



## Long Lake Stormwater Retrofit Analysis

*Prepared by:*

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## Executive Summary

Long Lake is located within Bradford Township of Isanti County, Minnesota. This study provides recommendations for cost effectively improving treatment of stormwater from areas draining directly to Long Lake. This report identifies potential projects, ranks projects by cost effectiveness at removing phosphorus and begins project planning. It includes project concepts and relative cost estimates for project selection. Site-specific planning, designs and refined cost estimates should be done after committed partnerships for project installation are in place.

Long Lake, 387 acres, is one of Isanti County's most sought-after lakes for recreation such as boating, swimming and fishing. With a maximum depth of 15 ft, Long Lake is categorized a shallow water lake, thus follows Minnesota Clean Water Goals for shallow lakes set by the Minnesota Pollution Control Agency (MPCA). In 2015 Long Lake was added to the Minnesota impaired waters list for having high nutrients. The listing triggered the completion of a Total Maximum Daily Load Study (TMDL). TMDL's are studies that quantify the Total Phosphorus (TP) reduction necessary to make the lake healthy again.

The land area draining to the lake (watershed) is a total of 2089 acres. The majority of the shore around Long Lake is developed with medium-density and low-density residential land use, both seasonal and year-round. Much of the landscape directly draining to Long Lake is very flat and low in elevation with several wetland complexes that act as natural filters for stormwater. Long Lake has three major inlets. One from the north end of the lake, one from the west and one from the south. The outlet of the lake is located on the south east section of the lake. The continuously flowing outlet meanders for 2.6 miles before joining the Rum River.

To better understand stream and lake water quality trends, volunteers from the lake improvement district (LID), in partnership with the Isanti SWCD, annually monitor total phosphorus, chlorophyll, suspended solids, water clarity and other parameters. The LID is driven to understand the lake's water quality relationship with the goal of protecting and enhancing the resource. Furthermore, the LID dedicates funding annually for their landowner-driven lakeshore restoration program.

This stormwater analysis focuses on "stormwater retrofitting" and ranking projects based on cost effectiveness for reducing nutrients flowing into the lake. Stormwater retrofitting refers to adding storm water treatment to an already developed area. This process is investigative and creative. Stormwater retrofitting success is sometimes improperly judged by the number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this analysis we estimated both costs and pollutant reductions and used them to estimate cost effectiveness of each possible project.

The watershed was delineated using available digital mapping information and divided into small catchments to help modeling and area prioritization. For each catchment, modeling of stormwater runoff volume and pollutants was completed using Wisconsin's NRCS erosion calculator and the

WinSLAMM software. Current and existing conditions were modeled, including existing stormwater treatment practices.

Potential stormwater retrofits identified during this analysis were then modeled to estimate reductions in total phosphorus, and total suspended solids. Finally, cost estimates were developed for each retrofit project, including 30 years of operations and maintenance. Projects were ranked by cost effectiveness with respect to their reduction of total phosphorus.

A variety of storm water retrofit approaches were identified. They included:

- Vegetative swales
- Rain Gardens
- Permanent vegetation
- Shoreline restorations

If all these practices were installed, significant pollution reduction could be accomplished. However, funding limitations and landowner interest makes this unlikely. Instead, it is recommended that projects are installed in order of cost effectiveness. Other factors, including a project's educational value/visibility, construction timing, total cost, or non-target pollutant reduction also affect project installation decisions and will need to be weighed by resource managers when selecting projects to pursue.

The intent is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property.

## About this Document:

This document presents the findings of Long Lake's watershed study. Stormwater Retrofit Analysis is a watershed management tool to help prioritize stormwater retrofit projects by performance and cost-effectiveness. This process helps maximize the value of each dollar spent.

### Urban/Residential Catchments:

This section covers land adjacent to and directly draining to the lake. These areas are largely medium and low-density residential. Field investigation along with computer analysis were completed to identify areas near the lake that had the highest potential of contributing sediment and nutrients to Long Lake. Project areas were identified and computer modeling was completed to understand the effectiveness of specific water quality projects.

### Shoreline Analysis:

This section covers the entire shoreline surrounding Long Lake. A boat survey along with computer analysis were completed to identify areas of the shoreline that had the highest potential of contributing sediment and nutrients. Project areas were identified and computer modeling was completed to understand the effectiveness of specific water quality projects.

### Retrofit Ranking:

This section ranks stormwater retrofit projects across all selected catchments to create a prioritized project list. The list is sorted by cost per pound of total phosphorus removed for each project. The final cost per pound treatment value includes installation and maintenance costs.

There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Other considerations for prioritizing installation may include:

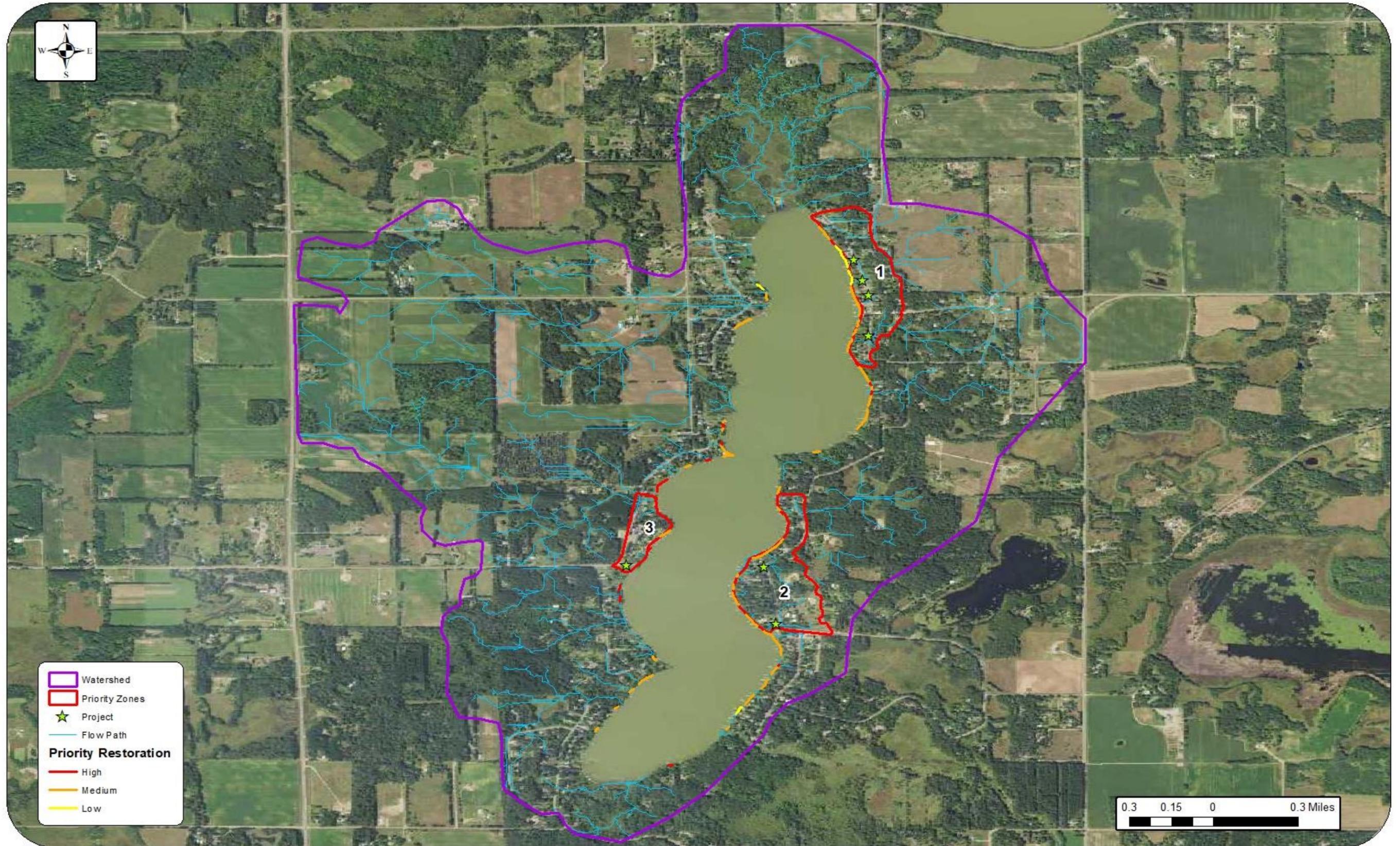
- Non-target pollutant reductions
- Timing projects to occur with other road or utility work
- Project visibility
- Availability of funding
- Total project costs
- Educational value
- Landowner willingness

## Project Ranking

The cost per pound of phosphorus treated was calculated for potential retrofit projects and projects were ranked by this cost-effectiveness measure. Local officials may wish to revise the recommended project list based on water quality goals, finances, public opinion and feasibility.

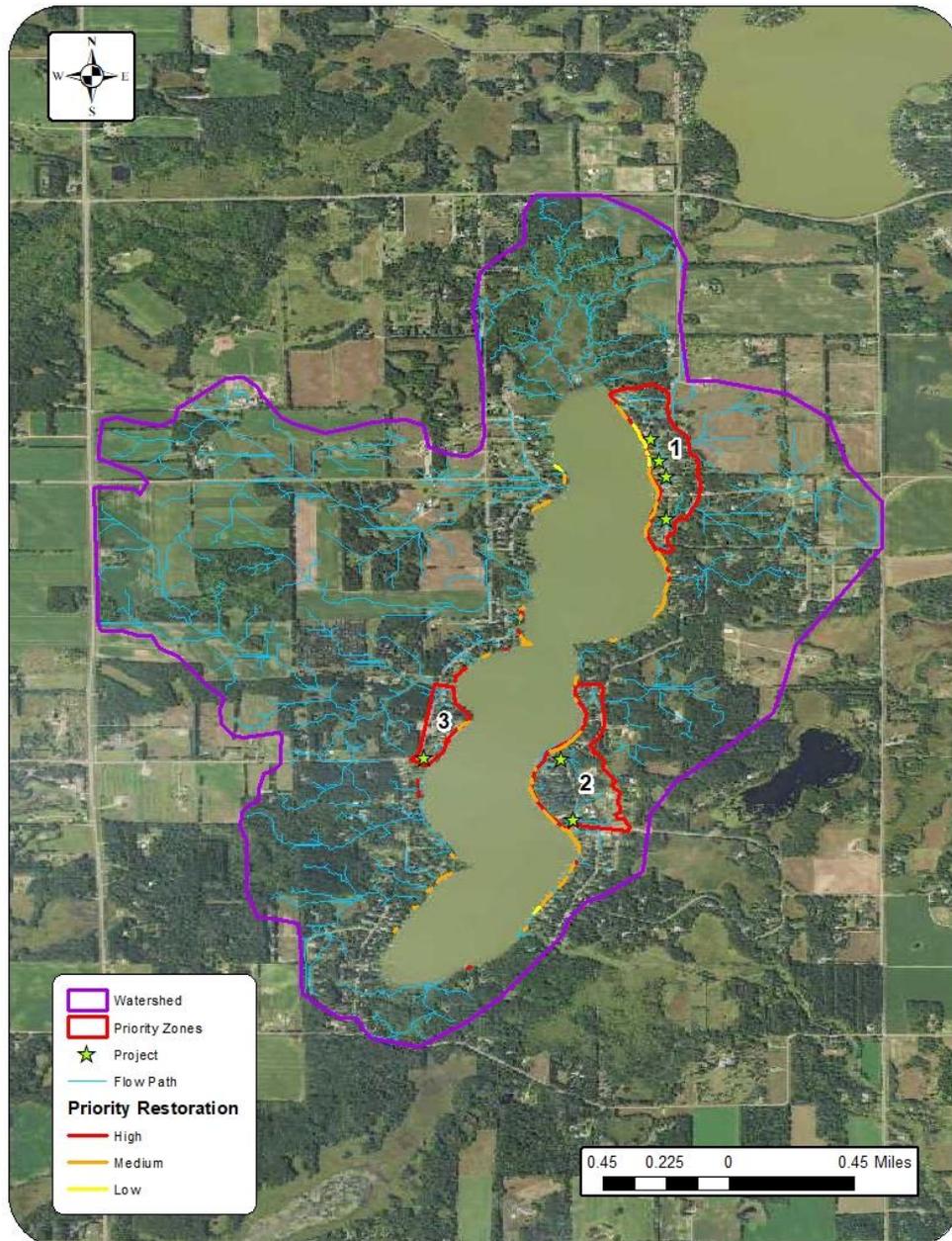
Summary of all stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosphorus (TP) reduction.

Project Rank	Priority Catchment ID	Retrofit Type (refer to catchment profile pages for additional detail)	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Total Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS (30-year)	Estimated cost/ lb-TP (30-year)	Notes/Description
1	Nearshore All	Vegetative Swale: 5 acre drainage	1.5	658	\$5,443	\$75	\$390	\$166	This project has not been identified on the land. This data should be used as a guide when site specific projects are identified in the future
2	Nearshore All	Vegetative Swale: 4 acre drainage	1.3	556	\$5,443	\$75	\$461	\$196	This project has not been identified on the land. This data should be used as a guide when site specific projects are identified in the future
3	Nearshore 2	Vegetative Swale 5	1.4	389	\$6,417	\$75	\$743	\$206	
4	Nearshore 1	Vegetative Swale 4	1.23	481	\$6,087	\$75	\$577	\$226	It may not be feasible to remove the current culvert.
5	Nearshore All	Vegetative Swale: 3 acre drainage	1.4	443	\$5,443	\$75	\$579	\$247	This project has not been identified on the land. This data should be used as a guide when site specific projects are identified in the future
6	Nearshore 1	Vegetative Swale 2	0.9	354	\$4,950	\$75	\$678	\$271	
7	Nearshore 1	Vegetative Swale 3	0.9	336	\$5,443	\$75	\$764	\$283	
8	Nearshore All	Vegetative Swale: 1 acre drainage	0.83	310	\$5,443	\$75	\$828	\$311	This project has not been identified on the land. This data should be used as a guide when site specific projects are identified in the future
9	Nearshore All	Vegetative Swale: 2 acre drainage	0.7	314	\$5,443	\$75	\$817	\$347	This project has not been identified on the land. This data should be used as a guide when site specific projects are identified in the future
10	Nearshore 1	Vegetative Swale 1	0.3	100	\$3,830	\$75	\$2,034	\$694	
11	Nearshore 2	Rain Garden 200 sq ft	0.5	119	\$9,320	\$100	\$3,427	\$763	
12	Nearshore 3	Lakes Access Restoration	1.0	1,352	\$20,435	\$100	\$578	\$788	
13	Nearshore 2	Rain Garden 300 sq ft	0.5	133	\$10,520	\$100	\$3,378	\$838	
14	Nearshore 2	Rain Garden 500 sq ft	0.6	147	\$12,920	\$100	\$3,611	\$901	
15	Lakeshore	High Priority 1045 ft	4.4	6,219	\$106,036	\$1,900	\$874	\$1,244	
16	Lakeshore	High Priority 880 ft	3.7	5,237	\$89,428	\$1,600	\$875	\$1,245	
17	Lakeshore	High Priority 605 ft	2.5	3,601	\$61,748	\$1,100	\$877	\$1,248	
18	Lakeshore	High Priority 330 ft	1.4	1,964	\$34,068	\$600	\$884	\$1,258	
19	Lakeshore	High Priority 55 ft	0.2	327	\$6,388	\$100	\$956	\$1,361	



## Priority Catchments – Nearshore

Computer data and field analysis was used to identify areas near Long Lake where water quality projects could be installed. Three stormwater catchments were identified as having the highest potential for installing cost-effective stormwater projects. Much of the land near Long Lake is low in elevation with minimal separation between the soils surface and ground water. These are great land characteristics to have when the goal is to keep stormwater on the land however in some cases it may be difficult to install infiltration practices. Planting native deep-rooted vegetation in areas of concentrated stormwater flow was determined to be the most effective option for reducing nutrient loading in these areas.



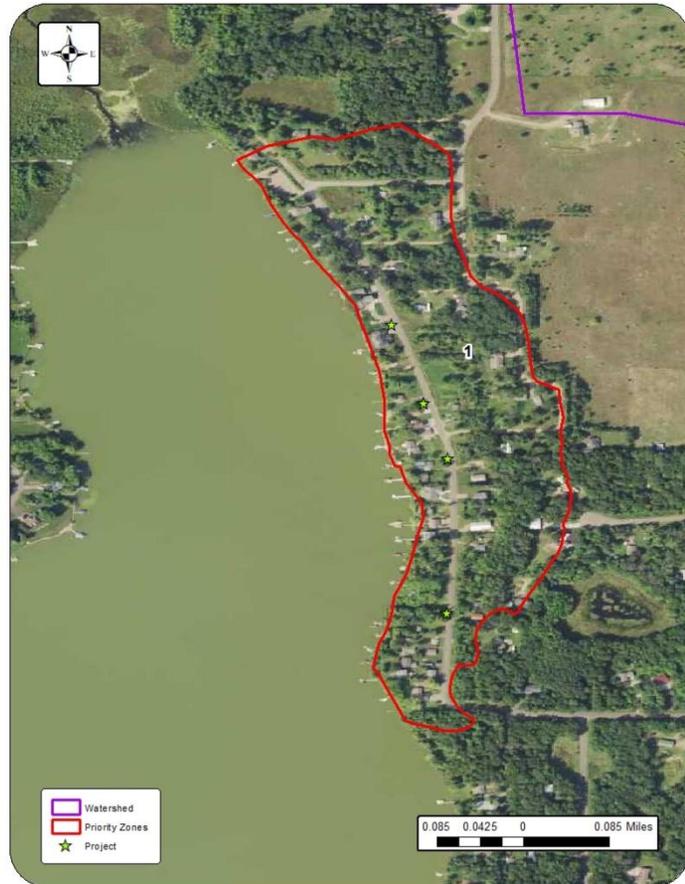
# Priority Zone 1

Existing Catchment Summary	
Acres	37.0
Dominant Land Cover	Medium Density Residential

## Catchment Description

Catchment 1 consists of medium-density residential and open space land-use within the 120 parcel, 37 acre area. The priority areas where water quality projects are assumed most beneficial are located on the downstream side of several culverts that drain directly into Long Lake. Because of the low elevation and flat terrain, it is recommended to install native vegetative swales from the outlet of a culvert to the lakeshore. It is assumed that infiltration basins such as raingardens would not function properly due to the proximity of the water table.

Currently, there is a culvert running under the boat access parking area that outlets into the lake. Because of the upstream wetlands and vegetated ditches, the stormwater entering the lake at this location is assumed to be naturally treated. However, this location may be considered for a project in the future, if deemed feasible.

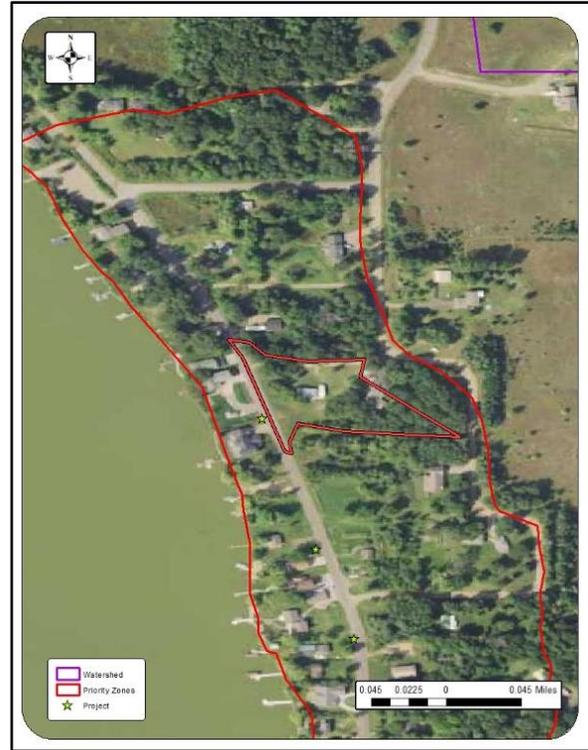


Existing Catchment Summary	
Acres	1.6
Dominant Land Cover	Open Space
TP (lb/yr)	0.4
TSS (lb/yr)	135

**Location** – Lakewood Drive NW

**Property Ownership** – Private Landowner cooperation needed for project to proceed.

**Description** – This project ranked 10<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Currently, 1.6 acres drain through a culvert from the east side of Lakewood Drive NW. The stormwater outlets into a residential yard then flows directly into Long Lake with minimal treatment. The vegetative swale is designed to slow down the flow of stormwater, settle out suspended material and filter nutrients before entering the lake.



**Cost Analysis:**

Swale			
		Cost/Removal Analysis	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs*	125 ft. x 5 ft.	
	TP (lb/yr)	0.292	73.6%
	TSS (lb/yr)	100	73.8%
Cost	Administration, Promotion & Design Costs	\$937	
	Construction Costs**	\$2,893	
	Total Estimated Project Cost	<b>\$3,830</b>	
	Annual O&M***	\$75	
Efficiency	30-yr Average Cost/lb-TP	\$694	
	30-yr Average Cost/1,000lb-TSS	<b>\$2,034</b>	

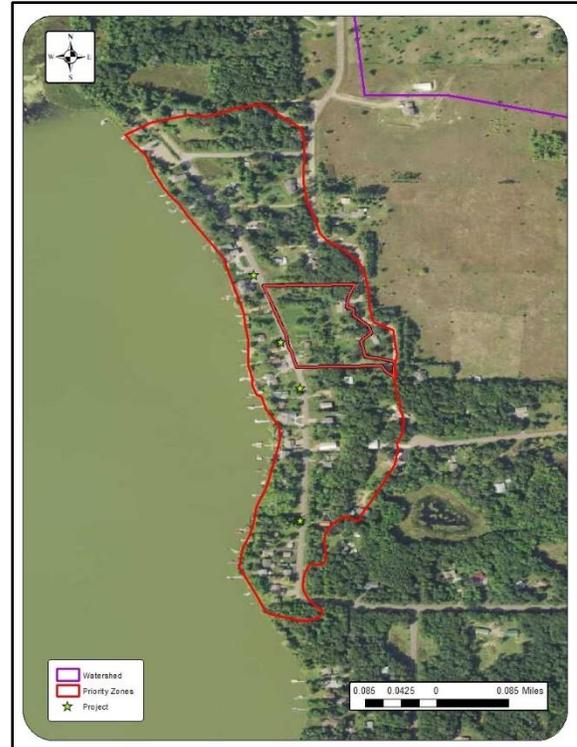


Existing Catchment Summary	
Acres	4.1
Dominant Land Cover	Open Space
TP (lb/yr)	1.56
TSS (lb/yr)	600.00

**Location** - Lakewood Drive NW

**Property Ownership** – Private Landowner cooperation needed for project to proceed.

**Description** – This project ranked 6<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Currently, 4.1 acres drain through a culvert from the east side of Lakewood Drive NW. The stormwater outlets into another culvert then flows directly into Long Lake with no treatment. The vegetative swale is designed to slow down the flow of stormwater, settle out suspended material and filter nutrients before entering the lake.



The culvert currently installed in the residential yard will need to be removed to allow the installation of the swale.

**Cost Analysis:**

Swale			
		Cost/Removal Analysis	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs*	150 ft. x 5 ft.	
	TP (lb/yr)	0.88	56.8%
	TSS (lb/yr)	354	59.0%
Cost	Administration, Promotion & Design Costs	\$937	
	Construction Costs**	\$4,013	
	Total Estimated Project Cost	\$4,950	
	Annual O&M***	\$75	
Efficiency	30-yr Average Cost/lb-TP	\$271	
	30-yr Average Cost/1,000lb-TSS	\$678	



Existing Catchment Summary	
Acres	5.2
Dominant Land Cover	Open Space
TP (lb/yr)	1.33
TSS (lb/yr)	478



**Location** – Lakewood Drive NW

**Property Ownership** – Private Landowner cooperation needed for project to proceed.

**Description** – This project ranked 7<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Currently, 5.2 acres drain through a culvert from the east side of Lakewood Drive NW. The stormwater outlets into a residential yard then flows directly into Long Lake with minimal treatment. The vegetative swale is designed to slow down the flow of stormwater, settle out suspended material and filter nutrients before entering the lake.

**Cost Analysis:**

Swale			
		Cost/Removal Analysis	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs*	195 ft. x 5 ft.	
	TP (lb/yr)	0.91	68.3%
	TSS (lb/yr)	336	70.2%
Cost	Administration, Promotion & Design Costs	\$937	
	Construction Costs**	\$4,506	
	Total Estimated Project Cost	<b>\$5,443</b>	
	Annual O&M***	\$75	
Efficiency	30-yr Average Cost/lb-TP	\$283	
	30-yr Average Cost/1,000lb-TSS	\$764	

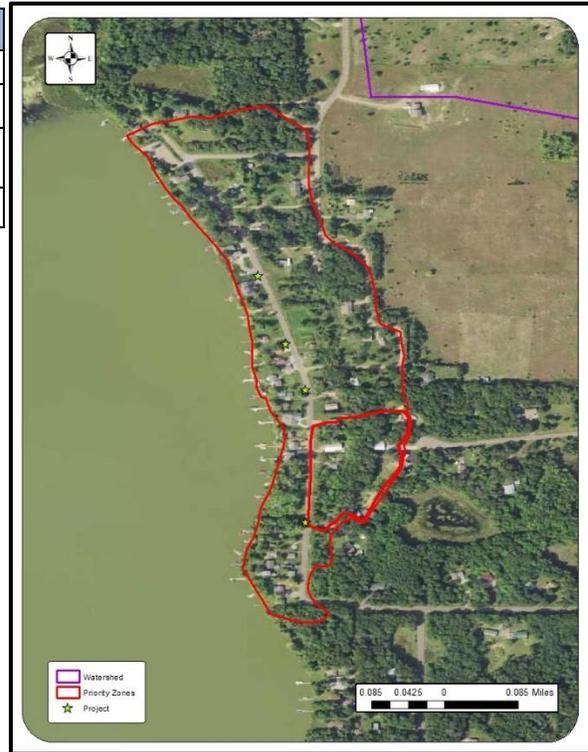


Existing Catchment Summary	
Acres	4.3
Dominant Land Cover	Open Space
TP (lb/yr)	1.33
TSS (lb/yr)	478

**Location** – Lakewood Drive NW

**Property Ownership** – Private Landowner cooperation needed for project to proceed.

**Description** – This project ranked 4<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Currently, 4.3 acres drain through a culvert from the east side of Lakewood Drive NW. The stormwater outlets into another culvert then flows directly into Long Lake with no treatment. The vegetative swale is designed to slow down the flow of stormwater, settle out suspended material and filter nutrients before entering the lake.



The culvert currently installed in the residential yard will need to be removed to allow the installation of the swale. This might not be feasible due to the proximity to the trees. Installing a riser at the culvert’s inlet may allow for some nutrient reduction; however, careful analysis of the surrounding elevations should be done to ensure the project doesn’t increase flooding.

**Cost Analysis:**

Swale				
		Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1		
	Total Size of BMPs*	200 ft. x 5 ft.		
	TP (lb/yr)	1.23		54.9%
	TSS (lb/yr)	481		57.1%
Cost	Administration, Promotion & Design Costs	\$937		
	Construction Costs**	\$5,150		
	Total Estimated Project Cost	<b>\$6,087</b>		
	Annual O&M***	\$75		
Efficiency	30-yr Average Cost/lb-TP	\$226		
	30-yr Average Cost/1,000lb-TSS	\$577		

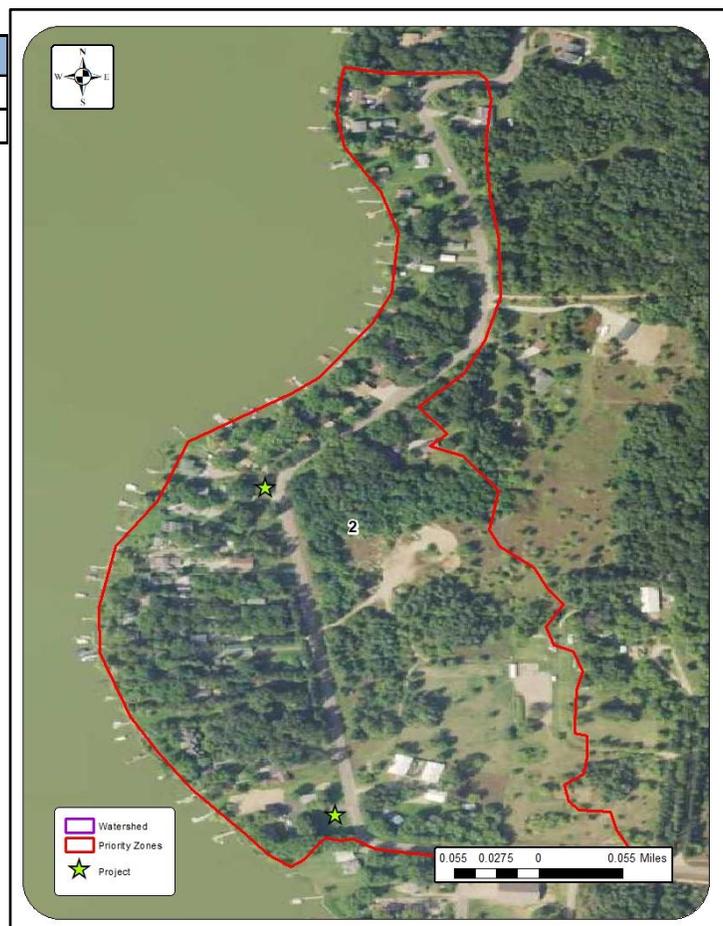


## Priority Zone 2

Catchment two consists of medium density residential and open land use type within the 54 parcel, 41 acre area. The priority areas where water quality projects are estimated to be most beneficial are located where street elevations promote stormwater runoff. Similar to priority zone one, the elevation of the land near the lake is low and within two to three feet of the water table. It was noted during field investigations that some areas in priority zone two may allow for the installation of an effective rain garden or other filtration basins.

Currently, there are wetlands on the east side of Lakewood Drive NW that act as natural stormwater filters. It was also noted during field investigations that the ditch where Lakewood Drive NW turns into 275<sup>th</sup> Avenue NW is heavily vegetated and provides some holding capacity for stormwater.

Existing Catchment Summary	
Acres	41.0
Dominant Land Cover	Medium Density Residential

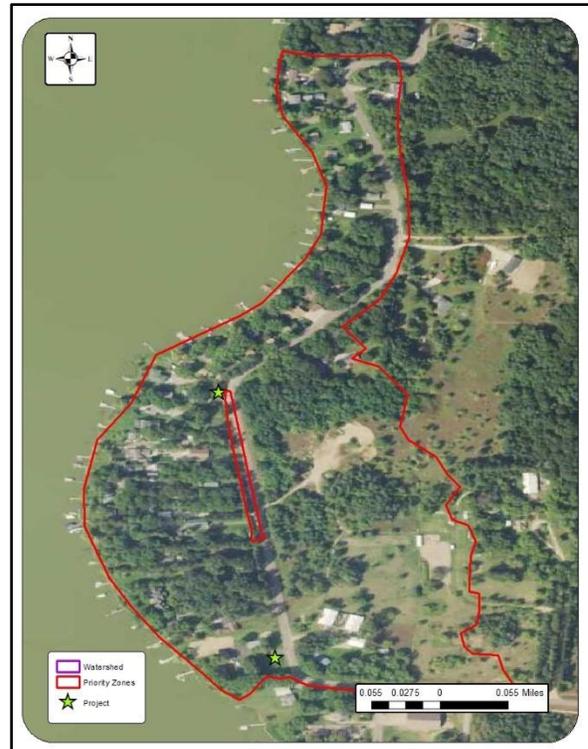


Existing Catchment Summary	
Acres	0.4
Dominant Land Cover	Medium Density Residential
TP (lb/yr)	1.4
TSS (lb/yr)	363

**Location-** Lakewood Drive NW

**Property Ownership** - Private landowner.  
Cooperation needed for project to proceed.

**Description** - This project ranked 11<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a raingarden installed in a residential yard. The raingarden would collect and infiltrate stormwater runoff from Lakewood Drive NW and surrounding landscape. The rain garden is designed to hold water for no more than 48 hours after a storm, but the ponding time is often much shorter in areas with sandy soils. Septic system setbacks should be addressed prior to project design and installation.



We've analyzed scenarios where one of three raingardens are installed: 200 sqft , 300 sqft and 500sqft. The results indicate that it would be most cost effective to install a 200 sqft raingarden.

Cost Analysis:

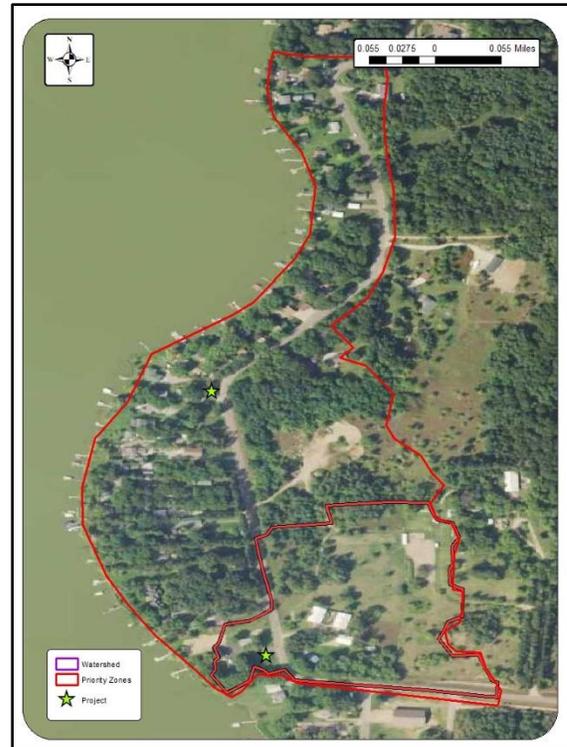
Rain Gardens							
Cost/Removal Analysis		New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		1		1	
	Total Size of BMPs	200	sq-ft	300	sq-ft	500	sq-ft
	TP (lb/yr)	0.5	88.2%	0.5	88.2%	0.6	96.5%
	TSS (lb/yr)	119.9	79.0%	133.4	88.0%	147	96.9%
Cost	Administration & Promotion Costs*	\$2,920		\$2,920		\$2,920	
	Design & Construction Costs**	6,400		7,600		10,000	
	Total Estimated Project Cost	\$9,320		\$10,520		\$12,920	
	Annual O&M***	\$100		\$100		\$100	
Efficiency	30-yr Average Cost/lb-TP	\$763		\$838		\$901	
	30-yr Average Cost/1,000lb-TSS	\$3,427		\$3,378		\$3,611	

Existing Catchment Summary	
Acres	11.1
Dominant Land Cover	Open Space
TP (lb/yr)	1.89
TSS (lb/yr)	503

**Location** - Lakewood Drive NW

**Property Ownership** – Private landowner. Cooperation needed for project to proceed.

**Description** – This project ranked 3<sup>rd</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Currently, 11.1 acres drain through a culvert from the east side of Lakewood Drive NW. The stormwater outlets into a residential yard then flows directly into Long Lake with minimal treatment. The vegetative swale is designed to slow down the flow of stormwater, settle out suspended material and filter nutrients before entering the lake.



**Cost Analysis:**

Swale				
		Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1		
	Total Size of BMPs*	240 ft. x 5 ft.		
	TP (lb/yr)	1.40	74.3%	
	TSS (lb/yr)	389	77.3%	
Cost	Administration, Promotion & Design Costs	\$937		
	Construction Costs**	\$5,480		
	Total Estimated Project Cost	\$6,417		
	Annual O&M***	\$75		
Efficiency	30-yr Average Cost/lb-TP	\$206		
	30-yr Average Cost/1,000lb-TSS	\$743		

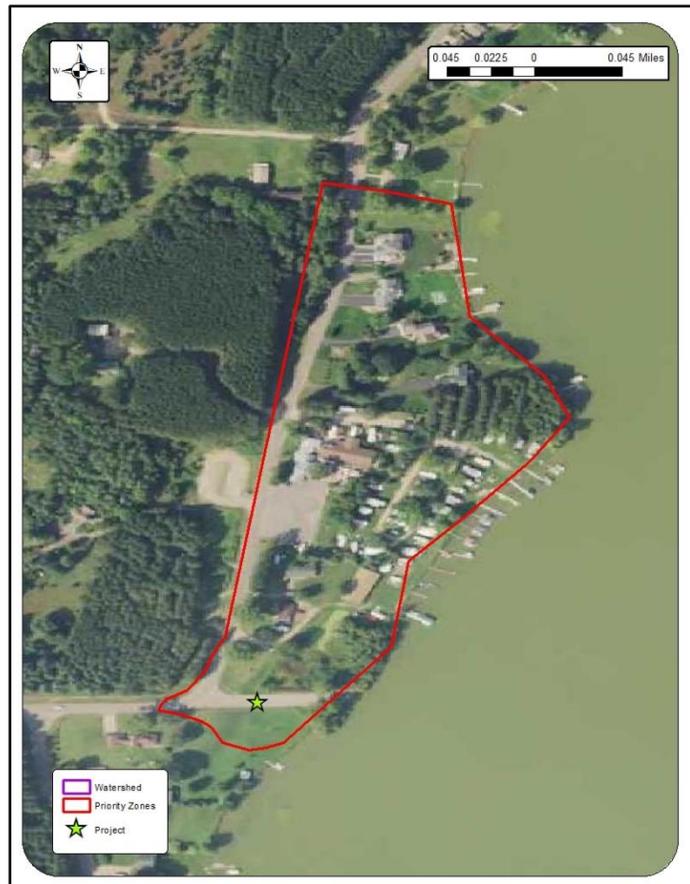


## Priority Zone 3

Catchment three primarily consists of the commercial land use type within the 5 parcel, 12 acre area. The priority areas where water quality projects are estimated to be the most beneficial are located where street elevations promote stormwater runoff. Campground docking areas tend to have more active shoreline erosion due to increased wave action from boat traffic. The shoreline near the docking area may benefit from nearshore stabilization and restoration.

During field investigations, it was noted that a culvert running under Bayshore Drive NW emptied directly into the lake. This information was studied using computer modeling programs and found the culvert was an outlet to a nearly 275-acre watershed. Because of the size of the watershed, the feasibility of installing an effective stormwater project is in question. However, further analysis could be done to better understand the feasibility and effectiveness of a stormwater project here.

It should be noted that much of the 275 acre watershed draining to the lake flows through several wetland complexes that provide some water filtration.

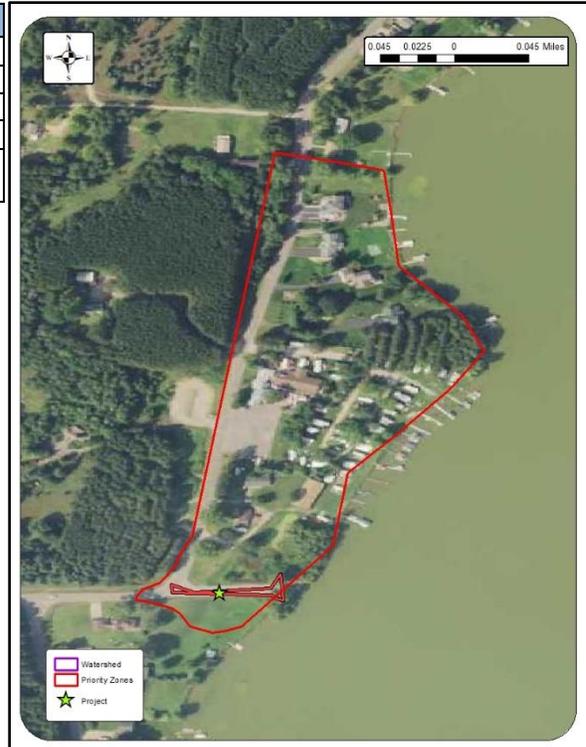


Existing Catchment Summary	
Acres	0.1
Dominant Land Cover	Street
Parcels	1
TP (lb/yr)	1.00
TSS (lb/yr)	1,353

**Location** - Lakewood Drive NW

**Property Ownership** – Township owned. Cooperation needed for project to proceed.

**Description** – This project ranked 12<sup>th</sup> in cost efficiency for reducing phosphorus among all projects in this assessment. The proposed project is a shoreline and habitat restoration at the boat landing. The access is located at the end of 277<sup>th</sup> Ave. NW. The road slopes to the lake and provides no treatment of sediment and nutrients flowing into the lake. Furthermore, it was observed during field investigation that the shore adjacent to the lake had minimal established vegetation which increases erosion and nutrient loading in the lake.



The goal would be to restore the upland area with native vegetation to reduce nutrient and sediment loading into the lake. Also, stabilizing the shoreline will prevent future shoreline erosion and nutrient loading.

Lake Access Restoration					
		Existing Conditions		New Treatment	% Reduction
Treatment	Number of BMPs			1	
	Total Size of BMPs*			115 linear ft	
	TP (lb/yr)	1.0			99.9%
	TSS (lb/yr)	1,352			100.0%
	Volume (acre-feet/yr)	0.200			96.7%
Cost	Administration, Promotion & Design Costs			\$2,945	
	Construction Costs**			\$17,490	
	Total Estimated Project Cost			\$20,435	
	Annual O&M***			\$100	
Efficiency	30-yr Average Cost/lb-TP			\$788	
	30-yr Average Cost/1,000lb-TSS			\$578	
	30-yr Average Cost/ac-ft Vol.			\$3,906	



## Other Opportunities

In some cases, it is difficult to access private property while completing field investigations. Because of this, areas that could benefit from water quality projects may be overlooked. To guide future outreach and project identification, several scenarios were modeled based on average land condition around the lake. Based on the data analysis, it was determined that one of the most cost efficient storm water projects that could be installed are native vegetative swales. The following data can be used to guide future installation of these types of projects.

**Location** - Lakewood Drive NW

**Property Ownership** – Private landowners. Cooperation needed for project to proceed.

**Description** – These projects ranked 1, 2, 5, 8 and 9 for cost efficiency in reducing phosphorus among all projects in this assessment. The proposed project is a vegetative swale installed in a residential yard. Treating 5 acres with a 150ft vegetated swale was ranked number 1 on the potential project list. These are average inputs and would need to be adjusted based on site location.

		Swale											
		<i>Cost/Removal Analysis</i>											
		New Treatment		%		New Treatment		%		New Treatment		New Treatment	
		Reduction		Reduction		Reduction		Reduction		Reduction		Reduction	
Treatment	Acres Treated	1		2		3		4		5			
	Total Size of BMPs*	150 ft. x 5 ft.		150 ft. x 5 ft.		150 ft. x 5 ft.		150 ft. x 5 ft.		150 ft. x 5 ft.			
	TP (lb/yr)	0.83	85.2%	0.74	88.6%	1.04	83.1%	1.31	78.2%	1.54	74.0%		
	TSS (lb/yr)	310	86.2%	314	88.7%	443	83.3%	556	78.5%	658	74.2%		
Cost	Administration, Promotion & Design Costs	\$937		\$937		\$937		\$937		\$937			
	Construction Costs**	\$4,506		\$4,506		\$4,506		\$4,506		\$4,506			
	Total Estimated Project Cost	<b>\$5,443</b>		<b>\$5,443</b>		<b>\$5,443</b>		<b>\$5,443</b>		<b>\$5,443</b>			
	Annual O&M***	\$75		\$75		\$75		\$75		\$75			
Efficiency	30-yr Average Cost/lb-TP	<b>\$311</b>		<b>\$347</b>		<b>\$247</b>		<b>\$196</b>		<b>\$166</b>			
	30-yr Average Cost/1,000lb-TSS	<b>\$828</b>		<b>\$817</b>		<b>\$579</b>		<b>\$461</b>		<b>\$390</b>			

# Lakeshore Restoration

## DESCRIPTION

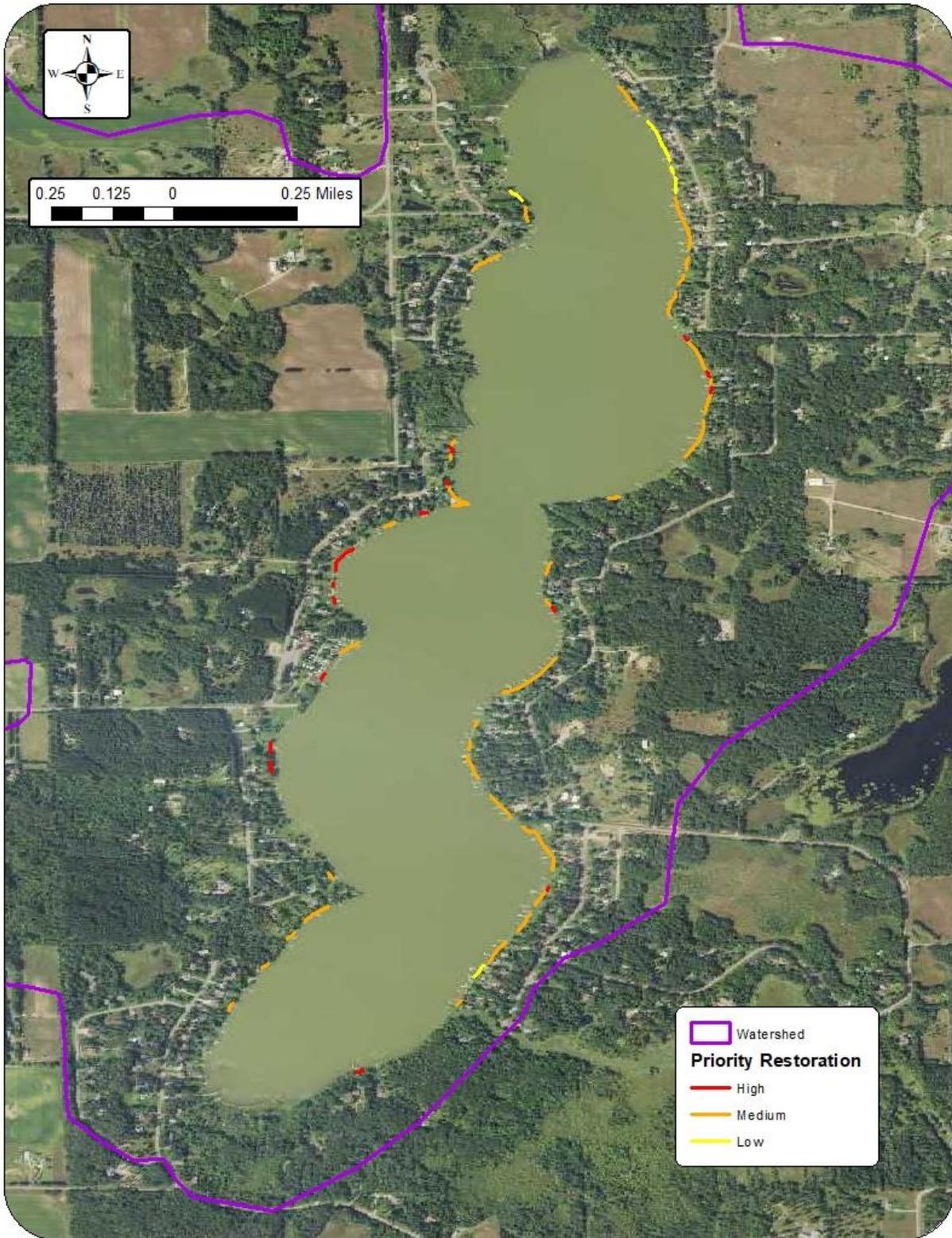
The lakefront was examined separately from upland areas. This was done because erosion and runoff from the lakeshore is delivered directly into the lake. It is a problematic area, where residents attempt to balance recreational access, aesthetics, wave erosion, and water quality.

Overall, Long Lake's shoreline is highly developed with homes around the entire lake. Much of the land adjacent to the lake is only a half foot above the ordinary high-water level. These land characteristics tend to promote shoreline erosion, especially in areas with little to no established native vegetation. In areas where natural vegetation is not present, the land is commonly managed by mowing to the water's edge, sand beaches, beach raking and aquatic vegetation removal. Some landowners have used rock rip-rap or retaining walls. These areas are candidates for a lakeshore restoration, including correcting erosion and installing vegetated buffers.

A total of 9,694 linear feet of shoreline was identified as a priority for restoration. Using a scoring system developed by the SWCD that include variables such as buffer depth, eroding face, upland slope, stream flow and shoreline erosion, we were able to rank areas as low, medium or high priority. Of the 9,694 ft of priority shoreline, 1,045 ft was identified as high priority or areas that have the highest potential for sediment and phosphorus loading.

## EXISTING STORMWATER TREATMENT

Many properties have vegetated buffers, or other measures to prevent erosion and/or filter overland flow before it reaches the lake. We did not quantify the benefits from these practices. We did conclude that pollutant loading from lakeshores are a high priority.



High priority site restoration: Restoring 1,045 linear ft of shoreline

**Location** – Dispersed around the lakeshore, see maps

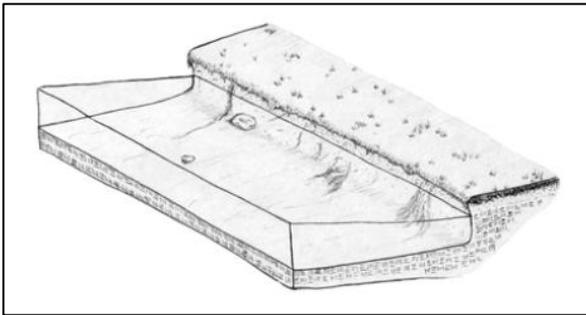
**Property Ownership** – Private

**Description** – 9,694 linear feet of potential lakeshore restorations were identified in spring 2018. Using a scoring system that include variables such as buffer depth, eroding bank, upland slopes, stream flow and shoreline erosion, we were able to rank areas as low, medium or high priority. Of the 9,694 ft of priority shoreline, 1,045 ft was identified as high priority or areas that have the highest potential for sediment and phosphorus loading. The high priority areas were used to model cost benefits for removal of phosphorus and sediment.

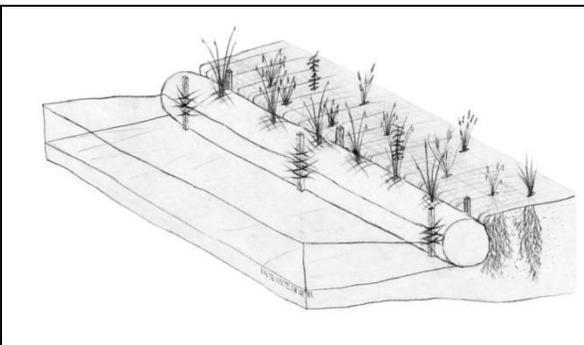
At each candidate lakeshore site, we assumed that 65% of the lakeshore (i.e. 65 ft of an average 100 ft frontage) would be stabilized to prevent future erosion and an un-mowed vegetated buffer that is 15 feet wide (i.e. spanning 15 ft from the water's edge to manicured lawn). Bioengineering techniques which utilize deep rooted native plants and biodegradable materials, such as coconut fiber logs and erosion blankets, are favored. Hard structures, including rock alone or retaining walls, are not favored because they lack habitat attributes.

**Conceptual images** –

Lakeshore restorations with bioengineering and native vegetation.



Source: Metro Conservation District



Source: Metro Conservation District



Project ID: high priority lakeshore restorations

**Location** – Dispersed around the lakeshore, see maps

**Property Ownership** – Private

**Description** – Of the 9,694 linear feet of lakeshore restoration we identified, 1,045 ft was noted as the highest priority.

### Cost effectiveness analysis

We modeled five different scenarios to determine the most cost beneficial option when restoring portions of the high priority selected lakeshore, 55ft, 330ft, 605ft, 880ft and the entire 1045ft. Results showed that restoring all 1,045ft of shoreline would be the most cost-effective option for phosphorus removal.

Lakeshore Restorations											
Existing Conditions		New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		6		11		16		19	
	Total Size of BMPs*	55	ft	330	ft	605	ft	880	ft	1,045	ft
	TP (lb/yr)	0.2	0.6%	1.4	3.6%	2.5	6.5%	3.7	9.5%	4.4	11.3%
	TSS (lb/yr)	327	1.9%	1,964	11.2%	3,601	20.5%	5,237	29.7%	6,219	35.3%
	Volume (acre-feet/yr)	0.016	0.1%	0.097	0.6%	0.178	1.1%	0.259	1.6%	0.308	1.9%
Cost	Administration, Promotion & Design Costs	\$2,083		\$8,235		\$14,388		\$20,541		\$24,233	
	Construction Costs**	\$4,305		\$25,832		\$47,359		\$68,886		\$81,803	
	Total Estimated Project Cost	<b>\$6,388</b>		<b>\$34,068</b>		<b>\$61,748</b>		<b>\$89,428</b>		<b>\$106,036</b>	
	Annual O&M***	\$100		\$600		\$1,100		\$1,600		\$1,900	
Efficiency	30-yr Average Cost/lb-TP	\$1,361		\$1,258		\$1,248		\$1,245		\$1,244	
	30-yr Average Cost/1,000lb-TSS	\$956		\$884		\$877		\$875		\$874	
	30-yr Average Cost/ac-ft Vol.	\$19,317		\$17,856		\$17,723		\$17,673		\$17,656	

## Methods:

### Selection of Watershed

Many factors are considered when choosing which watershed to assess for stormwater retrofits, but always focus on the drainage to an important lake, river, or stream. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available digital mapping data, etc.) to greater facilitate the assessment also rank highly. The focus is always on a high priority waterbody.

### Urban/residential Subwatershed Selection

This assessment includes the area of land draining directly to Long Lake. These areas were chosen because its proximity to the lake translates into direct water quality impacts, it is the area of densest development in the watershed and has little or no stormwater treatment. Furthermore, near-lake landowners are often most vested in the lake's water quality and a Lake Improvement District (LID) covers this area and is a valuable partner for installing projects.

### Subwatershed Assessment Methods

#### Step 1: Retrofit Scoping

Retrofit scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local land use managers and lake group members to determine the issues in the watershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria.

#### Step 2: Desktop Retrofit Analysis

The desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don't need to be assessed because of existing stormwater infrastructure or current land uses. Accurate GIS data is extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include: 2-foot or finer topography, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries and high-resolution aerial photography.

#### Step 3: Retrofit Field Investigation

After identifying potential retrofit sites through the desktop search, a field investigation was conducted to evaluate each site and identify additional opportunities. During the investigation, the drainage area and stormwater infrastructure mapping data were verified. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have revealed additional retrofit opportunities that went unnoticed during the desktop search.

In addition to in field investigation, a survey of the lakeshore was completed for Long Lake by boat. This allowed staff to document stormwater outfalls, inventory the shoreline condition and see potential project locations from a different perspective.

#### Step 4: Treatment Analysis/Cost Estimates

Sites most likely to be conducive to addressing the pollutant reduction goals and appearing to have feasible design, installation, and maintenance were chosen for a cost/benefit analysis. Estimated costs included design, installation, and maintenance annualized across the anticipated project lifespan (10-30 yrs). Estimated benefits included are pounds of phosphorus and total suspended solids removed, though projects were ranked only by cost per pound of phosphorus removed annually.

#### Treatment analysis

##### Urban/Residential Catchments:

For each potential project pollutant removal estimates were obtained using the Wisconsin NRCS Erosion Calculator and the stormwater model WinSLAMM. WinSLAMM uses an abundance of stormwater data from the upper Midwest and elsewhere to quantify runoff volumes and pollutant loads from urban areas. It is useful for determining the effectiveness of proposed stormwater control practices. It has detailed accounting of pollutant loading from various land uses and allows the user to build a model “landscape” that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It uses rainfall and temperature data from a typical year, routing stormwater through the user’s model for each storm. The output data gives an estimate of how much sediment is being lost in that area.

A “base” model was created which estimated pollutant loading from selected catchments in its present-day state. To accurately model the land uses in each catchment, we delineated each land use in each catchment using ArcGIS and assigned each a WinSLAMM standard land use file. This process resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment. For certain source areas critical to our models we verified that model estimates were accurate by measuring actual acreages in ArcGIS and adjusting the model acreages if needed.

Once the “base” model was created, each proposed stormwater treatment practice was added to the model and pollutant reductions were generated. Because neither a detailed design of each practice nor in-depth site investigation was completed, a generalized design for each practice was used. Whenever possible, site-specific parameters were included. Design parameters were modified to obtain various levels of treatment.

## Lakeshore Erosion and Runoff Pollutant Estimation

WinSLAMM modeling alone could not accurately estimate pollutants generated from eroding lakeshore, nor the pollutant reduction that may occur by installing a project. To estimate lakeshore pollutants, we used a two-step process that accounted for (1) overland flow from lakeshore backyards plus (2) the eroding lakeshore face.

1. **Overland Flow** - We used WinSLAMM to estimate pollutant generation from the backyards of lakeshore homes. We created a custom WinSLAMM standard land use that replicated typical high priority Spectacle Lakeshore properties, including home's roof, backyard and landscaping. In our base model the runoff from these surfaces flowed over sandy loam backyard soils to the lake. In our proposed project models the runoff was directed through a vegetated swale at the water's edge.
2. **Eroding Lakeshore Face** - We used a modified version of the Wisconsin NRCS streambank erosion method to calculate sediment loss from the lakeshore face. Assumptions for the NRCS bank erosion method included a 1 ft tall eroding face with a lateral recession rate of 0.1 feet/year (moderate erosion). The bulk density of the eroded material was assumed to be 100 lbs per cubic foot, the NRCS published value for sandy loam. This yielded an estimation of pounds of eroded material lost per year. The phosphorus content of that material was calculated based on a conversion factor of one pound of phosphorus per 1,481 pounds of soil, as derived from the BWSR erosion calculator.

We categorized candidate lakeshore restoration sites as either "low priority", "medium priority" or "high priority." A scoring system was used to determine what category a selected shoreline belongs in. Variables such as, buffer depth, eroding face, upland slope, extent of shoreline erosion, etc. were designated a number based on its potential for nutrient and sediment loading. High priority candidates fall within the range of 11 and up, medium priority candidates fall within the range of 6 to 10 and low priority candidates fall within the range of 0 to 5.

## Cost Estimates

### Urban/Residential Catchments:

Cost estimates were annualized costs that incorporated design, installation, installation oversight, and maintenance over a 30-year period. In cases where promotion to landowners is important, such as raingardens and lakeshore restorations, those costs were included as well. Design assistance from an engineer is assumed for practices in-line with the stormwater conveyance system, involving complex stormwater treatment interactions, or posing a risk for upstream flooding. It should be understood that no site-specific construction investigations were done as part of this stormwater assessment, and therefore cost estimates account for only general site considerations.