approach that combines tight controls to minimize surface water runoff from new and re-developed areas to the lake with continued monitoring of the lake as it evolves, helping the lake establish a desirable in-lake biological community, and "retrofit" projects to reduce surface runoff-driven loads from existing developed areas within the lake's watershed, if necessary.

This phased approach is outlined below.

1. Continue efforts through the TMDL process already underway to meet in-lake phosphorus goals for Long and Farquar Lake. The lift station outlet for the Long/Farquar Lake system discharges water that travels through a number of ponds in the Cobblestone Lake watershed and eventually reaches Cobblestone Lake itself.

2. New and re-development activities in the Cobblestone Lake watershed should be required to meet the City requirements for reducing runoff volume as well as control of total phosphorus and total suspended solids for surface water runoff prior to discharge of runoff from the sites to Cobblestone Lake.

3. Based on monitoring results and assessments, implement watershed capital improvement project(s) to reduce phosphorus loading from indirect drainage, as outlined below:
   a. First Priority – Clean-out and re-configure Pond EVR-43. This project is aimed at removing accumulated sediment and selective removal of emergent vegetation so that it provides added wet volume to treat runoff from its direct drainage and improves infiltration of the stormwater reaching it, if possible. The area appears to be a jurisdictional wetland, so wetland impacts and mitigation costs will be a consideration in deciding whether to move ahead with the project.
   b. Reserve Project – Install underground infiltration structure in district EVR-400 between Delaney and Diamond Path parks. This project would be considered only if there is a compelling need to reduce the large volume (and associated phosphorus load) of stormwater conveyed down the main truck of the storm system from the upper watershed. It is NOT being proposed for construction at the present time, though estimated costs and benefits are presented in the report.

4. Best Management Practices in the direct drainage of Cobblestone Lake should be evaluated for restoration and expansion. Active participation of the residents/homeowners associations in this area to help execute some of these initiatives should be sought, as these residents live in areas that have the highest proportional impact on Cobblestone Lake and have the most to gain from a good-quality lake. Recommended BMP's for this area include:
   a. Restoration of existing and installation of new raingardens, emphasizing increasing infiltration of runoff from impervious areas.
   b. Installation of lakeshore buffers of native, deep-rooted vegetation within the park adjacent to the lake. This effort should begin with a limited pilot scale project affecting at least 100 feet of shoreline to be completed within 2 years after adoption of this plan, with a long-term goal of having 30% of the lake's shoreline in native buffer within 5 years after adoption of the plan.
   c. Information education program aimed primarily at residents and businesses in the direct drainage of Cobblestone Lake and emphasizing, at a minimum, lawn soil testing and use of no-phosphorus fertilizer where possible, minimizing runoff volume from individual properties, and education on the direct connection between the storm sewer system and Cobblestone Lake.
   d. Periodic street cleaning by the City, focused on sweeping the direct drainage to the lake with the City's vacuum sweeper at least 3-4 times per year, particularly as early in the spring as possible, in late May/early June immediately after seed drop, as well as in the fall during and after leaf fall.

5. Monitor in-lake water quality as well as in-lake biota to guide actions in managing the lake system to achieve clear water with a native macrophyte-dominated aquatic plant community and a balanced fish community. Elements of this component include:
   a. Conduct bi-weekly water quality monitoring through CAMP each year, supplemented with collection of dissolved oxygen/temperature/conductivity profile data during every sampling outing and hypolimnetic total phosphorus sampling at least three times per season.
   b. Conduct a macrophyte survey of Cobblestone Lake once every two years. Depending on the findings of the surveys, consider planting native submergent and emergent aquatic plants in the lake to help establish a desirable plant community.
   c. Once every two years, conduct a field survey of upstream ponding systems to determine presence of exotic invasives such as curly-leaf pondweed, eurasian watermilfoil, and purple loosestrife as well as rough fish such as bullheads and stunted panfish which could act as infection centers for Cobblestone Lake. Take action to control invasives as necessary.
   d. Conduct a fishery survey of Cobblestone Lake once every 2-3 years. Work with MnDNR to structure a fish community in Cobblestone Lake to maintain adequate population of predatory fish to control small panfish and roughfish populations. Predatory fish stocking possibilities include walleye, bass, and channel catfish. Consider a joint initiative with MnDNR to protect predatory gamefish from excessive harvest if necessary.

As with other lakes in the City, an adaptive management approach should be used for Cobblestone Lake consistent with the City's 2007 Surface Water Management Plan. This approach recognizes that lakes are complex systems, the future condition of which is difficult to predict. This is especially true with Cobblestone Lake, since both the watershed and the lake itself are changing. A high priority should be placed on management measures that have a reasonable cost and a reasonable chance of generating a positive outcome for the lake, then monitoring the system thoroughly enough to determine the effectiveness of those management measures in achieving the goals for the system. After the five-year implementation period as summarized below in Table E-2, Cobblestone Lake should be re-evaluated to determine its long-term potential to consistently meet in-lake water quality criteria better than the standards. This won't be known until a longer record of in-lake water quality data for normal precipitation conditions is generated, the in-lake biological community develops more, and ultimate development conditions in the watershed-especially near the lake – are reached.

Table E-2 below presents a summary of the recommended schedule, estimated costs, and estimated benefits of the implementation items presented above over a five-year implementation cycle.

Table E-2 – Summary of five year implementation plan with associated costs and load reduction benefits

Measure	Year & Cost (in 2008 Dollars)					Estimated TP load reduction to Cobblestone Lake*
	1	2	3	4	5	
1. Improve outflow quality of Farquar Lake through on-going TMDL process	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	28 lbs/year
2. Assure compliance of development/re-development activities with SWMP stormwater treatment policies	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	128 lbs/year
3a. Clean out and re-configure Pond EVR-P43				$49,000 for feasibility assessment/ preliminary engineering	$162,000 for design and construction	98 lbs/year
3b. *Install underground infiltration structure in EVR-400 (reserve project)*				*$145,000 for feasibility assessment/ preliminary engineering*	*$484,000 for design and construction*	*41 lbs/year*
4. Evaluate, restore, and expand BMPs in direct drainage. This includes developing a native shoreline buffer	$5,000-$10,000	$10,000-$15,000	$10,000-$15,000	$10,000-$15,000	$10,000-$15,000	Up to 13 lbs/year
5. Monitoring, management of in-lake water quality and biological community	City staff time plus $2,000 for lab costs	City staff time plus $2,000 for lab costs and $5,000 for consulting (fish and plant survey)	City staff time plus $2,000 for lab costs	City staff time plus $2,000 for lab costs and $5,000 for consulting (fish and plant survey)	City staff time plus $2,000 for lab costs	N/A

*Estimated load reduction based from ultimate watershed development condition. Load reduction shown is based on planning level modeling of expected loads and management performance for an average year. Actual benefit can be refined as part of preliminary engineering/ feasibility studies for each capital improvement project, supplemented with post-project monitoring. Measure 5 does not include a TP load reduction estimate as this management is intended to improve the in-lake conditions including improving Chl-*a* and water clarity

1 Introduction

1.1 PURPOSE AND BACKGROUND

The goal of this Lake Management Plan is to develop and present a strategy to meet the water quality and lake management goals established for Cobblestone Lake in the City's 2007 Surface Water Management Plan.

Cobblestone Lake is identified as a priority resource in the Surface Water Management Plan (SWMP) for Apple Valley (June 2007). The 36-acre lake was created as part of the Cobblestone Lake development and according to the AUAR (2001) prepared for the development, was intended to be a regional stormwater management facility as well as provide an amenity for the development. The ultimate (fully developed) watershed area draining to the lake will be approximately 3,400 acres, of which over 90% will drain first through one or more upstream ponds or lakes before runoff from those areas is discharged to the lake.

The location of Cobblestone Lake and the surrounding development occupies an area formerly used for a gravel mining operation. A lift station was constructed to provide an outlet for the lake. However, because of the high infiltration capacity of the surficial geology within which the lake is constructed, the lift station has not been needed thus far. Large amounts of infiltration occur within the lake and may occur in some areas in the watershed above the lake as well. Cobblestone Lake's shoreland area is owned by the City of Apple Valley and managed by the Parks and Recreation Department. There is no developed boat access at the lake, however residents may launch small boats such as canoes at any number of places along the lake's shoreline, and canoes can be rented or stored at the north end of the lake. A large fishing pier extends into the lake approximately 200-feet to the south west from a point on the north shore.

1.2 LAKE WATER QUALITY PRIMER

The following sections are intended to introduce the reader to key concepts and terminology regarding lake ecology and lake management that are used throughout this report.

1.2.1 WATER QUALITY AND LAKES

There are two types of lakes that are distinguished for lake management purposes: shallow lakes and deep lakes. This distinction is made on the basis of certain physical characteristics of a lake. Differences in the physical characteristics of lakes effect how lakes respond to seasonal changes and watershed inputs. Therefore management strategies must be based on whether a lake is considered shallow or deep.
Based on criteria defined by the MPCA, Cobblestone Lake is considered shallow.

Shallow lakes are defined as lakes with 80% or more of the lake area less than 15 feet deep (MPCA 2005). At its natural water elevation over the last several years, Cobblestone Lake would be considered a shallow lake based on lake depth (bathymetric) data collected by City staff in 2006.
Lake Alimagnet, Long Lake, Farquar Lake and Keller Lake are also shallow lakes.

Shallow lakes can be strongly affected by wind and wave action. It is not uncommon to see a shallow lake that is intermittently weakly stratified, then mixed periodically during the open water season. Because they can mix many times throughout the open water period, they are referred to as "polymictic." The constant mixing during open water conditions facilitates a high degree of interaction between the water and underlying sediment. This dynamic makes shallow lakes more prone to nutrient enrichment compared to deep lakes of similar surface area and watershed size. During winter, the limited volume of shallow lakes can result in low oxygen condition which can result in fish kills. These low oxygen conditions often have a greater negative impact on gamefish species like bass, northern, and walleye than on roughfish like carp and bullhead because the former require higher levels of oxygen in the water to survive.

In a natural, pristine state, shallow lakes typically have clear water and a rich aquatic vegetation community almost everywhere in the lake that is dominated by rooted aquatic plants (Scheffer 1998). Figure 1.1 shows a diagram illustrating how light penetration determines whether a lake supports rooted aquatic plants and therefore whether it is considered shallow or deep.

Shallow lakes with relatively low nutrient content usually have vegetation dominated by relatively small rooted aquatic plants. Shallow lakes that receive large stormwater inputs from urban areas (like Long, Farquar, Keller, and Alimagnet) often have significantly higher concentrations of plant nutrients like phosphorus than pristine lakes. In these lakes, the total mass of aquatic plants increases as more nutrients are available to support plant growth. Plants that fill the entire water column or concentrate much of their growth near the lake surface dominate the vegetative community in these lakes. If something is done to eradicate the rooted aquatic plants, algal blooms often result which can lead to a highly turbid condition in the lake. Ultimately, shading by algal blooms leads to a collapse of the rooted aquatic vegetation due to light limitation. Invertebrates associated with the vegetation disappear and with these also disappear the birds and fish that feed on them or on the plants. Once a lake has turned to a turbid condition without rooted aquatic plants, it can be difficult to restore it to a clear water vegetated state (Scheffer 1998).

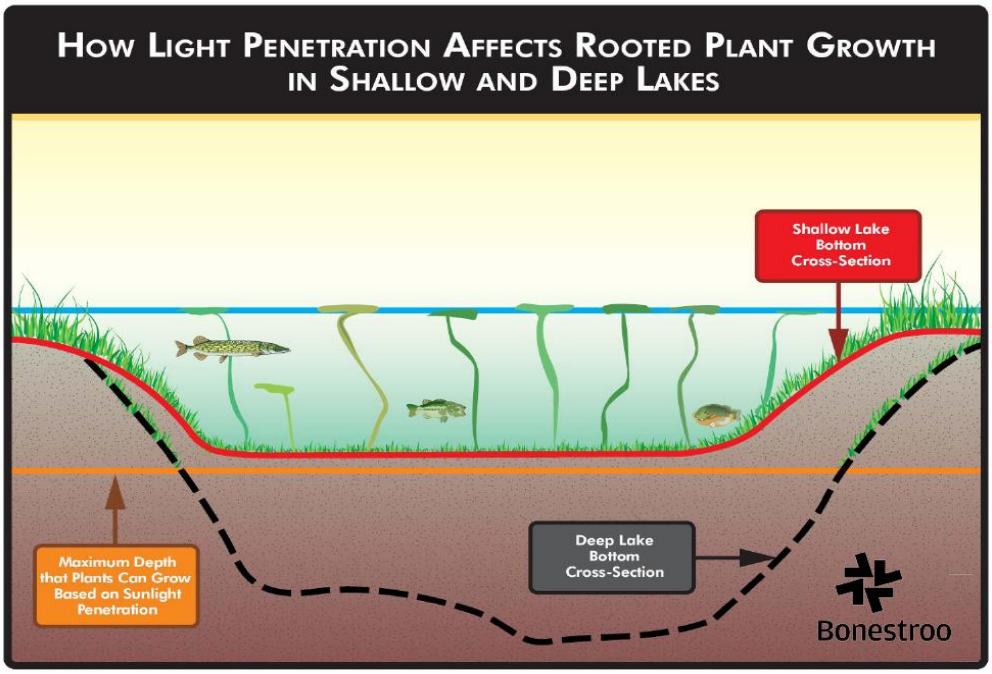


Figure 1.1 – Comparison of how light penetration determines whether a lake is shallow or deep

In short, there is no such thing as a shallow lake without abundant vegetation (whether algae or rooted aquatic plants or some combination thereof); it is more a question of what types of plants will dominate in the system. A native rooted aquatic plant dominated system with clear water is generally considered the most desirable condition of shallow lakes because of the diversity and perceived value of the plants and animals it supports. Further, state water quality standards also support achieving this type of condition. Therefore as stated in the 2007 SWMP, the City intends to restore its shallow lakes to a clear water condition with a diverse emergent and submergent native-dominated plant community.

1.2.2 WATER QUALITY VARIABLES

Water quality data has only been collected since 2005 for Cobblestone Lake. The information collected includes data on total phosphorus, chlorophyll-*a*, secchi disk transparency, and dissolved oxygen.

Total Phosphorus (TP) is a measure of all of the different forms of phosphorus in water. TP includes phosphorus dissolved in water, or incorporated in algae or other organisms. Because of its importance in managing lakes, it is discussed in considerably more detail in Sections 1.2.3 and 1.2.4.

The chlorophyll-*a* concentration is a measure of algae (phytoplankton) in the water. The amount of algal growth strongly influences the clarity of the water. In general, higher phosphorus concentrations cause more algal growth which decrease water clarity. High chlorophyll-*a* concentrations indicate a nutrient-rich environment with large amounts of algae in the lake.

A secchi disk provides a visual estimate of water clarity and the depth of light penetration in a lake. Water clarity is a key physical parameter affecting user perceptions of the suitability of a lake for recreation. As water clarity decreases, human perceptions of the suitability of a lake for recreational use also drop. A secchi disk is a circular disk with alternating white and black quadrants. It is lowered through the water column and the depth at which it disappears from view is recorded as the water clarity.

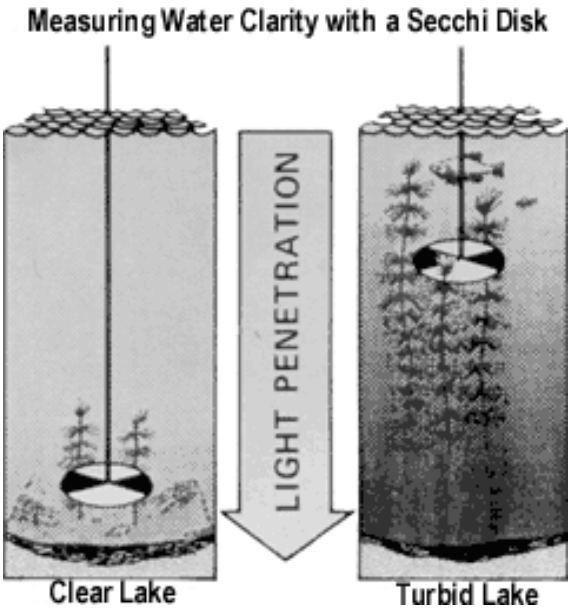


Figure 1.2 – Comparison between water clarity in clear and turbid lakes

Dissolved Oxygen (DO) is the molecular oxygen that is in solution in water. Aquatic plants and algae produce DO as a result of photosynthesis while fish, zooplankton, and bacteria consume DO. Generally, DO concentrations provide insight on:

- Habitat suitability for fish and other vertebrate populations;
- Stratification of a lake system; and
- Potential for internal nutrient cycling.

1.2.3 ROLE OF PHOSPHORUS IN LAKE QUALITY

Phosphorus is an essential nutrient for plant growth. It is the nutrient most commonly limiting plant and algae growth in lakes in the upper Midwest. This is because, compared with other plant nutrients such as nitrogen, the supply of phosphorus in a lake is generally lowest relative to the demand by algae.

If phosphorus concentrations are low, algal growth will be low.
Conversely, high phosphorus concentrations often foster high algal productivity.

Algae obtain almost all of their nutrients from the water column in a dissolved form. A balanced population of algae is an important part of the biological system within a lake. However, too great an abundance of algae adversely affects both the ecology of the lake as well as the suitability of the lake for use by people. Under nutrient enriched conditions (i.e., high phosphorus concentrations in the water column), populations of certain types of algae can explode during the summer growing season, causing what is commonly referred to as a "bloom". A particular type of algae, blue-green algae or cyanobacteria, can cause significant nuisance blooms in late summer. They are particularly problematic for several reasons:

- They decrease water clarity, which affects the perceived suitability of the lake for direct contact recreation such as swimming and wading.

- They form objectionable surface scums. The decomposition of these surface scums often forms a pattern on the water's surface much like spilled paint and generates strong odors that negatively impact the recreational use and aesthetic appeal of the lake.

- The ecology of bluegreen algae is such that most of the population dies off naturally. Decomposition of this organic mass depletes the lake of oxygen. The resulting lower dissolved oxygen concentrations can threaten the survival of desirable gamefish, make the lake more suitable for rough fish, and trigger other undesirable conditions, such as release of phosphorus held in the bottom sediments of the lake.

- On occasion, bluegreen algae can secrete toxins poisonous to warm-blooded animals. While no human deaths have been reported, there are many documented cases of wildlife and domestic animal deaths as a result of ingestion of these toxins.

Phosphorus concentration is the most critical factor in the quality of any lake. Controlling and reducing the amount of phosphorus that reaches a lake is essential in managing lake quality. Phosphorus can be delivered to a lake from a watershed in many ways.

Elevated phosphorus loadings from developed areas are in part a consequence of more runoff volume as a result of increased impervious surfaces such as roads, rooftops, and driveways. They are also a consequence of higher concentrations of pollutants in runoff from urbanized areas.

For example, major sources of phosphorus in urban runoff include improperly applied fertilizers containing phosphorus, vegetative material left on hard surfaces, soil and dust particles, and animal waste. Municipal storm drainage systems installed to prevent flooding provide an efficient vehicle for delivery of these pollutants from their places of origin to the receiving water.

1.2.4 INTERNAL NUTRIENT CYCLING

Elevated nutrient loading (phosphorus) to lake systems can greatly affect lake management strategies. As a result of long-term elevated phosphorus loads, a lake can accumulate a large reserve of phosphorus in its sediments. Phosphorus accumulation promotes a perpetual condition of internal nutrient cycling within a lake system. This is not the case with Cobblestone Lake as it is relatively young, but preventing a build-up of excess phosphorus in the lake sediments will make management of in-lake water quality easier in the future.

Internal nutrient cycling can exist in both shallow and deep lakes. The cycling process is triggered by periods of low Dissolved Oxygen (DO) at the sediment/ water interface as a result of thermal stratification. Low DO causes the nutrient enriched bottom sediments to release the accumulated phosphorus content into the overlying water. The phosphorus released from the sediments is made available to algae at the lake surface during periods of mixing.

In deep lakes, the mixing can be expected during spring and fall "turn-over" events and occasionally in the summer during strong storms. In shallow lakes, intermittent calm summer conditions promote a temporary lake stratification which is frequently broken by the mixing effect of wind and wave actions.

The mixing transfers sediment-released phosphorus from lower to upper layers of the lake. The re-introduction of phosphorus to the water column from bottom sediments is known as "internal loading." The loading contributes to algae blooms that negatively affect the ecology of the lake as well as the suitability of the lake to support desirable uses such as swimming, fishing, or boating. Eventually the algae die, sink to the bottom of the lake and decompose, ultimately returning the organic material (including phosphorus) back to the sediment and completing the internal nutrient cycle.

Most rooted aquatic plants obtain their nutrients from lake sediments. Nutrient enriched sediments can foster an overabundance of aquatic plants causing nuisance conditions. The proliferation of the aquatic plant Curly-leaf pondweed can also contribute to internal nutrient loads. This plant grows during early spring before water temperatures are favorable for other aquatic plants. Curly-leaf pondweed completes its growing cycle and begins to die off by mid-summer. As with algal blooms, Curly-leaf pondweed sinks to the lake bottom and decomposes, further contributing to TP reserves and internal release of phosphorus by oxygen depletion during decomposition.

Effective lake management strategies must account for internal nutrient cycling dynamics. In-lake conditions favoring internal phosphorus recycling can sustain poor water quality conditions, even while watershed sources of phosphorus are being mitigated. Even if watershed inputs are brought to near-zero conditions, water quality can remain impacted until the reserves of phosphorus in the sediment are exhausted, a process which could possibly take decades for many lake systems.

1.3 GENERAL MANAGEMENT PLAN APPROACH

The approach of this Plan is to develop a lake and watershed management plan for Cobblestone Lake that will:

- Present essential data to characterize the current condition of the lake and what influences lake water quality.
- Establish management goals for the lake that are consistent with those in the City's 2007 SWMP and with anticipated state and federal regulatory criteria.
- Identify on-the-ground projects and management actions that can be undertaken to protect or improve the ability of the lake to support desired uses and achieve goals set for the lake.

2 Lake and Watershed Characterization

2.1 HISTORY OF THE LAKE AND WATERSHED

Between the early 1990's and the creation of Cobblestone Lake in 2001, the land area that drains to the current site of the lake was managed as a gravel mining operation. Prior to 1990, the area was primarily managed for row crop agriculture. The AUAR (2001) prepared for the Cobblestone Lake development anticipated that Cobblestone Lake would provide regional stormwater management function and be an amenity for the local community. Once constructed, the lake was connected to existing drainages to the north and became the terminus for the East Vermillion River (EVR) sub-watershed as identified in the City's Surface Water Management Plan (2007). This watershed includes drainage from the Long and Farquar Lakes region in northeastern and north central Apple Valley and is predominately suburban residential. Previously this area was discharged to the mining area pre-dating the lake, where water quickly infiltrated to the groundwater system. After the remaining gravel mine remnants around the lake are developed, the ultimate planned contributing drainage area will be 3,400 acres.

2.2 SOILS AND GEOLOGY

The current watershed for Cobblestone Lake extends from the northern portion of the City near Lebanon Hills Regional Park to the far southern portion of the City where Cobblestone Lake itself is located.
The soils in the northern part of Apple Valley are from the Kingsley-Mahtomedi association that are characterized as gently sloping to very steep, loamy and silty textured soils. These well drained to excessively well drained soils are extensively intermingled. The Waukegan-Wadena-Hawick association is common in the southern portion of the city. These are characterized as level to very steep, silty, loamy and sandy textured soils. The hydrologic soil groups found in the watershed are predominately in Group B with some Group A interspersed. In general, this indicates that the soils are suitable in many places to support infiltration practices as a stormwater management feature.

The surficial geology of the watershed is a moraine topography caused by relatively recent geologic process. The advance and retreat of glacial lobes approximately 10,000 years ago deposited the rock material that characterizes the topography. As a result, two major geomorphic regions are found within the Cobblestone Lake drainage: moraine topography in the north and valley outwash in the south. Soils and surficial geology are particularly conducive to infiltration practices in the area immediately around Cobblestone Lake itself, as confirmed by the fact that this was a sand and gravel mining area with extremely permeable sub-soils.

The topographic elevations vary from a high of about 1,060 feet Mean Sea Level (MSL) in the northwest edge of the watershed to a low of 900 feet MSL near Farquar Lake. Farquar Lake is pumped south over a ridge near 140th Street to EVR-P39, which resides at 946 feet MSL, and surface water discharges by gravity down to Cobblestone Lake which resides at about 909.5 feet MSL The rugged terrain in the north is characterized by steep slopes with many hills and depressions. These many depressions and natural ponds are ideal for long term storage of stormwater runoff. In contrast, the southern portion of the City is relatively flat. It features gently sloping land draining into several draws that eventually reach Cobblestone Lake and generally infiltrate to the groundwater system.

2.3 CLIMATOLOGICAL SUMMARY

Annual normal precipitation in this part of the Twin Cities Metropolitan area (1971 – 2000), as measured at the Rosemount Agricultural Experiment Center, is about 34.6 inches, of which about two-thirds occurs during the summer months of May - September. The annual snowfall in Apple Valley averages approximately 50 inches of snow; with the most severe melt runoff conditions usually occurring in March and early April. Twin Cities mean annual lake evaporation is about 30.5 inches per year. On average, lakes in the area experience about 132 days of ice cover a year, with the average freeze and thaw dates occurring the last week of November and the first week of April respectively. The average date of the last below freezing temperature (32°F) in the spring is April 27 while the average date of the first below freezing temperature in the fall is October 2. Thus, the normal growing season is about 157 days.

2.4 WATERSHED SIZE, LAND USE CHARACTERISTICS, AND HYDROLOGY

The watershed of Cobblestone Lake is currently about 3,290 acres and occupies the eastern third of Apple Valley. It stretches north to south from Lebanon Hills Regional Park to the municipal border with Lakeville, and east to west from the municipal border with Rosemount to a line that generally follows Pilot Knob Road north to County Road 42 and along Johnny Cake Ridge Road north of County Road 42 to 140th Street, and extends to just north of McAndrews Road (Map 1). The watershed to the lake will expand slightly to just over 3,400 acres as gravel mining areas in the vicinity of Cobblestone Lake which contribute virtually no surface runoff to the lake in their current state are developed and stormwater management infrastructure is installed.

Figure 2.1 shows both the actual land use composition of the Cobblestone Lake watershed in 2005 as well as the expected land use composition under ultimate development conditions. The largest single block of non-urban area that is expected to develop into urban land uses in the future is near Cobblestone Lake itself. As mentioned above, most of this area is currently comprised of gravel mining land uses which generate almost no runoff to Cobblestone Lake itself. Limiting the volume of runoff and the load of phosphorus and other pollutants to Cobblestone Lake from areas in this vicinity as they develop will be extremely important in protecting Cobblestone Lake. Figure 2.2 shows the land use for ultimate conditions.

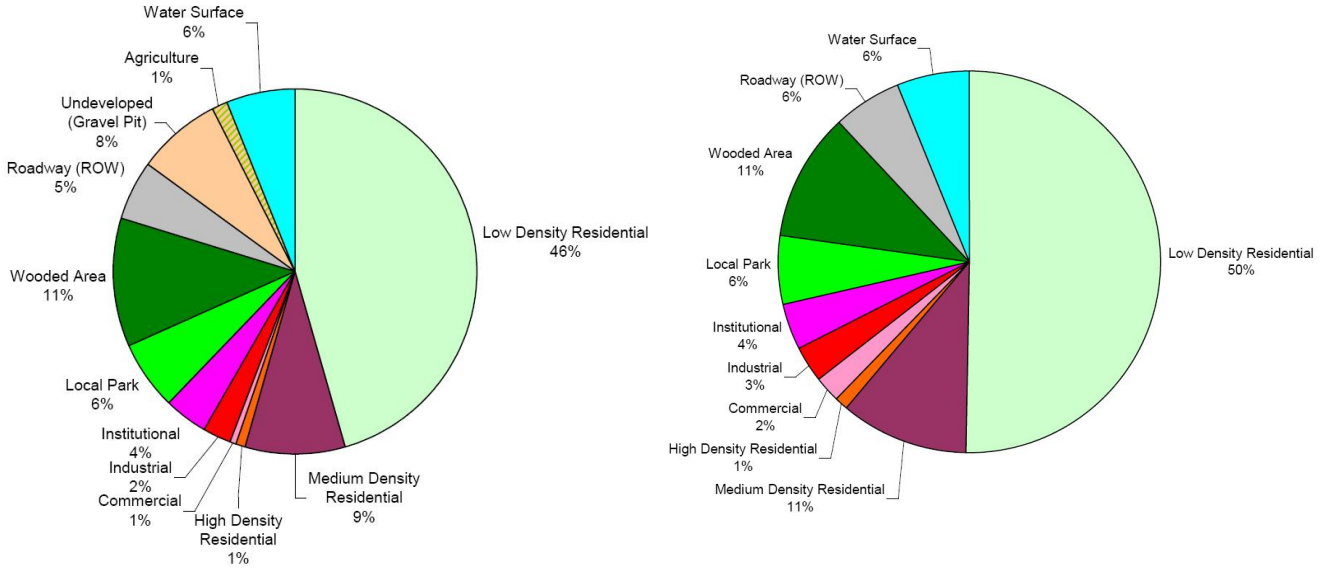


Figure 2.1 – Watersheds land use composition – Left: 2005 conditions, Right: Ultimate conditions

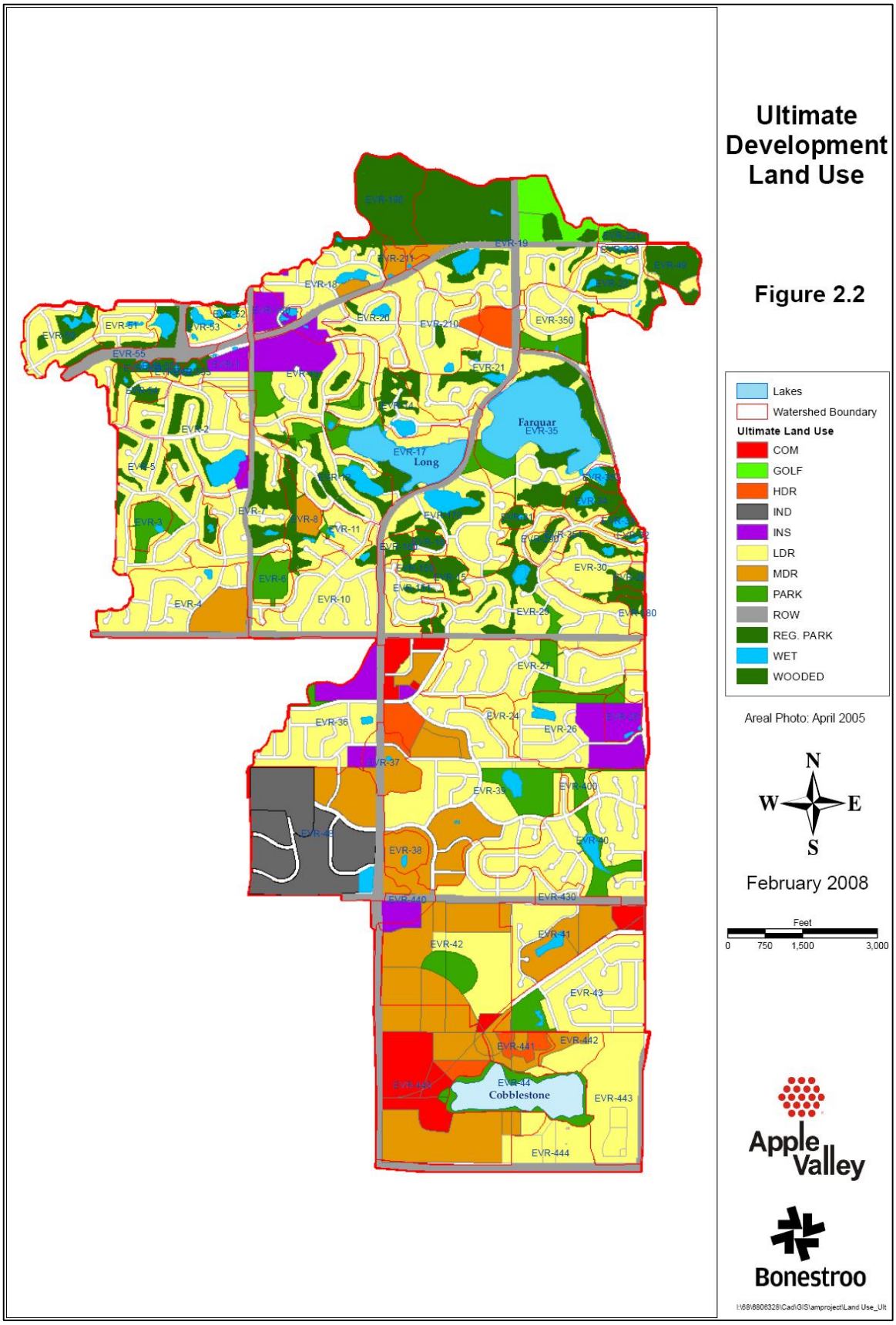

Ultimate Development Land Use
Figure 2.2
Lakes
Watershed Boundary
Ultimate Land Use
COM
GOLF
HDR
IND
INS
LDR
MDR
PARK
ROW
REG. PARK
WET
WOODED
Areal Photo: April 2005
N
W
E
S
February 2008
Feet
0
750
1,500
3,000
Farquar
EVR-35
EVR-17
Long
EVR-44
Cobblestone
EVR-19
EVR-18
EVR-20
EVR-210
EVR-350
EVR-21
EVR-55
EVR-51
EVR-2
EVR-3
EVR-4
EVR-5
EVR-7
EVR-8
EVR-11
EVR-10
EVR-30
EVR-25
EVR-27
EVR-24
EVR-26
EVR-36
EVR-37
EVR-33
EVR-400
EVR-38
EVR-430
EVR-42
EVR-41
EVR-43
EVR-441
EVR-442
EVR-443
EVR-444
Apple Valley
Bonestroo

Figure 2.3 (also see 11 x 17 large copy at the back of this report) shows the major structural inlets to the lake (numbered 1-5). Also shown are the sub-watersheds that did not generate runoff to Cobblestone Lake under 2005 watershed development conditions but will in the future once they develop (see cross-hatched areas). This includes the developed area north of CR 42 (sub-watershed EVR-440). Storm sewers serving the development currently discharge to the open field south of CR 42, where the discharged storm water infiltrates. In the future, these storm sewers will be routed to EVR-42 which is located within the current gravel mining area. Finally, the drainage to EVR-41 is also shown as non-contributing under current conditions. The pond's normal water level generally remains well below the controlled outlet elevation due to seepage. This pond is assumed to discharge only about 10% of the annual runoff volume it receives under ultimate development conditions. All of these areas will discharge to some degree to Cobblestone Lake under ultimate watershed development conditions. The amount of the discharges, especially for new developed areas, will depend largely on stormwater mitigation practices, which are detailed later in this report.

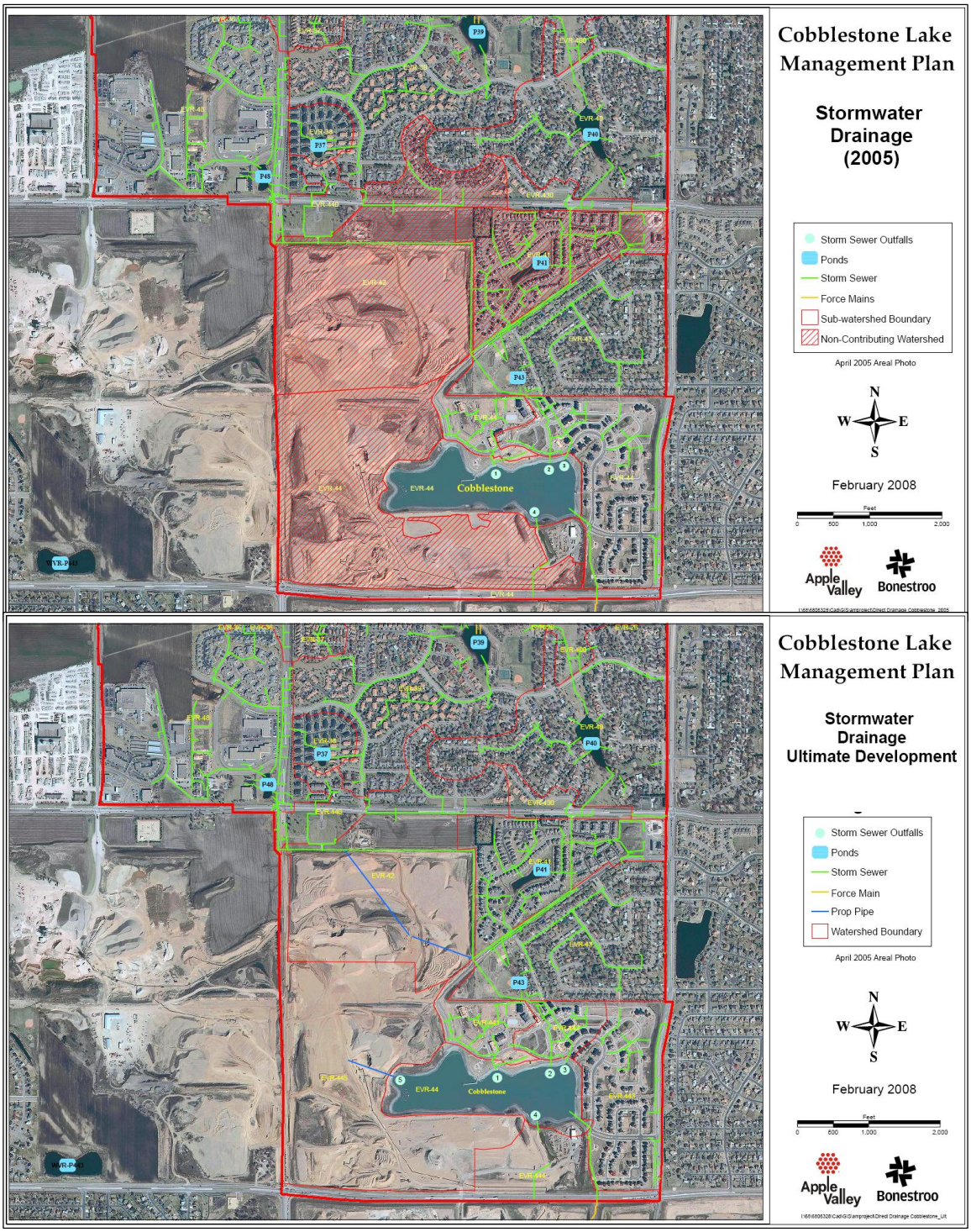


Figure 2.3 – Direct drainage watershed to Cobblestone Lake (Cross-hatched areas represent land-locked areas)
Top: 2005 watershed configuration, Bottom: Ultimate watershed configuration. (See 11 x 17 copy at the back of this report)

Stormwater that runs off the watershed drains ultimately into Cobblestone Lake. Much of the stormwater is routed through one or more natural or man-made ponds prior to discharge into the lake. About two-thirds of the watershed first drains through Farquar and/or Long Lakes before being pumped via lift station down to Pond EVR-P39 in Delaney Park. There are a total of 68 constructed and natural ponding areas within the watershed that are incorporated into the City's storm drainage system. Based on recent pumped discharge records for the Farquar Lake lift station and monitoring at Pond EVR-P43 conducted in 2006 and 2007, volumetric runoff coefficients were estimated for much of the Cobblestone Lake watershed. These data showed that for 2005 watershed development conditions and near-normal annual precipitation, only about 9.7% of precipitation would actually reach Cobblestone Lake as surface runoff. In general a watershed with the land use composition found in the Cobblestone Lake watershed would produce approximately 23% of the rainfall volume as runoff. This suggests that a significant amount of runoff is lost, likely due to losses in the system such as infiltration in detention ponds. This monitoring data was used in calibrating the watershed model as explained in Section 4.

Table 2.1 presents tabular data for the area of all sub-watersheds draining to Cobblestone Lake for the 2005 and ultimate development scenario. See Map 1 and Figure 2.3 for references to the storm sewer outfalls and the associated sub-watersheds.

Table 2.1 – Summary of the drainage areas to Cobblestone Lake (labeled by Outfall and Sub-watersheds)

Outfall (Sub-watersheds draining to outfall)	**Area (acres)**	
Cobblestone Lake	***2005***	***Ultimate Development***
1 (EVR-441)	24	24
2 (EVR-442)	18	18
3 (EVR-41, EVR-42*, EVR-43, EVR-48*, EVR-440*, EVR-443)	2,986	3,132
4 (EVR-444)	45	45
5 (EVR-445)	n/a	170
Overland drainage direct to Cobblestone Lake (EVR-P44)**	42	51
Total	**3,115**	**3,440**

** Sub-watershed EVR-42 was noncontributing in 2005; sub-watersheds EVR-48 and EVR-440 are routed to EVR-42 for ultimate development*

***Includes Cobblestone Lake area*

The watershed around Cobblestone Lake is in transition. In 2005 sub-watershed district EVR-48 discharged directly to the lake through a bypass storm sewer at outfall #3. EVR-440 discharged into the field south of CR-42 where stormwater is infiltrated. As the intervening area develops, these sub-watersheds will be connected and routed through ponding in EVR-42 before being discharged to the lake. Additionally, areas that were not contributing storm water in 2005, including EVR-42 and EVR-445, will ultimately discharge to the lake.

2.5 LAKE MORPHOMETRY AND WATER LEVELS

2.5.1 LAKE MORPHOMETRY

Cobblestone Lake has a surface area of 36 acres. Figure 2.4 shows the bathymetry as surveyed by the City and Bonestroo staff in 2006. The depth contours are from a water elevation of 909.5, at the high end of the range of normal water elevations recorded in the lake over the last several years.

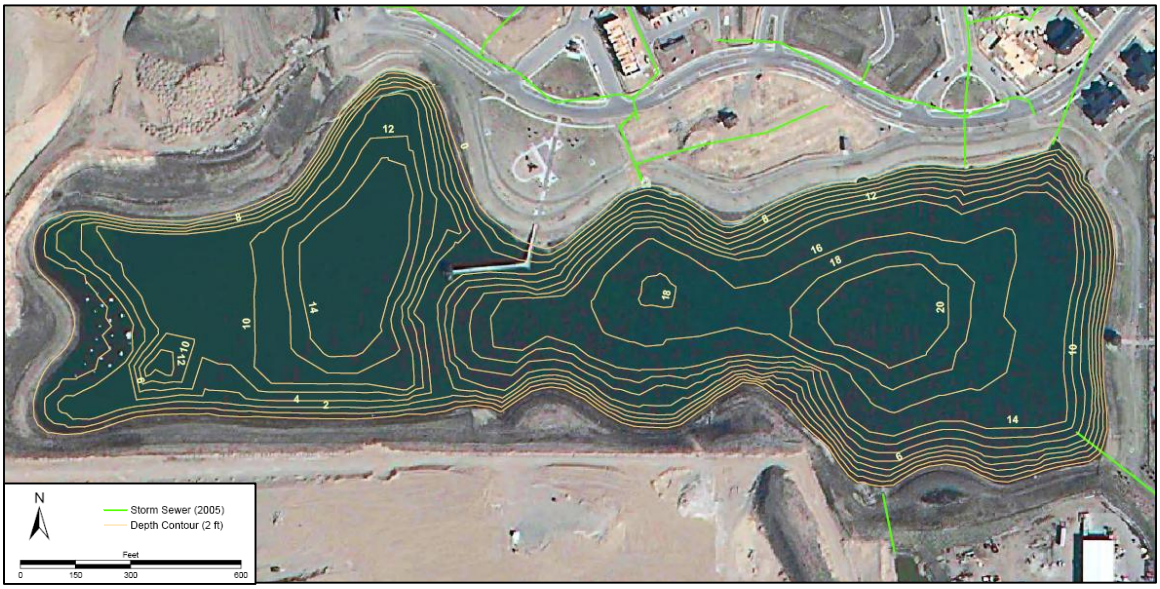


Figure 2.4 – Cobblestone Lake bathymetry (based on survey by City staff and Bonestroo. NWL = 909.5 ft. MSL)

Historical "normal" water level elevations in Cobblestone Lake between 2005 and 2006 have ranged between 908.5 and 909.3. At and below an expected normal elevation of 909.5, Cobblestone Lake would be considered a shallow lake, as defined by the MPCA, because 80% of the lake area at this water level elevation is less than 15 feet deep. If normal water elevations increase to above this elevation, the lake could be considered deep. This distinction is important because different, more stringent water quality requirements could be applied by MPCA based on their eutrophication standards if the lake is considered deep.

Table 2.2 summarizes key morphometric characteristics of the lake and the watershed draining to it under both existing and future (ultimate development) conditions.

Table 2.2 – Cobblestone Lake Characteristics: 2005 and Potential Ultimate Conditions

Characteristic	Cobblestone Lake (2005)	Cobblestone Lake Ultimate Development
DNR ID	19-0456	19-0456
Water Surface Level (Ft. MSL)	908.7*	909.5
Surface Area (Ac)[1]	35	36
Volume (Ac-ft)[2]	327	375
Max. Depth (Ft)[2]	18	20
Mean Depth (Ft)	9.3	10.4
Watershed Area (Ac)^	3,290	3,404
Watershed: Lake Ratio	85 : 1	95 : 1
Residence Time (years)	0.31	0.29

^ Watershed area does not include landlocked sub-districts or Lake surface area
** Average seasonal water level recorded at the outlet lift station for 2005*
Data Sources:
1. Obtained from georeferenced aerial photography using GIS
2. City of Apple Valley: lake depth survey

Cobblestone Lake has a very large watershed area to lake area ratio at 95:1. Natural lakes often have ratios less then 5:1. A large watershed area-to-lake area ratio is common in urbanized areas because of the interconnection of basins to facilitate stormwater conveyance and flood control, but the large ratio indicates that Cobblestone Lake could be vulnerable to stress from watershed inputs if aggressive steps are not taken to reduce runoff volumes from the watershed.

2.5.2 LAKE WATER LEVEL

Figure 2.5 shows the lake water level and precipitation recorded at the Cobblestone Lake lift station for 2005 and 2006. The water level in Cobblestone Lake reflects the elevation of the local surficial groundwater elevation in the area. Based on historic lake water level behavior as shown in the graph, Cobblestone Lake's normal water elevation fluctuates between 908.5 and 909.3. Moderate to large runoff events have caused the lake surface elevation to "bounce" temporarily to as high as 912.5. As mentioned previously, the lift station that acts as the surface outlet for the lake is set to begin pumping when the elevation of the lake reached 912.5, several feet above the apparent seasonal high groundwater elevation. The graph shows that even a large runoff volume, such as that generated by the rainfall event in October, 2005 did not generate a significant increase in the long-term base elevation of the lake.

It is anticipated that the water elevation in Cobblestone Lake will continue to be reflective of the local groundwater surface elevation and that this elevation will over the long term remain largely unchanged from its recent historical levels. The lake will therefore remain a "shallow" lake under the definition used by MPCA. The City's policy is to maintain infiltration capacity of the Cobblestone Lake system and to minimize surface discharges from the lake to Lakeville as much as possible. However, water elevation monitoring in Cobblestone Lake will be continued to track trends in long-term base water surface elevations in the lake to determine whether this remains the case.

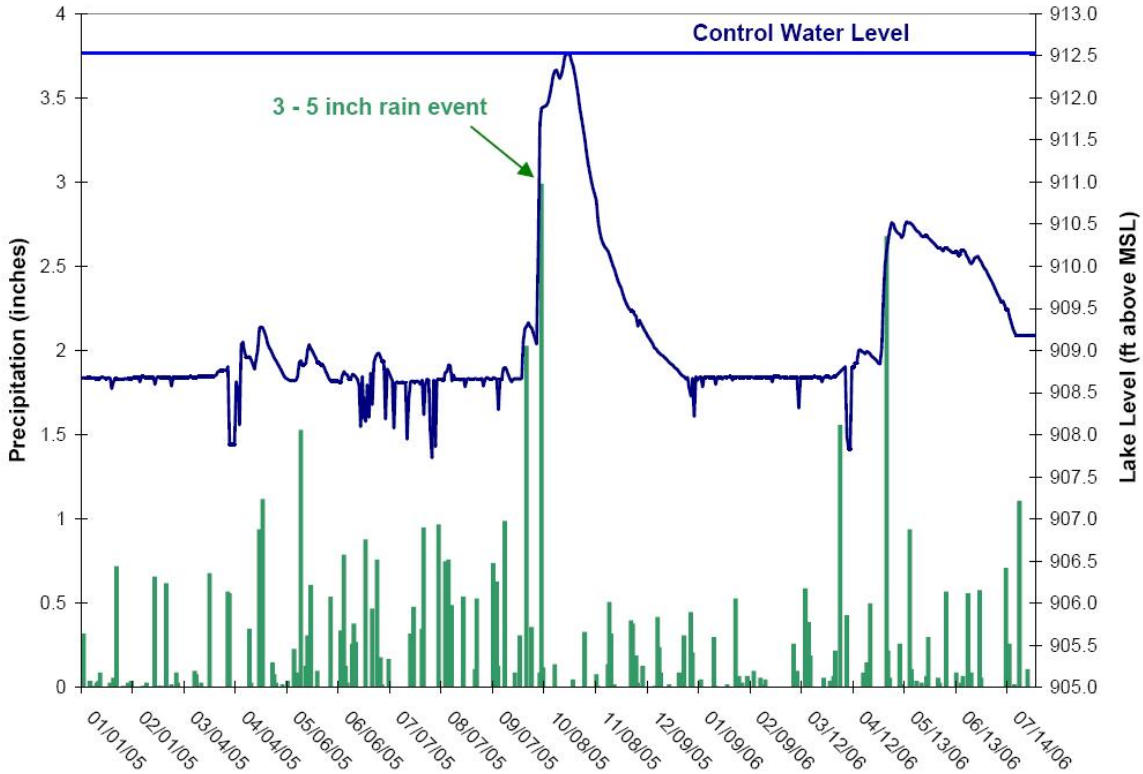


Figure 2.5 – Cobblestone Lake water level and precipitation recorded at the Cobblestone Lake lift station outlet

2.6 CURRENT WATER QUALITY AND RELATIONSHIP TO GOALS/ STANDARDS

The City's 2007 SWMP sets a series of in-lake water quality goals for Cobblestone Lake for total phosphorus, chlorophyll-*a*, and water clarity. The goals for Cobblestone Lake were based on the Minnesota Pollution Control Agency's (MPCA) eutrophication standards for shallow lakes in the Western Corn Belt Plains (WCBP) ecoregion, which is the ecoregion within which Cobblestone Lake and its surface watershed lie. The criteria are used by the MPCA to determine whether a lake should be listed as impaired and could be applied to Cobblestone Lake (see discussion later in this section). If Cobblestone Lake is listed, a Total Maximum Daily Load (TMDL) would then need to be prepared and implemented, much like the one prepared for Long and Farquar Lake in 2007.

Guidance provided by MPCA indicates that to avoid creation of in-lake conditions considered "impaired", one of the two following conditions must be met:

1. The monitored in-lake TP concentration and at least one of the other two parameters, chlorophyll-*a* or water clarity, must be better than or equal to the applicable standard.

2. The monitored value for both chlorophyll-*a* and water clarity must be equal or better than the applicable standard, even if the TP concentration is worse than the standard.

Monitoring data has been collected by City staff as part of the Metropolitan Council's Citizen-Assisted Monitoring Program in 2005, 2006, and 2007. Data for 2007 was not available at the time of preparation of this report. June through September mean values to 2005 and 2006 for total phosphorus, chlorophyll-*a*, and water clarity are presented in Figure 2.6. The number annotations on the bars indicate the number of data points included in each seasonal average value. Finally, the MPCA thresholds for shallow lakes in the WCBP ecoregion are shown as dashed lines.

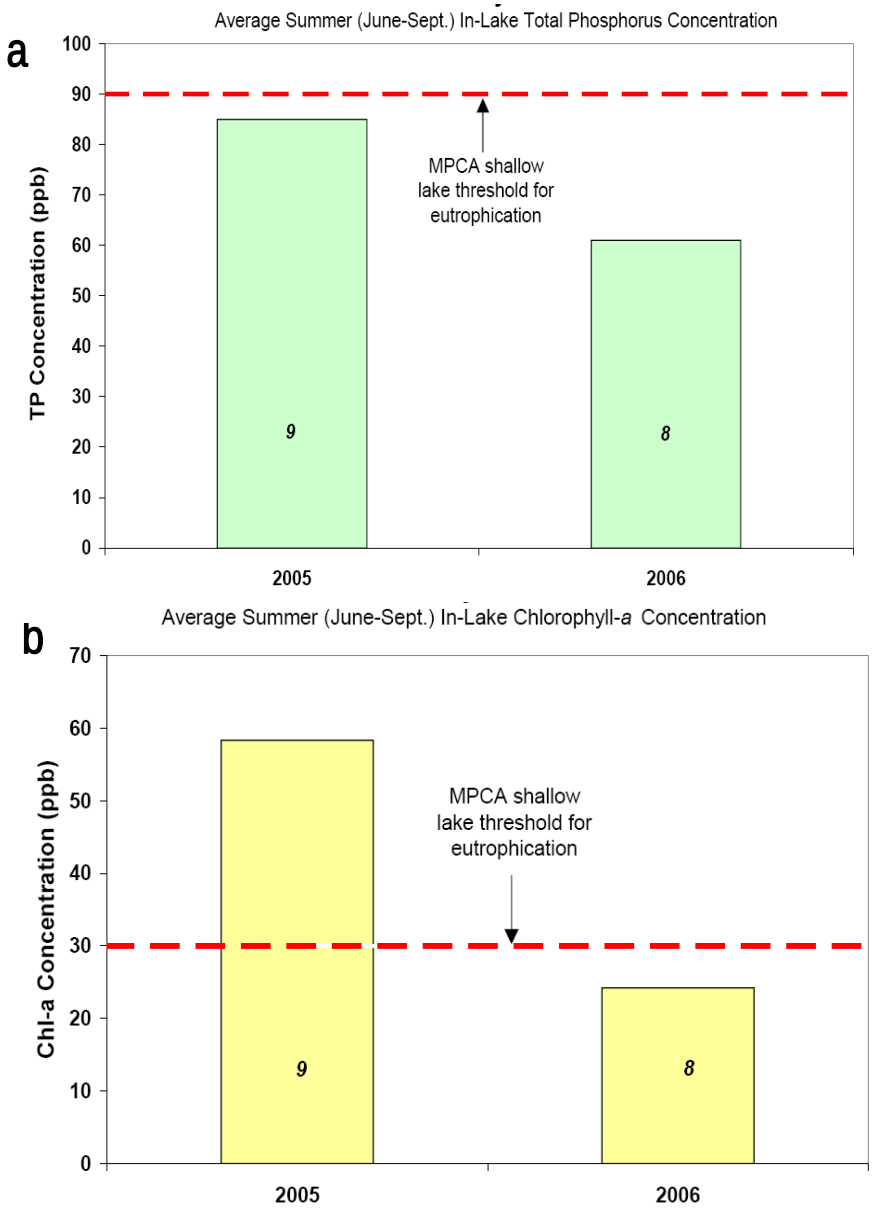
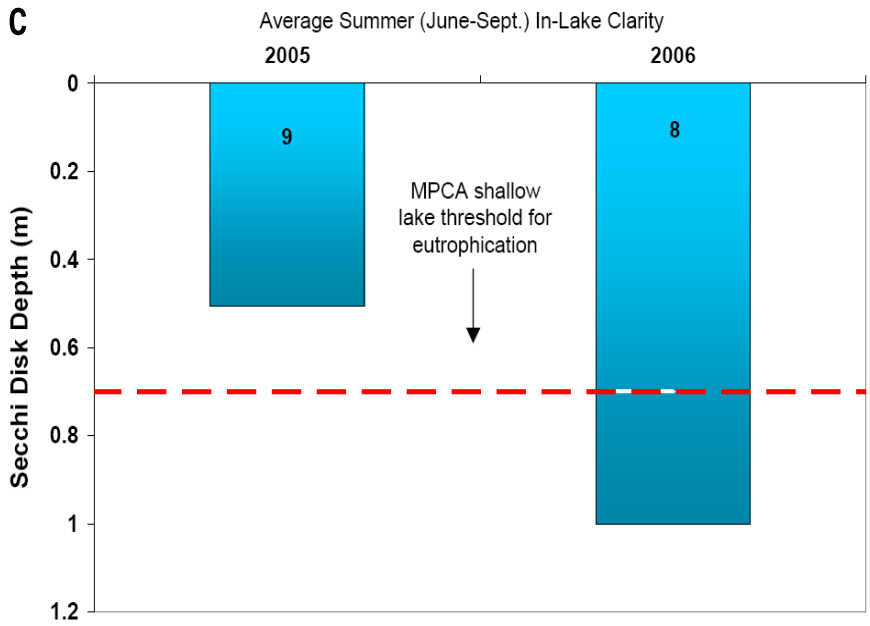


Figure 2.6 – Graphs of average annual summer water quality conditions for Cobblestone Lake. Numbers on the bars indicate the number of samples included in the average value. **a.** Total Phosphorus, **b.** Chlorophyll-*a*, **c.** Secchi Disk



Based on 2005 data, Cobblestone Lake did not meet either MPCA's shallow lake eutrophication standards nor the in-lake water quality criteria adopted in the City's Surface Water Management Plan (SWMP) for either water clarity or chlorophyll-*a*. The total phosphorus value was just below the threshold. Thus, the lake could have been listed as impaired on the basis of these data, so there is some urgency for action. Based on 2006 data, Cobblestone Lake met all three criteria. In 2006, precipitation (and therefore likely runoff) was somewhat below normal during the monitoring period and year. The difference in quality may be the result of some combination of differences in runoff volumes from the watershed, changes in groundwater influence (groundwater is generally of much better quality than surface water runoff), and/or changes in the state of the in-lake biological community (especially rooted aquatic plants and fish). The fact that the lake is very "young" means that it probably has few of the mechanisms developed yet to stabilize the lake water quality from year to year.

Cobblestone Lake is not listed as an "impaired water" on the Minnesota Pollution Control Agency's list of impaired waters, including the draft list published for 2008. It is not clear what the status of the lake is with regard to TMDL's. Steve Heiskary, staff limnologist with MPCA, indicated in an e-mail on May 3, 2006 that it is possible that the lake may be exempted from listing if it is a "man-made basin developed as part of a stormwater treatment network" (Heiskary 2006). It appears that with the language in the AUAR (2001), there would be a strong basis for making this argument. On the other hand, in conversations with Heiskary in July 2007, he indicated that if the lake is being used as a recreational resource, it could be eligible for listing in spite of its origin or use for stormwater management (Heiskary 2007). Thus this issue is somewhat uncertain at this time. Regardless of the outcome of this issue, the rationale for doing a lake management plan and putting in measures to protect the water quality in the lake still seems strong because of the priority given this resource in the City's updated SWMP.

Figure 2.7 shows the seasonal hypolimnetic (deep water) TP concentration data and gives an indication of the potential for internal loading of nutrients. The two measurements of TP concentration below the thermocline in Cobblestone Lake were taken at the beginning of the season and again at the end of the season in 2006. The concentration data indicate that there is evidence of a build up of TP below the thermocline during the summer. This increase signals the potential for internal loading. As will be discussed later, analyses presented later in this report indicates that there isn't yet evidence that this hypolimnetic load is significantly affecting surface water quality in Cobblestone Lake. However, the issue may become important in the future and deepwater TP concentrations should continue to be monitored to aid in future assessment.

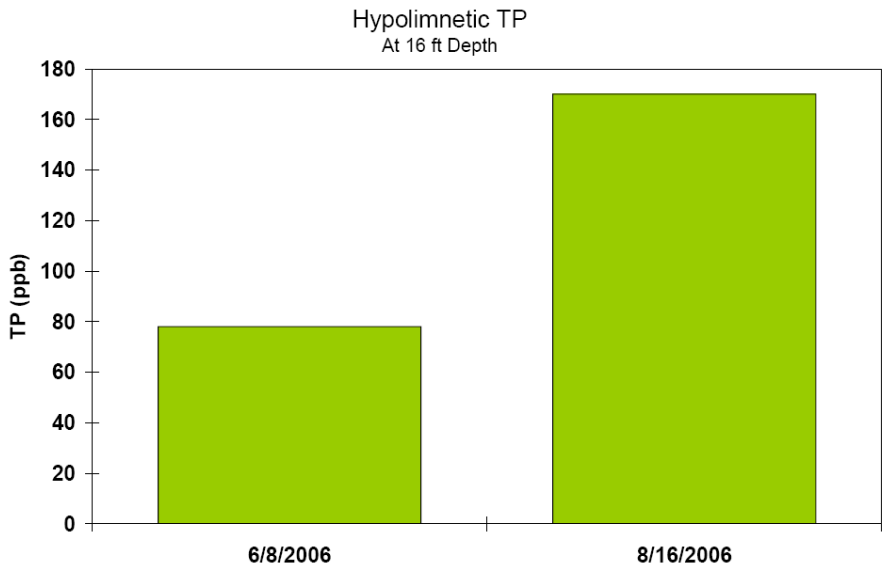


Figure 2.7 – Hypolimnetic TP concentration measurements showing build-up of TP below the thermocline

2.7 FISHERIES STATUS

The MnDNR conducted a fish population survey June 13, 2005. The survey found high populations of black bullhead and hybrid sunfish. No predatory gamefish were noted in the survey. Figure 2.8 shows the table from MnDNR with the breakdown of fish caught in the survey. Bullhead have been shown to be particularly devastating to the ecological community of shallow lakes, as in the Long and Farquar Lakes Nutrient TMDL (2008). The nutrients that have settled out of the water column and trapped in the sediments may be released by bullhead as they search for food in the sediments. The high populations of bullheads found during the survey in Cobblestone Lake may be a significant contributor to internal nutrient loadings at some point in the future and will be a key factor to track.

MnDNR stocked about 10,900 fish in Cobblestone Lake in 2005. A combination of black crappie, bluegill, and large numbers (over 10,000) of walleye fingerlings were stocked. If the walleye population matures and becomes established, they could exert some predatory pressures on bullheads and small panfish that may help limit the adverse impact of this population of the fish community on the ecology of the lake through top down predatory control of plankktivores (Zimmer et al. 2003). This could help the large-bodied zooplankton community to become established which can help to control the algal population through grazing and thereby improve water clarity.

Fish Sampled up to the 2005 Survey Year

Species	Gear Used	Number of fish per net: Caught	Normal Range	Average Fish Weight (lbs)	Normal Range (lbs)
Black Bullhead	Gill net	60.0	N/A - N/A	0.12	N/A - N/A
	Trap net	147.4	N/A - N/A	0.11	N/A - N/A
Bluegill	Trap net	9.2	N/A - N/A	0.04	N/A - N/A
Green Sunfish	Gill net	1.0	N/A - N/A	0.07	N/A - N/A
	Trap net	1.8	N/A - N/A	0.21	N/A - N/A
Hybrid Sunfish	Gill net	208.0	N/A - N/A	0.20	N/A - N/A
	Trap net	51.2	N/A - N/A	0.11	N/A - N/A

Normal Ranges represent typical catches for lakes with similar physical and chemical characteristics.

Length of Selected Species Sampled for All Gear for the 2005 Survey Year

Species	Number of fish caught in each category (inches): *0-5*	*6-8*	*9-11*	*12-14*	*15-19*	*20-24*	*25-29*	*>29*	*Total*
Black Bullhead	49	118	1	0	0	0	0	0	168
Bluegill	44	2	0	0	0	0	0	0	46
Green Sunfish	5	5	0	0	0	0	0	0	10
Hybrid Sunfish	139	45	1	0	0	0	0	0	185

Fish Stocked by Species for the Last Five Years

Year	Species	Age	Number
2005	*Black Crappie*	Adult	23
	Bluegill	Adult	406
	Walleye	Unknown	10,468

Figure 2.8 – MnDNR fish survey and stocking report – 2005 (MnDNR Lakefinder)

Periodic monitoring of the fish population will help in understanding the abundance, distribution, and species composition of the fish community. If populations of rough fish or stunted panfish dominate the lake over the long-term, the City should look for options to manipulate the fish populations. The City may focus on a combination of approaches, including stocking of the lake with predatory game fish (walleye, bass and/or channel catfish) as well as more direct methods to remove roughfish or stunted panfish from the system, such as netting and removal from the system. Lake drawdown, supplemented with treatment using the chemical Rotenone could also be considered if near total eradication of the fish population and re-stocking were desired.

2.8 AQUATIC VEGETATION

Shallow lakes rely on a robust aquatic plant community to help achieve and maintain good water quality. It is important for a young lake like Cobblestone to establish a healthy native-dominated aquatic plant community to help prevent a permanent transition to a turbid, algae-dominated system of limited ecological and recreational value. Aquatic plant establishment occurs either through voluntary recruitment from upstream water bodies or through transplanting species. Cobblestone Lake is a very young lake and is changing. It may take many years (5-10) for a stable aquatic plant community to form. There is a moderate to high possibility that the invasive plant Curly-leaf pondweed may become established in the lake. This is especially likely as it dominates the lake systems of Long and Farquar. Monitoring the

evolution of the aquatic plant community to identify and head off any problems is a recommendation of this plan.

An aquatic plant survey was conducted for Cobblestone Lake by Bluewater Science of St. Paul, MN in 2006 along with a benthic sediment analysis to help predict the likelihood of aquatic invasive plant growth. Two plant surveys were conducted, one in June and a follow-up in August. Each survey used the point-intercept method. The methods and results of that survey are summarized in a report by McComas (2006) located in Appendix A.

The survey showed that aquatic plant diversity in the lake is low with the favorable native species Chara being the dominant species covering approximately nine acres of the lake. Figure 2.9 shows a map of the lake and the coverage of plants. Rooted aquatic plants were found in water depths of 4 feet or less. Plant distribution is very limited, most likely because the lake is very "young" and does not have an established seed bank. No aquatic plants have been intentionally planted. Thus, all plants found in the lake represent volunteer specimens that have made their way into the lake via natural vectors, such as being carried in through storm sewer to the lake from upstream colonized areas. Excessive numbers of rough fish and stunted panfish may also be limiting native plant distribution and abundance. Bullheads for instance will root around in the sediments up-rooting plants as they search for food. Another factor may be seasonal water level fluctuations, discussed in Section 2.5 that may prevent establishment.

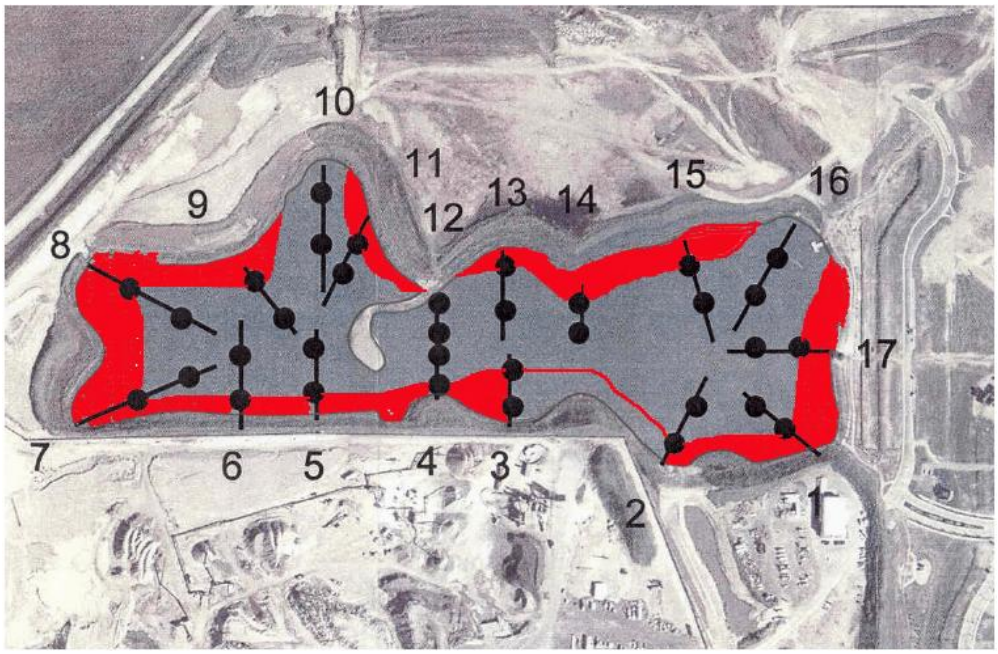


Figure 2.9 – Aquatic plant survey by Bluewater Science shows approximately 9 acres of sparse plant coverage

A similar plant survey was conducted in 2003 which did find some Curly-leaf pondweed in some areas of the lake. Comparing the results of the 2006 survey with 2003 shows Curly-leaf pondweed no longer shows up, but filamentous algae is now present. At nuisance levels, Curly-leaf pondweed can cause poor in-lake water quality. When the plants die back in midsummer, they release a pulse of nutrients back into the water column leading to algae blooms. Additionally, as the plants decay they can cause low oxygen conditions in the lake decreasing top-level predator fish habitat. See Appendix A for the complete aquatic survey and sediment survey reports.

One of the challenges in establishment of a stable native aquatic plant community in Cobblestone Lake will be the frequency, magnitude, and duration of water level fluctuations within the system. There are no "hard and fast" rules for deciding when water level fluctuations are too large or too long in duration to allow establishment of a stable native aquatic plant community. However, minimizing surface water runoff volumes to the lake by enhancing watershed infiltration, especially for small and medium precipitation events (i.e. for rainfalls up to a 2-year 24-hour rainfall or 2.8 inches of rainfall in 24 hours) will help decrease the frequency and magnitude of water level fluctuations and provide a more suitable habitat for development of both native emergents and submergent aquatic plants. Occasional large fluctuations in water level of several feet caused by large runoff events are probably unavoidable, since Cobblestone Lake lies at the bottom of a large surface water drainage and is a key storage facility for stormwater. It will be important to monitor the system after these events to see how the plant community recovers and whether these disturbances make the system more vulnerable to exotic invasives such as curly leaf pondweed and purple loosestrife, which could require periodic control efforts.

3 Water Quality Goals

3.1 WATER QUALITY STANDARDS FOR DESIGNATED USES

Cobblestone Lake is primarily used by the local neighborhood residents for fishing and aesthetic viewing of wildlife. City residents use the lake primarily for fishing as there is a 200-foot fishing pier in the City Park located on the north shore. There is no developed boat access to the lake. However, residents have access to carry-in sites along the lakes perimeter as the shoreland is owned and managed by the City's Parks and Recreation Department.

Cobblestone Lake is recognized by the MnDNR and designated as a Class 2B waters. Class 2B waters are lakes that support recreational use and provide habitat for cool and warm water fisheries with top-level predators, such as bass and walleye. The lake and its watersheds are located in the Western Corn Belt Plains (WCBP) ecoregion. The lake is considered shallow based on MPCA guidance (i.e. at least 80% of the lake less than 15 feet deep). In June 2008, the MPCA completed a process of revising the water quality standards presented in Minn. R. Chap. 7050 to include water quality standards for shallow lakes. The numeric standards for Class 2B shallow lakes compared with the deep lake standards in the WCBP ecoregion are shown in Table 3.1.

Table 3.1 –Eutrophication Standards for WCBP Ecoregion

Water Quality Parameter	WCBP (June – September Mean Values)	
	Shallow Lake	Deep Lake
Total Phosphorus (µg/L)	< 90	< 65
Chlorophyll-*a* (µg/L)	< 30	< 22
Water Clarity (m)	> 0.7	> 0.9

Minnesota's standards include narrative criteria for nutrients which limits the quantity of nutrients that may enter the waters. The State's standards (Minn. R. Chap 7050. Subp3 and Subp 5) state that all Class 2 waters of the state shall be free from any material increase in undesirable slime growths or aquatic plants including algae. Since MPCA does not currently have state-wide numeric criteria for nutrients in shallow lakes, the MPCA's phosphorus, chlorophyll-*a*, and water clarity standards for the Class 2B shallow lakes in the WCBP ecoregion (see preceding paragraph) are being used as the basis for the proposed numeric target for Cobblestone Lake. The MPCA numeric standards for these parameters are designed to meet the current applicable narrative water quality standards for the designated uses of shallow lakes.

Meeting the above State standards will also meet the City's criteria for these lakes based on the classification of Cobblestone Lake as a Class II water body, as proposed in the City's Surface Water Management Plan (2007). The SWMP defines Class II lakes by the following:

- Class II – These water bodies are intended to support indirect contact recreation activities that involve incidental contact with lake water. Examples include fishing, canoeing, and perhaps limited use of motor-driven water-craft. They also have depth characteristics (maximum depth > 6.6 feet and mean depth >3 feet) that allow these uses for the vast majority of the summertime recreation season in almost all years.

The water quality goals are quantitative for the three main parameters, total phosphorus, chlorophyll-*a* and water clarity. In order to meet these goals, a number of other indicators including water level, macrophyte composition, fisheries population, land use and BMP use and management are important factors. Managing these will ultimately determine the success of meeting the MPCA standards.

4 Phosphorus Source Assessment

4.1 MODELING METHODS

The watershed modeling and lake response modeling as well as analysis of the in-lake water quality data indicated that stormwater runoff and some internal loading were the primary sources of nutrients to Cobblestone Lake. The models also showed that the majority of external loading to the lake can be attributed to urban runoff.

4.1.1 SELECTION OF MODELS AND TOOLS

Models used to analyze phosphorus loading from the Cobblestone Lake watershed included a calibrated, urban watershed water quality spreadsheet model, PondNET (updated from Walker 1989). The original model was developed during the City's nondegradation review (Bonestroo 2007). The nondegradation model was calibrated for the Cobblestone Lake watershed using flow monitoring data gathered during 2005 and 2006 at the outlet of Farquar Lake and at the outlet of Pond EVR-P43. The watershed of Farquar Lake comprises approximately 68% of the drainage area to Cobblestone Lake, and the watershed of Pond EVR-P43 comprises about 87% of the lake's drainage area. For the most part, the land use based export factors for water load and phosphorus are those incorporated in the Nondegradation model. However, the land use composition was refined based on on-the-ground data and aerial photography from 2005. This resulted in differentiating the north and south Low Density Residential (LDR) land use areas, delineated at 140th Street. Impervious cover associated with LDR was significantly different between the two areas, with the area south of 140th Street having significantly higher impervious coverage per unit area than the area north of 140th Street. The resulting modeled export factors for LDR were also differentiated. In addition, areas of the northern part of the drainage contained a large land area with dense old growth tree stands. These areas were separated from LDR areas and reassigned to "Wooded" land use.

Table 4.1 shows the land use and associated export factors used in the PondNET model.

Table 4.1 – PondNET land use, associated impervious cover, water and pollutant export factors

Land Use	%Imp	Hydrologic Runoff Coefficient (Rv)	Unit P-Loading (lbs/ac/yr)
Low Density Residential (~2 units/acre) - generally north of 140th Street	24%	0.18	0.59
Low Density Residential (~3 units/acre) - generally south of 140th Street	40%	0.28	0.91
Medium Density Residential (4-12 units/acre)	45%	0.31	1.01
High Density Residential (12+ units/acre)	65%	0.43	1.41
Commercial	65%	0.43	1.09
Industrial	80%	0.52	1.33
Institutional	50%	0.34	0.86
Local Park	10%	0.09	0.17
Wooded Area (previously Reg. Park in SWMP)	0%	0.03	0.05
Golf Course	10%	0.09	0.38
Zoo	15%	0.12	0.23
Right-of-Way	40%	0.28	0.81
Undeveloped (Gravel Pit with 100% infiltration)	0%	0.00	0.00
Agriculture	0%	0.14	0.55

The export factors are based on the Nondegradation PondNET model with additional refinements based on calibration with GIS based aerial photography.

The Canfield-Bachman lake response model for artificial lakes/reservoirs as found in the Wisconsin Lake Modeling Suite (WILMS) (Panuska et al. 1994) and "Bathtub" (Walker, 1996) was used to estimate lake phosphorus concentrations for each watershed loading scenario. All 13 empirical models included in the WILMS suite were investigated to determine the model with the lowest mean error comparing 2005 and 2006 model scenarios with in-lake monitored phosphorus. The Canfield-Bachman growing season mean empirical model for artificial lakes is based on 433 lakes surveyed in the EPA National Eutrophication Survey conducted on reservoirs in the United States. This model had the lowest mean error, of the models available in WILMS, for 2005 and 2006 seasons of approximately 20%.

Additionally, sub-models were used from the Core of Engineers lake response model, "Bathtub" to estimate the Chlorophyll–*a* (Option #5) and Secchi Disk Transparency (Option #3) response based on modeled phosphorus concentration. Both are established empirical models used by the Army Corp of Engineers for conducting eutrophication studies on lakes.

Finally a calibrated P8 Urban Catchment Model was used to assess the average annual infiltration benefits of individual indirect drainage BMP retrofits. The model uses 10 years of climate data, from 1986 to 1995 to approximate an average annual volume infiltrated within the modeled BMPs. The model was calibrated to the same flow data used for the PondNet model based on the assumption that the 10 years of modeling could be considered to replicate the average volumes and loads experienced for an approximate average precipitation year. This analysis was used to provide the associated volume reduction applied within the PondNET pond infiltration sub-model for the new/retrofit BMPs for corresponding scenarios.

4.1.2 PHOSPHORUS BUDGETS AND RECEIVING WATER RESPONSE MODELING

The PondNET model was then run using 2005 precipitation as measured in Rosemount at the Agriculture Research Station, available through the Minnesota Climatology Working Group. The 2005 precipitation, land use and drainage conditions were used to run the model, as 2005 produced an approximate average precipitation year. The same precipitation was also used for future conditions scenario to determine average annual loads. In order to validate the in-lake model the PondNET model was run using 2006 precipitation and land use.

Watershed Calibration – The watershed hydrology was calibrated for 2005 based on pumped discharge volume records for the lift station at the outlet to Farquar Lake and continuous discharge monitoring at the outlet of EVR-P43 (conducted in 2006 and 2007). The runoff data was used to develop a relationship between rainfall and runoff for the watershed. This relationship was used to determine the equivalent runoff for the 2005 precipitation. The results provided the basis for the infiltration within ponds across the watersheds. Additionally soils data along with anecdotal knowledge of the system was also taken into account.

Based on a composite land use, the expected annual runoff coefficient (runoff volume / precipitation volume) for this watershed is approximately 0.23. However based on monitoring at the outlet to EVR-P43 in Apple Valley East Park, the estimated composite runoff coefficient is 0.097. That means approximately 60% less runoff is generated from this watershed which makes up over 90 percent of the ultimate contributing drainage area. See Appendix B for watershed calibration analysis of EVR-P43. Preserving and/or enhancing the infiltration of runoff within this section of the watershed will provide protection to the lake by decreasing the phosphorus load as the nutrients will be captured in the watershed and not discharged to the lake.

There are a total of 68 constructed and natural ponding areas within the watershed that are incorporated into the City's storm drainage system and whose treatments are modeled in PondNET for the 2005 scenario. After calibration of the water load, the watershed model estimates an average annual TP load of 597 lbs/year to Cobblestone Lake. For the ultimate development and drainage scenario, including implementing BMPs based on the City's current development infiltration policy, the total watershed TP load to the lake is predicted to be 778 lbs/year. Table 4.2 shows the breakdown of TP loads to Cobblestone Lake by outlet as referenced in Figure 2.3. Note: Direct drainage are all areas draining overland and through stormsewer that is not first routed to a BMP before entering Cobblestone Lake.

Table 4.2 – Modeled Watershed TP loads to Cobblestone Lake (ultimate conditions)

Outfall (Sub-watershed draining to the outfall)	TP Load (lbs/year)	Percent of Total TP Load
Cobblestone Lake		
1 (EVR-P441)	26.6	3.4%
2 (EVR-P442)	17.3	2.2%
3 (EVR-P41, P42, P43, P443)	598.3	76.9%
4 (EVR-P444)	39.5	5.1%
5 (EVR-P445)	93.7	12.0%
Overland drainage direct to Cobblestone Lake (EVR-P44)	*2.6*	*0.3%*
Total	**778**	**100%**

Based on the modeled watershed loads, the Canfield-Bachman model was used to estimate in-lake phosphorus concentration. The model estimates phosphorus concentrations based on the total phosphorus load delivered to the lake from watershed, atmospheric, and internal sources on an average annual basis and on mean lake depth and lake flushing rate (or residence time). The model was compared to monitored in-lake phosphorus to estimate internal TP loading for average precipitation year of 2005 and for 2006 which was a dry year. For 2005 an internal load of 128 lbs/year was estimated, whereas in 2006 the lake model showed a net loss of load to the lake of approximately 85 lbs/year. Using the "Bathtub" model, estimates for Chlorophyll-*a* and water clarity (secchi disk transparency) were determined for both scenarios based on modeled TP concentrations.

Table 4.3 compares the results from 2005 in-lake monitoring and the in-lake modeling for ultimate conditions, including the City's infiltration policy. The lake water quality goals are also referenced from Section 3.

Table 4.3 – Modeled in-lake water quality for ultimate development compared with 2005 monitored water quality

Water Quality Parameters	Observed (2005)	Predicted Ultimate Development*	MPCA Std. Shallow Lakes
Cobblestone Lake			
Total Phosphorus (μg/L)	85.0	88	< 90
Chlorophyll-*a* (μg/L)	58.3	56†	< 30
Water Clarity (m)‡	0.51	0.59‡	> 0.70

** Based on Canfield-Bachman for Artificial Lakes (1981) empirical model based on 433 lakes from the EPA National Eutrophication Study.*

† Based on Bathtub Chl-a model Option #5

‡ Based on Bathtub secchi depth model Option #3

4.2 ANALYSIS OF PHOSPHORUS CONTRIBUTIONS

4.2.1 URBAN STORMWATER

Modeling shows a significant increase in TP load to the lake from the watershed during the period from 2005 to ultimate land use conditions. The model shows the watershed TP load increases by 193 pounds per year (25%) for the ultimate condition for a final TP load of 778 pounds per year compared to an estimated 585 pounds per year in 2005. The ultimate conditions model assumes that new development implements volume reduction for the first ½ inch of runoff from the site, as per current City policy.
The results show that even with these new development controls there will be a substantial increase in runoff volume and phosphorus loading to the lake. The primary reason for this is that all the area that will be developed in the future (335 acres) does not contribute any runoff to the lake under 2005 conditions because it is comprised of sand and gravel mining land uses that infiltrate virtually all precipitation.

The phosphorus loads from sub-watersheds to the lake through outlets 1 – 5, illustrated in Map 1 and Figure 2.3, are shown in Figure 4.1 for an average precipitation year, 2005, and for ultimate land use conditions.

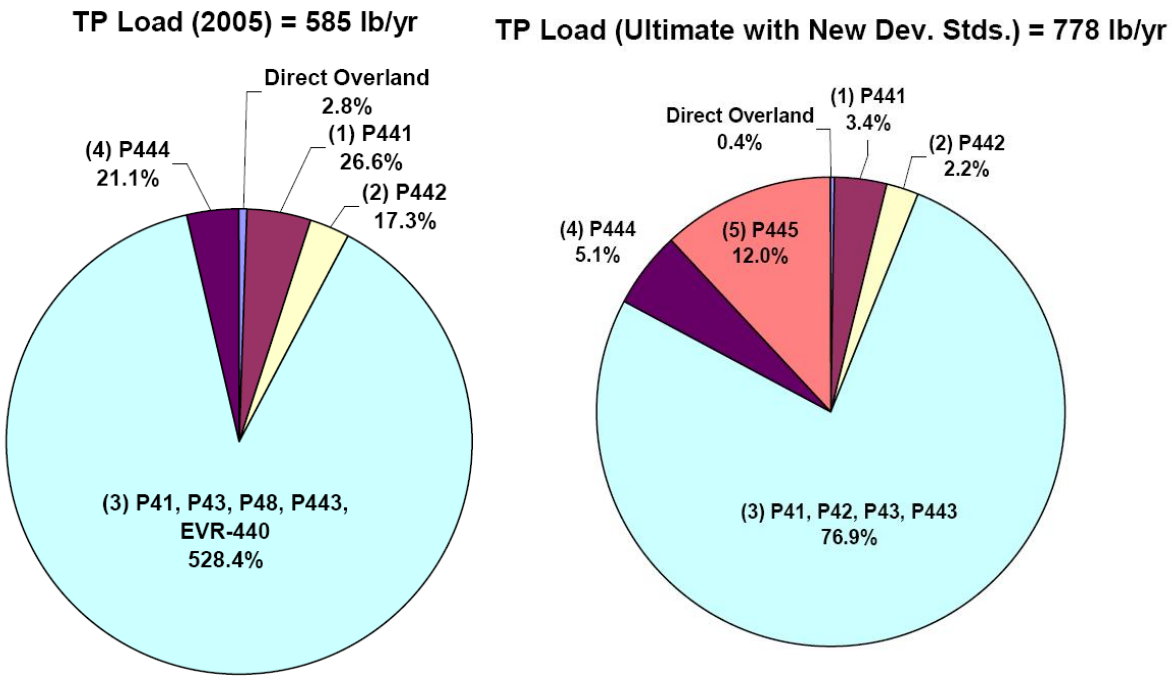


Figure 4.1 – Percent of average annual phosphorus load to Cobblestone Lake by contributing sub-watershed
Left: 2005 conditions for four outfalls, **Right:** Ultimate conditions assuming new development pre-treatment and infiltration of the first ½ inch of runoff before discharge to the Lake for five outfalls.

As new development occurs there will be a reconfiguration of the storm sewer system. Currently pond EVR-P48 discharges directly to Cobblestone Lake via storm sewer that routes the stormwater around the former gravel mine to the northwest of the lake. The untreated sub-watershed EVR-440 currently discharges to the field south of CR 42. Once the intervening area develops, ponding will be used to manage stormwater runoff, and the three sub-watersheds will discharge to the new pond before being routed to the lake through Outfall #3. Additionally, development of sub-watershed EVR-445 will create the need for a new outfall at Cobblestone Lake, labeled "Outfall #5" on Map 1 and Figure 2.3.

4.2.2 INTERNAL PHOSPHORUS RELEASE

Lakes that receive larger phosphorus loads then they can assimilate into biomass, will store the phosphorus in benthic (bottom) sediments. Over time, a high enough concentration builds up such that the sediments can no longer hold additional phosphorus. At this point, phosphorus may be released back into the water column, often called internal loading or recycling. In shallow lakes without a stable thermocline, the phosphorus released is periodically mixed up into the surface waters of the lake and can contribute to algae growth, especially in the middle and later part of the growing season. It is also important to realize that because Cobblestone Lake effectively has no surface outlet, what reaches the lake stays in the lake. Thus, incoming phosphorus will be retained to an even greater degree in Cobblestone Lake than in lakes that discharge, which is likley to increase the risk of internal phosphorus loading in the future.

Internal loading is not uncommon in many shallow lakes and so far, the internal load in Cobblestone Lake appears to be a relatively small portion of the overall load. Modeling of 2005 conditions showed internal loading contributed approximately 17 percent of the total TP load, whereas in 2006 there was a net loss. The summer of 2006 was relatively dry with only 8.8 inches of rain between May and the beginning of August compared to a 30 year average of 13.3 inches. During this time there was little runoff from the watershed producing a smaller than average watershed TP load. However, given that the lake retains almost all the phosphorus reaching it because of the absence of any surface outlet, internal loading may become a problem in the future, and should be tracked through annual monitoring.

4.2.3 ATMOSPHERIC DEPOSITION

The deposition of phosphorus from the atmosphere over the surface of the lakes is accounted for in the modeling but is small in comparison to the watershed loads. An estimate based on average depositional rates in the upper Midwest area was used for Cobblestone Lake. The rate is estimated to be between 5 – 30 pounds per year (up to 3% of the total TP load); this corresponds to the average load suggested in the BATHTUB in-lake water quality model (Walker, 1996). While the area previously mined around the lake is under construction with little to no cover, large amounts of dust may transport higher than normal loads of phosphorus to the lake via the atmosphere, but this will quickly diminish as the area is developed over the next few years.

5 Watershed Scenarios and Lake Response

5.1 INTRODUCTION

Using the models described above various watershed scenarios were analyzed to determine how changes in land use and implementation of BMPs would affect phosphorus loading to the lake and subsequent lake water quality response. The following section outlines various management scenarios to provide a framework for proposed management and implementation recommendations presented in Section 6.

5.2 FUTURE WATERSHED SCENARIOS

The models were used to analyze average annual conditions in the watershed and lake for five scenarios:

1. 2005 (existing conditions)
2. Ultimate development based on no stormwater treatment for new development
3. Same as #2 and including current City development stormwater mitigation policy (volume reduction based on infiltration of the first ½ inch of runoff from the site)
4. Same as #3 and including enhancement of BMPs in the indirect watershed (excavation of EVR-P43)
5. Same as #4 and including the "Reserve" project infiltration installation in subwatershed EVR-400

All ultimate development scenarios incorporate the 90 μg/L TP discharge goal from Farquar Lake as outlined in the Long and Farquar TMDL.

Scenario 5 is a reserve project and would only be considered if future monitoring indicates additional measures are needed to reduce watershed loads so that Cobblestone Lake can consistently meet in-lake water quality goals.

Table 5.1 shows the modeling results for the various scenarios outlined above under average annual precipitation conditions. For comparison, the Existing Conditions (Scenario 1) scenario based on watershed development conditions as of 2005 and a hypothetical Ultimate Development Conditions with no stromwater treatment (Scenario 2) provides estimates of phosphorus loads and in-lake water quality without application of the City's current infiltration policy are provided.

Because of how young the Cobblestone Lake system is, the modeling results are more useful as a relative predictor of future in-lake quality than an absolute predictor. The range in modeled in-lake water quality for phosphorus, chlorophyll-*a*, and water clarity is intended to reflect the inherent uncertainty associated with how Cobblestone Lake itself will evolve in the future. For example, if an in-lake biological community comprised of a robust native aquatic plant community and a balanced fish population develops, in-lake water quality could be as good as or better than the higher quality end of the range. If there is little to no native aquatic plant community and the fish population is dominated by roughfish or stunted panfish, in-lake water quality could easily be as bad as or worse than the lower quality end of the range. Finally, it should be noted that the fifth scenario represents a reserve project that is not recommended for design and construction at this time because it is both relatively expensive and will be temporarily disruptive to park

land during installation. This project is identified in case watershed phosphorus loads need to be reduced further than runoff volume reduction and re-configuration of Pond WVR-P43 can provide.

Table 5.1 – In-lake water quality modeling predictions for capital management scenarios

1. 2005 (Existing Conditions)	2. Ultimate Development w/out additional BMPs	3. Ultimate Development with volume reduction of the first ½ inch of runoff	4. Ultimate Development with Upstream Improvements (P43)	5. "Reserve" Ultimate Development with Upstream Improvements (P400 & P43)
TP_{Load} = 610 lbs/year	TP_{Load} = 924 lbs/year	TP_{Load} = 793 lbs/year	TP_{Load} = 693 lbs/year	TP_{Load} = 653 lbs/year
TP = 75 - 86 μg/L	TP = 89 - 98 μg/L	TP = 83 - 94 μg/L	TP = 79 - 91 μg/L	TP = 79 - 91 μg/L
Chl-*a* = 44 - 54 μg/L	Chl-*a* = 57 – 65 μg/L	Chl-*a* = 51 - 62 μg/L	Chl-*a* = 48 - 59 μg/L	Chl-*a* = 48 - 59 μg/L
Water clarity = 0.60 m – 0.67 m	Water clarity = 0.55 m – 0.59 m	Water clarity = 0.56 m – 0.62 m	Water clarity = 0.58 m – 0.64 m	Water clarity = 0.58 m – 0.64 m

** Based on Canfield-Bachman for Artificial Lakes (1981) empirical model based on 433 lakes from the EPA National Eutrophication Study. Range presented based on an equivalent load range of ± 0.02 kg/ha-yr or approximately ± 60 lbs/year.*

The watershed management measures outlined in Table 5.1 are described in more detail in the following sections.

5.2.1 New and re-development controls following the SWMP policies

Over 300 acres of gravel mining area to the south, west and northwest of Cobblestone Lake in sub-watersheds EVR-42 and EVR-445 will be developed to residential and commercial land uses. This area currently infiltrates all the precipitation that lands on or drains to it. Once developed, the area will incorporate storm sewer to collect runoff from impervious areas and convey a portion of it to Cobblestone Lake. Although the area will generate a greater amount of runoff than under existing conditions, the first ½ inch of runoff from the entire site will be infiltrated as per current City policy. Meeting the City's infiltration requirements will reduce the proportion of annual precipitation that drains into Cobblestone Lake from 30-45% to 15%. Because this area generates no runoff under the current "pre-development" condition, application of the City's infiltration policy will still increase watershed phosphorus loads by about 130 lbs/year from 2005 watershed development conditions for average annual precipitation. For comparison, without application of the infiltration policy to new development, phosphorus loads to Cobblestone Lake would increase by 260 lbs/year.

If reasonable and practical, the City should consider fostering infiltration of runoff over and above the ½-inch policy. This could potentially be accomplished if the City creates additional ponding in the watershed. Where pond BMPs are used in new development, the ponding can be designed to infiltrate water by creating vertical separation between the area of the pond bottom that may be sealed to hold standing water and the outlet elevation. Additionally, outlet structures should be fitted with restricted outlets to enhance side slope infiltration for small to moderate runoff events. However no attempt was made to account in the model for any additional infiltration associated with future development beyond the ½-inch runoff depth identified in the City's current policy.

5.2.2 CLEANOUT/RE-CONFIGURATION OF POND EVR-P43 IN APPLE VALLEY EAST PARK

Over 63% of the total TP load was routed to Cobblestone Lake through EVR-P43 in 2005. Under ultimate land use conditions and following recommendations in Section 5.4.1, 46% of the total TP load will discharge through this watershed, still representing the highest load of any of the indirect sub-watershed. The pond near the ball field in Apple Valley East Park is currently not adequate to treat stormwater. The pond surface water area is about 0.8 acres and it has a mean depth of approximately 0.6 feet. The PondNET model estimated the current treatment efficiency (based on 2005 conditions) is 2%.

To improve treatment efficiency the pond may be excavated to a mean depth of four feet. The modeled efficiency would increase to 30% which assumes an increase in infiltration potential after excavation into the parent type "B" soils. Due to the location near the former sand and gravel mining operation it is assumed the pond, once excavated to remove the seal, could infiltrate at a rate of 0.6 inches per hour. Based on the P8 model, the reconfigured pond is estimated to infiltrate approximately 20 percent of the hydraulic load routed to it.

If the pond can be re-configured and infiltration can be achieved as assumed above, the TP load to Cobblestone Lake through outfall #3 could be reduced by as much as 98 lbs/year with this project. One potential complication is that the area occupied by Pond EVR-P43 appears to be the site of a jurisdictional wetland. As such, wetland impact and sequencing issues will need to be addressed as part of the effort to determine the feasibility of this project.

5.2.3 INFILTRATION STRUCTURE IN EVR-P400 (RESERVE PROJECT)

Outflow from Farquar Lake comprises almost half of the overall volume of surface water runoff flowing into Cobblestone Lake. However, the discharge is routed through several stormwater treatment ponds before discharging into Cobblestone Lake. The resulting hydraulic loading reduces efficiencies in these ponds for treating runoff within the Cobblestone drainage area. The Lake Management Plan for Long and Farquar Lakes will ultimately decrease nutrient loading resulting from high phosphorus concentrated discharge from Farquar Lake. However, the decreased efficiency due to large hydraulic loading will not change substantially. To improve the treatment efficiencies of BMPs between Delaney Park (EVR-400) and Cobblestone Lake as well as to decrease loading from upstream areas, infiltration of water pumped from Farquar Lake is proposed between EVR-P39 in Delaney Park and EVR-P40 in Diamond Path Park, in the EVR-400 sub-watershed.

The proposed structure will cover about one acre. Approximately 23% of water routed through the structure is estimated to infiltrate on an average annual basis (based on P8 model of proposed structure with an assumed infiltration rate of 0.6 inches/hour). This runoff will already have pretreatment in EVR-P39 and direct drainage in the sub-watershed is treated by filtering through grass as overland flow. Therefore unlike other infiltration BMPs, the proposed structure will not require additional pretreatment.

This proposed reserve project will decrease TP loading to Cobblestone Lake through outfall #3 by approximately 41 lbs/year.

5.3 OTHER MANAGEMENT MEASURES

As shown in Table 5.1, even after reaching the target TP goal of 90 μg/L, Cobblestone Lake may not meet the Chl-*a* and water clarity criteria for shallow lakes in Section 3 and by MPCA. To improve the in-lake water quality beyond what watershed load reductions will achieve, additional projects are recommended.

The projects include:

- Carry out management and maintenance measures in direct drainage (i.e. raingardens and other infiltration features, street-sweeping, public education, etc.)
- Establishing a native shoreline buffer up to 30% of the lakes shoreline in the next 5 years
- Management and enhancement of aquatic plant community and fisheries

5.3.1 MANAGEMENT/MAINTENANCE/ENHANCEMENT OF DIRECT DRAINAGE BMP'S

There are six raingardens in the Cobblestone Lake Development along the north and east sides of the lake within sub-watershed EVR-443. These raingardens were installed with the final grading and landscaping of the lots. The drainage areas and treatment efficiencies of these raingardens is unknown (rough estimate of approximately 12 acres of rooftops and backyards), and there is evidence that most of them may not be working as originally intended or have even been installed.

Low Impact Development practices, like raingardens, can treat stormwater from residential lots and a number of well positioned and designed raingardens can provide a significant level of treatment to the drainage area they serve. They also provide an educational element; as residents interact with these features to provide maintenance they become aware of how decisions of individuals can affect Cobblestone Lake. Making sure existing raingardens are functioning as intended will help reduce TP loading to Cobblestone Lake by 6-10 lbs/year, based on the above assumptions and an estimated treatment efficiency between 70 and 83 percent (EPA Storm Water Technology Fact Sheet).

In addition, the City should increase the intensity of its sweeping program in the direct drainage of the lake to 3-4 times per year with a vacuum sweeper. The City should also work with the homeowners association(s) on public education of residents in the lake's direct drainage area emphasizing, at a minimum, lawn soil testing and use of no-phosphorus fertilizer where possible, minimizing runoff volume from individual properties, and education on the direct connection between the storm sewer system and Cobblestone Lake. Finally, any public improvements, whether associated with streets, trails, or park facilities, should consider incorporation of features to enhance infiltration of runoff from impervious and maintained pervious surfaces.

5.3.2 LAKESHORE BUFFER CREATION

Planting and maintenance of a native shoreline buffer around Cobblestone Lake also has a role in protection of lake water quality. A native buffer along the shoreline will provide a number of benefits including:

- Masks water level variations so water level fluctuations are less noticeable to the public
- Limits the need for mowing on the steep shoreline banks
- Creates a waterfowl deterrent which will decrease the amount of excrement supplying nutrients to the lake

- Provides a buffer strip to filter overland runoff entering the lake
- Provides shoreline stabilization and erosion control from waves and water level fluctuations

A 20-30 foot wide native shoreline buffer is recommended to ultimately line as much of the shoreline as possible. The buffer could be installed in stages, with an initial buffer installation along 100-200 feet during the first 1-2 years and a goal of installing a buffer along 30% of the shoreline within 5 years. Achieving the later objective could decrease phosphorus loading to the lake by about 3 lbs./year.

5.3.3 Management of in-lake biological community

Achieving the TP load reductions outlined in Table 5.1 will reduce in-lake total phosphorus concentrations to about 90 μg/L. The "Bathtub" lake response model predicts, however, the lake could remain in a turbid, algal-dominated state and that the chlorophyll-*a* levels for the lake may be above the threshold and water clarity below the threshold needed to meet the applicable eutrophication standards.

In order to bring one or both of these parameters into compliance with the standards, a biomanipulation approach will be taken. This approach involves making adjustments in the biological community of the lake's ecosystem to achieve the desired end (Moss 1996). In this case, the goal will be to achieve the applicable chlorophyll-*a* and water clarity standards for the lake. This will be accomplished through a combination of fostering establishment of the native aquatic plants, preferably from the voluntary seed bank derived from upstream supplemented by transplanting native pioneer species as necessary. In addition, establishing a piscivorous fish population adequate to control benthivores and planktivores is also a priority in Cobblestone Lake.

Aquatic plants – Cobblestone Lake is very young with an unstable and evolving in-lake ecology. Recent surveys have shown the beginnings of a good quality aquatic plant community with Chara being the dominant species. However, the sediment analysis by Blue Water Science (see Appendix A) showed a potential for nuisance invasive aquatic plants, likely through voluntary recruitment from upstream of Curly-leaf pondweed. To help prevent the infestation from occurring in Cobblestone Lake, the City should investigate ponds downstream of Farquar Lake to determine the extent of spread of the plants. Ponds to be inspected include: EVR-P39, EVR-P40 and EVR-P43.

Monitoring of the aquatic plant community in Cobblestone should be continued every 2 years to determine the quality of establishment and identify any precursors to an invasive outbreak. Depending on the findings of future surveys, it may be recommended to plant additional plants in the lake and/or potentially remove invasive plant growth.

Fisheries – The MnDNR stocked Cobblestone Lake in 2005 with primarily top level feeders which, if they become established, will likely promote a zooplankton population that may be able to control algae growth through the control of the pan fish population. The City should consider conducting a follow-up fish survey of the lake in 2 years to make an assessment of the fish population to determine whether the lake is supporting a balanced fish population.

The goals of these activities does not necessarily reduce the TP load delivered to the lake, but focuses on the ecologic factors that influence the other two eutrophication parameters, to minimize Chl-*a* and maximize water clarity at any given in-lake phosphorus concentration.

5.4 ADAPTIVE MANAGEMENT

Lake and watershed systems are highly dynamic and influenced by climate, ecological variability and anthropogenic activities. To ensure that the City can react to changing conditions and achieve the goals outlined in this plan, the Lake Management Plan implementation will be carried out on an iterative basis under an adaptive management strategy (Freeman, et. al. 2004) so that course corrections based on periodic monitoring and evaluation of the data can be used to adjust the strategy. After the first 5-year phase of nutrient reduction efforts, through new development and upstream BMP improvements, a re-evaluation will occur based on the monitored response of the system to those changes, and activities will be identified that need to be modified, removed, or added to reach the goals.

Since Cobblestone Lake is very young, the lake will likely experience highly variable water quality until a stable ecosystem is established. It will be important to control loads from the watershed, but also closely monitor the biological structure of the lake ecosystem itself and make adjustments in management of that system as necessary.

6. Implementation Plan

6.1. RECOMMENDED WATERSHED AND LAKE MANAGEMENT STRATEGIES

This implementation plan focuses on reducing the movement of phosphorus from the watershed area into Cobblestone Lake as well as working within the lake to reduce potential for phosphorus recycling, decrease algal production as defined by chlorophyll-*a*, and improve water clarity to meet the MPCA WCBP ecoregion shallow lake criteria, as presented in Section 3. Consistent with the philosophy of adaptive management outlined in Section 5, there will be an emphasis on assessing the impacts of the management actions to a reasonable extent and applying lessons learned to guide future actions as progress is made toward the goals.

The proposed management strategy for Cobblestone Lake takes a phased approach that combines tight controls to minimize surface water runoff from new and re-developed areas to the lake with continued monitoring of the lake as it evolves, helping the lake establish a desirable in-lake biological community, and implementing projects to reduce surface runoff-driven loadings from existing developed areas within the lake's watershed. This phased approach is outlined below.

The reductions from the portions of the developing urban watershed to Cobblestone Lake are summarized below in Table 6.1. In addition, internal loading which is not currently a significant source of phosphorus loading to the lake will be monitored to help assess the eutrophication status of the lake. If internal loading becomes an identified problem in the future, in-lake management measures are available to counteract internal loading by biological and chemical methods.

Table 6.1 – Summary of proposed phosphorus reductions to be implemented

Management Action	Estimated TP Load Reduction
1. Improve outflow quality of Farquar Lake through TMDL	28 lbs/year
2. New Development Controls	128 lbs/year
3. Expansion of Pond EVR-P43	98 lbs/year
4. Infiltration Structure in sub-watershed EVR-400 (reserve)	41 lbs/year
5. Evaluate, restore, expand BMPs in direct drainage. This includes developing a native shoreline buffer	Up to 13 lbs/year^
6. Monitor, management of in-lake water quality and biologic community	N/A*

^ Determined reductions based on EPA Storm Water Technology Fact Sheet: TP reduction = 70% - 83%
* In-lake Management efforts may or may not have a significant effect on TP in the lake.
The improvements of a well managed aquatic ecosystem will be through improved Chl-*a* and Water Clarity.

The following sections summarize the specific activities that comprise the implementation plan, provide additional guidance in implementing each measure as necessary and presents planning-level cost ranges for those elements. Table 6.2 at the end of this section shows a planning-level cost estimate (in 2008 dollars) for each element, and presents a proposed timetable to guide implementation and budgeting.

6.1.1 Improve water quality through the Long and Farquar Lakes TMDL implementation

Continue efforts through the TMDL process already underway to meet in-lake phosphorus goals for Long and Farquar Lake. The lift station outlet for the Long/Farquar Lake system discharges water that travels through a number of ponds in the Cobblestone Lake watershed and eventually reaches Cobblestone Lake itself.

The implementation activities related to achieving the goals in the Long and Farquar TMDL are budgeted within the Lake Management Plan for those lakes. The timeframe associated with reaching the water quality goals are likely longer then the five year schedule laid out for this Plan.

6.1.2 New and re-development controls following the SWMP policies

New and re-development activities in the Cobblestone Lake watershed will be required to meet the City requirements for reducing runoff volume as well as control of total phosphorus and total suspended solids for surface water runoff prior to discharge of runoff from the sites to Cobblestone Lake. The key criteria will be to achieve infiltration of the first ½" of runoff from these sites. The cost for implementation will be incurred by the development. The only cost to the City will be related to review of development planning and associated BMPs. The implementation will occur until this area has been completely built out.

6.1.3 Expansion of pond EVR-P43 in Apple Valley East Park

The pond EVR-P43 is located within City parkland at Apple Valley East Park, just north of Cobblestone Lake. The pond has filled with sediment from upstream flow over many years. Aerial photos from 1990 show the pond clear of emergent macrophytes. Today, the pond is over grown with cattail which present a flood hazard as high flows can cause uprooting and clogging of the outlet structure. This pond should be cleaned out and re-configured to improve nutrient removal efficiency from 2% to as high as 30%, if additional infiltration capacity and treatment volume within the pond can be created. The mean depth of the pond should be increased to 4 feet which will include removing dense cattail stands currently in the pond. This action will also improve flood control functions served by this pond. The pond would be excavated to sufficient depth to prevent re-growth of the cattails.

As the pond is in close proximity to the backstop of a City baseball field it maybe desirable to design a buffer along the fringe of the pond to provide screening and slow errant balls from rolling into the water.

This implementation measure is the top priority indirect drainage management measure as it provides a substantial TP load reduction second only to the previous activity. However, the area appears to be a jurisdictional wetland, so wetland impacts and mitigation costs will need to be considered in deciding whether to move ahead with the project. The estimated costs for feasibility/ design and for construction are $48,000 and $162,000 respectively. The costs do include up to $70,000 for wetland mitigation if necessary, based on current Dakota County purchase rates of $1 per sq. ft for banked wetland credit.

6.1.4 Infiltration structure in EVR-P400 (Reserve Project)

The reserve project is to construct an underground infiltration structure downstream of pond EVR-P39 in sub-watershed EVR-400 between Delaney and Diamond Path Parks. This land is owned by the City, and managed by the Parks and Recreation Department. The City desires to retain the usability of the area which has led to proposing the underground infiltration BMP alternative. Pretreatment is already provided by EVR-P39 and the underground structure will preserve the park land for public use. The structure would

have an approximate one acre area and is estimated to infiltrate approximately 33% of stormwater routed to it.

This project would be considered only if there is a compelling need to reduce the large volume (and associated phosphorus load) of stormwater conveyed down the main truck of the storm system from the upper watershed. It is NOT being proposed for construction at the present time, though estimated costs and benefits are presented. The estimated costs for feasibility/ design and construction are $145,000 and $484,000 respectively.

6.1.5 EVALUATE, RESTORE, EXPAND BMPS IN DIRECT DRAINAGE

Best Management Practices in the direct drainage of Cobblestone Lake should be evaluated for restoration and expansion. Active participation of the residents/homeowners associations in this area to help execute some of these initiatives should be sought, as these residents live in areas that have the highest proportional impact on Cobblestone Lake and have the most to gain from a good-quality lake. The interaction will also provide a valuable education opportunity for residents to understand how activities in the watershed affect lake water quality.

Recommended BMP's for this area include:

a. Restoration of existing and installation of new raingardens, emphasizing increasing infiltration of runoff from impervious areas.
b. Installation of lakeshore buffers of native, deep-rooted vegetation within the park adjacent to the lake. This effort should begin with a limited pilot scale project affecting 100 – 200 feet of shoreline to be completed within 2 years after adoption of this plan, with a long-term goal of having 30% of the lake's shoreline in native buffer within 5 years after adoption of the plan. This activity may be focused in areas with shoreline erosion and near areas of public viewing.
c. Information education program aimed primarily at residents and businesses in the direct drainage of Cobblestone Lake and emphasizing, at a minimum, lawn soil testing and use of no-phosphorus fertilizer where possible, minimizing runoff volume from individual properties, and education on the direct connection between the storm sewer system and Cobblestone Lake.
d. Periodic street cleaning by the City, focused on sweeping the direct drainage to the lake with the City's vacuum sweeper at least 3-4 times per year, particularly as early in the spring as possible in late May/early June immediately after seed drop, as well as in the fall during and after leaf fall.

The activities in this implementation action are scheduled to continue for the five years after Plan adoption and will cost approximately $10,000 to $15,000 per year.

6.1.6 AQUATIC PLANT AND FISHERIES MANAGEMENT

Monitor in-lake water quality as well as in-lake biota to guide actions in managing the lake system to achieve clear water with a native macrophyte-dominated aquatic plant community and a balanced fish community. Elements of this component include:

a. Conduct bi-weekly water quality monitoring through CAMP each year, supplemented with collection of dissolved oxygen/temperature/conductivity profile data during every sampling outing and hypolimnetic total phosphorus sampling at least three to four times per season.

b. Conduct a macrophyte survey of Cobblestone Lake once every two years. Depending on the findings of the surveys, consider planting native submergent and emergent aquatic plants in the lake to help establish a desirable plant community.
c. Once every two years, conduct a field survey of upstream ponding systems to determine presence of exotic invasives such as Curly-leaf pondweed, Eurasian water milfoil, and purple loosestrife as well as rough fish such as bullheads and stunted panfish which could act as infection centers for Cobblestone Lake. Key ponds include: EVR-P39, EVR-P40 and EVR-P43. Take action to control invasives as necessary.
d. Conduct a fishery survey of Cobblestone Lake once every 2-3 years. Work with MnDNR to structure a fish community in Cobblestone Lake to maintain adequate population of predatory fish to control small panfish and roughfish populations. Predatory fish stocking possibilities include walleye, bass, and channel catfish. Consider a joint initiative with MnDNR to protect predatory gamefish from excessive harvest if necessary.

The water quality monitoring will be conducted by City staff, and $2,000/year is budgeted for lab analysis to support the effort. The implementation plan allows for $5,000-$8,000 in Years 2 and 4 of the timeline for a combination of plant and fish surveys, aquatic plant management associated with helping native rooted aquatic plants become well-established in the lake through transplantation, and/or some netting and removal of rough fish or stunted panfish. Stocking of piscivores to control planktivores and benthivores is assumed to be done in cooperation with MnDNR at no cost to the City. A wholesale eradication of the fish population and follow-up stocking is not contemplated for this 5-year implementation plan cycle and is therefore not included in the cost estimate.

6.1.7 MONITORING PLAN

Continued monitoring of the watershed loading and in-lake water quality and biology will be important to determine adequacy of improvements and help ensure a quality resource for the City. To facilitate this, City staff should coordinate to conduct the following monitoring activities and provide summary information to staff in Natural Resources. Many of the activities are described in detail above, but are included in this summary for completeness.

- Continue the monitoring effort associated with the Metropolitan Council CAMP program.
- Supplemental monitoring of dissolved oxygen, temperature and conductivity profiles along with samples of hypolimnetic TP and Chlorides.
- Monitor discharge from EVR-P43 through the completion of upstream improvements to help determine their ultimate effectiveness.
- Direct drainage monitoring should include assessing the volume and quality of sediment removed from the hydrodynamic water quality device (Contech Vortechs unit) treating CR 46 and the buildup and removal of sediment from the infiltration chamber treating the Super Target drainage. This type of monitoring should also be applied to any future structural BMPs installed in the new development draining to the lake.
- Monitoring of the fish population and aquatic plant coverage, every 2 years, will assist in future management recommendation for in-lake controls as part of the adaptive management program.
- Monitor upstream ponds to assess the risk of voluntary transport of invasive aquatic plants reaching Cobblestone Lake through the storm sewer system.
- Monitor precipitation and Lake water level measured at the lift station outlet.

6.1.8 IMPLEMENTATION PLAN SUMMARY

Table 6.2 shows each implementation element with its responsible party, cost estimate (in 2008 dollars), and implementation year within the 5–year plan.

Table 6.2 – Implementation Plan Recommendations, Estimated Costs, and Schedule

Measure	Implementation Plan Year & Estimated Cost (in 2008 Dollars)				
	1	2	3	4	5
1. Improve outflow quality of Farquar Lake through on-going TMDL process	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project	Budgeted for through L/F TMDL project
2. Assure compliance of development/re-development activities with SWMP stormwater treatment policies	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer	City staff time; implementation costs to be born by developer
3a. Clean out and re-configure Pond EVR-P43				$49,000 for feasibility assessment/ preliminary engineering	$162,000 for design, construction and mitigation
3b. *Install underground infiltration structure in EVR-400 (reserve project)*				*$145,000 for feasibility assessment/ preliminary engineering*	*$484,000 for design and construction*
4. Evaluate, restore and expand BMP's in direct drainage	$5,000-$10,000	$10,000-$15,000	$10,000-$15,000	$10,000-$15,000	$10,000-$15,000
5. Monitoring, management of in-lake water quality and biological community	City staff time plus $2,000 for lab costs	City staff time plus $2,000 for lab costs and $5,000-$8,000 for fish and plant survey/management	City staff time plus $2,000 for lab costs	City staff time plus $2,000 for lab costs and $5,000-$8,000 for fish and plant survey/management	City staff time plus $2,000 for lab costs
TOTALS	$7,000-$12,000	$17,000-$25,000	$12,000-$17,000	$66,000-$74,000	$174,000-$179,000
TOTAL FOR ALL IMPLEMENTATION ACTIVITIES AS OUTLINED $276,000-$307,000					

Capital cost estimates include 30% of estimated construction costs for design, administration, and contingency.
For capital improvements for sub-watersheds EVR-43 and EVR-400, 4% of capital cost estimate is budgeted for the year prior to scheduled year for the capital improvement for feasibility assessment and preliminary engineering. Totals do not include the cost for items associated with the reserve project.

Glossary

Acre-Feet: Volume of water that would cover an acre of land to a depth of one foot. 43,560 cubic feet.

Degradation: A decrease in quality. In lakes, this is called eutrophication.

Dissolved Oxygen (DO): Oxygen that is dissolved in water. Fish and other water organisms "breathe" dissolved oxygen.

Ecosystem: A community represented by interaction among animals, plants, and microorganisms, and the physical, biological, and chemical environment in which they live.

Empirical: Based on experiment and observation; used to describe water quality models which are developed from measured data.

Eutrophication: The process of over-enrichment of lakes with nutrients, particularly phosphorus. The term also refers to the results of nutrient enrichment such as algae blooms and excessive plant growth.

Hydrology: The science and study of water in nature, including its circulation, distribution, and its interaction with the environment.

Impervious Surface: A surface that is impermeable to the downward seepage of water; e.g., pavement and roof tops.

mg/l: Unit of nutrient or pollutant concentration, milligrams per liter, also parts per million (ppm).

μg/l: Unit of nutrient or pollutant concentration, micrograms per liter, also parts per billion (ppb).

Model: A mathematical representation of an event or process.

Non-Point Source: Runoff (usually containing nutrients and other pollutants) from sources not discharged from a single point, e.g., runoff from farm fields or paved streets.

Nutrient Loading: The input of nutrients to a lake.

pH: A measure of the acidic or basic nature of the water; it is defined as the logarithm of the reciprocal of the hydrogen-ion concentration in moles/liter.

Phosphorus: A nutrient essential to plant growth. Phosphorus is the nutrient most commonly limiting plant growth in lakes.

Suspended Solids: Particulate material which floats in or is carried along in water (e.g., algae, soil particles).

Total Phosphorus (TP): A measure of all of the different forms of phosphorus in water. Includes phosphorus dissolved in the water, suspended or incorporated in algae or other organisms.

Watershed: The area of land draining into a specific body of water.

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Appendix – A

- Aquatic Plant Survey
- Lake Sediment Analysis and Prediction of invasive plant growth
- MnDNR Fisheries Report

DRAFT

Cobblestone Lake, Apple Valley, August 31, 2006

Aquatic Plant Surveys for Cobblestone Lake, Apple Valley, Minnesota

Early Summer Survey: June 16, 2006
Late Summer Survey: August 31, 2006

Prepared for:
City of Apple Valley
Apple Valley, Minnesota

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Submitted: February 2007

Aquatic Plant Surveys for Cobblestone Lake, Apple Valley, Minnesota

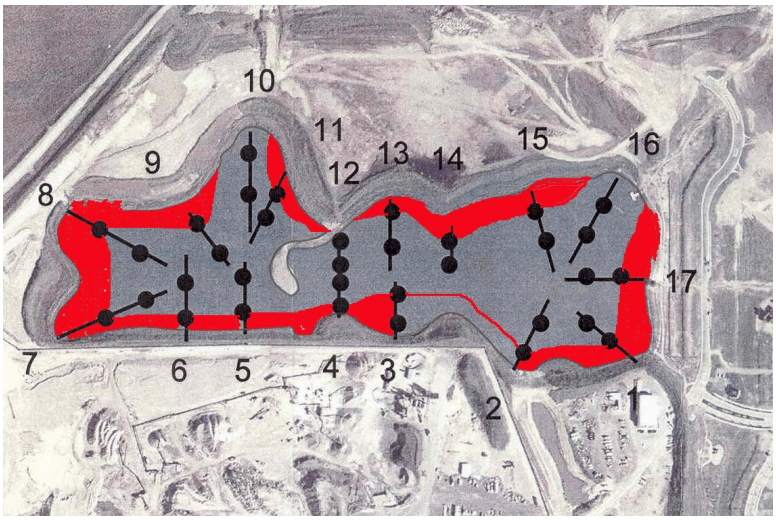
Summary

Two aquatic plant surveys were conducted in Cobblestone Lake in 2006. The first survey was conducted on June 16, 2006 and the second was conducted on August 31, 2006.

In the early season survey no aquatic plants were found on the 17 transects that were monitored. In the late summer survey, chara was the most common plant observed (Table 1). A total of five submerged plant species were observed in the late summer survey and no non-native plant species were observed. The maximum depth that plants grew to was 6 feet, but typically plants grew out to about 4 feet of water depth or less.

Table 1. Cobblestone Lake aquatic plant occurrences and densities for the August 31, 2006 survey based on 17 transects and 2 depths, for a total of 34 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	June 16, 2006 All Stations (n=34)			August 31, 2006 All Stations (n=34)		
	Occur	% Occur	Density	Occur	% Occur	Density
Chara (*Chara sp*)	--	--	--	12	35	1.6
Needle spike rush (*Eleocharis sp*)	--	--	--	2	6	0.7
Floating pondweed (*Potamogeton natans*)	--	--	--	1	3	0.5
Stringy pondweed (*Potamogeton sp*)	--	--	--	3	9	0.6
Stringy pondweed (*Potamogeton strictifolius*)	--	--	--	2	6	0.5
Filamentous algae	--	--	--	3	9	0.5



On August 31, 2006, the aquatic plant coverage was approximately 9 acres with the dominant plant being chara. Plant growth was sparse.

Cobblestone Lake is relatively new. It was formerly a gravel pit and the end of excavation and final grading occurred in the 1990s. Because no aquatic plants were intentionally planted and there was no long-term seedbank, all plant species found in the lake represent volunteer introduced species.

As is typical for a newly constructed lake, aquatic plant species will suddenly appear and some will become established while others will disappear. Comparing plant survey results from August of 2003 to August of 2006, found three new species appeared while four species disappeared (Table 2). Chara appears to be the dominant plant at this time. Curlyleaf pondweed was present in 2003 but was not found in either the early survey or the late summer survey in 2006.

Table 2. Cobblestone Lake aquatic plant occurrences for the August 20, 2003 and for the August 31, 2006 surveys.

	2003 (August 20) % Occurrence (sites = 34)	**2006** (August 31) % Occurrence (sites=34)	**Species that have appeared or disappeared from 2003 to 2006**
Chara (*Chara sp*)	21	35	0
Needle spike rush (*Eleocharis sp*)	--	6	+
Naiads (*Najas sp*)	21	--	--
Curlyleaf pondweed (*Potamogeton crispus*)	6	--	--
Floating pondweed (*Potamogeton natans*)	--	3	+
Stringy pondweed (*Potamogeton sp*)	24	9	0
Stringy pondweed (*Potamogeton strictifolius*)	--	6	+
Sago pondweed (*Stuckenia pectinata*)	9	--	--
Water stargrass (*Zosterella dubia*)	6	--	--
Filamentous algae	--	9	+

Cobblestone Lake, Apple Valley, Minnesota

Size: 37 acres (source: MnDNR Fish Survey Report, 2005)

1. Introduction

Cobblestone Lake is a 37 acre fertile lake in Dakota County, Minnesota. The lake was excavated as a result of a gravel mining operation. It has a maximum depth of about 18 feet (based on water levels in August 2006).

The City of Apple Valley authorized an aquatic evaluation to characterize the plant community. Steve McComas, Blue Water Science, conducted two aquatic plant surveys, the first was on June 16, 2006 and the second was on August 31, 2006 in Cobblestone Lake. The objectives of the plant surveys were to characterize the distribution of aquatic plants in Cobblestone Lake.

2. Aquatic Plant Survey Methods

For the aquatic plant surveys, 17 line transects in Cobblestone Lake were evaluated (Figure 1) and a recording sonar (Lowrance X-16) was used to delineate the depths of weed colonization. Two depths (0-4 feet and 5-8 feet) on a transect were sampled with a rake to characterize plant species presence and density. The 2006 transect locations were the same as the 2003 transect locations.

For each depth category, at least four samples were taken. Plant species were identified and a density rating of 0.5 to 5 was assigned with 5 being the highest density. For each plant species, a density rating was averaged for each depth category.

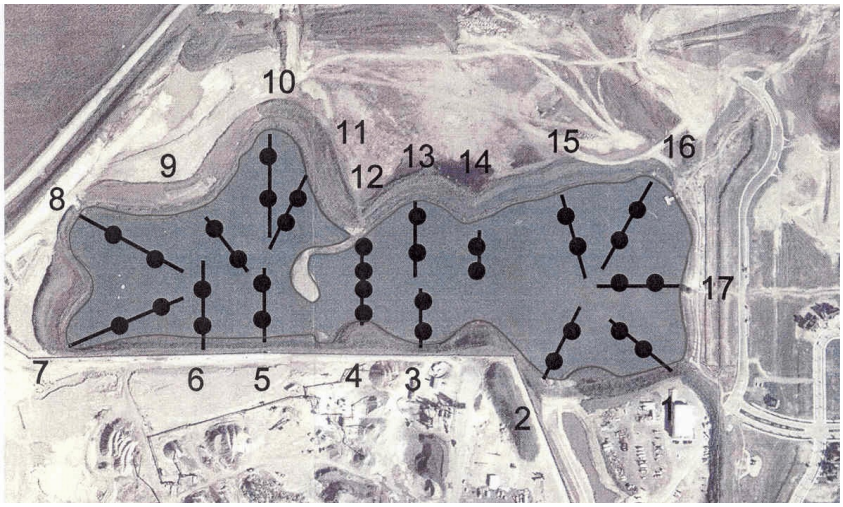


Figure 1. Transect map for the aquatic plant surveys conducted on Cobblestone Lake on June 16 and August 31, 2006.

3. Results of Cobblestone Lake Aquatic Plant Survey

Results for June 16, 2006

No aquatic plants species were found in Cobblestone Lake in June of 2006 (Table 1). Two depths on 17 transects were sampled (Tables 1 and 2).

Table 1. Cobblestone Lake aquatic plant occurrences and densities for the June 16, 2006 survey based on 17 transects and 2 depths, for a total of 34 stations.

	Depth 0-4 feet (n=17)			Depth 5-8 feet (n=17)			All Stations (n=34)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
No plants	0	0	0	0	0	0	0	0	0

Table 2. Individual transect data for June 16, 2006.

	T1		T2		T3		T4		T5		T6		T7	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
No plants	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	T8		T9		T10		T11		T12		T13		T14	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
No plants	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	T15		T16		T17	
	0-4	5-8	0-4	5-8	0-4	5-8
No plants	X	X	X	X	X	X

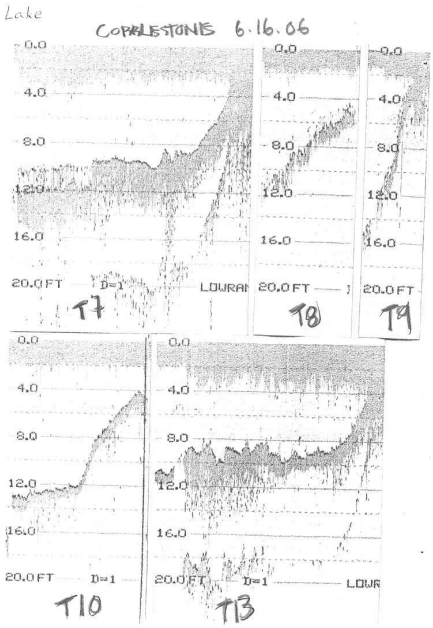


Figure 2. Sonar graphs of Transects 7, 8, 9, 10, and 13 show no aquatic plants were present.

Results for August 31, 2006

In August of 2006 Cobblestone Lake had a low to moderate plant diversity with six species of submerged aquatic plants observed (Table 3).

The maximum depth of plant colonization was 6 feet with chara the only plant found at that depth in one location. Typical depth of colonization was about 4 feet. Total plant coverage in Cobblestone Lake was estimated at 9 acres and was dominated by stringy pondweed and chara.

Plant occurrence on individual transects and depths is shown in Table 4. A plant distribution map is shown in Figure 5.

Table 3. Cobblestone Lake aquatic plant occurrences and densities for the August 31, 2006 survey based on 17 transects and 2 depths, for a total of 34 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (n=17)			Depth 5-8 feet (n=17)			All Stations (n=34)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Chara (*Chara sp*)	11	65	1.7	1	6	0.5	12	35	1.6
Needle spike rush (*Eleocharis sp*)	2	12	0.7	--	--	--	2	6	0.7
Floating pondweed (*Potamogeton natans*)	1	6	0.5	--	--	--	1	3	0.5
Stringy pondweed (*Potamogeton sp*)	3	18	0.6	--	--	--	3	9	0.6
Stringy pondweed (*Potamogeton strictifolius*)	2	12	0.5	--	--	--	2	6	0.5
Filamentous algae	3	18	0.5	--	--	--	3	9	0.5

Figure 3. Chara at a density of a "2" from Cobblestone Lake on August 31, 2006.

Table 4. Individual transect data for August 31, 2006.

	T1		T2		T3		T4		T5		T6		T7	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Chara	2		1		1.5	0.5	1.5		1		0.3			
Needle spike rush											1		0.3	
Floating pondweed							0.5							
Stringy pondweed													0.3	
Stringy pondweed - strict											0.5			

	T8		T9		T10		T11		T12		T13		T14	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Chara							1.5				2		3	
Needle spike rush														
Floating pondweed														
Stringy pondweed	1													
Stringy pondweed - strict			0.5											

	T15		T16		T17	
	0-4	5-8	0-4	5-8	0-4	5-8
Chara	3				1.8	
Needle spike rush						
Floating pondweed						
Stringy pondweed	0.5					
Stringy pondweed - strict						

Figure 4. Chara at a density of a "1" and needle spike rush at a density of a "2" in Cobblestone Lake on August 31, 2006.

Aquatic Plant Coverage: The bottom coverage of aquatic plants in Cobblestone Lake on August 31, 2006 was about 9 acres. A map of plant coverage is shown in Figure 5. Growth was generally sparse from the zero to four-foot water depth range.

Figure 5. Aquatic plant coverage on August 31, 2006 is shown in red and covers about 9 acres.

Comparing 2003 and 2006 Plant Surveys

Cobblestone Lake is relatively new. It was formerly a gravel pit and the end of excavation and final grading occurred in the 1990s. Because no aquatic plants were intentionally planted and there was no long-term seedbank, all plant species found in the lake represent volunteer introduced species.

As is typical for a newly constructed lake, aquatic plant species will suddenly appear and some will become established while others will disappear. Comparing plant survey results from August of 2003 to August of 2006, found three new species appeared while four species disappeared (Table 5). Chara appears to be the dominant plant at this time. Curlyleaf pondweed was present in 2003 but was not found in either the early survey or the late summer survey in 2006.

Table 5. Cobblestone Lake aquatic plant occurrences for the August 20, 2003 and for the August 31, 2006 surveys.

	2003 (August 20) % Occurrence (sites = 34)	**2006** (August 31) % Occurrence (sites=34)	**Species that have appeared or disappeared from 2003 to 2006**
Chara (*Chara sp*)	21	35	0
Needle spike rush (*Eleocharis sp*)	--	6	+
Naiads (*Najas sp*)	21	--	--
Curlyleaf pondweed (*Potamogeton crispus*)	6	--	--
Floating pondweed (*Potamogeton natans*)	--	3	+
Stringy pondweed (*Potamogeton sp*)	24	9	0
Stringy pondweed (*Potamogeton strictifolius*)	--	6	+
Sago pondweed (*Stuckenia pectinata*)	9	--	--
Water stargrass (*Zosterella dubia*)	6	--	--
Filamentous algae	--	9	+

Cobblestone Lake, 2006

Predicting Curlyleaf Pondweed and Eurasian Watermilfoil Growth Characteristics Based on Cobblestone Lake Sediment Sampling

[Sediments Collected August 31, 2006]

Prepared by: Steve McComas, Blue Water Science

Introduction

For managing non-native plants it is helpful to know where the plants have the potential to grow to nuisance conditions. A technique developed by Blue Water Science shows where nuisance growth of curlyleaf pondweed and Eurasian watermilfoil can occur in a lake based on lake sediment characteristics. This technique was applied to Cobblestone Lake.

Cobblestone Lake sediments were collected from eight sites around the lake on August 31, 2006. The sediments have been analyzed and results interpreted and are presented in this report.

Methods

Lake Soil Collection: A total of eight lake sediment samples were collected from the depth of 5 feet on August 31, 2006 by Steve McComas and Jo Stuckert, Blue Water Science. Samples were collected using a modified soil auger, 5.2 inches in diameter (Figure 1). Soils were sampled to a depth of 6 inches. The lake soil from the sampler was transferred to 1-gallon zip-lock bags and delivered to a soil testing laboratory.

Lake sediment samples were collected in the littoral zone. At each sample location, within about a 5-foot radius we noted all aquatic plant species and rated their density on a scale from 1 to 5 with one representing a low density.

Lake Soil Analysis: At the lab, sediment samples were air dried at room temperature, crushed and sieved through a 2 mm mesh sieve. Sediment samples were analyzed using standard agricultural soil testing methods. Sixteen parameters were tested for each soil sample. A summary of extractants and procedures is shown in Table 1. Routine soil test results are given on a weight per volume basis.

Table 1. Soil testing extractants used by University of Minnesota Crop Research Laboratory. These are standard extractants used for routine soil tests by most Midwestern soil testing laboratories (reference: Western States Laboratory Proficiency Testing Program: Soil and Plant Analytical Methods, 1996-Version 3).

Parameter	Extractant
P-Bray	0.025M HCL in 0.03M NH_4F
P-Olsen	0.5M $NaHCO_3$
NH_4-N	2N KCL
K, Ca, Mg	1N NH_4OA_c (ammonium acetate)
Fe, Mn, Zn, Cu	DTPA (diethylenetriamine pentaacetic acid)
B	Hot water
SO_4-S	$Ca(H_2PO_4)_2$
pH	water
Organic matter	Loss on ignition at 360°C

Figure 1. Soil auger used to collect lake sediments.

Reporting Lake Soil Analysis Results: Lake soils and terrestrial soils are similar from the standpoint that both provide a medium for rooting and supply nutrients to the plant.

However, lake soils are also different from terrestrial soils. Lake soils (or sediments) are water logged, generally anaerobic and their bulk density ranges from being very light to very dense compared to terrestrial soils.

There has been discussion for a long time on how to express analytical results from soil sampling. Lake sediment research results are often expressed as grams of a substance per kilogram of lake sediment, commonly referred to as a weight basis (mg/kg). However, in the terrestrial sector, to relate plant production and potential fertilizer applications to better crop yields, soil results typically are expressed as grams of a substance per cubic foot of soil, commonly referred to as a weight per volume basis. Because plants grow in a volume of soil and not a weight of soil, farmers and producers typically work with results on a weight per volume basis.

That is the approach used here for lake sediment results: they are reported on a weight per volume basis or $\mu g/cm^3$.

A bulk density adjustment was applied to lake sediment results as well. For agricultural purposes, in order to standardize soil test results throughout the Midwest, a standard scoop volume of soil has been used. The standard scoop is approximately a 10-gram soil sample. Assuming an average bulk density for an agricultural soil, a standard volume of a scoop has been a quick way to prepare soils for analysis, which is convenient when a farmer is waiting for results to prepare for a fertilizer program. It is assumed a typical silt loam and clay texture soil has a bulk density of 1.18 grams per cm^3. Therefore a scoop size of 8.51 cm^3 has been used to generate a 10-gram sample. It is assumed a sandy soil has a bulk density of 1.25 grams per cm^3 and therefore a 8.00 cm^3 scoop has been used to generate a 10-gram sample. Using this type of

standard weight-volume measurement, the lab can use standard volumes of extractants and results are reported in ppm which is close to $\mu g/cm^3$. For all sediment results reported here a scoop volume of 8.51 cm^3 was used.

However lake sediment bulk density has wide variations but only a single scoop volume of 8.51 cm^3 was used for all lake sediment samples. This would not necessarily produce a consistent 10-gram sample. Therefore, for our reporting, we have used corrected weight volume measurements and results have been adjusted based on the actual lake sediment bulk density. We used a standard scoop volume of 8.51 cm^3, but sediment samples were weighed. Because test results are based on the premise of a 10 gram sample, if our sediment sample was less than 10 grams, then the reported concentrations were adjusted down to account for the less dense bulk density. If a scoop volume weighed greater than 10.0 grams than the reported concentrations were adjusted up. For example, if a 10-gram scoop of lake sediment weighed 4.0 grams, then the correction factor is 4.00 g/ 10.00 g = 0.40. If the analytical result was 10 ppm based on 10 grams, then it should be 0.40 x 10 ppm = 4 ppm based on 4 grams. The results could be written as 4 ppm or 4 $\mu g/cm^3$. Likewise, if a 10-gram scoop of lake sediment weighed 12 grams, then the correction factor is 12.00 g / 10.00 g = 1.20. If the analytical result was 10 ppm based on a 10 gram scoop, then it should be 1.20 x 10 ppm = 12 ppm based on 12 grams. The result could be written as 12 ppm or 12 $\mu g/cm^3$. These are all dry weight determinations.

Delineating Areas of Potential Nuisance Curlyleaf and Milfoil Growth: Delineating an area of potential nuisance plant growth is based on conventional soil survey methods. When a sediment sample analysis has a nitrogen reading over 10 ppm and has an organic matter content of less than 20%, it has a high potential for nuisance milfoil growth. For sediment results with a high growth potential collected in a cove, typically, the water depths in the cove from 5 to 7 feet would be designated as having a potential for nuisance growth. If high potential samples are found along a stretch of shoreline, a designated high potential area would be delineated until there was a shoreline break or change in sediment texture. In other cases, if the next site down the shoreline records a low potential reading, then the designated nuisance area would extend midway between a high and low potential sample sites.

Results

Potential for Nuisance Growth of Non-native Invasive Plants Based on Lake Sediment Characteristics

A total of eight sediment sites were sampled around Cobblestone Lake. Sediment sites and locations are shown in Table 2 and Figure 2.

Table 2. Cobblestone Lake sediment sample locations and field observations on August 31, 2006.

Transect Number	Water Depth (ft)	Transect Description
1	5	Beach house with stone wall.
2	5	Right of huge culvert.
3	5	Across from cove (T10).
4	5	Middle of bay.
5	5	Left of stone wall.
6	5	Culvert.
7	5	Boathouse.
8	5	Gazebo.

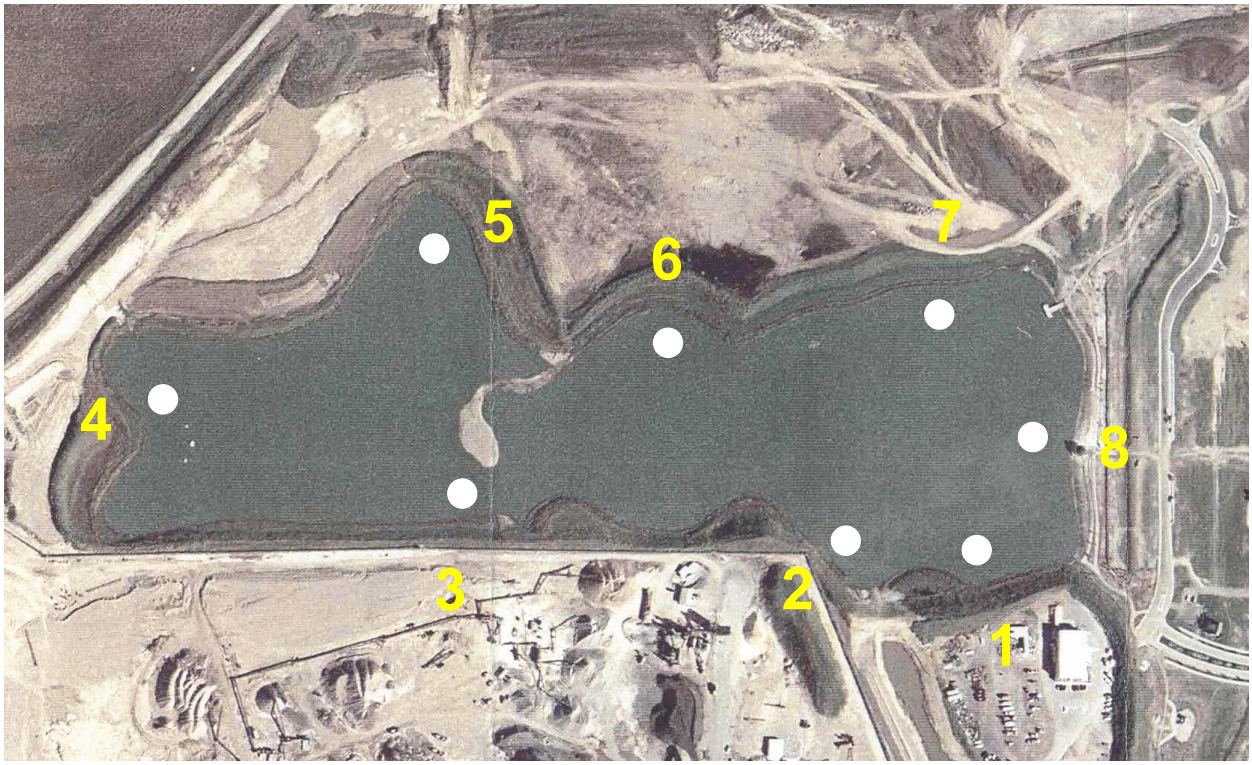


Figure 2. Lake sediment sample locations (shown with orange squares) and aquatic plant survey transect locations are shown with numbers in parenthesis and represented with black dots.

Cobblestone Lake sediment results are shown in Table 3. A total of 16 parameters were analyzed for each sediment sample. A low bulk density (less than 0.60 g/cm^3) indicates lake sediments are soft and mucky. Typically high organic matter content is associated with the soft mucky sediments sample sites. Lake sediment phosphorus concentrations are moderate to high.

Table 3. Cobblestone Lake soil data. Sample were collected on August 31, 2006. Soil chemistry results are reported as µg/cm^3-dry which is equivalent to ppm except for organic matter (%) and pH (standard units).

Sample	Depth (ft)	Bulk Density (g/cm3)	O.M. (%) by L.O.I.	pH	Bray-P (ppm) (corr)	Olsen-P (ppm) (corr)	K (ppm) (corr)	Ca (ppm) (corr)	Mg (ppm) (corr)	Boron (ppm) (corr)	NH4-N (ppm) (corr)	NO3-N (ppm) (corr)	Fe (ppm) (corr)	Cu (ppm) (corr)	Mn (ppm) (corr)	Zn (ppm) (corr)	SO4-S (ppm) (corr)
C1	5	1.41	1.55	7.5	21.00	24.00	91.20	2242	250	0.36	31.02	3.36	170	2.94	77.28	1.08	22.20
C2	5	1.41	1.2	7.5	12.00	7.20	63.60	3515	196	0.24	5.16	2.16	89.40	3.12	11.88	2.76	175
C3	5	1.62	0.3	8.2	22.08	5.52	31.74	2183	130	0.14	3.04	2.07	40.71	1.93	10.76	0.41	12.42
C4	5	1.58	0.2	8.4	6.75	2.70	35.10	3471	123	0.14	3.24	2.57	19.17	0.68	7.02	0.27	14.85
C5	5	1.47	0.4	7.9	1.25	3.75	65.00	4658	188	0.13	5.63	2.25	50.13	2.25	8.38	0.63	113
C6	5	1.49	1	7.8	19.05	13.97	90.17	3614	232	0.25	7.49	4.95	86.36	2.16	9.40	1.14	78.74
C7	5	1.36	1.1	7.5	10.35	12.65	118.45	2318	406	0.23	7.94	3.11	114	2.42	7.94	0.58	232
C8	5	1.35	1.9	7.5	12.65	13.80	104.65	2646	357	0.23	8.17	4.03	144	3.22	10.93	1.73	204

Lake Areas that Could Support Nuisance Curlyleaf Growth Based on Lake Sediment Characteristics: Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth. Based on the key sediment parameters of pH, sediment bulk density, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table 4 and Figure 3.

Curlyleaf pondweed growth is predicted to produce nuisance growth (where plants top out in a solid canopy) at several locations.

Table 4. Cobblestone Lake sediment data and ratings for potential nuisance curlyleaf pondweed growth.

Site	pH (su)	Bulk Density (g/cm³ dry)	Organic Matter (%)	Fe:Mn Ratio	Potential for Nuisance Curlyleaf Pondweed Growth
Non-Nuisance	6.8	1.04	5	4.6	Low (green)
Light Nuisance	6.2	0.94	11	5.9	Medium (yellow)
Heavy Nuisance	>7.7	<0.51	>20	<1.6	High (red)
1	7.5	1.41	1.55	2.2	
2	7.5	1.41	1.2	7.5	
3	8.2	1.62	0.3	3.8	
4	8.4	1.58	0.2	2.7	
5	7.9	1.47	0.4	6.0	
6	7.8	1.49	1	9.2	
7	7.5	1.36	1.1	14.4	
8	7.5	1.35	1.9	13.1	

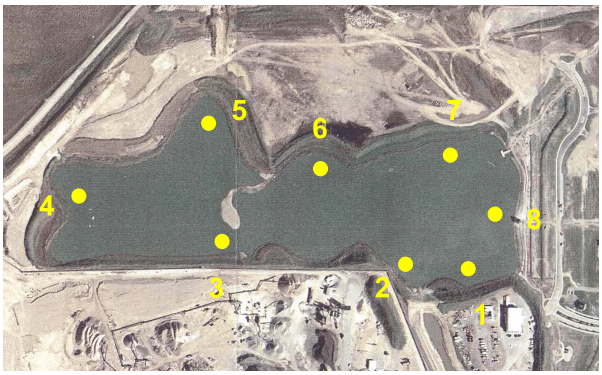


Figure 3. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.

Non-nuisance growth (left) refers to non-nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a sediment bulk density less than 0.51.

Lake Areas that Could Support Nuisance Eurasian Watermilfoil Growth Based on Lake Sediment Characteristics: Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance EWM growth. At this time, no Eurasian watermilfoil has been found in Cobblestone Lake. Based on the key sediment parameters of NH_4 and organic matter (McComas, unpublished), a table and map were prepared that predict what type of growth could be expected in the future if milfoil were to invade (Table 5 and Figure 4).

The sediment nitrogen conditions in Cobblestone Lake are relatively low. Eurasian watermilfoil may grow widely through Cobblestone Lake, but it is predicted that it not will produce extensive perennial nuisance matting conditions (which are defined as heavy nuisance condition).

Table 5. Cobblestone Lake sediment data and ratings for potential nuisance EWM growth.

Site	NH_4 Conc (ppm)	Organic Matter (%)	Potential for Nuisance EWM Growth
Non-Nuisance or Light Nuisance	<10	>20	Low (green) to Medium (yellow)
Heavy Nuisance	>10	<20	High (red)
1	31.02	1.55	
2	5.16	1.2	
3	3.04	0.3	
4	3.24	0.2	
5	5.63	0.4	
6	7.49	1	
7	7.94	1.1	
8	8.17	1.9	

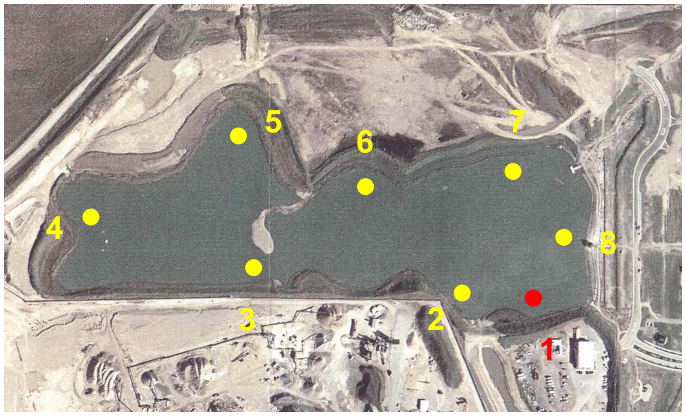
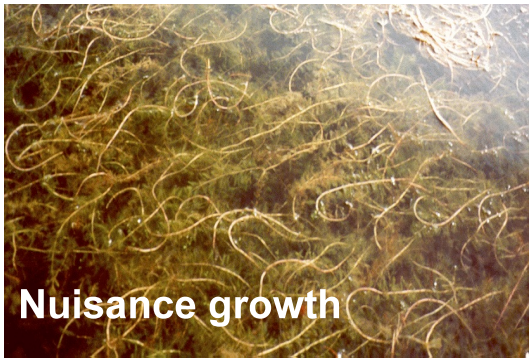


Figure 4. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance Eurasian watermilfoil to occur at that site. Key: green = low; yellow = medium; red = high potential.



Non-nuisance growth (left) refers to non-nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting Eurasian watermilfoil. This is the kind of nuisance growth predicted by high sediment nitrogen values and a sediment organic matter content less than 20%.

Appendix A

Management Options for Curlyleaf Pondweed and Eurasian Watermilfoil Based on Lake Sediment Characteristics

Steven R. McComas, Blue Water Science, St. Paul, MN,
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Presented at the North American Lake Management Society Conference, 2005, Madison, Wisconsin

Sampling results from over 50 lakes indicated lake sediment characteristics help delineate areas of potential nuisance verses non-nuisance growth for two invasive aquatic plant species, curlyleaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) (where nuisance growth is defined as plants matting at the surface). Lake sediments were collected using a zone sampling program and standard agricultural soil test methods were used for lake sediment analysis. For curlyleaf pondweed, the primary parameter correlated with nuisance growth conditions was a sediment pH above 7.7. Other important parameters included a bulk density less than 0.50 g/cm^3-dry, organic matter greater then 30% and a Fe:Mn ratio of less than 1.6. Nuisance growth of Eurasian watermilfoil was influenced by different conditions. The two most significant sediment parameters were nitrogen, as exchangeable ammonia greater than 10 µg/cm^3-dry, and organic matter, less than 20%.

Knowing the delineation of potential nuisance and non-nuisance plant growth using lake sediment sampling assists managers in formulating aquatic plant management actions. For example, where sediment results indicate non-nuisance growth conditions would be expected, those areas can be left alone because the non-native plants present no ecological or recreational problem. In addition, knowing the primary influences that drive the nuisance growth of invasive species could produce long-term control solutions. For example, iron additions to a lake should control nuisance curlyleaf pondweed growth. Alternatively, sediment nitrogen reductions should control nuisance milfoil growth.

Name: Cobblestone

Nearest Town: Apple Valley
Primary County: Dakota

Survey Date: 06/13/2005
Inventory Number: 19-0456-00

Public Access Information

Ownership	Type	Description
City	Carry-in	No formal access for carry-in but most of shore is accessible for carry-in.

Lake Characteristics

Lake Area (acres): 37.00
Littoral Area (acres): N/A
Maximum Depth (ft): 18.00
Water Clarity (ft): 1.25

Dominant Bottom Substrate: N/A
Abundance of Aquatic Plants: N/A
Maximum Depth of Plant Growth (ft): N/A

Fish Sampled up to the 2005 Survey Year

Number of fish per net

Species	Gear Used	Caught	Normal Range	Average Fish Weight (lbs)	Normal Range (lbs)
Black Bullhead	Gill net	60.0	N/A - N/A	0.12	N/A - N/A
	Trap net	147.4	N/A - N/A	0.11	N/A - N/A
Bluegill	Trap net	9.2	N/A - N/A	0.04	N/A - N/A
Green Sunfish	Gill net	1.0	N/A - N/A	0.07	N/A - N/A
	Trap net	1.8	N/A - N/A	0.21	N/A - N/A
Hybrid Sunfish	Gill net	208.0	N/A - N/A	0.20	N/A - N/A
	Trap net	51.2	N/A - N/A	0.11	N/A - N/A

Normal Ranges represent typical catches for lakes with similar physical and chemical characteristics.

Length of Selected Species Sampled for All Gear for the 2005 Survey Year

Number of fish caught in each category (inches)

Species	*0-5*	*6-8*	*9-11*	*12-14*	*15-19*	*20-24*	*25-29*	*>29*	*Total*
Black Bullhead	49	118	1	0	0	0	0	0	168
Bluegill	44	2	0	0	0	0	0	0	46
Green Sunfish	5	5	0	0	0	0	0	0	10
Hybrid Sunfish	139	45	1	0	0	0	0	0	185

Fish Stocked by Species for the Last Five Years

Year	Species	Age	Number
2005	*Black Crappie*	Adult	23
	Bluegill	Adult	406
	Walleye	Unknown	10,468

Fish Consumption Advisory

No fish consumption information is available for this lake. For more information, see the "Fish Consumption Advice" pages at the Minnesota Department of Health.

Status of the Fishery (as of 06/13/2005)

Cobblestone Lake is located in southeastern Apple Valley, Dakota County. The lake is a former gravel mining pit that has been allowed to fill with groundwater and is now an amenity for the housing development built around it. Property along the shoreline is an Apple Valley Park and provides for public access to the lake for recreational purposes. Mid-way along the north shore a large 200 foot long pier is sited and designed for recreational use. A second smaller fishing pier will be located in the northeastern corner of the lake. The maximum depth found during the survey was 18 feet. The 2005 netting survey is the first fish survey conducted on Cobblestone Lake.

Black bullhead were the fish sampled in the highest numbers during the survey. Some bluegill were sampled in the trapnets but were of a small average size (4.1 inches). Green sunfish were present and hybrid sunfish were sampled in high abundance. No other gamefish were sampled during this survey.

For Additional Information

Area Fisheries Supervisor:

1200 WARNER ROAD
ST. PAUL, MN 55106
(651) 772-7950

Lake maps can be obtained from:

Minnesota Bookstore
660 Olive Street
St. Paul, MN 55155
(651) 297-3000 or (800) 657-3757
To order, use 0000 for the map-id.

General DNR Information:

DNR Information Center
500 Lafayette Road
St. Paul, MN 55155-4040
(651) 296-6157 or (888) MINNDNR
TDD: (651) 296-5484 or (800) 657-3929
E-Mail: info@dnr.state.mn.us

Turn in Poachers (TIP):

Toll-free: (800) 652-9093

Appendix – B

- Tabular lake water quality monitored from the Met Council CAMP program
- Tabular lake water quality monitored from the City of Apple Valley
- Watershed monitoring analysis for watershed model calibration

DRAFT

Appendix - B

Station Name Station ID

LAKE:

Cobblestone IN

APPLE VALLEY *19-0456*

Sample Date Units of Measure	Sample Depth	Chlorophyll A µ g/l	Dissolved oxygen mg/L	Field pH	Pheophytin-A (H2O) µ g/l	Phosphorus mg/L	Secchi Disk Meters
10/17/2006	0 m	12				0.038	
10/17/2006	0 m						1.1
10/5/2006	0 m	22				0.039	
10/5/2006	0 m						1.15
9/21/2006	0 m						1.2
9/21/2006	0 m	7.5				0.054	
9/6/2006	0 m	12				0.059	
9/6/2006	0 m						1.1
8/23/2006	0 m						1.1
8/23/2006	0 m	4.1				0.047	
8/11/2006	0 m	19				0.054	
8/11/2006	0 m						1.9
7/26/2006	0 m	35				0.027	
7/26/2006	0 m						0.7
7/13/2006	0 m	40				0.066	
7/13/2006	0 m						0.6
6/28/2006	0 m						0.7
6/28/2006	0 m	40				0.127	
6/15/2006	0 m						0.7
6/15/2006	0 m	36				0.054	
5/31/2006	0 m						0.8
5/31/2006	0 m	31				0.045	
5/18/2006	0 m	14				0.058	
5/18/2006	0 m						0.8
4/26/2006	0 m	35			0.63	0.054	
4/26/2006	0 m						0.75
4/18/2006	0 m		7.52	8.29			0.625
4/18/2006	0 m	29				0.061	
10/14/2005	0 m	66	7.5	8.34		0.106	
10/14/2005	0 m						0.45
9/27/2005	0 m	35	7.52	8.36		0.066	
9/27/2005	0 m						0.8
9/14/2005	0 m						0.7
9/14/2005	0 m	44				0.076	
9/2/2005	0 m	32				0.09	
9/2/2005	0 m						0.6
8/16/2005	0 m		8.15	8.35			0.45
8/16/2005	0 m	70				0.099	
8/4/2005	0 m	57				0.074	
8/4/2005	0 m						0.4
7/21/2005	0 m						0.4
7/21/2005	0 m	63				0.081	
7/6/2005	0 m						0.4
7/6/2005	0 m	89				0.094	
6/24/2005	0 m						0.35
6/24/2005	0 m	87				0.087	
6/9/2005	0 m						0.45
6/9/2005	0 m	48				0.098	
5/23/2005	0 m						0.4
5/23/2005	0 m	56				0.129	
5/10/2005	0 m	58				0.137	
5/10/2005	0 m						0.43
4/28/2005	0 m						0.4
4/28/2005	0 m	41				0.105	
4/14/2005	0 m						0.4
4/14/2005	0 m	56				0.124	

Appendix - B

		measurement 1			measurement 2			measurement 3			measurement 4			measurement 5			measurement 6			measurement 7			measurement 8		
Date	Time	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)
4/18/2006																									
4/26/2006	10:20 AM	17	0.29	11.6	16	1.02	11.9	15	1.37	12.0	14	2.91	12.2	13	5.58	12.7	12	7.93	13.2	11	10.86	13.7	10	11.07	13.7
5/18/2006	10:15 AM	17	4.56	12.2	16	5.06	12.3	15	5.53	12.4	14	5.78	12.6	13	6.26	13.1	12	6.95	13.8	11	8.01	14.6	10	8.64	14.8
5/31/2006	11:40 AM	18	0.32	12.4	17	0.30	12.7	16	0.30	13.0	15	0.29	13.4	14	1.22	14.2	13	2.28	14.9	12	3.90	15.9	11	5.68	17.1
6/8/2006	11:45 AM	18	0.27	12.9	17	0.16	12.7	16	0.15	13.1	15	0.15	13.7	14	0.14	14.7	13	0.15	16.3	12	0.59	17.7	11	2.23	19.6
6/15/2006	1:45 PM	16	0.23	14.5	15	0.20	15.4	14	0.19	16.7	13	1.99	17.6	12	3.79	18.1	11	4.54	18.4	10	5.71	18.7	9	6.59	19.0
6/28/2006	11:20 AM	17	0.21	14.3	16	0.17	14.8	15	0.16	15.8	14	0.16	17.7	13	0.16	19.3	12	0.16	20.6	11	2.47	21.2	10	3.82	21.6
7/13/2006	2:05 PM																								
7/14/2006	9:00 AM	17	0.26	14.7	16	0.23	15.1	15	0.21	16.0	14	0.20	17.6	13	0.19	19.1	12	0.18	20.8	11	0.18	22.2	10	0.23	23.0
7/26/2006	9:00 AM	15.5	0.25	16.2	14.5	0.20	17.2	13.5	0.18	18.7	12.5	0.17	20.4	10.5	0.16	22.8	9.5	0.18	23.6	8.5	2.33	24.2	7.5	5.1	24.4
8/11/2006	9:00 AM	17	0.30	16.6	16	0.25	17.6	15	0.23	19.0	14	0.21	21.1	13	0.21	22.4	12	0.20	24.0	11	5.31	25.1	10	5.65	25.1
8/16/2006	9:00 AM	17	0.37	16.4	16	0.33	17.9	15	0.29	20.4	14	0.24	22.4	13	1.8	23.1	12	3.08	23.3	11	3.6	23.4	10	3.90	23.4
8/23/2006	11:40 AM	17	0.52	17.3	16	0.40	18.5	15	0.37	20.1	14	0.30	21.7	13	0.71	22.8	12	3.08	23.1	11	6.13	23.3	10	5.79	23.3
9/6/2006	10:30 AM	17	0.44	18.6	16	0.39	19.9	15	0.37	20.9	14	0.75	21.2	13	1.70	21.3	12	3.29	21.3	11	3.78	21.4	10	5.16	21.5

Appendix - B

	measurement 9			measurement 10			measurement 11			measurement 12			measurement 13			measurement 14		
Date	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)
4/18/2006																		
4/26/2006	9	11.21	13.9	8	11.34	13.9	7	11.39	13.9	6	11.43	13.9	5	11.48	14.0	4	11.50	14.0
5/18/2006	9	9.09	15.4	8	9.13	15.4	7	9.21	15.4	6	9.27	15.4	5	9.30	15.4	4	9.30	15.5
5/31/2006	10	6.17	18.7	9	8.08	20.3	8	8.69	21.7	7	9.11	23.5	6	10.03	24.0	5	10.46	24.1
6/8/2006	10	4.48	21.7	9	6.41	22.7	8	7.48	23.1	7	8.5	23.6	6	8.98	23.9	5	9.61	24.4
6/15/2006	8	8.30	19.6	7	9.56	20.4	6	11.73	21.3	5	11.85	21.9	4	11.84	21.9	3	11.85	21.9
6/28/2006	9	5.11	21.9	8	6.92	22.0	7	8.50	22.2	6	9.22	22.4	5	9.88	22.6	4	9.96	22.7
7/13/2006																		
7/14/2006	9	2.3	23.7	8	7.1	25.0	7	9.26	25.8	6	10.05	26.0	5	10.21	26.0	4	10.35	26.0
7/26/2006	6.5	6.96	25.2	5.5	8.48	26.2	4.5	8.98	26.6	3.5	9.37	26.8	2.5	9.5	26.9	1.5	9.57	27.0
8/11/2006	9	5.95	25.1	8	5.79	25.1	7	5.81	25.1	6	6.01	25.2	5	6.14	25.2	4	6.19	25.2
8/16/2006	9	4.43	23.6	8	4.83	23.6	7	5.41	23.7	6	5.74	23.8	5	7.7	24.0	4	8.54	24.2
8/23/2006	9	4.22	23.4	8	5.78	23.5	7	10.45	23.9	6	11.74	24.1	5	12.52	24.3	4	12.74	24.3
9/6/2006	9	6.42	21.6	8	6.83	21.8	7	7.08	22.1	6	8.52	22.3	5	9.87	22.4	4	10.16	22.4

Appendix - B

	measurement 15			measurement 16			measurement 17			measurement 18					weather - MPLS Airport		
Date	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	secchi disk depth (m)	approximate lake depth (ft)	air temperature (C°)	wind speed (mph)	weather
4/18/2006													0.625				
4/26/2006	3	11.61	14.0	2	11.63	14.1	1	11.63	14.1				0.75		15.6	13	sunny
5/18/2006	3	9.33	15.5	2	9.34	15.5	1	9.34	15.5				0.8	17.75	15.0	15	mostly sunny, breezy
5/31/2006	4	10.80	24.4	3	10.89	24.5	2	10.79	24.5	1	10.85	24.6	0.8	19	26.1	6	partly cloudy
6/8/2006	4	9.69	24.5	3	9.66	24.6	2	9.67	24.6	1	9.63	24.6	0.7	19	23.9	10	mostly sunny
6/15/2006	2	11.90	22.0	1	11.81	22.0							0.7	17.25	26.1	13	partly cloudy
6/28/2006	3	10.33	23.2	2	10.50	23.5	1	10.50	23.6				0.7	18	21.7	7	sunny
7/13/2006													0.6	17	31.1	15	partly cloudy
7/14/2006	3	10.39	26.1	2	10.35	26.1	1	10.3	26.2				0.575	18	21.7	6	sunny, clear, slight breeze
7/26/2006	0.5	9.50	27.0										0.7	16.5	23.3	3	mostly sunny, humid
8/11/2006	3	6.25	25.2	2	6.24	25.2	1	6.26	25.2				1.9	17.75	20.0	14	parlty cloudy
8/16/2006	3	8.52	24.3	2	8.51	24.3	1	8.47	24.3				not taken	18	20.0	5	partly cloudy
8/23/2006	3	12.60	24.4	2	12.64	24.5	1	12.45	24.6				1.1	18	23.3	8	few clouds, hazy, slight breeze
9/6/2006	3	10.31	22.5	2	10.52	22.5	1	10.6	22.8				1.1	18	17.8	3	partly cloudy
													1.2				

Appendix - B

Date	other observations
4/18/2006	
4/26/2006	
5/18/2006	movement of boat on lake due to wind, use motor to stay in relatively same place, started sampling at 18.75 ft but boat moved so sampling was restarted at a part of the lake that was 17.75 ft deep
5/31/2006	anchor not holding, one curlyleaf plant found
6/8/2006	greenish water, grading activity occurring along a portion of the shoreline - exposed soils in buffer - no ESC
6/15/2006	very windy, boat movement during measurement
6/28/2006	
7/13/2006	a DO/Temp profile was attempted, but too windy to keep boat in place and probe cord vertical
7/14/2006	rained yesterday evening, 9 & 8 foot measurements were bouncy - error should be ± 0.2, 1 foot measurement also bouncy with range of ± 0.1
7/26/2006	greenish water, 7.5 ft reading bouncy with error estimate at about ± 0.1, accidently skipped reading for 11.5
8/11/2006	some minor boat movement, measurements11-8 ft bouncy, some submerged aquatic vegetation now growing in near shore area
8/16/2006	some minor boat movement, measurements 14-11 and measurement 5 ft bouncy, measurements 13, 11, & 5 ft averaged with with bounce of ± 0.2, some random bubbles coming to surface of water
8/23/2006	
9/6/2006	14ft and 1 ft measurements bouncy averages ± 0.3

Appendix - B

			other samples 1				other samples 2				CAMP Results			
Date	other samples taken	name of test	depth sample taken	test result	test units	name of test	depth sample taken	test result	test units	Total P (ppb)	TKN (ppm)	CLA (ppb)	MPCA Secchi Criteria	Hypo TP (ppb)
4/18/2006										61.0	1.1	30.0	0.9	
4/26/2006	CAMP									54.0	1.2	37.0	0.9	
5/18/2006	CAMP									58.0	1.0	15.0	0.9	
5/31/2006	CAMP									45.0	1.2	31.0	0.9	
6/8/2006	deep water SRP and Total P	Ortho Phosphate as P, dissolved	16 ft	0.024	mg/L	Total Phosphorus	16 ft	0.078	mg/L				0.9	78
6/15/2006	CAMP												0.9	
6/28/2006	CAMP												0.9	
7/13/2006	CAMP												0.9	
7/14/2006													0.9	
7/26/2006	CAMP												0.9	
8/11/2006	CAMP												0.9	
8/16/2006	deep water SRP and Total P	Ortho Phosphate as P, dissolved	16 ft	0.059	mg/L	total phosphorus	16 ft	0.17	mg/L				0.9	170
8/23/2006	CAMP												0.9	
9/6/2006	CAMP												0.9	
													0.9	

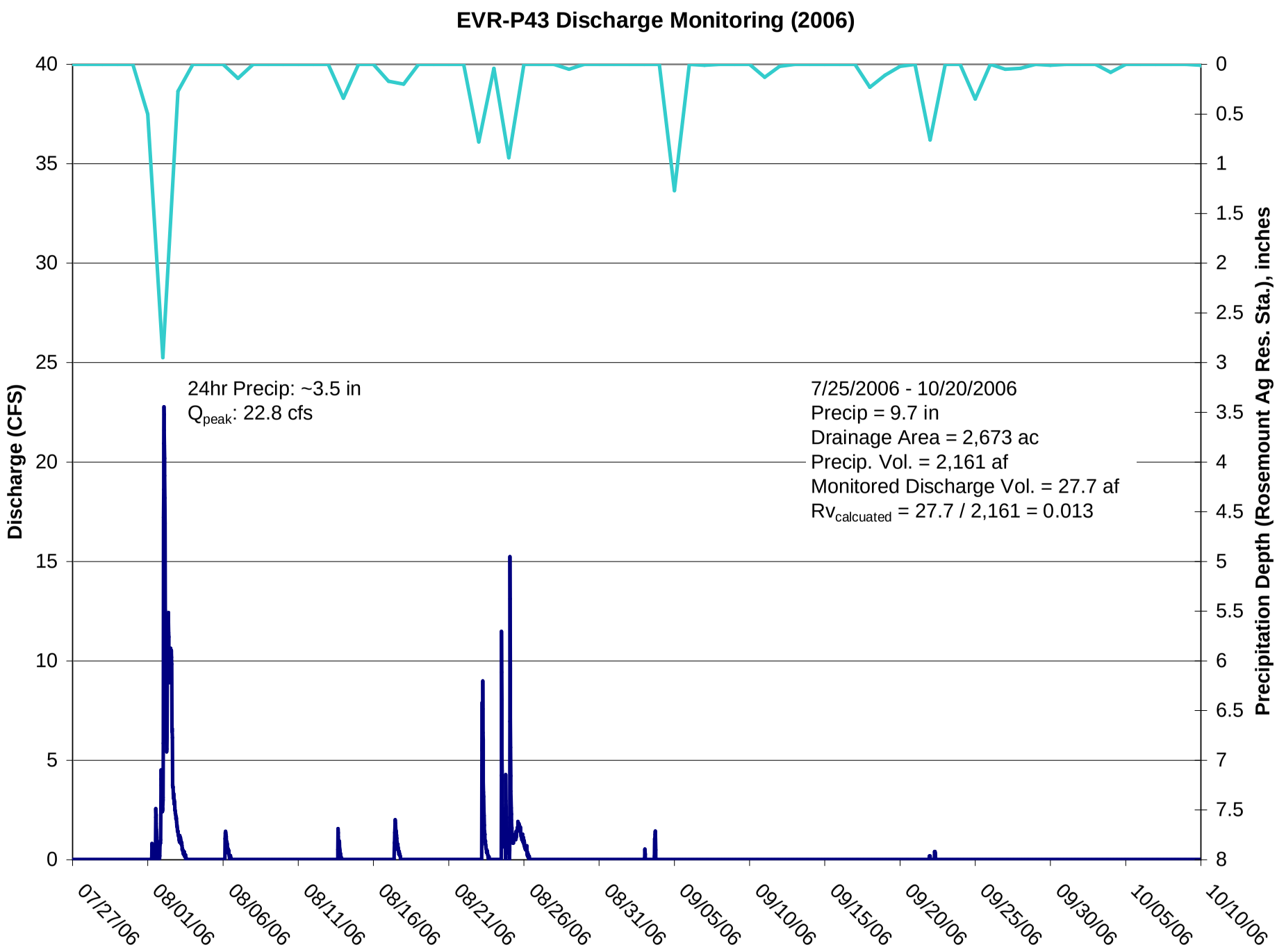
Appendix - B

Dissolved Oxygen and Temperature Profile

		measurement 1			measurement 2			measurement 3			measurement 4				
Date	Time	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	depth (ft)	DO (mg/L)	Temp (C°)	secchi disk depth (ft)	approximate lake depth (ft)
3/9/2007	11:30 AM	15	0.33	4.2	10	8.79	3.9	5	9.09	3.1	2	11.04	1.7		
5/22/2007	1:15 AM														19.25
6/20/2007	11:00 AM														16
7/23/2007	2:05 PM													3	15
8/22/2007	2:05 PM														18
9/27/2007	11:15 AM														17.25

Appendix - B

weather - MPLS Airport					Water Quality Samples Taken other samples 1			
air temperature (F°)	wind speed (mph)	weather	other obse	other samples taken	name of test	depth sample taken	test result	test units
79°F	37	windy, hot, cloudy	water very	yes	chlorides	16 ft	120	mg/L
		sunny, clear, wind >25 mph		yes	chlorides	15 ft	100	mg/L
80°F	7	overcast, hot, humid	some dried out dead fish along sh		chlorides	13 ft	96	mg/L
72	calm		murky		chlorides	15 ft		mg/L
60.1	9	mostly sunny		yes	chlorides	15 ft		mg/L


EVR-P43 Discharge Monitoring (2006)
Discharge (CFS)
Precipitation Depth (Rosemount Ag Res. Sta.), inches
24hr Precip: ~3.5 in
Qpeak: 22.8 cfs
7/25/2006 - 10/20/2006
Precip = 9.7 in
Drainage Area = 2,673 ac
Precip. Vol. = 2,161 af
Monitored Discharge Vol. = 27.7 af
Rvcalcuated = 27.7 / 2,161 = 0.013
40
35
30
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
07/27/06
08/01/06
08/06/06
08/11/06
08/16/06
08/21/06
08/26/06
08/31/06
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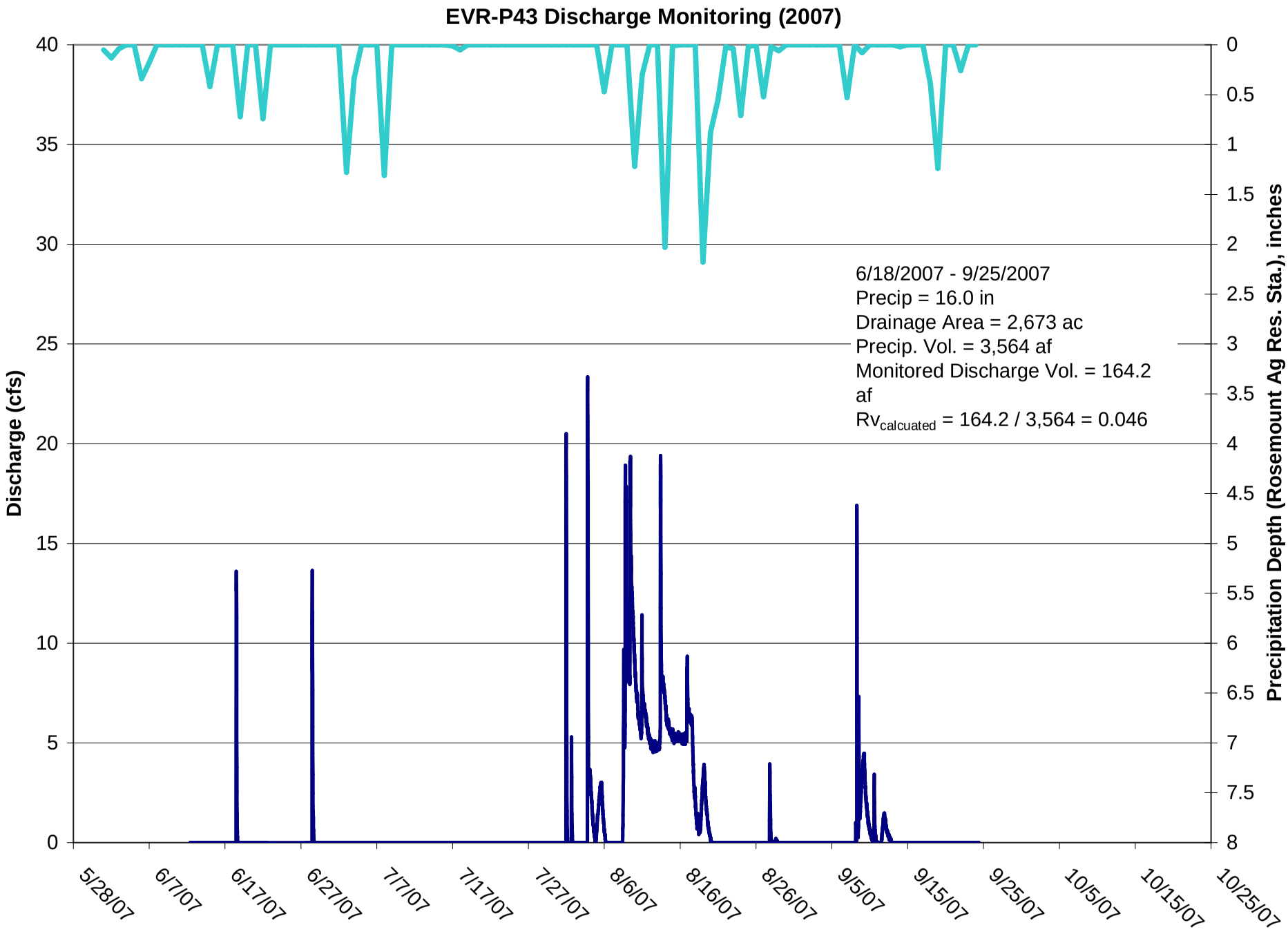
10/05/06
10/10/06


EVR-P43 Discharge Monitoring (2007)
Discharge (cfs)
Precipitation Depth (Rosemount Ag Res. Sta.), inches
6/18/2007 - 9/25/2007
Precip = 16.0 in
Drainage Area = 2,673 ac
Precip. Vol. = 3,564 af
Monitored Discharge Vol. = 164.2 af
Rv$_{calcuated}$ = 164.2 / 3,564 = 0.046
40
35
30
25
20
15
10
5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
5/28/07
6/7/07
6/17/07
6/27/07
7/7/07
7/17/07
7/27/07
8/6/07
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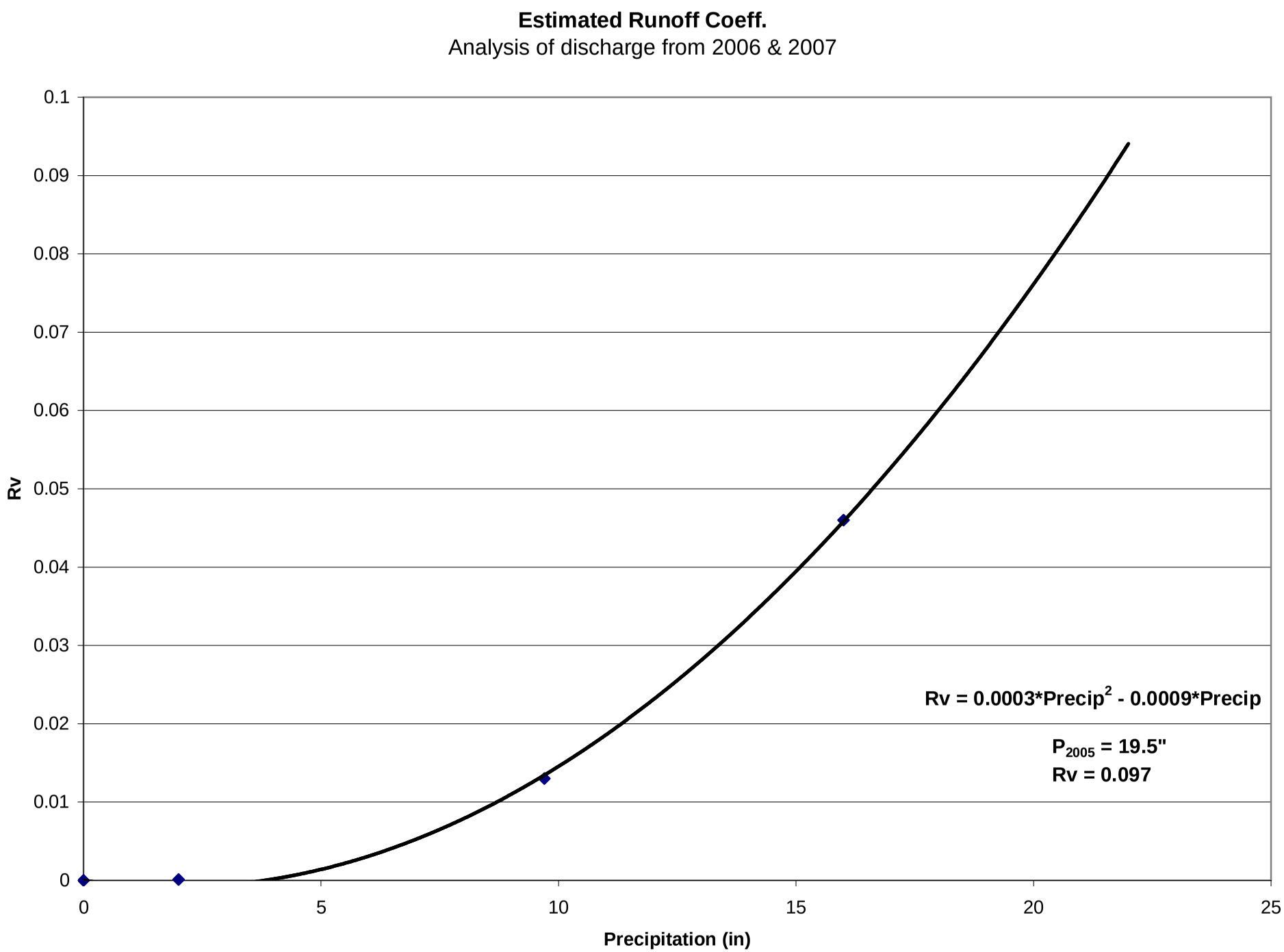
10/5/07
10/15/07
10/25/07

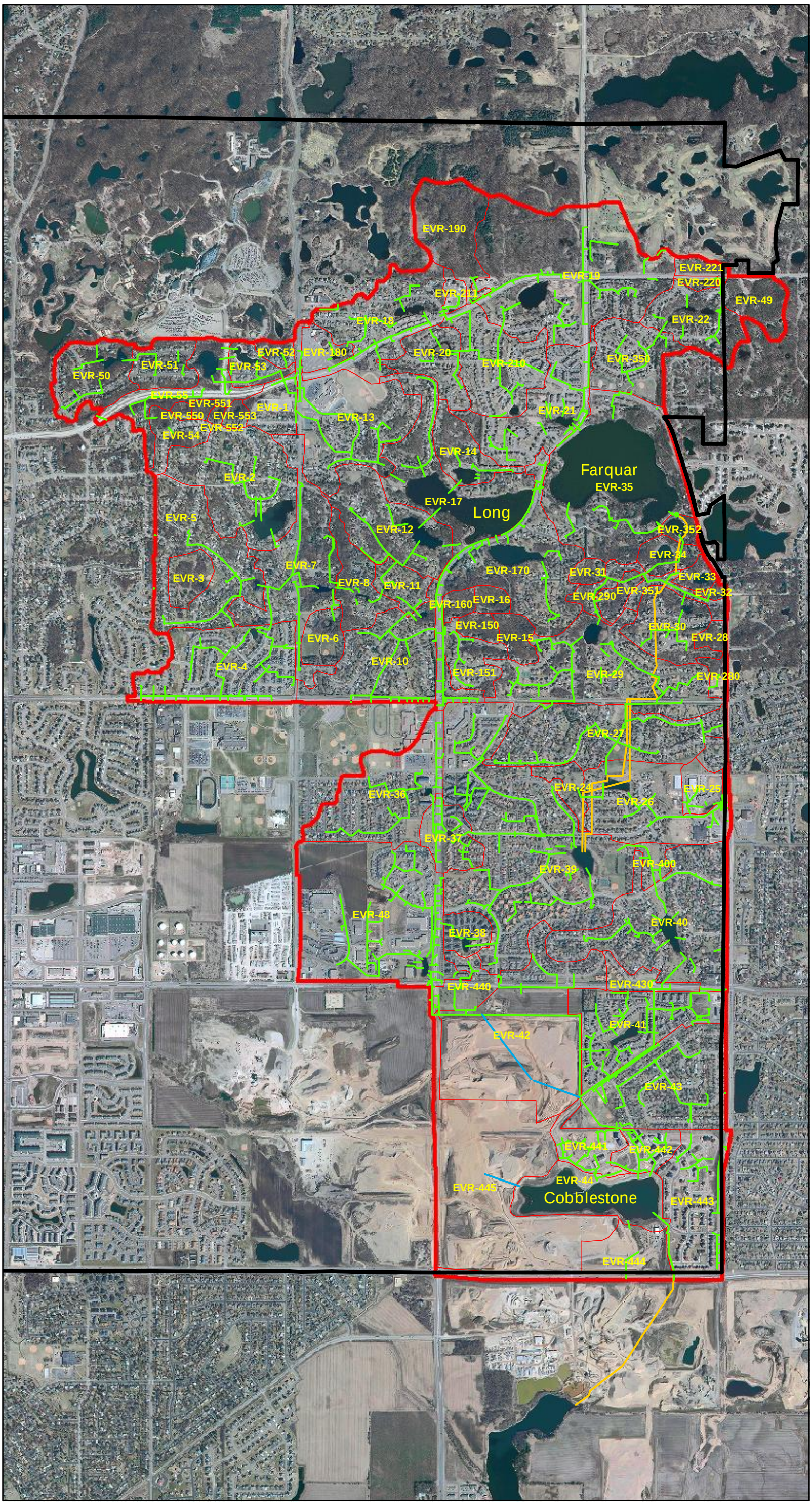

Estimated Runoff Coeff.
Analysis of discharge from 2006 & 2007
Rv
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
Precipitation (in)
Rv = 0.0003*Precip2 - 0.0009*Precip
P2005 = 19.5"
Rv = 0.097

Maps

- Map 1 Stormwater Drainage
- Figure 2.3 11x17 copy of direct drainage watershed map
- Figure 2.4 11x17 copy of lake bathymetry

DRAFT

Cobblestone Lake Management Plan



Stormwater Drainage

Map 1

City Limits
Prop Pipe
Storm Sewer
Force Mains
Lakes
Watershed Boundary

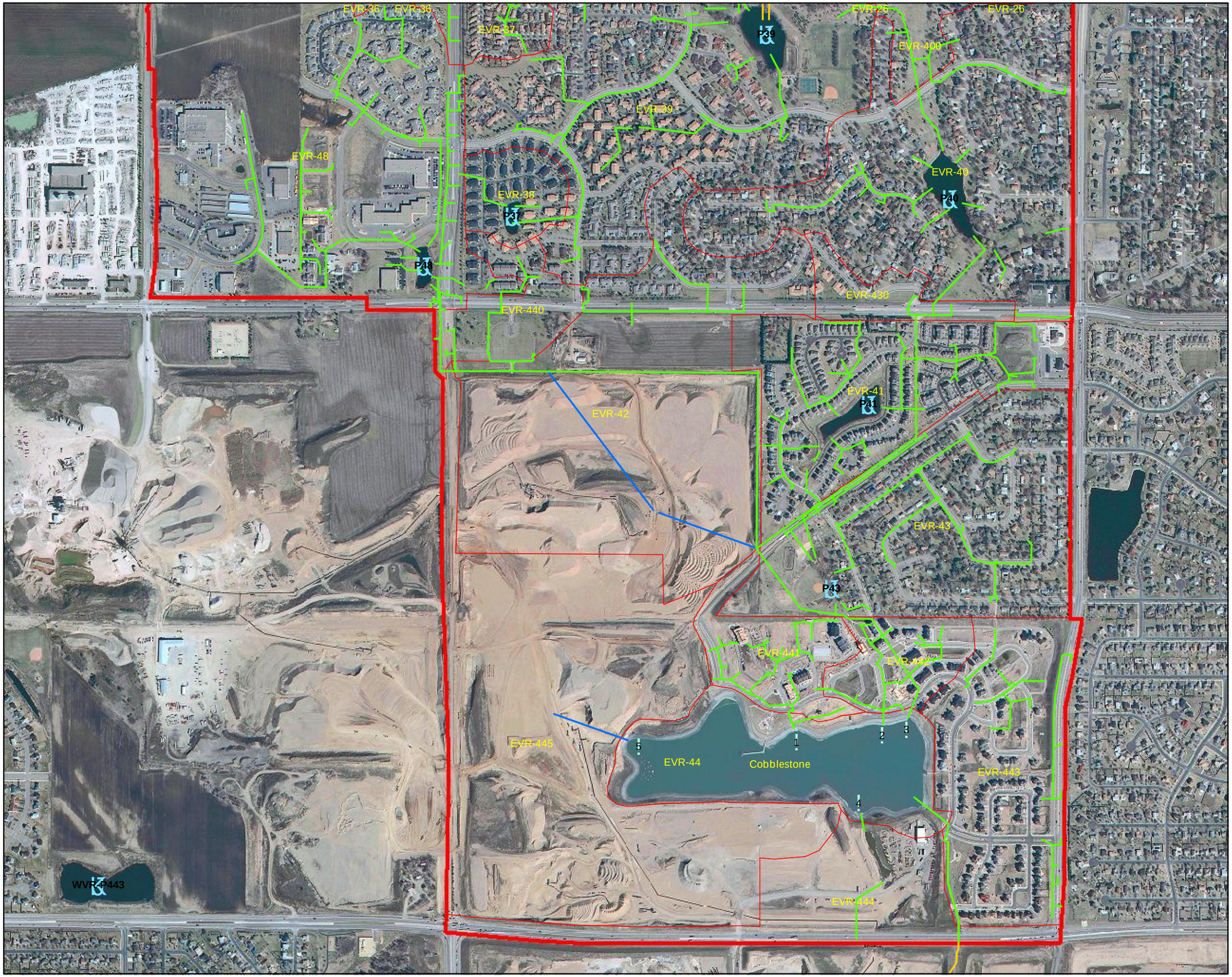
February 2008

Feet
0 750 1,500 3,000

Apple Valley

Bonestroo

I:\68\6806328\Cad\GIS\amproject\Storm Drainage



Cobblestone Lake Management Plan

Stormwater Drainage Ultimate Development

Figure 2.3

- Storm Sewer Outfalls
- Ponds
- Storm Sewer
- Force Main
- Prop Pipe
- Watershed Boundary

April 2005 Areal Photo

February 2008

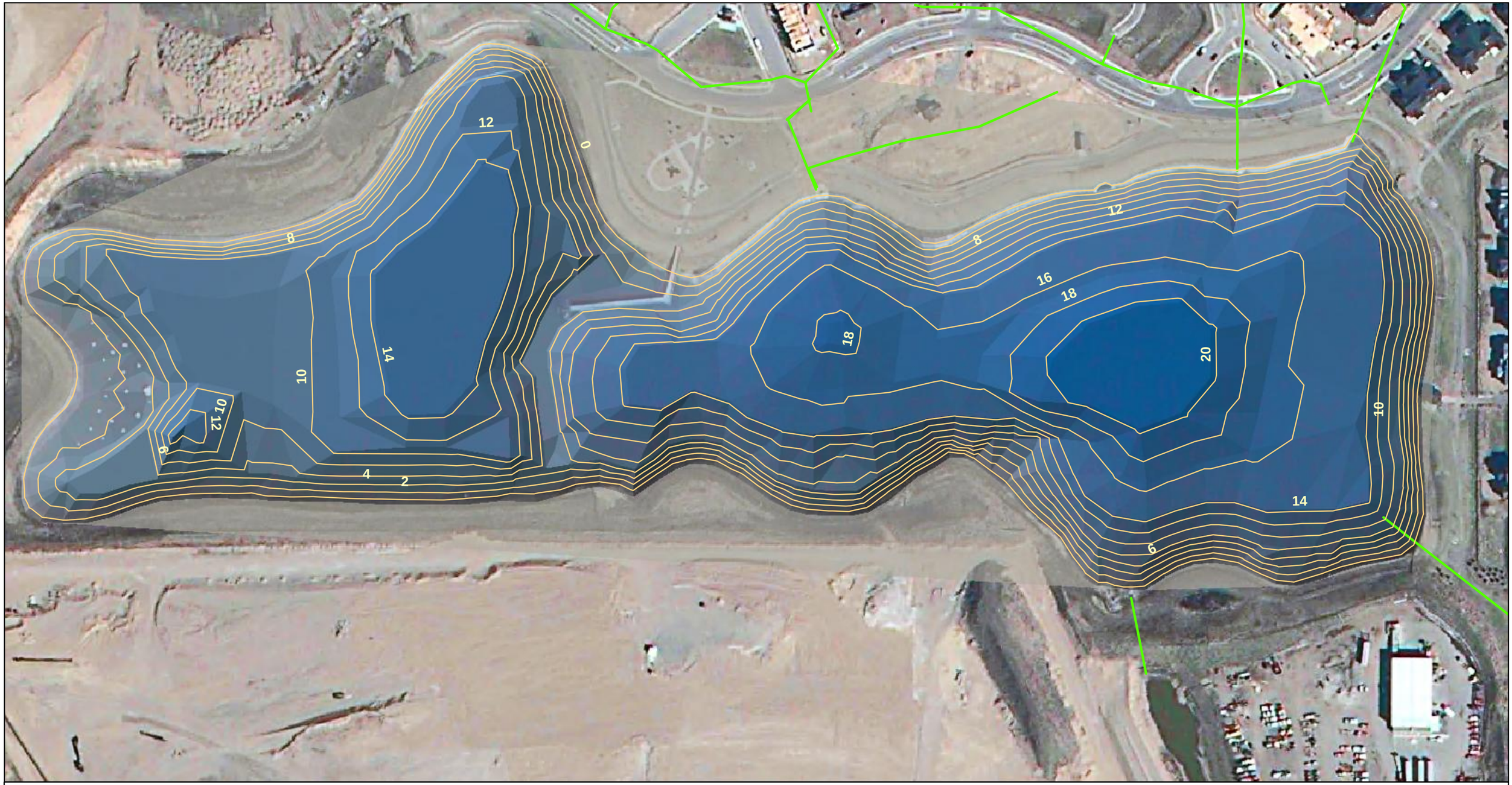
Feet

0 500 1,000 2,000

Apple Valley

Bonestroo

I:\68\6806328\Cad\GIS\amproject\Direct Drainage Cobblestone_Ult



Cobblestone Lake Management Plan

Lake Bathymetry

Figure 2.4

Normal Water Level = 909.5
Surveyed: Summer 2006

Storm Sewer (2005)
Depth Contour (2 ft)

Feet
0 150 300 600

Apple Valley

Bonestroo

I:\68\6806328\Cad\GIS\amproject\Cobblestone Lake Bathymetry