Feasibility of a Chemical Treatment System Downstream of Buck Lake

Prepared for
Prior Lake-Spring Lake Watershed District

October, 2014

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1.0 Background and Purpose of Feasibility Study

The Prior Lake-Spring Lake Watershed District (PLSLWD)—in keeping with the 2011 Spring/Upper Prior Nutrient TMDL study (Wenck, 2011)—determined that a chemical treatment facility may be a key component in reducing watershed phosphorus loading to Spring Lake. Modeling performed for the EPA-approved TMDL study determined that approximately 1,891 pounds/year, or 38% of the total phosphorus watershed loading to Spring Lake, was contributed through the Buck Lake system. More recent monitoring data indicates that approximately 26% of the total phosphorus watershed loading to Spring Lake originates from the Buck Lake tributary, which represents the second highest watershed source behind County Ditch 13 (EOR, 2013).

In both its permit conditions and other correspondence with PLSLWD, the Minnesota Pollution Control Agency (MPCA, 2013) has indicated that chemical treatment systems must be off-line with no element of the facility located within a public water. Figure 1-1 shows that the potential project location, at the Kingdom Hall site (east of the Hwy. 13-180th St. intersection), is the closest off-line area to the Buck Lake tributary immediately upstream of the Ducks Unlimited (DU) wetland and Spring Lake. The project location has an existing non-public wetland that will need to be considered as a part of the decision making, beyond the project permitting and estimated costs associated with mitigation. Monitoring of the downstream DU wetland was also necessary to determine whether it serves as a phosphorus trap or source of phosphorus to Spring Lake and the conceptual design at the proposed site needed to account for the flat topography and tailwater effects that could limit gravity-based designs.

The following sections assess the feasibility of a chemical treatment downstream of Buck Lake system (at the identified project location, only) and are intended to guide the Prior Lake-Spring Lake Watershed District in considering the most cost effective methods to reduce watershed phosphorus loading from the Buck Lake inflow. The project objectives are to complete a comprehensive study of chemical treatment alternatives and their associated strengths, weaknesses, opportunities and threats, including estimated phosphorus load reductions, a cost-benefit analysis (based on detailed cost estimates contained in Appendix A) and a concept plan for the recommended approach based on the gathered information and analysis.

Following the feasibility study and dissemination process, the District and local stakeholders will know:

- The feasibility and long-term cost-effectiveness of each chemical treatment alternative, as well as any other identified methods for reducing phosphorus loading from the Buck Lake tributary
- The operation and maintenance requirements for each treatment alternative
- The permit implications for each treatment alternative
- The conceptual layout of the chemical treatment facility
- The land acquisition needs or site constraints at the Kingdom Hall site
- Whether the Ducks Unlimited wetland is a potential source or sink for phosphorus loading to Spring Lake

The last two items were addressed during the first phase of this feasibility study to determine whether site constraints or downstream phosphorus sources would constrain the overall effectiveness of the chemical treatment option for the Buck Lake tributary. The results of the first phase of the feasibility study were summarized in a memorandum prepared for the District by Barr (2013), which is included in Appendix B.

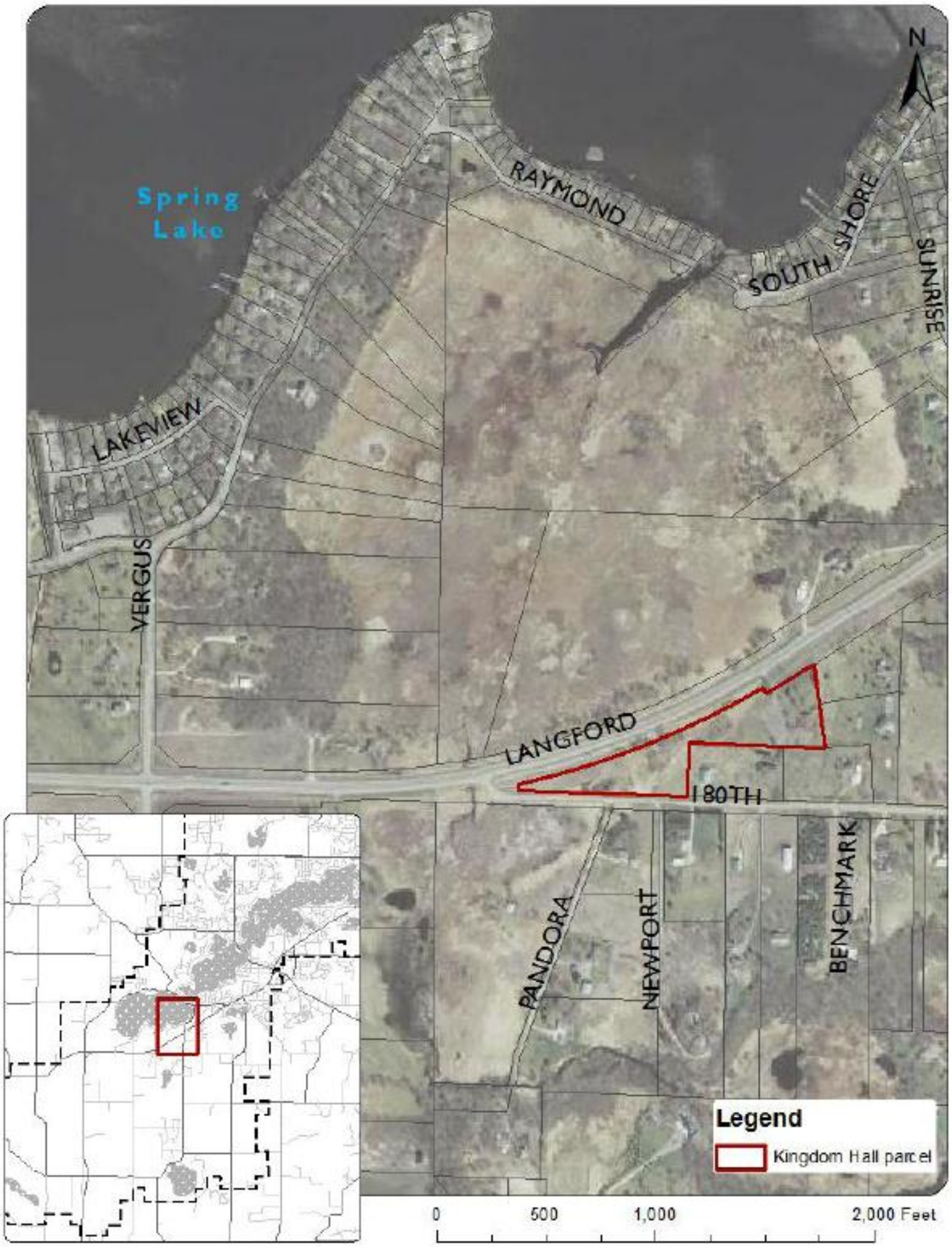

Figure 1-1 Proposed chemical treatment facility location map

1.1 Results of First Phase of Feasibility Study

For the initial task of the Buck Lake Feasibility Study, Barr (2013) worked with the District to determine whether nutrient dynamics within the Buck Lake tributary to Spring Lake would allow for the best treatment at the Kingdom Hall site and/or whether site constraints would affect the feasibility of the chemical treatment system under consideration. For this task, Barr also coordinated the development of a monitoring plan with District staff that was intended to evaluate whether the DU wetland, Buck Lake and any of the other upstream wetlands would function as a source, sink or pass-through of phosphorus during the growing season. As a result, this section summarizes past monitoring and analysis, the results of the 2013 monitoring in the Buck Lake tributary and provided considerations for treatment alternatives.

1.1.1 Past monitoring and analysis

Both synoptic and continuous water quality monitoring has occurred in some form or another in the Buck Lake tributary system since 2009. Figure 1-2 shows the Buck Lake tributary monitoring sites.

Deployment of continuous dissolved oxygen (DO) equipment at Site 14 during 2009 indicated that DO was never above 5 mg/L and the minimum measurements were also lower than any other site. Synoptic DO measurements revealed low DO during several summer events at Sites 10, 12, 14 and 15.

During 2010, Site 14 experienced low DO from May 19 through September 23rd. Low DO was also observed at Site 16, but at levels that were typically a little higher than Site 14. Dissolved oxygen measurements at Site 11 were higher than 5 mg/L throughout the period of record in 2010.

The 2009 and 2010 data indicated that some of the wetland complexes in the Buck Lake tributary switch from filtering to releasing nutrients during the course of the year. Most wetlands have fluctuating water levels or drawdowns for at least part of the year. When the water is oxygenated, iron in the wetland soil bonds with phosphorus and forms an insoluble complex. When water in the wetland becomes stagnant, the system becomes anaerobic due to the increased use of oxygen by microbial organisms, and ferric iron is chemically reduced and the iron complex releases its phosphorus. If a wetland is stagnant for a week or more, the soil can release soluble phosphorus through its own chemical activity, that is, without any new influx of phosphorus from the watershed.

The 2011 through 2012 flow and water quality monitoring data were previously used to estimate annual total phosphorus loadings at Sites 8, 11 and 14. Based on previous analysis, it was expected that a significant portion of the Buck Lake tributary phosphorus load originates within the Buck Lake and Concord subwatersheds (or the subwatershed areas upstream of Site 14 and downstream of Sites 8 and 11).

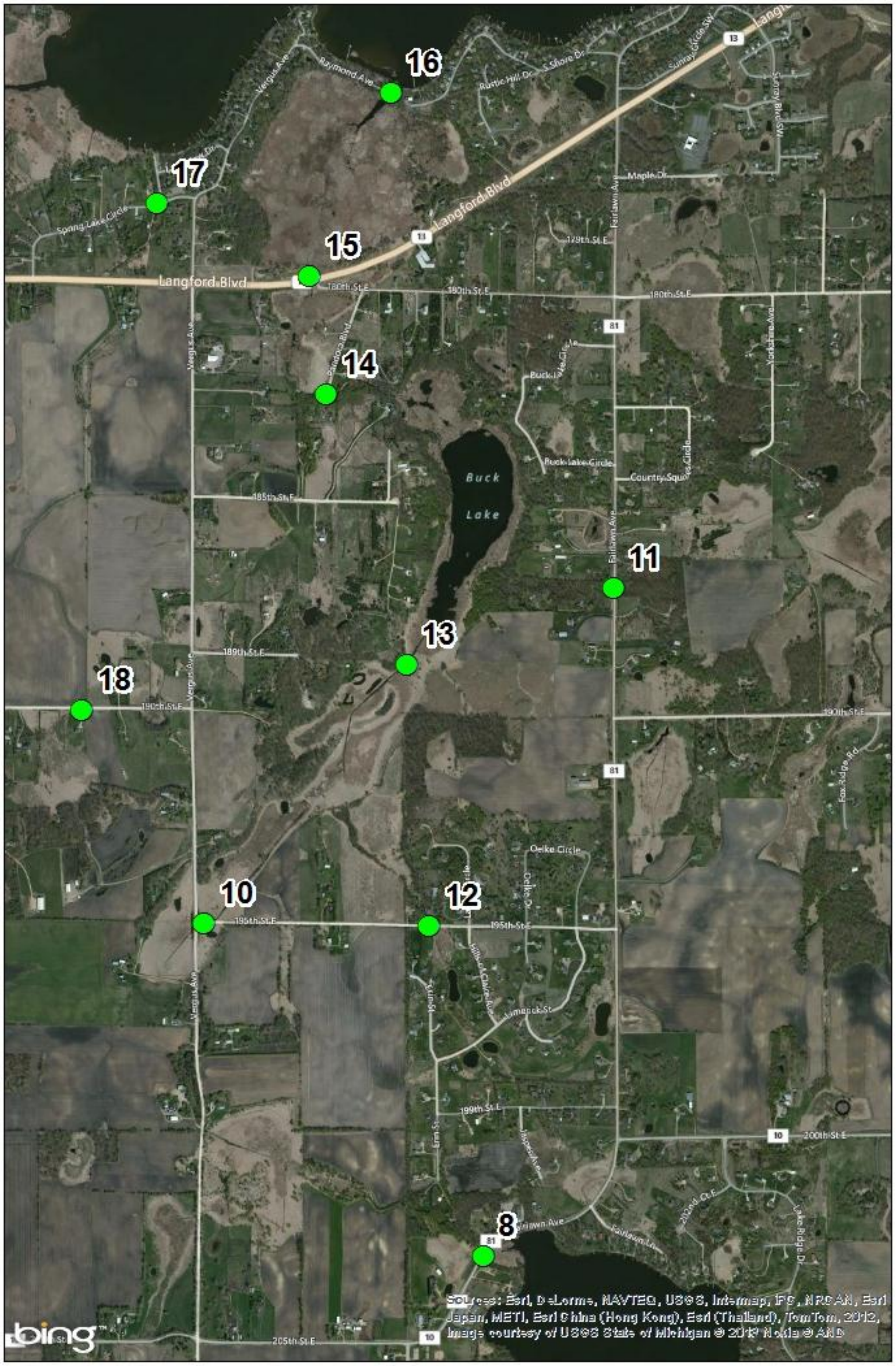

Figure 1-2 Buck Lake tributary monitoring sites

1.1.2 2013 monitoring and analysis

All of the monitoring sites shown in Figure 1-2 represent stream channel monitoring sites. More extensive monitoring was conducted at most of these sites in 2013, along with a detailed lake water quality sampling event that occurred on September 5, 2013 at Buck Lake (which had not been monitored in the past). The Buck Lake monitoring event coincided with a low flow condition with low dissolved oxygen in the streamflow and no oxygen in the bottom 3.5 feet of Buck Lake. A review of all of the available continuous dissolved oxygen (DO) data shows that Site 13 has the highest frequency of anoxic conditions, with 86% of the readings below 1 mg/L during the 2013 growing season, followed by Site 14 (69%) and Site 16 (57%). The continuous DO data from Site 11 shows that the flow at this site is well oxygenated and would not be subject to the type of sediment phosphorus release that is described in the previous section. Grab sampling at the remaining sites shown in Figure 1-2 indicate that dissolved oxygen is typically present at concentrations greater than 1 mg/L.

Figure 1-3 shows how the total phosphorus observations at each site varied during 2013 in relation to flow. The data indicate that snowmelt and/or spring runoff likely is a significant portion of the annual phosphorus load to Spring Lake from the Buck Lake tributary. A comparison of the total phosphorus concentrations at Sites 14 and 16 generally show close agreement which indicates that the Duck Unlimited and upstream wetland complexes (between Pandora Avenue and Spring Lake) are not a significant source or sink of phosphorus during the course of the year. Higher phosphorus concentrations during the summer at Sites 14 and 16 typically correspond with low flow, which indicates that sediment phosphorus release from wetland soils could represent a significant source of phosphorus. Higher flow at Site 11 tends to correspond with higher phosphorus, indicating that streambank erosion may be a significant source, although Site 11 has several smaller wetlands in the headwater watershed area that could have accounted for the higher concentration in early July.

Phosphorus observations from the September 5th Buck Lake monitoring event showed that the surface water concentration corresponded with what is shown for Site 14 (in Figure 1-3) at the same time that the anoxic bottom water phosphorus concentration was 0.32 mg/L. As previously discussed, the bottom 3.5 feet of Buck Lake was anoxic and the weak thermal stratification of the lake indicates that sediment phosphorus release from Buck Lake would also represent a significant source of phosphorus to Spring Lake during the summer.

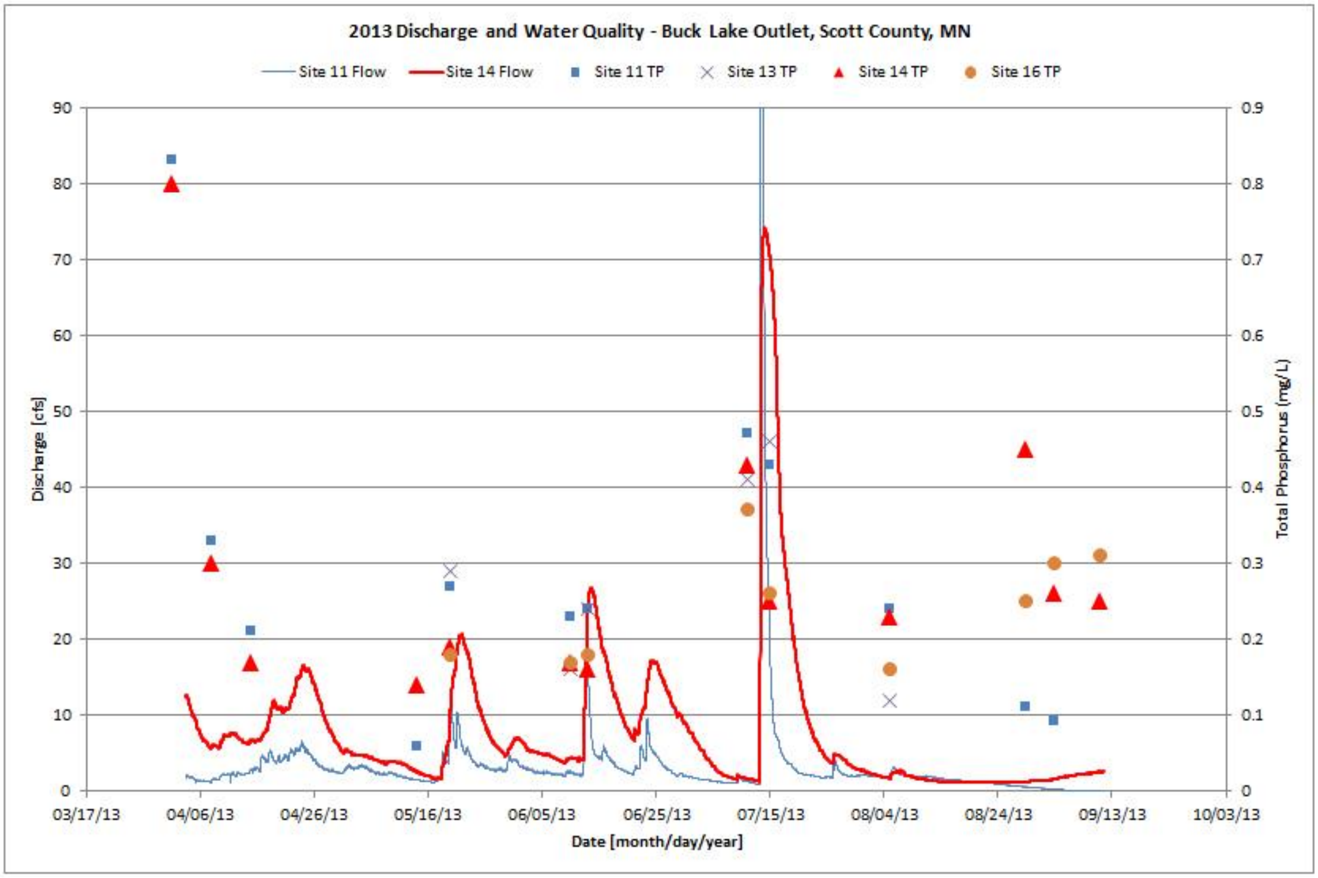

Figure 1-3 Buck Lake tributary 2013 flow and water quality monitoring

1.1.3 Recommendations for feasibility study alternatives analysis

Preliminary data analysis indicated that the DU wetland and the large wetland complex downstream of Pandora Avenue may not be contributing excess phosphorus to the existing load from the Buck Lake tributary, but it does appear that both systems are typically passing the upstream phosphorus load through to Spring Lake with no appreciable treatment. It was also expected that the footprint of the chemical treatment system that is being considered for the Kingdom Hall site can be accommodated there, but concerns about the construction and ongoing operation/maintenance costs, permitting and feasibility would have to be addressed in the alternatives analysis. In addition, our analysis of the available monitoring and GIS data, along with a review of the aerial photography, indicate that the following options for controlling phosphorus export and sediment release from the upstream watershed should also be considered (both alone and in combination) and compared with the chemical treatment system in the final feasibility study of the Buck Lake tributary:

- In-lake alum treatments of Buck Lake and Fish Lake
- Stabilization of streambank erosion within the Site 11 tributary area
- Targeted (field-scale) agricultural Best Management Practices (BMPs)

2.0 Alternatives Analysis

This section represents a compilation of all of the relevant information necessary to formulate the chemical treatment system alternative at the Kingdom Hall site that includes an evaluation of the most cost-effective precipitant (either ferric chloride or alum), a do-nothing alternative and an alternative that involves an optimal combination of the following upstream treatment options to meet revised TMDL goals. The revised TMDL goals have been developed for this study based on the assumption that Spring Lake will be subject to a site-specific standard, currently under consideration by the MPCA, which would change the summer average phosphorus goal from 0.040 mg/L to 0.060 mg/L. The lake response modeling contained in Appendix B of the TMDL study was used to adjust the expected watershed load reductions that would be required to meet the 0.060 mg/L phosphorus goal for Spring Lake. On average, the watershed phosphorus load would need to be reduced by approximately 60% for the nine years of simulated watershed and in-lake modeling completed for the TMDL study to meet the revised goals.

2.1 Do-Nothing Alternative

For the this study, the implications of the do-nothing alternative were measured against the changes that would result to the in-lake phosphorus concentration in Spring Lake under the existing condition in comparison to the revised TMDL goals (described above), which in turn, were then used to estimate how much the effective lifespan of the Spring Lake alum treatment would be reduced. In preparation for the July 29, 2013 public meeting regarding the Spring Lake alum treatment, Barr had determined that the estimated longevity of the in-lake alum treatment would be extended by three to five years if the Buck Lake tributary annual phosphorus loading were reduced by 50%. Since the revised TMDL goals correspond to an approximate 60% annual watershed phosphorus load reduction, the Spring Lake alum treatment longevity could be extended by 3.5 to 6.5 years.

In other words, the do-nothing alternative would be expected to shorten the Spring Lake alum treatment by 3.5 to 6.5 years, which would in turn, significantly increase the probability that there will be more time where the lake water quality is not meeting water quality standards before another in-lake alum treatment would be necessary. Since it is unclear whether future in-lake alum treatments will be subject to increased regulatory oversight than currently exists, the District should be looking for ways to increase the longevity of the in-lake alum treatment wherever possible.

2.2 Chemical Treatment System Alternative

2.2.1 Evaluation of wetland impacts and issues related to environmental permitting

This section discusses environmental review and permitting needs potentially required for the construction and operation of the Buck Lake chemical treatment facility proposed in the southeast quadrant of the intersection of State Highway 13 and 180th Street in Scott County.

2.2.1.1 Environmental Review (EAW) under MN Rules 4410

The proposed project components and potential impacts were reviewed to determine whether the project would require an Environmental Assessment Worksheet (EAW). The categories of projects that require a mandatory EAW are provided in MN Rules 4410.4300 and 4410.4400. Specifically, MN Rules 4410.4300 describes the types of projects that require a standard EAW. MN Rules 4410.4400 describes projects with potential impacts that warrant preparation of an Environmental Impact Statement (EIS). The preliminary step in the EIS process is preparation of a Scoping EAW that defines the potential impacts to be evaluated in the EIS.

Review of the project categories and impact criteria in MN Rules 4410 indicates that the proposed chemical treatment facility would not require an EAW. The closest potential project category for a mandatory EAW is MN Rules 4410.4300, Subpart 27, Wetlands and Public Waters. Under this project category, projects “that will change or diminish the course, current, or cross-section of one acre or more of any public water or public waters wetland” (Subpart 27A). This project category also requires an EAW for projects that “will change or diminish the course, current, or cross-section of 40 percent or more…of types 3 through 8 wetland of 2.5 acres or more, excluding public waters wetlands, if any part of the wetland is within a shoreland area, delineated flood plain, a state or federally designated wild and scenic rivers district, the Minnesota River Project Riverbend area, or the Mississippi headwaters area” (Subpart 27 B).

The proposed project does not meet the EAW criteria listed in MN Rules 4410.4300, Subpart 27 A for the following reasons:

- The chemical treatment facility, including the floc pond, would be constructed in an existing Type 3 shallow marsh wetland. Impacts would exceed one acre. However, this wetland is not a Minnesota Public Waters wetland.
- Diversion of water from public waters wetland 206W on the west side of 180th Street may require construction of a weir, or similar structure. However, construction of the structure would affect less than one acre of public waters wetland.

Please note that impacts in public waters wetland 206W (southwest quadrant of the State Highway 13/180th Street intersection) must be kept under one acre in order to avoid meeting the mandatory EAW criteria in MN Rules 4410.4300, Subpart 27 A.

The proposed project does not meet the EAW criteria listed in MN Rules 4410.4300, Subpart 27 A for the following reason:

- The existing wetland is greater than 2.5 acres, and the project would potentially alter the cross-section of more than 40 percent of the wetland. However, no part of the wetland is within a shoreland, delineated floodplain, or any of the other designated areas listed in MN Rules 4410.4300, Subpart 27 B.

The proposed chemical treatment facility does not meet the criteria for any of the projects requiring a mandatory EIS/Scoping EAW, as defined in MN Rules 4410.4400.

2.2.1.2 Federal/State/Local Permitting Requirements

Wetlands

Wetland permitting would require coordination with both the U.S. Army Corps of Engineers (Corps), which administers Section 404 of the Clean Water Act (CWA), and the Board of Water & Soils Resources (BWSR), which administers the Wetland Conservation Act (WCA). The Corps would coordinate with the Minnesota Pollution Control Authority (MPCA) to obtain water quality certification under Section 401 of the CWA. A *Minnesota Joint Application for Activities Affecting Water Resources* would be prepared for both the Corps and WCA permit applications. The joint application would also cover the Minnesota DNR Public Waters permit application. A wetland delineation and report would be needed to support the joint application. Details on the federal and state regulatory agencies are below:

U.S. Army Corps of Engineers (Corps) Clean Water Act Section 404 (wetlands)

Construction of the chemical treatment facility and pond would result in impacts to ~1.5 to 2 acres of Type 3 shallow marsh wetland. Impacts would include filling a portion of the wetland to construct a landscaped berm around the floc pond and excavation of an additional portion of the wetland for the floc pond itself. The Corps would consider the excavation for the floc pond as part of the wetland impacts to be regulated under Section 404, despite the fact that the area would be a pond. An additional component of the overall chemical treatment facility is the placement of a weir in a separate wetland across 180th Street. However, it appears that the total impacts from the floc pond excavation, the landscaped berm and the weir placement would not exceed the 3-acre threshold for a Section 404 Individual Permit. The overall project design should keep the total wetland impacts to less than 3 acres to avoid the more costly and time-consuming Section 404 Individual Permit.

On the assumption that the total wetland impacts are less than 3 acres, the Corps permit could be completed under a Letter of Permission (LOP), which covers projects with impacts up to 3 acres. The LOP would likely be processed within about 3 months. Mitigation costs for 1.5 to 2 acres of wetlands could cost up to $65,000 to $87,000[1], if mitigation is completed using bank credits. This is based on current bank credit costs in the Scott County area (Bank Service Area 9) of $1/square foot, or $43,560/acre.

Per a May 7, 2014 conversation with Sarah Wingert, the Corps regulatory contact for Scott County, the joint application would need to include a comprehensive alternatives analysis that demonstrates that there is no feasible alternative the selected project site.

The estimated cost of the Corps CWA wetland permit, including delineation, delineation report, joint application preparation, processing assistance, LOP and mitigation would be $83,000 to $105,000, and would take an estimated 4-6 months from the delineation to the completion and approval of the LOP.

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[1] The mitigation bank credit cost estimate covers the costs of credits for both state (BWSR) and federal (Corps) regulated wetland impacts. There are additional service fees charged by BWSR (see BWSR/WCA section).

Minnesota Board of Water and Soil Resources (BWSR) (Wetland Conservation Act)

Under the Wetland Conservation Act (WCA), the project impacts would include the entire 1.5-2 acres of Type 3 wetland affected (i.e., BWSR would not exempt the portion converted to pond). In addition to the mitigation bank credit costs described above, BWSR would charge an additional $2,995/acre, or a total of ~$4,500 to $6,000 as a bank service fee. The WCA permit would be applied for using the *Minnesota Joint Application for Activities Affecting Water Resources in Minnesota*.

Minnesota Department of Natural Resources

License to cross public waters

The proposed project would require placement of a weir or similar water diversion structure in public water wetland 206W. Construction of the weir would require a MNDNR Public Waters Work Permit. The application for this permit is part of the *Minnesota Joint Application for Activities Affecting Water Resources*.

Take of sensitive species

Barr has a license with the Department of Natural Resources to access the Natural Heritage Information System (NHIS) database for documented occurrences of Minnesota endangered, threatened or special concern (ETSC) species. The NHIS database was accessed to check for records of ETSC species in the vicinity of the proposed project.

The NHIS database has no documented records of ETSC species within one mile of the project. However, the following records were just outside of the one mile search radius:

- *Desmodium cuspidatum* var. *longifolium*, Big tick-trefoil, SC. This is a vascular plant associated with mesic hardwood forests. There are two records. The nearest is from 1891 and is ~1.1 miles north of the site, somewhere along the north edge of Spring Lake. The other is more recent (2004), but is ~1.7 miles northeast of the site.
- *Emydoidea blandingii*, Blanding's turtle, T. The NHIS record is ~1.1 miles north-northwest of the project site, from 1995, near the northeast edge of Spring Lake.
- *Cygnus buccinator*, Trumpeter swan, T. – This is a 2011 NHIS record ~1.5 miles northwest of the project site, in the northeast end of Campbell Lake.

The proposed site does not provide suitable habitat for any of these species. Blanding's turtles in the area might possibly utilize the proposed site's wetland in spring and early summer; however, it is more likely that Blanding's turtles would utilize the better-quality and more accessible Spring Lake Marsh and/or the wetland (206W) west of the project site.

Based on consultation with the NHIS database, it is highly unlikely that the proposed project will require a MNDNR permit to take endangered or threatened species. A letter summarizing the NHIS database search and Barr's preliminary finding that the project would not affect ETSC species was sent to MNDNR March 21, 2014 for their concurrence. No response has been received; however, it is anticipated that MNDNR will concur with Barr's preliminary finding.

Minnesota Pollution Control Agency (Construction Stormwater Permit)

The project will disturb more than one acre of soil. It will therefore require a NPDES/SDS[2] construction stormwater permit from the Minnesota Pollution Control Authority (MPCA). The permit application will require preparation of a SWPPP for the project.

Minnesota State Historic Preservation Office (Cultural Resources)

The State Historic Preservation Office (SHPO) was contacted to determine whether there are any cultural resources (archaeological, architectural or historic site records) in the vicinity of the project. In a March 31, 2014 response, SHPO stated that no archaeological sites or historic structures were identified in a search of the Minnesota Archaeological Inventory and Historic Structures Inventory.

Minnesota Department of Transportation and/or Scott County Physical Development Department

Any alteration to State Highway 13 or 180th Street, including placement of a culvert under either road, would require coordination with MnDOT and/or Scott County, depending on which roadway is affected. MnDOT typically requires a set of design plans for the proposed action for their review and approval. It is assumed that Scott County would do the same. Application fees are negligible, with costs limited to preparation of preliminary design plan for MnDOT and/or Scott County review and approval.

Scott County Department of Planning

The project area is currently zoned RR-2, Rural Residential Single Family District. Construction of the proposed project would require a zoning variance from the Scott County Department of Planning. The Scott County Planning Board meets monthly to hear zoning variances, and there is about a six-week lag time between The Planning Department's receipt of a zoning variance request and scheduling of the hearing.

2.2.1.3 Summary

After review of the project and the applicable federal, state and local regulations, it appears that the project will require the following permits, mitigation and approvals, at the following estimated total costs (wetland permitting costs provided are for the anticipated maximum impact area of 2.0 acres):

- U. S. Army Corps of Engineers Section 404 Clean Water Act Letter of Permission - $105,000
- Minnesota Board of Water and Soils Resources - $6,000 (mitigation costs and joint permit application included with Corps permitting costs)
- Minnesota Department of Natural Resources License to Cross Public Waters- joint permit application costs included with Corps permitting costs; no mitigation costs.
- Minnesota Pollution Control Agency NPDES permit (SWPPP) - $6,000
- Minnesota Department of Transportation – costs limited to preparation of preliminary design plan for MnDOT review and approval
- Scott County Physical Development Department - costs limited to preparation of preliminary design plan for Scott County review and approval
- Scott County Department of Planning zoning variance. - $2,000

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[2] National Point Discharge Elimination System/State Disposal System

The total anticipated costs of permitting the proposed Buck Lake chemical treatment facility at the intersection of State Highway 13 and 180th Street are approximately $120,000. This does not include the cost of preparing preliminary design plans for alterations to State Highway 13 and/or 180th Street.

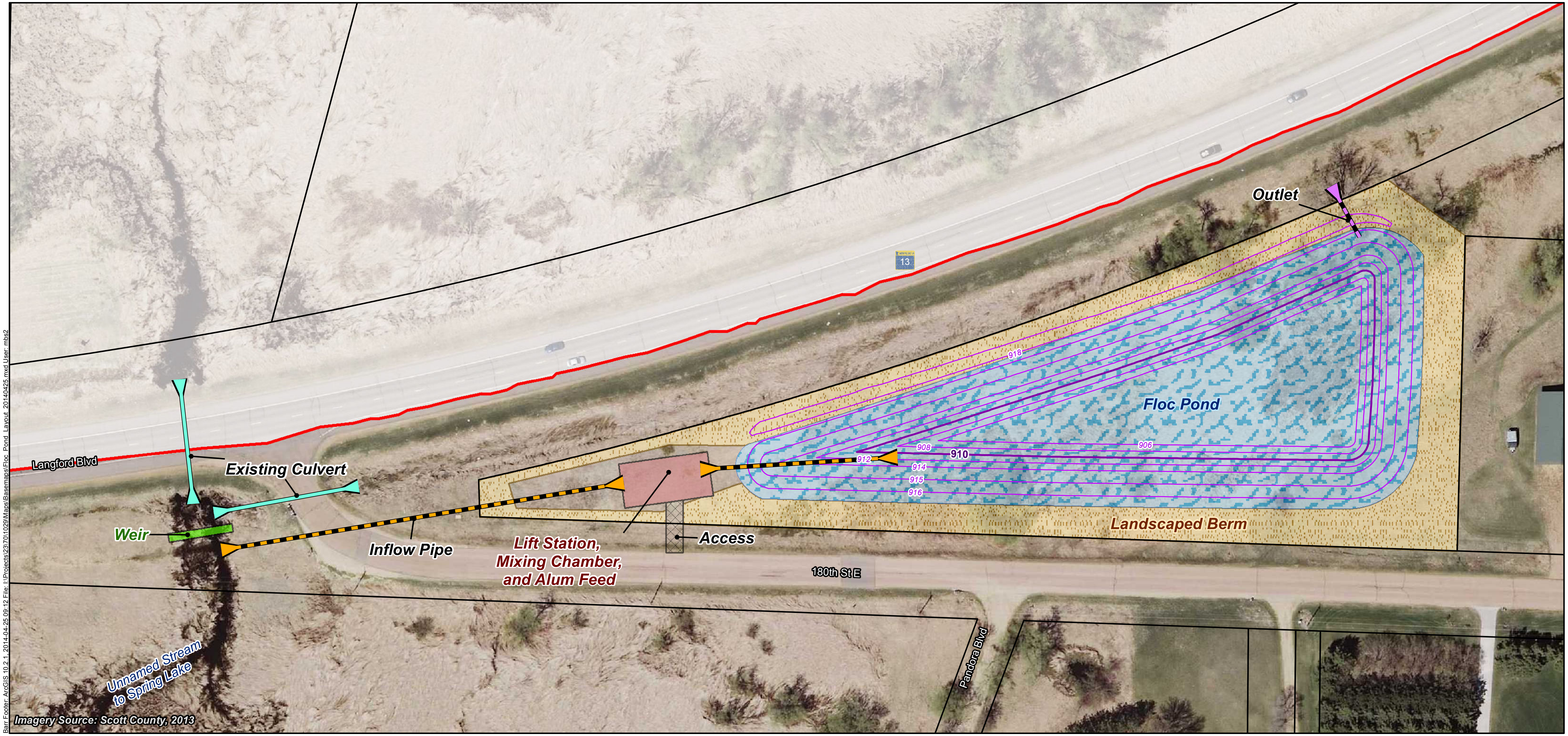
No permits or approvals would be needed form MNDNR for taking of endangered or threatened species or from SHPO for cultural resource impacts.

The project would not require preparation of an EAW or EIS, per MN Rules 4410.

2.2.2 Conceptual design of chemical treatment system

This section describes the conceptual design and provides the basis of the cost and estimated phosphorus removal performance (e.g., phosphorus load reductions) for a flocculent treatment system located at Highway 13 and 180th Street East. The treatment system is currently being described as a "flocculent treatment system" because alum (aluminum sulfate) and ferric chloride (iron chloride) are provided as viable and largely equivalent alternative flocculants. The relative merit of each flocculant is discussed subsequent sections. The treatment system consists of a weir that diverts water from the unnamed tributary to Spring Lake, pipes, pumps to raise water from the stream to the flocculent treatment system, chemical holding tanks, a flocculent feed system, a mixing chamber, and a floc settling and sludge holding pond.

The conceptual design layout for the flocculent treatment system is provided in plan view (top view) in Figure 2-1. A weir will be placed in the unnamed creek to divert water to the treatment system through a 24 inch concrete pipe. The pipe, placed just upstream of the weir, will need to be constructed beneath 180th Street East and extend to the treatment system building. Water will travel by gravity through this pipe to a 12 foot deep sump with submersible pumps (3, 25 horse power pumps). The sump with 3 submersible pumps is described herein as a lift station. The lift station was necessary because the ground elevation of the identified treatment facility site is approximately 2 feet above the surface elevation of the stream. The lift station will be constructed outside of the building that houses the chemical holding tanks, the chemical feed pumps, and the mixing chamber. Water pumped from the lift station will be directed into the treatment building where flocculent will be added prior to discharge into the mixing chamber (see Figure 2-1 for the potential building configurations). Iron or aluminum flocculent will form in the mixing chamber and the treated water will discharge to the floc settling pond to remove solids and phosphorus. The pond outlet is sited near the north east corner of the floc pond with discharged water traveling through an existing ditch, under 180th Street East using an existing culvert, and back into the unnamed creek just downstream of the weir.



Existing Culvert
Inflow Pipe
Outlet Pipe
Floc Pond
Landscaped Berm
Lift Station, Mixing Chamber, and Alum Feed
Weir
Site Access
Parcel Boundary
Watershed Boundary

Design Contours
10 Foot Contour
2 Foot Contour

N

Feet
75 0 75

Meters
25 0 25

Figure 2-1

PROPOSED SITE PLAN
Buck Lake Feasibility Study
Prior Lake - Spring Lake Watershed District
Scott County, Minnesota

2.2.2.1 Lift station

To develop a cost estimate for the lift station, a conceptual but feasible design was completed. This design consists of an inlet pipe, a 12-foot deep chamber that fills with water from unnamed creek, and 3 submersible pumps. Three 25 horse power pumps placed near the bottom of the chamber are provided to pump a wide range of stream flows with successively higher flows triggering the sequential operation of the pumps. The lift station would be placed on the outside of the treatment facility with pumped water directed into the facility where the alum or ferric chloride would be fed directly into the pipe leading from the lift station. This design minimizes the distance between the chemical feed and delivery to the untreated water and also minimizes the potential for precipitation and clogging of the alum or ferric chloride in the distribution tubing.

2.2.2.2 Mixing Chamber

Inclusion of a mixing chamber as part of the treatment system is recommended. This mixing chamber consists of a concrete structure (6 feet by 6 feet by 6 feet,) an impeller (the mixer), an impeller driver (motor), and a weir outlet. The conceptual design of such a system is provided in Figure 2-2. A mixing chamber provides a controlled rate of flocculent (alum or ferric chloride) and water mixing which in turn produces a consistent floc. At low alum or ferric chloride doses, very small floc are produced call “pin” floc. These floc do not settle well and phosphorus removal rates are typically low (e.g., 30 to 40 percent). In order to meet the TMDL load reduction requirements for Spring Lake, the treatment system at Highway 13 and 180th Street East will need to achieve high phosphorus removal rates and this will require higher alum or ferric chloride doses which will in turn generate large “sweep” floc. Based upon the work by Pilgrim (2002) and Harper (2000), it estimated that alum or ferric doses will need to be approximately 8 mg/L as aluminum (Al) or iron (Fe). To form consistent “sweep” floc and achieve a high phosphorus removal percentage, a mixing chamber and impeller will be necessary.

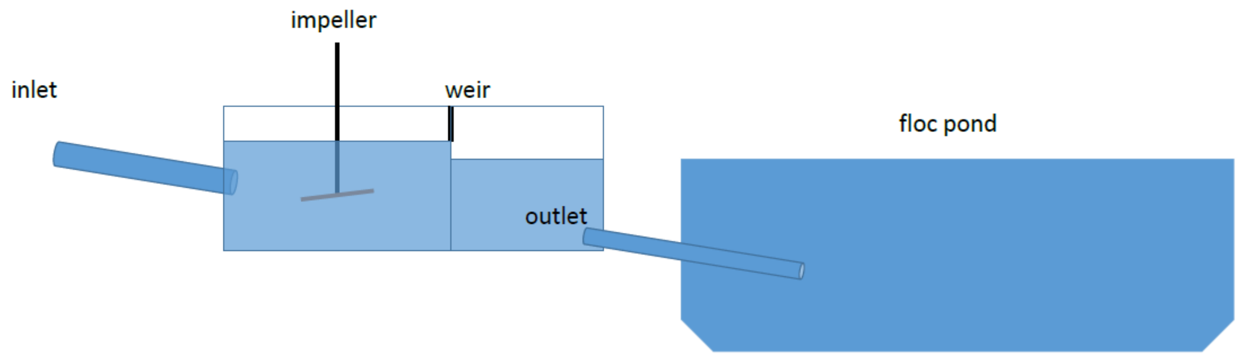


Figure 2-2 Conceptual layout of the mixing chamber

The chamber and mixer were sized to provide a specific mixing power, called Gt, of approximately 2,500 to 4,000. The chamber was sized to provide approximately 20 seconds of mixing time. The impeller specifications were based upon a Philadelphia mixer with a 28 inch turbine blade.

2.2.2.3 Floc Pond and Sludge Disposal

The concept level design for the floc pond is provided in Figure 2-1. The pond has a surface area of 1.7 acres, maximum depth of 11 feet and average depth of 2.7 feet. Assuming a maximum treated flow of 15 cubic feet per second or less, this pond should be capable of capturing all of the alum or iron floc produced by the treatment system. Assuming that sludge accumulated in the pond will need to be removed once the pond is half full, sludge excavation and disposal will need to occur once every 6 to 7 years.

In this feasibility study, it is estimated that equivalent iron chloride (8 mg/L as Fe) and alum (8 mg/L as Al) doses will be capable of achieving 70% phosphorus removal. This is based upon the work by Pilgrim (2002) and Harper (1997). It is recommended, however, that jar tests be conducted with alum an iron chloride before final design.

Assuming that iron chloride and alum have similar phosphorus removal capacities, the primary difference between these flocculants is disposal. It is understood that the Prior Lake Spring Lake Watershed District is currently land applying iron sludge generated at the Ferric Chloride Treatment System at County Ditch 13. Hence, it is presumed that the iron sludge is an acceptable soil amendment. Often it is assumed that alum sludge cannot be land applied because the alum creates a very strong bond with phosphorus and this may limit phosphorus uptake by plants. However, a study published by Illinois Department of Energy and Natural Resources (ENR, 1987), concluded that alum sludge could be used as a soil amendment without reduced crop growth. As a result, it is assumed at this time that alum sludge could be land applied, and hence the cost to dispose of a cubic yard of alum sludge is the same as the cost to dispose of a cubic yard of iron sludge. It is reasonable to assume that the cost to land apply a cubic yard of sludge can be based upon the volumes and estimated cost (of $9.10 per cubic yard) provided by EOR (2010).

Another option for sludge disposal, involving discharge to the Metropolitan Council's sanitary sewer system, was considered for comparison with the land application option. Based on Metropolitan Council's wastewater strength charges and our estimates of pumping and transportation costs, it is estimated that sludge disposal to the sanitary sewer system will cost approximately $20 per cubic yard. Since this alum sludge disposal option is more expensive and inconsistent with the land application option currently used for the Ferric Chloride Treatment System at County Ditch 13, it did not warrant further consideration in the alternatives analysis.

The frequency of sludge clean out and disposal was based upon the expected volume of water treated, alum or ferric chloride use in gallons, and the volume of sludge produced per gallon of flocculent used (see Tables 2-1 and 2-2).

Table 2-1 Treatment flow rates, alum usage, sludge generation and clean-out frequency

Percent of Total Flow Volume Treated[(1)]	Max Treatment Flow (cfs)	Average Flow (cfs)	Gallons of Alum Used Annually [(2)]	Cubic Yards of Sludge Generated Annually [(3)]	Tons Sludge Generated Annually [(4)]	Required Clean Out Frequency (years)
52	5.0	2.9	38,778	1,092	927	10.0
74	10.0	4.1	55,248	1,555	1,320	7.0
84	15.0	4.7	62,586	1,762	1,495	6.2

(1)This is the total volume of flows treated divided by the total volume of flows that discharge at monitoring point 14 (Buck Lake outlet) at Spring Lake.

(2) It is assumed that the treatment facility operates from May 1 through October 31 of each year (213 days).

(3) Experience with the Tanners Lake treatment facility in Oakdale, MN, indicates that 0.76 cubic feet of alum sludge are generated per gallon of alum used.

(4) Assumes alum sluge density of 1.0076 kg/L.

Alum specifications:

Alum Dose (mg/L) as Al	8
Alum density (lbs/gallon)	11.14
% Al in Alum	4.4
Al content of Alum (mg/gallon of alum)	222,497
Floc generated/gallon of alum (cf)	0.76
Dry sludge Production (mg/L) for an 8 mg/L Al dose	46.3

Table 2-2 Treatment flow rates, iron usage, sludge generation and clean-out frequency

Percent of Total Flow Volume Treated[(1)]	Max Treatment Flow (cfs)	Average Flow (cfs)	Gallons of Ferric Chloride Used Annually [(2)]	Cubic Yards of Sludge Generated Annually [(3)]	Tons Sludge Generated Annually [(4)]	Required Clean Out Frequency (years)
52	5	2.9	11,722	1,092	927	10.0
74	10	4.1	16,701	1,555	1,320	7.0
84	15	4.7	18,919	1,762	1,495	6.2

(1)This is the total volume of flows treated divided by the total volume of flows that discharge at monitoring point 14 (Buck Lake outlet) at Spring Lake.

(2) It is assumed that the treatment facility operates from May 1 through October 31 of each year (213 days).

(3) Experience with the Tanners Lake treatment facility in Oakdale, MN, indicates that 0.76 cubic feet of alum sludge are generated per gallon of alum used.

(4) Assumes iron sluge density of 1.0076 kg/L.

Ferric chloride specificaitons:

Iron Dose (mg/L) as Fe	8
Ferric Chloride Liquid density (lbs/gal)	11.75
% Fe in Ferric Chloride	13.8
Fe content of Ferric Chloride (mg/gallon of Ferric)	736,042
Floc generated/gallon of iron (cf)	2.51
Dry sludge Production (mg/L) for 8 mg/L FE dose	42.04

2.2.3 Treatment System Design Basis and Estimated Performance

Treatment system sizing (consisting of pump sizing for the lift station, building size to house the necessary chemical holding tanks, the mixing chamber and impeller size, as well as the pond size) is based upon the maximum stream flow rate treated by the system. Since small storms are more common than large storms, the total volume of storm water treated does not increase linearly with an increase in maximum stream flow rate treated by the system. For example, Figure 2-3 shows that a system designed to treat a maximum of 10 cubic feet per second can treat 74% of the annual steam flow volume (this is based upon flow monitoring conducted from 2011 through 2013). For events with flows of 10 cubic feet per second or less the entire stream flow is treated, while for storms greater than 10 cubic feet per second only 10 cubic feet per second will be treated and the rest will bypass the treatment system. If a system is designed to treat flows as high as 15 cubic feet per second, 84% of the annual steam flow volume will be treated. Conversely, treatment volume will be notably reduced by making a smaller system that treats, for example, a maximum of 5 cubic feet per second or less (see Figure 2-3). A system that treats a maximum of 10 cubic feet per second is optimal but a system that treats 15 cubic feet per second is also feasible (costs are provided below).

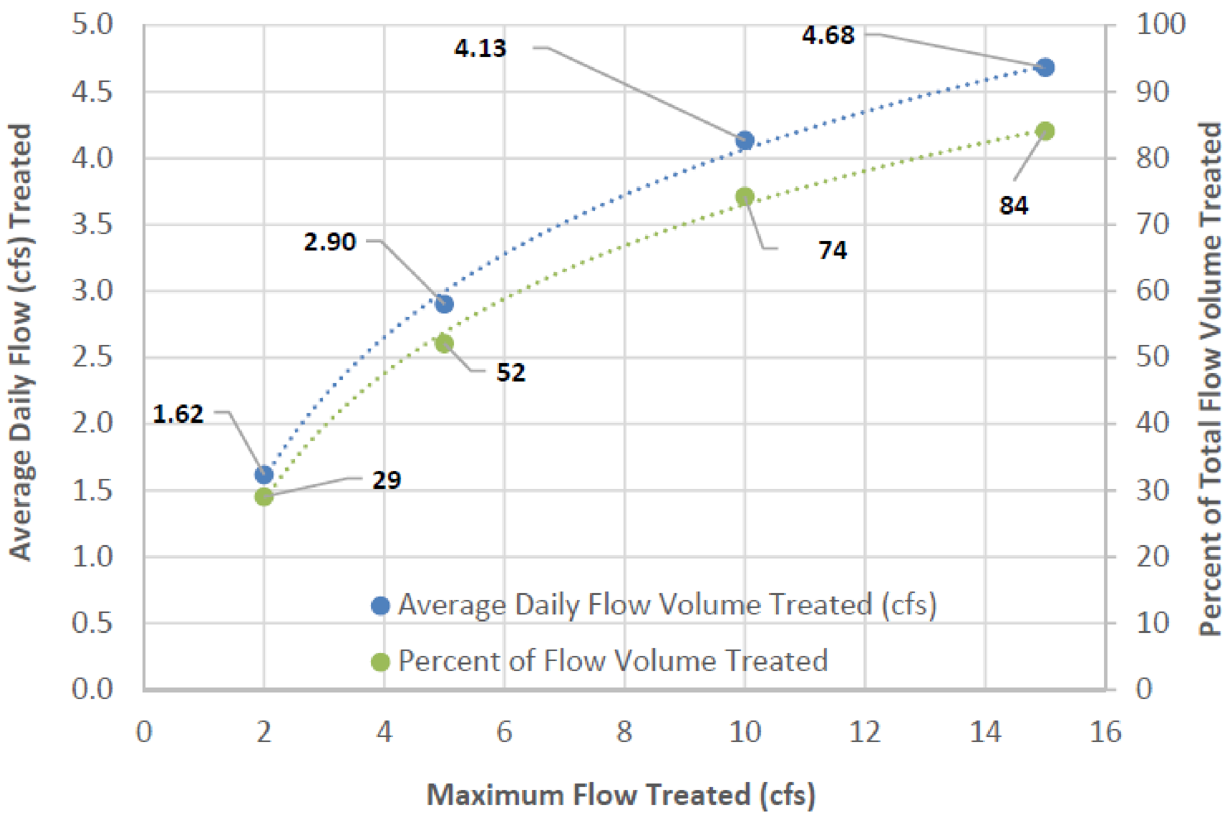


Figure 2-3 Relationship between treatment flow rate and volume/percentage treated

Another aspect of treatment system sizing is phosphorus removal and pond size limitations. The floc pond serves two purposes: (1) it provides for the settling and removal of treated stormwater particles and alum floc, and (2) it provides storage for floc sludge. The pond must be big enough to provide adequate time floc settling. Floc settling rates provided by Pilgrim, 2002, were used to estimate whether floc would have enough time to settle assuming a range of treatment flow rates. Figure 2-4 shows the time required for floc to settle in the 1.7 acre floc pond as well as the hydraulic residence time of the pond (required settling time is simply maximum pond depth divided by the settling rate). For floc to settle, the time that the floc resides in the pond (the hydraulic resident time) must be greater than the time required for the particle to settle to the bottom of the pond. Figure 2-4 shows the relationship between maximum treatment flow rate and floc pond residence time. The figure shows that at maximum flows of 15 cubic feet per second or less, it is expected that floc will be captured by the pond. However, at flow greater than 15 cubic feet per second some floc may pass through the pond. As maximum treatment flow rates are reduced from 15 cubic feet per second there will be greater certainty the floc generated by the treatment system will be captured by the floc pond.

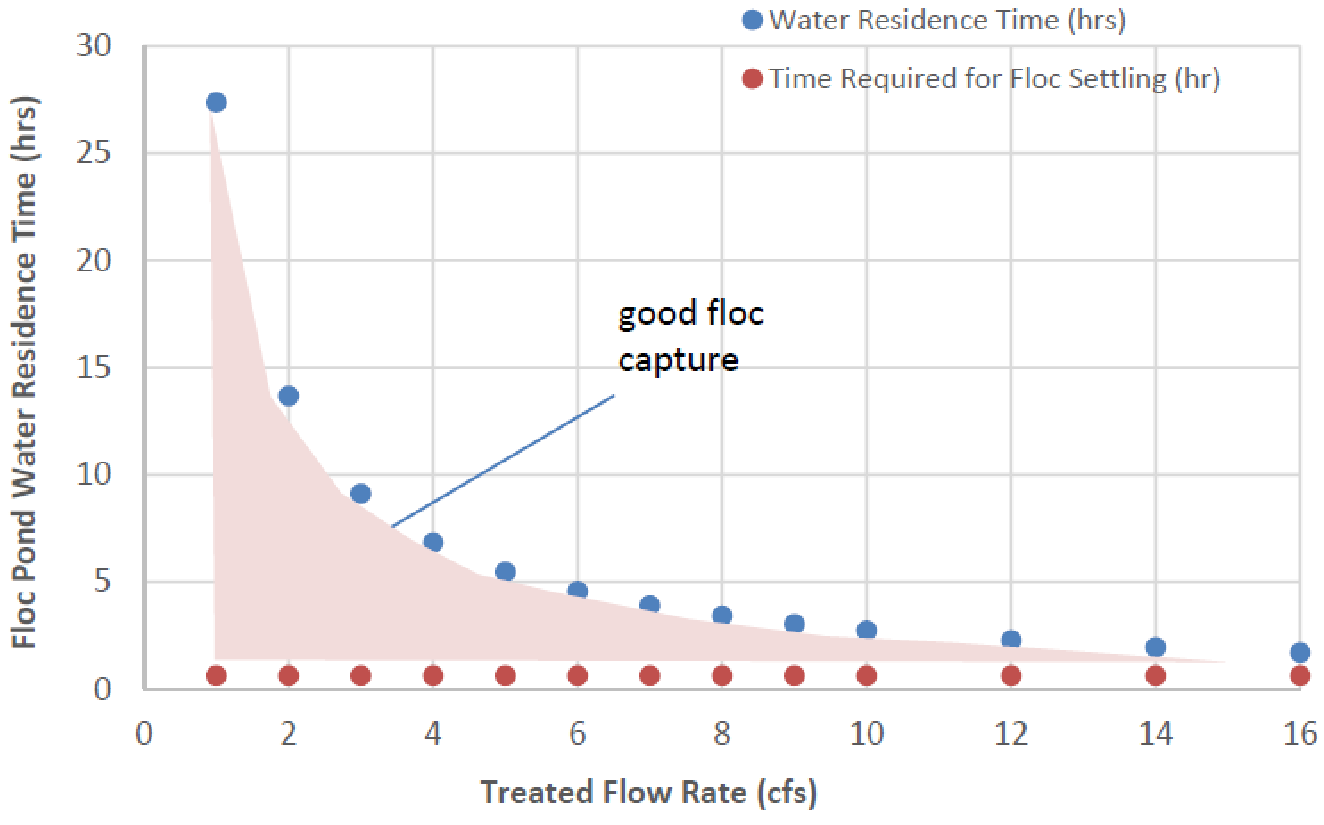


Figure 2-4 **Relationship between floc pond residence time, treated flow rate and time required for floc settling**

Table 2-3 shows the estimated phosphorus load reductions (as %) corresponding to a range of maximum treatment rates. The table shows that the treatment system identified in this study should be capable of reducing phosphorus loads from the unnamed creek by a maximum of approximately 59% at a maximum treatment rate of 15 cubic feet per second. At 15 cubic feet per second, the system would treat 84% of stream flow volume (during the treatment period) and remove approximately 70% of the phosphorus (load reduction = % stream flow treated * % phosphorus removal efficiency).

Table 2-3 Estimated load reduction for a range of maximum treatment rates

Operation from April 1 to October 31 of Year
Number of Treatment Days 213

Flow Treatment Cut Off (cfs)	Average Daily Flow Treated (cfs)	Average Daily Flow (cfs) in unnamed creek	% of Average Daily Flow Treated	Estimated Total Phosporus (mg/L) in Inflows	Estimated Total Phosphorus Out (mg/l)	% Annual Load Reduction
2	1.62	5.57	29	0.21	0.063	20
5	2.90	5.57	52	0.21	0.063	36
10	4.13	5.57	74	0.21	0.063	52
15	4.68	5.57	84	0.21	0.063	59

*Assumed that treatment with alum or ferric chloride willl remove 70 percent of the total phosphorus.

*Estimated TP into the treatment system is the flow-weighted average total phoshporus concentration at monitoring point 14 (Buck Lake outlet).

2.2.4 Engineers Estimate of Probable Cost

Table 2-4 shows the chemical treatment options cost comparison. Detailed cost estimates are provided in Appendix A for four viable options: **A.** alum treatment system treating a maximum flow of 15 cubic feet per second, **B**. alum treatment system treating a maximum flow of 10 cubic feet per second, **C**. ferric chloride treatment system treating a maximum flow rate of 15 cubic feet per second, and **D**. ferric chloride treatment system treating a maximum flow rate of 10 cubic feet per second. The opinion of probable project cost provided in this report is made on the basis of the specific subject site and Barr's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. Conceptual design was completed to the extent needed to develop reasonable cost estimate defined as Class 3. A Class 3 design cost can be expected to have an accuracy of +50%/-25%[3]. The cost opinion is based on project-related information available to Barr at this time and includes a conceptual-level design (the Class 3 design cost provided can be expected to have an accuracy of +50%/-25%) of the project. The opinion of cost may change as more information becomes available and further design is completed. In addition, since we have no control over the cost of labor, materials, equipment, or services furnished by others, or over the contractor's methods of determining prices, or over competitive

[3] The opinion of probable project cost provided in this report is made on the basis of Barr's experience and qualifications and represents our best judgment as experienced and qualified professionals familiar with the project. The opinion of cost may change as more information becomes available and further design is completed. In addition, since we have no control over the cost of labor, materials, equipment, or services furnished by others, or over the contractor's methods of determining prices, or over competitive bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinion of probable project cost prepared by Barr.

bidding or market conditions, Barr cannot and does not guarantee that proposals, bids, or actual costs will not vary from the opinion of probable project cost prepared by Barr.

Table 2-4 Chemical treatment options cost comparison

Option	Description	Total Capital Costs (incl. Eng., Design, Land Acquisition & Permitting)	Annual Operation and Maintenance	Annualized Costs	Estimated Phosphorus Load Reduction (lbs./year)	Annual Cost-Benefit ($/lb. TP removed)
A	15 cfs Alum Treatment	$ 1,500,000	$ 130,000	$ 224,000	793	$ 282
B	10 cfs Alum Treatment	$ 1,380,000	$ 120,000	$ 206,000	700	$ 294
C	15 cfs Ferric Chloride	$ 1,340,000	$ 60,000	$ 144,000	793	$ 182
D	10 cfs Ferric Choride	$ 1,240,000	$ 60,000	$ 137,000	700	$ 196

*Enginering and design includes permitting, wetland mitigation, land acquisition, engineering design and procurement, and construction services (e.g., construction observation).

*Maintenance cost includes electricity, chemical flocculent, and sludge disposal.

*Annualized costs assume a 20 year lifespan and a discount rate of 2.2%.

*Capital and engineering and design costs include a 30% contingency.

The treatment system sized to treat 10 to 15 cubic feet per second is estimated to have a phosphorus removal efficiency of 70%. With the treatment system operating between April 1 and October 31 of each year (213 days each year), total phosphorus load reductions were estimated to be between 52% (option B or D) to 59% (option A or C).

Table 2-5 was developed to compare the strengths, weaknesses, opportunities and threats associated with each of the chemical treatment options based on the estimated phosphorus load reductions and cost-benefit analyses, as well as consideration of the water quality treatment goals. Tables 2-4 and 2-5 show that Option C, a ferric chloride treatment system treating a maximum flow rate of 15 cubic feet per second, is expected to be the most cost-effective option for the chemical treatment alternative. It is recommended that jar testing of various doses of both ferric chloride and alum be conducted before proceeding with any chemical treatment option.

Table 2-5 SWOT (Strength/Weakness/Opportunity/Threat) Analysis

Treatment Option	Strengths	Weaknesses	Opportunities	Threats
A	Optimum treatment capacity; meets water quality goals	Higher cost	Reliable chemical	None identified
B	None identified	Highest cost; won't meet treatment goals	Reliable chemical	None identified
C	Most cost-effective option to meet water quality goals	None identified	Consistent with CD13 treatment	Floc may release phosphorus under anoxic conditions
D	Cheaper chemical	Won't meet treatment goals	Consistent with CD13 treatment	Floc may release phosphorus under anoxic conditions

2.3 Distributed Watershed Treatment Alternative

This alternative involves the development of an optimal combination of the upstream treatment options to meet the revised TMDL goals, as they apply to the Buck Lake tributary watershed.

The estimated cost of in-lake alum treatments for Buck Lake and Fish Lake were developed based on the unit costs and estimated area of anoxia. Expectations for downstream water quality improvement were based on the observed water quality at Sites 14 and 8, for Buck and Fish Lakes, respectively. An 80% nutrient delivery ratio was applied to the water quality improvement expected for Fish Lake, based on indications from the FLUX modeling that Buck Lake was removing approximately 20% of the existing watershed phosphorus load.

The estimated cost of streambank stabilization costs for the downstream portion of the Site 11 channel was developed based on the unit costs and estimated length of erosion. Expectations for downstream water quality improvement were based on the observed water quality at Site 11.

Table 2-6 summarizes the expected costs and benefits of the viable watershed treatment options for the Buck Lake tributary. Subtracting the expected water quality benefit of these three options from the water quality treatment expected for the chemical treatment alternative shows that approximately 660 lbs/yr of TP load reduction would be required from other distributed watershed Best Management Practices (BMPs). Applying the necessary load reduction to all of the developed/cultivated watershed area in the Buck Lake tributary results in a unit area load reduction of approximately 1 lb/acre, which is more than the total monitored load during each of the last three years. As a result, the distributed watershed treatment alternative will not feasibly meet the revised TMDL goals and no additional efforts were made to estimate the costs of implementing other watershed BMPs and/or specifying the locations and types of practices that should be considered.

While outside of the scope of this alternatives analysis for improving the water quality in Spring Lake, it should be noted that the in-lake alum treatments for both Buck Lake and Fish Lake should be further considered for the expected water quality benefits that it will provide to their respective water bodies, alone. The Buck Lake alum treatment, itself, also represents a cost-effective means to improve water quality for Spring Lake, but would not come close to the level required to meet the revised TMDL goals.

Table 2-6 Buck Lake tributary watershed treatment options

Treatment Option	TP Load Reduction (lbs/yr)	Estimated Capital Cost (does not including engineering, design, permitting or contingency costs)
Buck Lake alum treatment	90	$50,000
Fish Lake alum treatment	25	$440,000
Site 11 streambank stabilization	20	$290,000
Total	135	$780,000

3.0 Conclusions and Recommendations

Preliminary data analysis indicated that the DU wetland and the large wetland complex downstream of Pandora Avenue may not be contributing excess phosphorus to the existing load from the Buck Lake tributary, but it does appear that both systems are typically passing the upstream phosphorus load through to Spring Lake with no appreciable treatment. The following conclusions and recommendations can be drawn from the alternative analysis of this feasibility study:

- The do-nothing alternative would result in an additional 800 lbs/yr of TP load continuing to flow downstream and shorten the Spring Lake alum treatment by 3.5 to 6.5 years. This would in turn, significantly increase the probability that there will be more time where the lake water quality is not meeting water quality standards before another in-lake alum treatment would be necessary. Since it is unclear whether future in-lake alum treatments will be subject to the same regulatory oversight that currently exists, the District should be looking for ways to longevity of the in-lake alum treatment wherever possible.

- A ferric chloride treatment system, treating a maximum flow rate of 15 cubic feet per second, is expected to be the most cost-effective option for the chemical treatment alternative. This treatment alternative also possesses the following benefits:

    - It is feasible and can be permitted at Kingdom Hall site at the expense of removing an existing wetland

    - Treatment capacity meets revised TMDL allocations

    - Cost-effective based on life cycle treatment and annual operation and maintenance costs

- Although they will provide some lake water quality improvement allocations for Spring Lake, distributed watershed treatment options cannot be combined to feasibly meet the revised TMDL.

It is recommended that jar testing of various doses of both ferric chloride and alum be conducted before proceeding with any chemical treatment option.

References

Barr Engineering Company (Barr). 2013. Analysis of Phosphorus Sources and Nutrient Dynamics in the Buck Lake Tributary. November 5, 2013 Memorandum. Prepared for the Prior Lake-Spring Lake Watershed District.

Emmons and Olivier Resources (EOR). 2010. Ferric Chloride Treatment System Evaluation. Prepared for the Prior Lake Spring Lake Watershed District.

Emmons and Olivier Resources (EOR). 2014. Analysis of TP and TSS Loads based on 2011-2013 Monitoring Data. February 4, 2014 Memorandum. Prepared for the Prior Lake Spring Lake Watershed District.

ENR. 1997. Wastes from water treatment plants: literature review, results of an Illinois survey and effects of alum sludge application to cropland. Prepared by Illinois State Water Survey Water Quality Section P.O. Box 697 Peoria, IL 61652 Principal Investigators S. D. Lin, and C. D. Green.

Harper, H. H. 1997. Clear Lake stormwater treatment system preliminary design. Environmental Research and Design. Prepared for the City of LaPorte, Indiana.

Minnesota Pollution Control Agency (MPCA). 2013. March 4, 2013 Letter to Michael Kinney, District Administrator regarding Final Reissued NPDES/SDS Permit No. MN00667377, Prior Lk/Spring Lk Ferric Chloride Water Treatment Facility.

Pilgrim, K. M. 2002. Evaluation of the potential benefits and adverse effects of alum treatment to remove phosphorus from lake inflows. Ph.D. Thesis. University of Minnesota.

Wenck Associates (Wenck). 2011. Spring Lake – Upper Prior Lake Nutrient TMDL. Prepared for the Minnesota Pollution Control Agency and Prior Lake-Spring Lake Watershed District.

Appendix A

Detailed Cost Estimates for Chemical Treatment Options

Table A-1. Alternative A. Cost for treating a maxmimum flow rate of 15 cfs using alum.

Item	Unit	Unit Cost	Qty	Cost
Capital Costs				
Land aquisition	AC	$ 25,000	2.8	$ 70,000
Inflow Pipe[1]	LF	$ 30	330	$ 9,900
Pump Station[2]	LS	$ 157,000	1	$ 157,000
Building[3]	LS	$ 244,000	1	$ 244,000
Building Piping[4]	LF	$ 34,000	1	$ 34,000
Building Valves[5]	LS	$ 21,000	1	$ 21,000
Chemical Tanks[6]	EA	$ 8,800	4	$ 35,200
Chemical Pumps[7]	EA	$ 4,000	4	$ 16,000
Mixing Tank/Mixer[8]	LS	$ 30,000	1	$ 30,000
Electrical and control systems[9]	LS	$ 65,000	1	$ 65,000
Pond Inlet piping[10]	LF	$ 30	70	$ 2,100
Weir[11]	LS	$ 5,000	1	$ 5,000
Pond excavation and grading[12]	CY	$ 15	7300	$ 109,500
Pond outlet piping and structure[13]	LS	$ 7,500	1	$ 7,500
Civil/site work (grading, erosion control, rest.)[14]	LS	$ 41,000	1	$ 41,000
Upgrade existing culvert[15]	LS	$ 12,000	1	$ 12,000
Capital Cost Subtotal				$ 860,000
Capital Cost Contingency	30%			$ 260,000
Capital Cost Total				***$ 1,120,000***
Professional Services				
Permitting/Wetland Mitigation	LS	$120,000	1	$ 120,000
Design and procurement	10%	$ 112,000	1	$ 112,000
Construction services	5%	$ 56,000	1	$ 56,000
Professional Services Subtotal				$ 290,000
Professional Services Contingency	30%			$ 87,000
Professional Services Total				***$ 380,000***
Annual Operation and Maintenance				
Energy costs (for pump station)[16]	yr	$ 17,100.00	1	$ 17,100
Maintenance (sludge desposal)[17]	LS/yr	$ 16,031	1	$ 16,031
Alum cost	gal	$ 1.6	62,586	$ 99,825
Operation and Maintenance Total				$ 130,000
Present Value Factor[18]	16.04			
Present Value of Operation and Maintenance Cost				$ 2,090,000
Total Present Value				***$ 3,590,000***

Table 4. Continued..

Notes:

1. 24" CPEP, 4 to 12' deep
2. Engineer's Estimate - assume 3-25HP pumps, 12'x8' box culvert, 12' deep station, and installation of pump station
3. 35'X71' BLDG. Includes mobalization, excavation, foundation (strip footings and walls), slab, tank foundations, CMU walls, roof, and mechanical
4. 12-inch and 16-inch PVC schedule 40
5. 12-inch check and gate valves
6. Engineer's Estimate- assume 3,850 gallon tanks with fittings.
7. Engineer's Estimate
8. Engineer's Estimate- Includes mixer and 6'x6'x8' concrete tank
9. Engineer's Estimate
10. 24" CPEP, 4 to 12' deep
11. concrete - 20'x6'x8", $500/CY
12. 11400 cut, 4100 fill, 7300 CY hauled offsite
13. 70 LF of 24" CPEP, 60" MH with grate
14. 2.5 acres - 1/2 open water. $3/SY grading= $36,000, mulch and seed for 1.25 acres = $5,000
15. 120' of 48" CPEP @$75/LF = $9000, road demo, repair, traffic control = $3,000
16. Assumes 6 months of operation per year.
17. Disposal cost of $9.1/CY based upon the existing ferric chloride treatment system sludge maintenance costs
18. Time period: 20 years, discount rate: 2.2%

http://www.pgcalc.com/support/historical-irs-discount-rates.htm Discount rate= 2.2 for April 2014

Table A-2. Alternative B. Cost for treating a maxmimum flow rate of 10 cfs using alum.

Item	Unit	Unit Cost	Qty	Cost
Capital Costs				
Land aquisition	AC	$ 25,000	2.8	$ 70,000
Inflow Pipe[1]	LF	$ 30	330	$ 9,900
Pump Station[2]	LS	$ 115,000	1	$ 115,000
Building[3]	LS	$ 244,000	1	$ 244,000
Building Piping[4]	LF	$ 31,000	1	$ 31,000
Building Valves[5]	LS	$ 14,300	1	$ 14,300
Chemical Tanks[6]	EA	$ 8,800	4	$ 35,200
Chemical Pumps[7]	EA	$ 4,000	4	$ 16,000
Mixing Tank/Mixer[8]	LS	$ 21,000	1	$ 21,000
Electrical and control systems[9]	LS	$ 59,000	1	$ 59,000
Pond Inlet piping[10]	LF	$ 30	70	$ 2,100
Weir[11]	LS	$ 5,000	1	$ 5,000
Pond excavation and grading[12]	CY	$ 15	7300	$ 109,500
Pond outlet piping and structure[13]	LS	$ 7,500	1	$ 7,500
Civil/site work (grading, erosion control, rest.)[14]	LS	$ 41,000	1	$ 41,000
Upgrade existing culvert[15]	LS	$ 12,000	1	$ 12,000
Capital Cost Subtotal				$ 790,000
Capital Cost Contingency	30%			$ 240,000
Capital Cost Total				***$ 1,030,000***
Professional Services				
Permitting/Wetland Mitigation	LS	$120,000	1	$ 120,000
Design and procurement	10%	$ 103,000	1	$ 103,000
Construction services	5%	$ 51,500	1	$ 51,500
Professional Services Subtotal				$ 270,000
Professional Services Contingency	30%			$ 81,000
Professional Services Total				***$ 350,000***
Annual Operation and Maintenance				
Energy costs (for pump station)[16]	yr	$ 17,100.00	1	$ 17,100
Maintenance (sludge desposal)[17]	LS/yr	$ 14,152	1	$ 14,152
Alum cost	gal	$ 1.60	55,248	$ 88,120
Operation and Maintenance Total				$ 120,000
Present Value Factor[18]	16.04			
Present Value of Operation and Maintenance Cost				$ 1,920,000
Total Present Value				***$ 3,300,000***

Table 5. Continued..

Notes:

1. 24" CPEP, 4 to 12' deep
2. Engineer's Estimate - assume 3-25HP pumps, 12'x8' box culvert, 12' deep station, and installation of
3. 35'X71' BLDG. Includes mobalization, excavation, foundation (strip footings and walls), slab, tank
4. 12-inch and 16-inch PVC schedule 40
5. 12-inch check and gate valves
6. Engineer's Estimate- assume 3,850 gallon tanks with fittings.
7. Engineer's Estimate
8. Engineer's Estimate- Includes mixer and 6'x6'x8' concrete tank
9. Engineer's Estimate
10. 24" CPEP, 4 to 12' deep
11. concrete - 20'x6'x8", $500/CY
12. 11400 cut, 4100 fill, 7300 CY hauled offsite
13. 70 LF of 24" CPEP, 60" MH with grate
14. 2.5 acres - 1/2 open water. $3/SY grading= $36,000, mulch and seed for 1.25 acres = $5,000
15. 120' of 48" CPEP @$75/LF = $9000, road demo, repair, traffic control = $3,000
16. Assumes 6 months of operation per year.
17. Disposal cost of $9.1/CY based upon the existing ferric chloride treatment system sludge maintenance costs
18. Time period: 20 years, discount rate: 2.2%

http://www.pgcalc.com/support/historical-irs-discount-rates.htm Discount rate= 2.2 for April 2014

Table A-3. Alternative C. Cost for treating a maxmimum flow rate of 15 cfs using ferric chloride.

Item	Unit	Unit Cost	Qty	Cost
Capital Costs				
Land aquisition	AC	$ 25,000	2.8	$ 70,000
Inflow Pipe[1]	LF	$ 30	330	$ 9,900
Pump Station[2]	LS	$ 157,000	1	$ 157,000
Building[3]	LS	$ 183,000	1	$ 183,000
Building Piping[4]	LF	$ 19,000	1	$ 19,000
Building Valves[5]	LS	$ 21,000	1	$ 21,000
Chemical Tanks6	EA	$ 9,000	2	$ 18,000
Chemical Pumps[7]	EA	$ 4,000	2	$ 8,000
Mixing Tank/Mixer[8]	LS	$ 30,000	1	$ 30,000
Electrical and control systems[9]	LS	$ 65,000	1	$ 65,000
Pond Inlet piping[10]	LF	$ 30	70	$ 2,100
Weir[11]	LS	$ 5,000	1	$ 5,000
Pond excavation and grading[12]	CY	$ 15	7300	$ 109,500
Pond outlet piping and structure[13]	LS	$ 7,500	1	$ 7,500
Civil/site work (grading, erosion control, rest.)[14]	LS	$ 41,000	1	$ 41,000
Upgrade existing culvert[15]	LS	$ 12,000	1	$ 12,000
Capital Cost Subtotal				$ 760,000
Capital Cost Contingency	30%			$ 230,000
Capital Cost Total				***$ 990,000***
Professional Services				
Permitting/Wetland Mitigation	LS	$120,000	1	$ 120,000
Design and procurement	10%	$ 99,000	1	$ 99,000
Construction services	5%	$ 49,500	1	$ 49,500
Professional Services Subtotal				$ 270,000
Professional Services Contingency	30%			$ 81,000
Professional Services Total				***$ 350,000***
Annual Operation and Maintenance				
Energy costs (for pump station)[16]	yr	$ 17,100.00	1	$ 17,100
Maintenance (sludge desposal)[17]	LS/yr	$ 13,608	1	$ 13,608
Alum cost	gal	$ 1.55	18,919	$ 29,372
Operation and Maintenance Total				$ 60,000
Present Value Factor[18]	16.04			
Present Value of Operation and Maintenance Cost				$ 960,000
Total Present Value				***$ 2,300,000***

Table 6. Continued..

Notes:

1. 24" CPEP, 4 to 12' deep
2. Engineer's Estimate - assume 3-25HP pumps, 12'x8' box culvert, 12' deep station, and installation of
3. 35'X41' BLDG. Includes mobalization, excavation, foundation (strip footings and walls), slab, tank
4. 12-inch and 16-inch PVC schedule 40
5. 12-inch check and gate valves
6. Engineer's Estimate- assume 3,850 gallon tanks with fittings.
7. Engineer's Estimate
8. Engineer's Estimate- Includes mixer and 6'x6'x8' concrete tank
9. Engineer's Estimate
10. 24" CPEP, 4 to 12' deep
11. concrete - 20'x6'x8", $500/CY
12. 11400 cut, 4100 fill, 7300 CY hauled offsite
13. 70 LF of 24" CPEP, 60" MH with grate
14. 2.5 acres - 1/2 open water. $3/SY grading= $36,000, mulch and seed for 1.25 acres = $5,000
15. 120' of 48" CPEP @$75/LF = $9000, road demo, repair, traffic control = $3,000
16. Assumes 6 months of operation per year.
17. Disposal cost of $9.1/CY based upon the existing ferric chloride treatment system sludge maintenance costs
18. Time period: 20 years, discount rate: 2.2%

http://www.pgcalc.com/support/historical-irs-discount-rates.htm Discount rate= 2.2 for April 2014

Table A-4. Alternative D. Cost for treating a maxmimum flow rate of 10 cfs using ferric chloride.

Item	Unit	Unit Cost	Qty	Cost
Capital Costs				
Land aquisition	AC	$ 25,000	2.8	$ 70,000
Inflow Pipe[1]	LF	$ 30	330	$ 9,900
Pump Station[2]	LS	$ 115,000	1	$ 115,000
Building[3]	LS	$ 183,000	1	$ 183,000
Building Piping[4]	LF	$ 16,000	1	$ 16,000
Building Valves[5]	LS	$ 14,000	1	$ 14,000
Chemical Tanks6	EA	$ 8,800	2	$ 17,600
Chemical Pumps[7]	EA	$ 4,000	2	$ 8,000
Mixing Tank/Mixer[8]	LS	$ 21,000	1	$ 21,000
Electrical and control systems[9]	LS	$ 59,000	1	$ 59,000
Pond Inlet piping[10]	LF	$ 30	70	$ 2,100
Weir[11]	LS	$ 5,000	1	$ 5,000
Pond excavation and grading[12]	CY	$ 15	7300	$ 109,500
Pond outlet piping and structure[13]	LS	$ 7,500	1	$ 7,500
Civil/site work (grading, erosion control, rest.)[14]	LS	$ 41,000	1	$ 41,000
Upgrade existing culvert[15]	LS	$ 12,000	1	$ 12,000
Capital Cost Subtotal				$ 690,000
Capital Cost Contingency	30%			$ 210,000
Capital Cost Total				**$ 900,000**
Professional Services				
Permitting/Wetland Mitigation	LS	$120,000	1	$ 120,000
Design and procurement	10%	$ 90,000	1	$ 90,000
Construction services	5%	$ 45,000	1	$ 45,000
Professional Services Subtotal				$ 260,000
Professional Services Contingency	30%			$ 78,000
Professional Services Total				**$ 340,000**
Annual Operation and Maintenance				
Energy costs (for pump station)[16]	yr	$ 17,100.00	1	$ 17,100
Maintenance (sludge desposal)[17]	LS/yr	$ 14,152	1	$ 14,152
Ferric chloride	gal	$ 1.55	16,701	$ 25,928
Operation and Maintenance Cost Subtotal				$ 60,000
Present Value Factor[18]	16.04			
Present Value of Operation and Maintenance Cost				$ 960,000
Total Present Value				**$ 2,200,000**

Table 7. Continued..

Notes:

1. 24" CPEP, 4 to 12' deep
2. Engineer's Estimate - assume 3-25HP pumps, 12'x8' box culvert, 12' deep station, and installation of
3. 35'X41' BLDG. Includes mobalization, excavation, foundation (strip footings and walls), slab, tank
4. 12-inch and 16-inch PVC schedule 40
5. 12-inch check and gate valves
6. Engineer's Estimate- assume 3,850 gallon tanks with fittings.
7. Engineer's Estimate
8. Engineer's Estimate- Includes mixer and 6'x6'x8' concrete tank
9. Engineer's Estimate
10. 24" CPEP, 4 to 12' deep
11. concrete - 20'x6'x8", $500/CY
12. 11400 cut, 4100 fill, 7300 CY hauled offsite
13. 70 LF of 24" CPEP, 60" MH with grate
14. 2.5 acres - 1/2 open water. $3/SY grading= $36,000, mulch and seed for 1.25 acres = $5,000
15. 120' of 48" CPEP @$75/LF = $9000, road demo, repair, traffic control = $3,000
16. Assumes 6 months of operation per year.
17. Disposal cost of $9.1/CY based upon the existing ferric chloride treatment system sludge maintenance costs
18. Time period: 20 years, discount rate: 2.2%
http://www.pgcalc.com/support/historical-irs-discount-rates.htm Discount rate= 2.2 for April 2014

Appendix B

Analysis of Phosphorus Sources and Nutrient Dynamics of in the Buck Lake Tributary. November 5, 2013 Memorandum from Barr Engineering Company

Memorandum

To: Prior Lake-Spring Lake Watershed District (District)
From: Greg Wilson
Subject: Analysis of Phosphorus Sources and Nutrient Dynamics in the Buck Lake Tributary
Date: November 5, 2013
Project: Task 0, Buck Lake Feasibility Study—23701029.00GJW

For this initial task of the Buck Lake Feasibility Study, Barr worked with the District to determine whether nutrient dynamics within the Buck Lake tributary to Spring Lake would allow for the best treatment at the Kingdom Hall site and/or whether site constraints would affect the feasibility of the chemical treatment system under consideration.

Due to the original project schedule, Barr was concerned that the Ducks Unlimited (DU) wetland monitoring may not extend into the time of the year where sediment phosphorus release would be detected based on the current expectations for the monitoring program. In addition, the increasing trend (June through August) in phosphorus concentrations observed in the Pandora Avenue monitoring data during the growing season indicated that it was possible that sediment phosphorus release from Buck Lake may be another source that should be investigated, in more detail. As a result, the task of monitoring the DU wetland was extended through the growing season. For this task, Barr also coordinated the development of a monitoring plan with District staff that was intended to evaluate whether the DU wetland, Buck Lake and any of the other upstream wetlands would function as a source, sink or pass-through of phosphorus during the growing season.

This memorandum is intended to summarize past monitoring and analysis, the results of the 2013 monitoring in the Buck Lake tributary and provide considerations for treatment options and recommendations for the development of the remainder of the feasibility study.

Past monitoring and analysis

Both synoptic and continuous water quality monitoring has occurred in some form or another in the Buck Lake tributary system since 2009. Figure 1 shows the Buck Lake tributary monitoring sites.

Deployment of continuous dissolved oxygen (DO) equipment at Site 14 during 2009 indicated that DO was never above 5 mg/L and the minimum measurements were also lower than any other site. Synoptic DO measurements revealed low DO during several summer events at Sites 10, 12, 14 and 15.

During 2010, Site 14 experienced low DO from May 19 through September 23rd. Low DO was also observed at Site 16, but at levels that were typically a little higher than Site 14. Dissolved oxygen measurements at Site 11 were higher than 5 mg/L throughout the period of record in 2010.

The 2009 and 2010 data indicated that some of the wetland complexes in the Buck Lake tributary switch from filtering to releasing nutrients during the course of the year. Most wetlands have fluctuating water levels or drawdowns for at least part of the year. When the water is oxygenated, iron in the wetland soil bonds with phosphorus and forms an insoluble complex. When water in the wetland becomes stagnant, the system becomes anaerobic due to the increased use of oxygen by microbial organisms, and ferric iron is chemically reduced and the iron complex releases its phosphorus. If a wetland is stagnant for a week or more, the soil can release soluble phosphorus through its own chemical activity, that is, without any new influx of phosphorus from the watershed.

The 2011 through 2012 flow and water quality monitoring data were used to estimate annual total phosphorus loadings at Site 8 (127 lbs/yr), Site 11 (1,076 lbs/yr) and Site 14 (2,093 lbs/yr). As a result, it is expected that a significant portion of the Buck Lake tributary phosphorus load originates within the Buck Lake and Concord subwatersheds (or the subwatershed areas upstream of Site 14 and downstream of Sites 8 and 11).

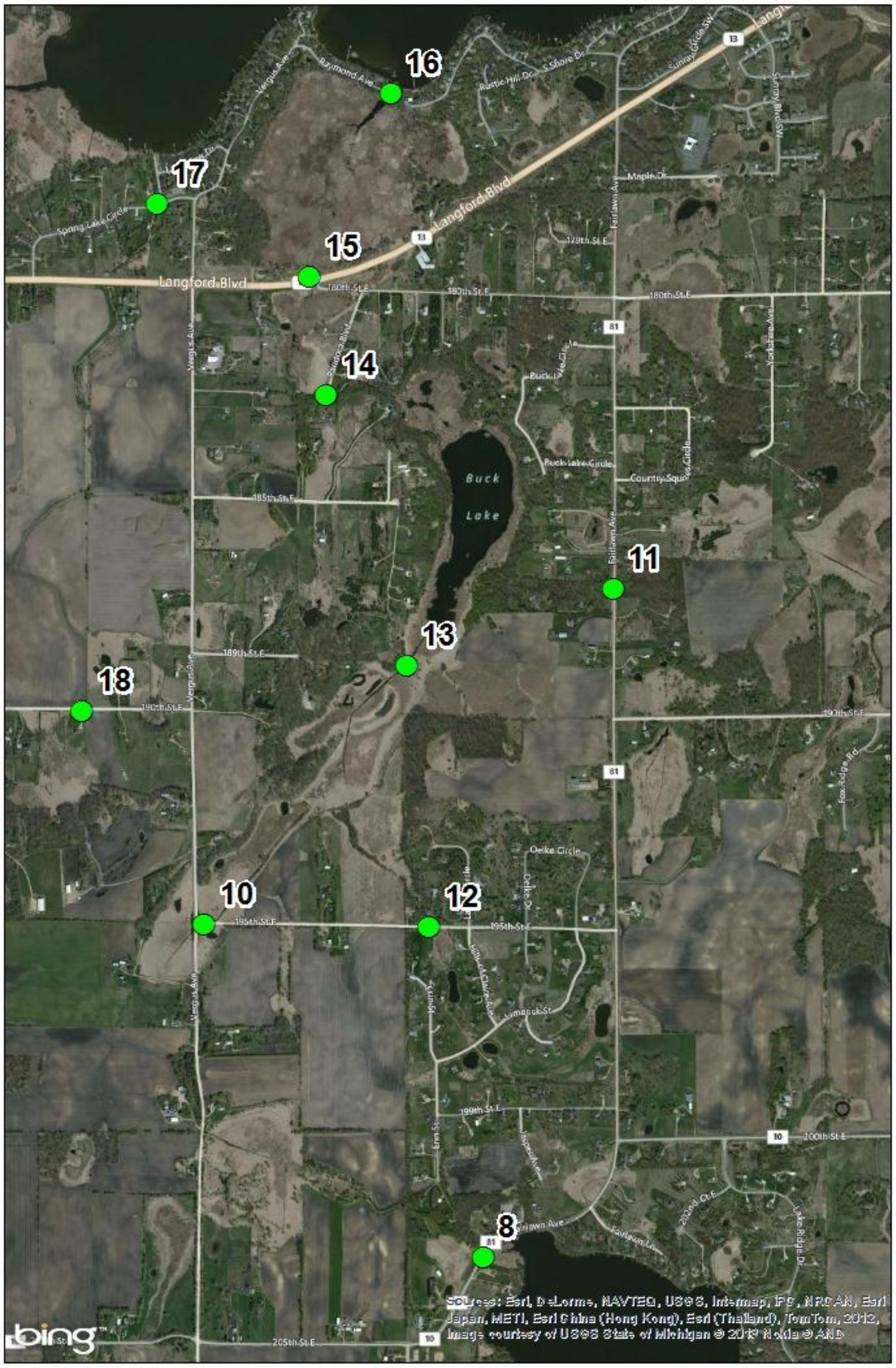


Figure 1: Buck Lake Tributary Monitoring Sites

2013 monitoring and analysis

All of the monitoring sites shown in Figure 1 represent stream channel monitoring sites. More extensive monitoring was conducted at most of these sites in 2013, along with a detailed lake water quality sampling event that occurred on September 5, 2013 at Buck Lake (which had not been monitored in the past). The Buck Lake monitoring event coincided with a low flow condition with low dissolved oxygen in the streamflow and no oxygen in the bottom 3.5 feet of Buck Lake. A review of all of the available continuous dissolved oxygen (DO) data shows that Site 13 has the highest frequency of anoxic conditions, with 86% of the readings below 1 mg/L during the 2013 growing season, followed by Site 14 (69%) and Site 16 (57%). The continuous DO data from Site 11 shows that the flow at this site is well oxygenated and would not be subject to the type of sediment phosphorus release that is described in the previous section. Grab sampling at the remaining sites shown in Figure 1 indicate that dissolved oxygen is typically present at concentrations greater than 1 mg/L.

Figure 2 shows how the total phosphorus observations at each site varied during 2013 in relation to flow. The data indicate that snowmelt or spring runoff is a significant portion of the annual phosphorus load to Spring Lake from the Buck Lake tributary. A comparison of the total phosphorus concentrations at Sites 14 and 16 generally show close agreement which indicates that the Duck Unlimited and upstream wetland complexes (between Pandora Avenue and Spring Lake) are not a significant source or sink of phosphorus during the course of the year. Higher phosphorus concentrations during the summer at Sites 14 and 16 typically correspond with low flow, which indicates that sediment phosphorus release from wetland soils could represent a significant source of phosphorus. Higher flow at Site 11 tends to correspond with higher phosphorus, indicating that streambank erosion may be a significant source, although Site 11 has several smaller wetlands in the headwater watershed area that could have accounted for the higher concentration in early July.

Phosphorus observations from the September 5th Buck Lake monitoring event showed that the surface water concentration corresponded with what is shown for Site 14 (in Figure 2) at the same time that the anoxic bottom water phosphorus concentration was 0.32 mg/L. As previously discussed, the bottom 3.5 feet of Buck Lake was anoxic and the weak thermal stratification of the lake indicates that sediment phosphorus release from Buck Lake would also represent a significant source of phosphorus to Spring Lake during the summer.

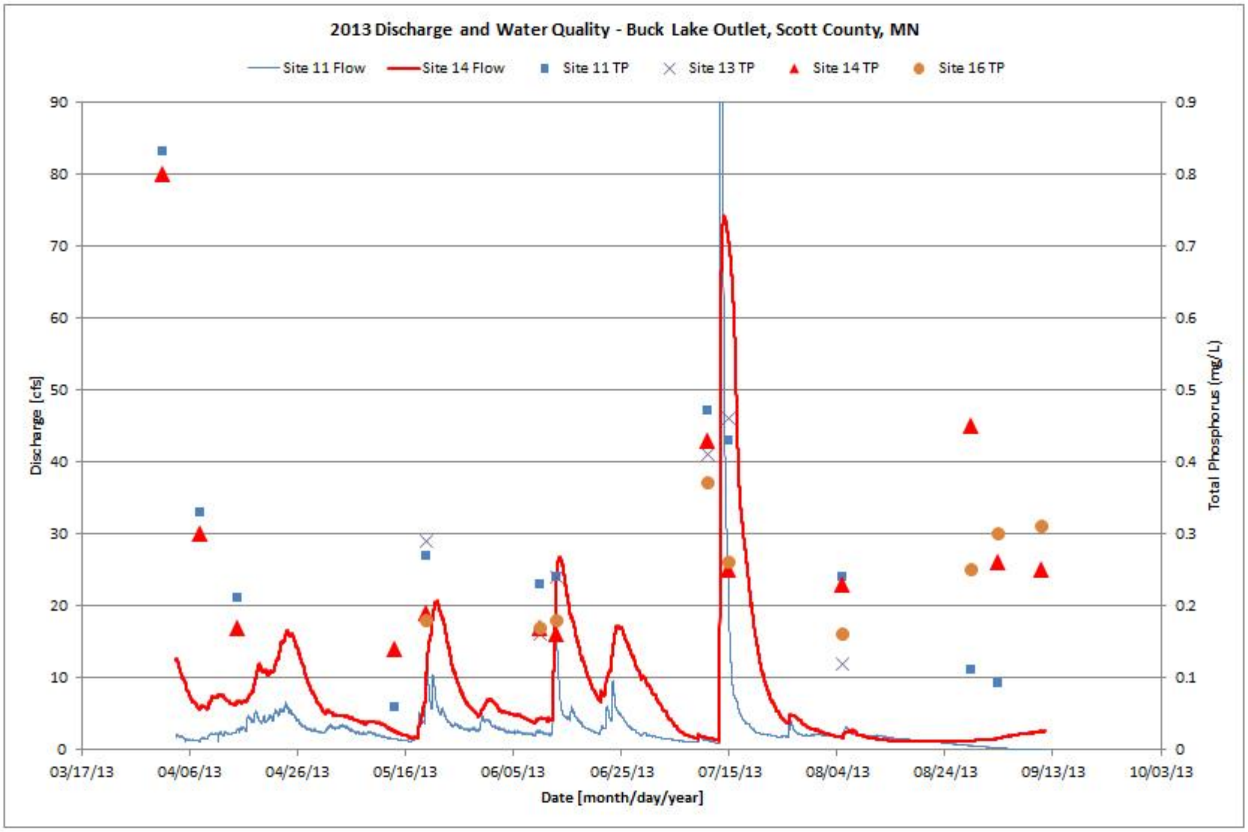


Figure 2: Buck Lake Tributary 2013 Flow and Water Quality Monitoring

Recommendations for final development of the feasibility study

Our analysis of all of the available data collected to-date indicates that the DU wetland and the large wetland complex downstream of Pandora Avenue may not be contributing excess phosphorus to the existing load from the Buck Lake tributary, but it does appear that both systems are typically passing the upstream phosphorus load through to Spring Lake with no appreciable treatment. It is expected that the footprint of the chemical treatment system that is being considered for the Kingdom Hall site can be accommodated there, but concerns about the construction and ongoing operation/maintenance costs, permitting and feasibility remain. In addition, our analysis of the available monitoring and GIS data, along with a review of the aerial photography, indicate that the following options for controlling phosphorus export and sediment release from the upstream watershed should also be considered (both alone and in combination) and compared with the chemical treatment system in the final feasibility study of the Buck Lake tributary:

- In-lake alum treatment of Buck Lake
- Installation of features to restore re-aeration within the channels tributary to, and downstream of, Buck Lake
- Stabilization of streambank erosion within the Site 11 tributary area
- Targeted (field-scale) agricultural Best Management Practices to address field erosion upstream of Buck Lake (see example area in Figure 3) and nutrient management planning to address high runoff concentrations in the spring

Figure 3: Example Field Erosion Area in Buck Lake Tributary