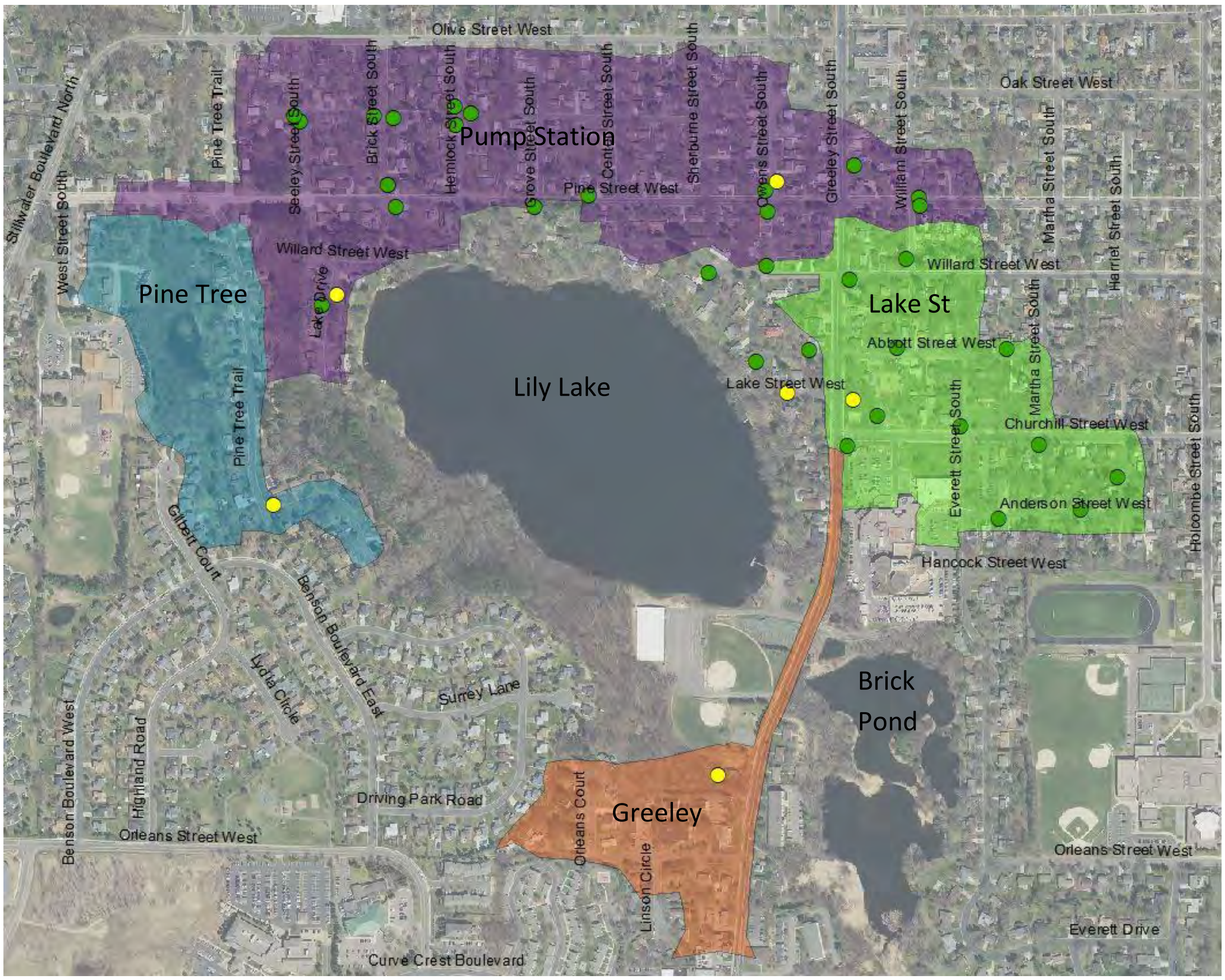
Lily Lake
Stormwater Retrofit Analysis

2018 Update



Prepared by:

WASHINGTON CONSERVATION DISTRICT

for the

MIDDLE ST. CROIX WATERSHED MANAGEMENT ORGANIZATION

Executive Summary

A Subwatershed Retrofit Analysis (SWA) was performed to evaluate the feasibility and cost effectiveness of best practices to complete the 145 lbs. annual phosphorus load reduction identified in the In 2007 the City of Stillwater Lily Lake Management Plan conducted by Wenck Engineering (Wenck). The report identified the total phosphorus load to Lily Lake was 285 pounds and a 145 pound or 51% reduction goal was identified to meet State water quality standards 40 mg/l.

This revised SWA re-evaluates the 2010 the Washington Conservation District (WCD) Lily Lake Subwatershed Assessment more precisely mapped the drainage areas for Lily Lake and conducted P8 water quality modeling and identified, prioritized, and ranked potential water quality best management practices. Since this report, 41 water quality BMPs have been installed in the contributing watersheds to Lily Lake of which 32 are evaluated in this SWA.

Additionally, in 2015 and 2016 the WCD monitored stormwater outfalls into Lily Lake and concluded 35% and 60% TP respectively was contributed by the two catchments; Lake Street (33.3 acres) and Greeley Street). It was long suspected that Brick Pond the largest contributor of phosphorus to Lily Lake. However, the data revealed annually of 78% TP was discharged during storm events and water discharging from Brick Pond to Lily Lake exhibited low concentrations. In 2015 the average phosphorus concentration was 0.091 mg/L, 2016 the average was 0.07 mg/L. Brick Pond was also monitored in 2017 and retained a low average phosphorus concentration of 0.06 mg/L.

Based on this data, the SWA focuses on the four catchments with a total of 137.9 acres contributing the majority of annual phosphorus load through storm sewer systems directly discharging to the Lake with no treatment.

This SWA utilized Washington county contours generated from Lidar data and stormwater pipe, structure, and catch basin data provided by the City of Stillwater in 2017. Field analysis of catchments and potential BMP locations were conducted to evaluate feasibility, estimate cost, and verify drainage areas and landscape types draining to potential practices. Pollutant loads were identified utilizing WinSLAMM v10.2.

This analysis incorporates modeling of 32 small scale BMPs that infiltrate, filtrate, or reduce gross solids and TSS. WinSLAMM modeling indicates these BMPs reduce annual total phosphorus by 14.6 pounds within the catchments discharging directly to Lily Lake through storm sewer outfalls. Two additional gully stabilization projects occurred within the direct discharge watershed but were not incorporated into this model because WinSLAMM does not accurately estimate loads and reductions for gully stabilization projects. Instead, gully stabilization project load reductions were estimated utilizing the Board of Water and Soil Resources Pollution Reduction Estimator (Version Sept, 2009).

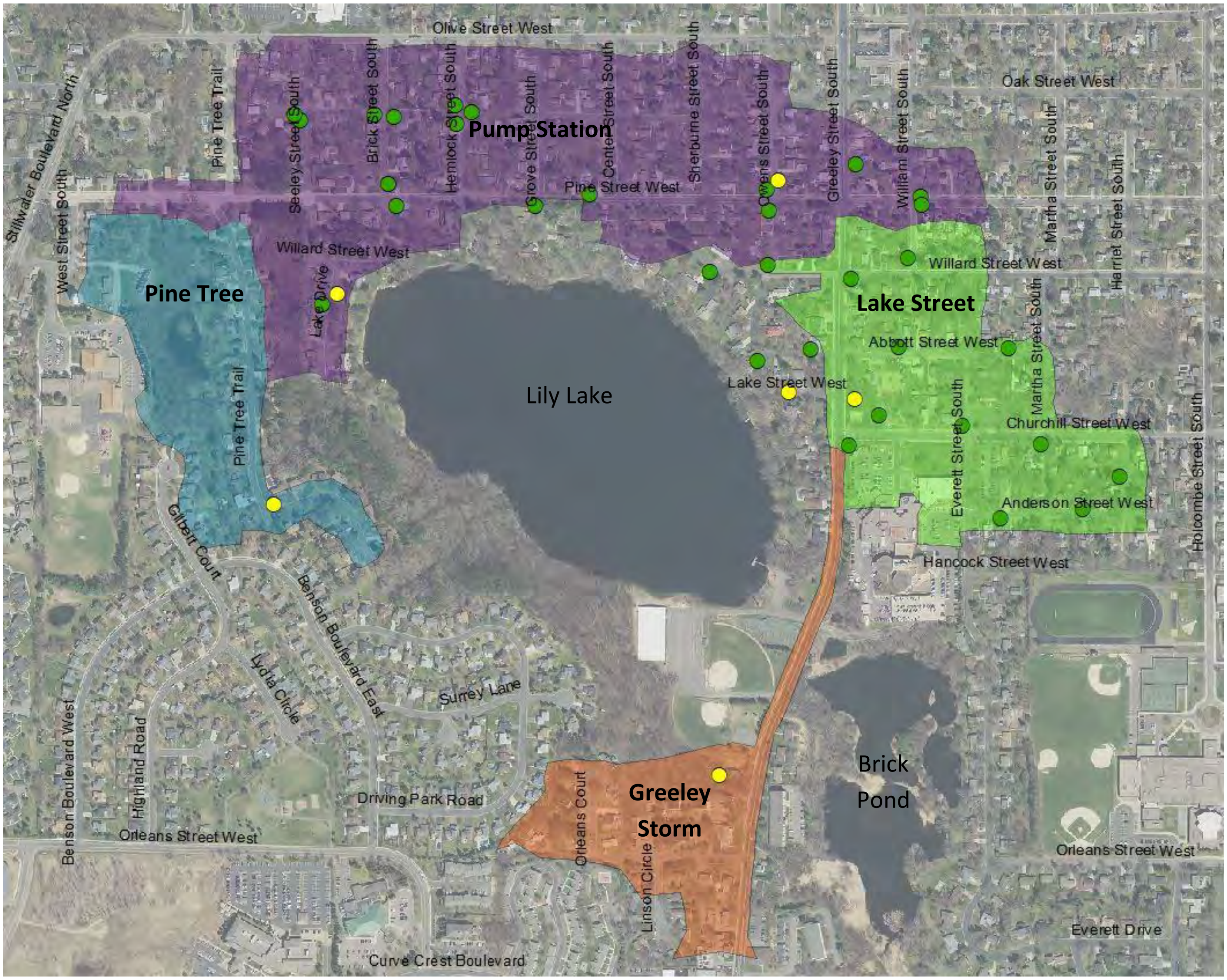
Retrofit analysis identified four small scale bioretention basins (0.78 -1.6 acre drainage areas), one catchment scale bioretention basin (17.3 acre drainage area), and one catchment scale underground infiltration gallery (33.1 acre drainage area). The small scale bioretention opportunities were evaluated by seeking sufficiently contributing catchments and sufficient right-

of-way area to reduce annual total phosphorus by at least 0.75 pounds per year without the need for a retaining wall greater than 3.0'. Larger scale BMPs were evaluated based on the potential to intercept and treat large drainage area without major utility conflicts and with suitable soils.

Additionally, the subwatershed models two large-scale BMPs identified through the Lily Final 45 Feasibility Study conducted by Emmons and Olivier Resources Inc. and WCD staff.

Map of Lily Lake Catchments

includes all existing and proposed BMP locations



Existing BMP

Proposed BMP

Map of Lily Lake BMPs

includes all existing and proposed BMP locations and their subcatchment boundaries.

Existing BMP

Proposed BMP

3.1 Methods

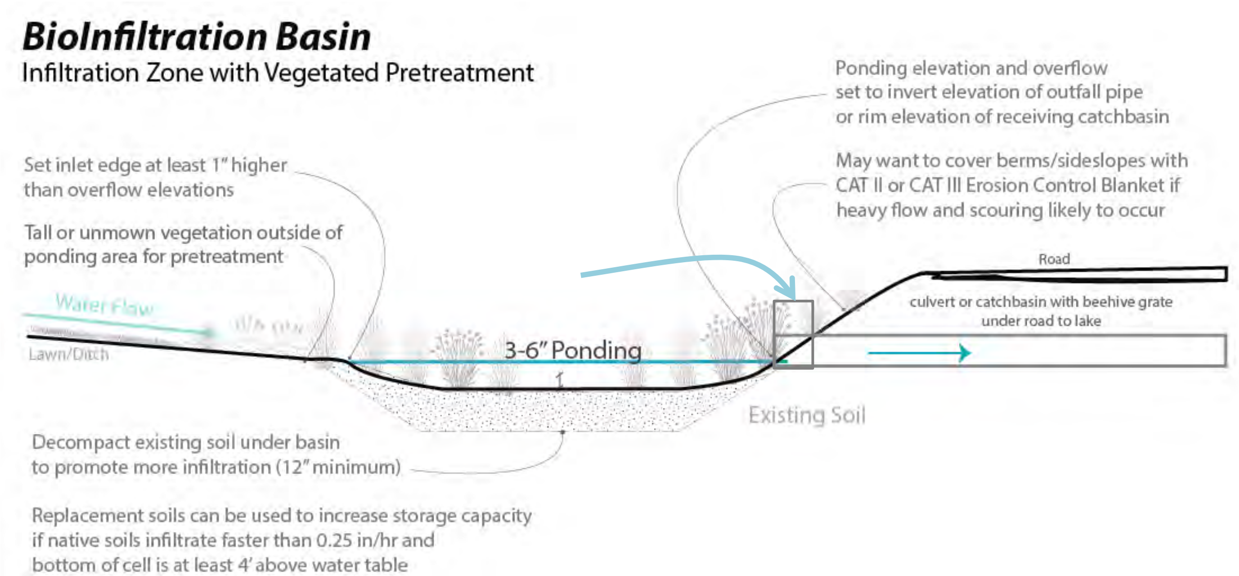
Typical Biofiltration and Bioinfiltration Basins

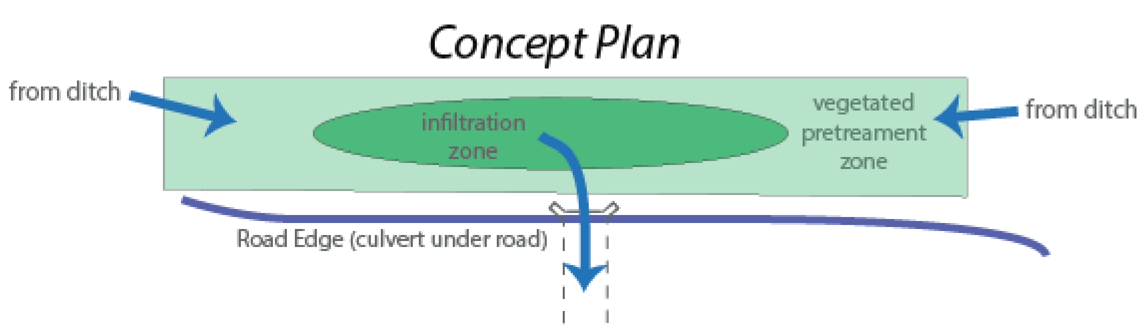
Summary

Biofiltration and Bioinfiltration Basins were the two primary BMPs chosen throughout the analysis area. Typical cross-sections are included below and describe the design assumptions used in the cost estimation process.

Bioinfiltration

Bioinfiltration is a basin that infiltrates into the native soil fast enough to allow for a fully drained basin within 48 hours. There are no underdrains in a Bioinfiltration Basin. All basins of either type in the analysis do not have pretreatment devices to limit gross solid accumulation and rely on additional tall vegetation upstream to capture sediment prior to entering the basin.





3.1 Methods

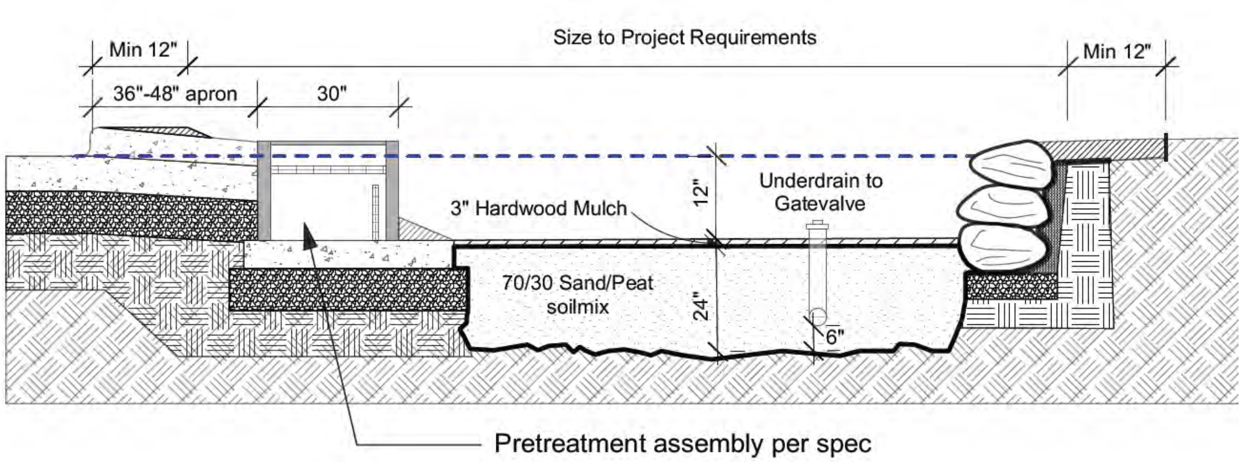
Typical Biofiltration, Bioinfiltration, and Ponded Swale Design

Biofiltration and Bioinfiltration

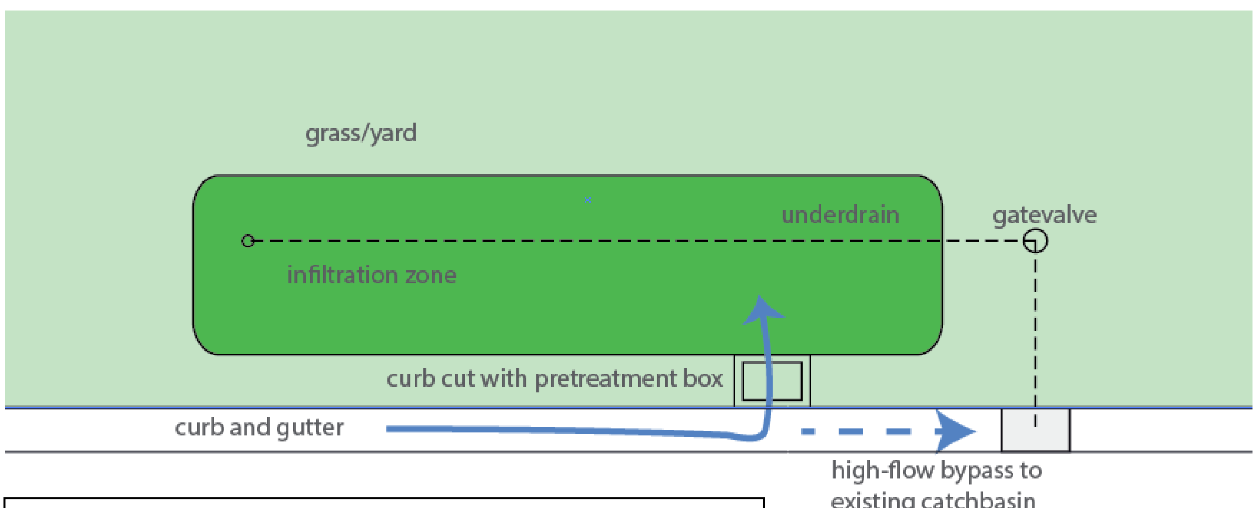
Biofiltration is bioretention basin that requires an underdrain. This is usually required when soils do not infiltrate fast enough or when there is a need for a liner beneath the cell. Cleanouts and gatevalves will typically accompany the draintile assembly. All basins of either type in the analysis do not have pretreatment devices to limit gross solid accumulation and rely on additional tall vegetation upstream to capture sediment prior to entering the basin.

Biofiltration Basin (aka, curb-cut raingarden)

- **With Underdrain and Gatevalve Assembly**



Curb Cut Raingarden – Typical Cross Section



Curb Cut Raingarden – Typical Conceptual Layout Plan

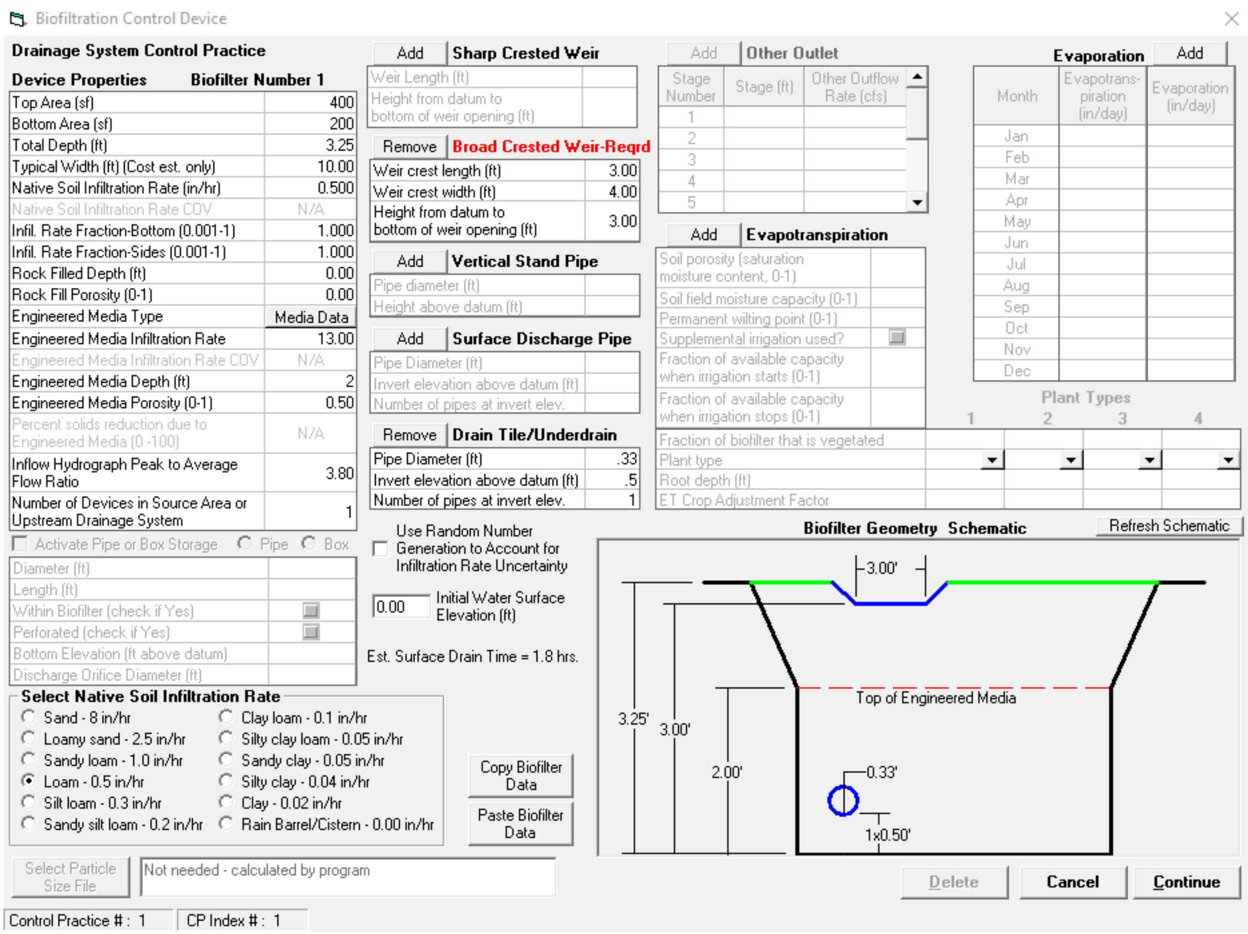
3.1 Methods

Curb Cut Raingarden (Bioinfiltration Basin)

(with and without underdrains)

Typical Model Design

Curb-cut raingardens are typically modelled in WinSLAMM per unique site-specific conditions; including catchment boundaries, soil conditions, and underdrain connection opportunities. Sediment pretreatment devices such as the RainGuardian Bunker box are not included in the WinSLAMM model design. Refer to diagram below for typical inputs of a curb cut raingarden.



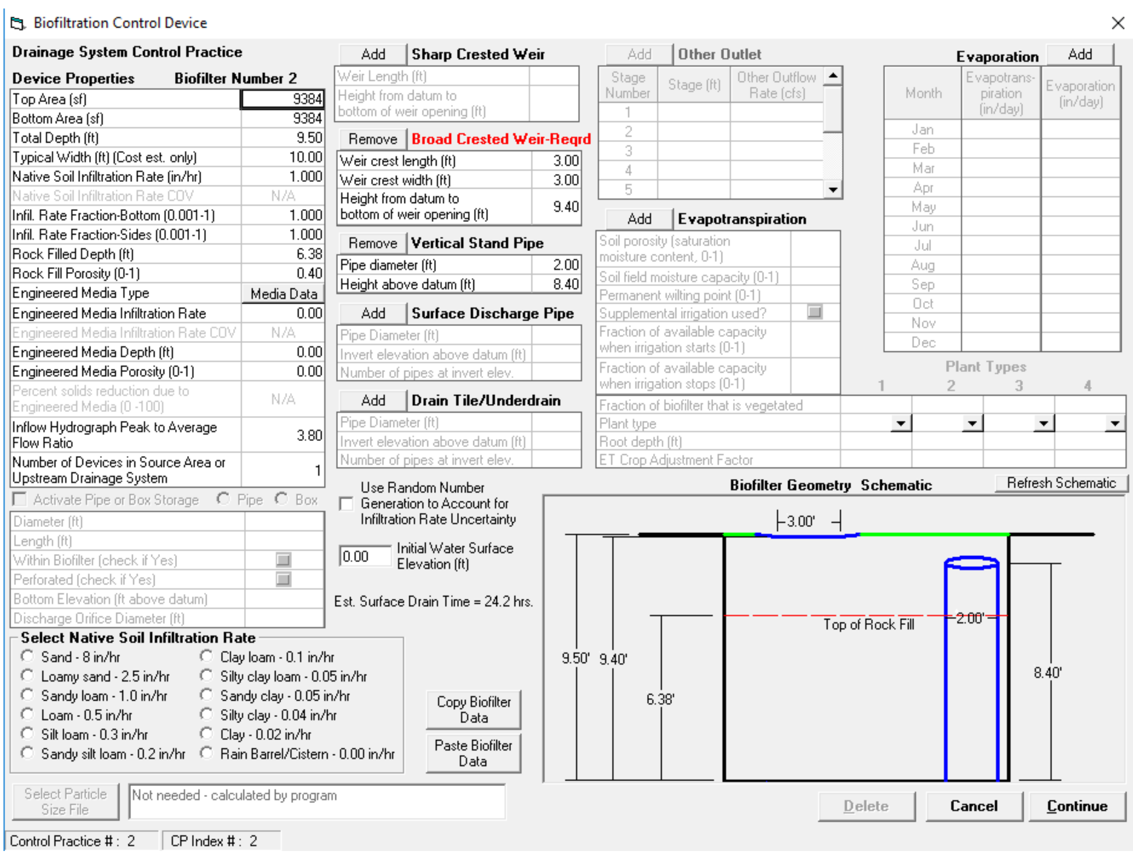
3.1 Methods

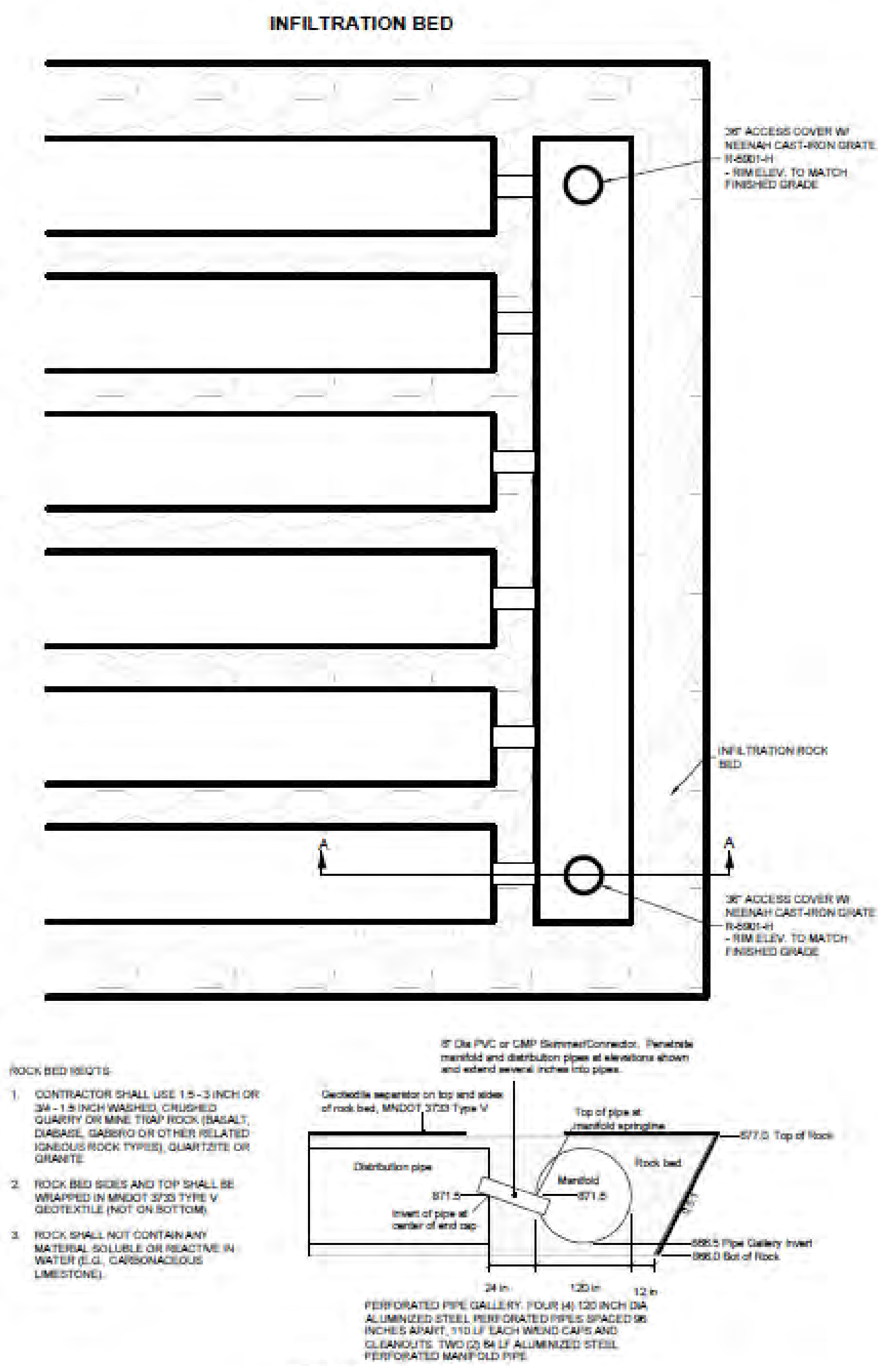
Infiltration Gallery

Infiltration Galleries are a variant of a subsurface infiltration system. There are many designs that use prefabricated storage cells, and others that improvise with standard pipes. The general premise is an underground series of open cavities (pipes/chambers) that can hold a substantial amount of runoff volume, and then infiltrate this volume into an open rock bed that the pipes are lain in. There is a pretreatment component to this cell that will collect gross solids in a separate chamber, allowing only clean water to pass into the chambers (prolonging the system's lifespan). There are multiple points for maintenance access, which will typically entail using a vacuum truck for cleanout operations on an annual schedule.

Typical Model Design

Since there is no conventional software that will model an underground infiltration system and all of its components precisely, a hybrid approach must be used. To model the system, the collective storage volumes of the pipes and the rock void spaces were calculated, and then entered into WinSLAMM as a Biofiltration Device. The collective pipes storage volume was entered as a ponding depth, and the collective rock volume was entered as a depth that underlay the ponding area. Due to limitations in how pipe and rock elevations can be entered into WinSLAMM, the top 2.6' of the rock cell was not calculated in the model and therefore the pollution reduction numbers may be conservative. A surface discharge pipe was entered at 24". The Native Soil Infiltration Rate was entered at 1" per hour, based on the findings of the soil borings at the project location. See below for model inputs and typical design layout.





SECTION A - A

01/11 UNDERGROUND INFILTRATION SYSTEM

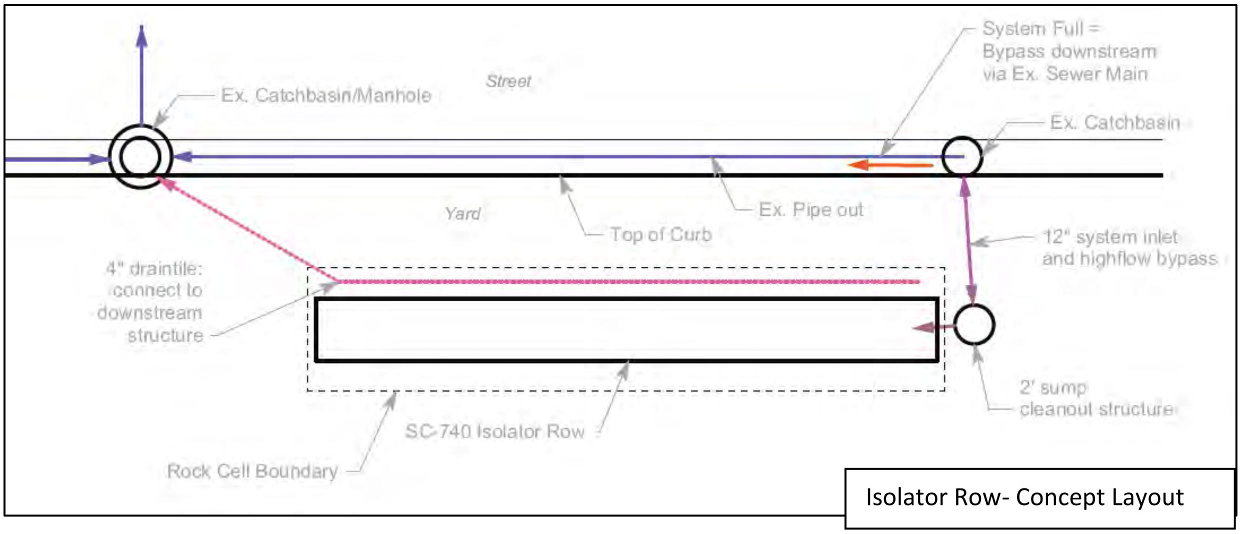
(No Scale)

3.1 Methods

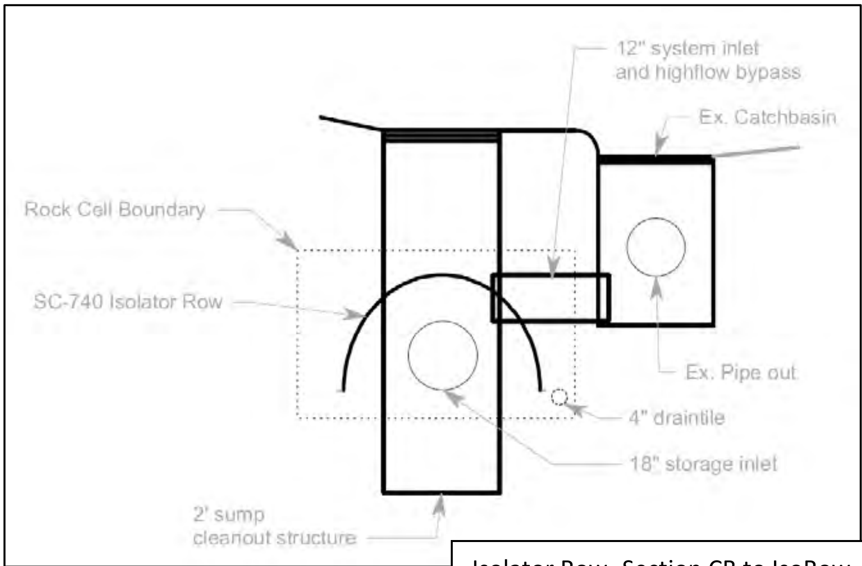
StormTech SC-740 Isolator Rows and Infiltration Chambers

Design Criteria

The StormTech Infiltration Chambers are an emerging product for underground volume control and pollutant treatment. They typically are designed as an offline system, where a high-flow bypass to an existing storm line is necessary. There are two components to the system: The Isolator Row (IsoRow), which captures the first flush of TSS; and the Infiltration Cells (Volume Cells), which can be sized to any target storm event for volume control or infiltration needs. The Isolator Rows (used as a standalone product, without the Volume Cells) have recently been tested and verified by multiple entities as a feasible practice for TSS treatment that outperforms catchbasin sump retrofits. This is due to its ability to infiltrate water from the Isolator Row between rain events, creating a dry offline sump that limits the resuspension of solids during rain events. This study incorporates the standard design criteria per manufacturer specifications, while it scales back the claims for TSS reduction in order to give a more safe conservative pollution reduction estimate. See below for typical design of the SC-740 StormTech System (used for all design and sizing assumptions).



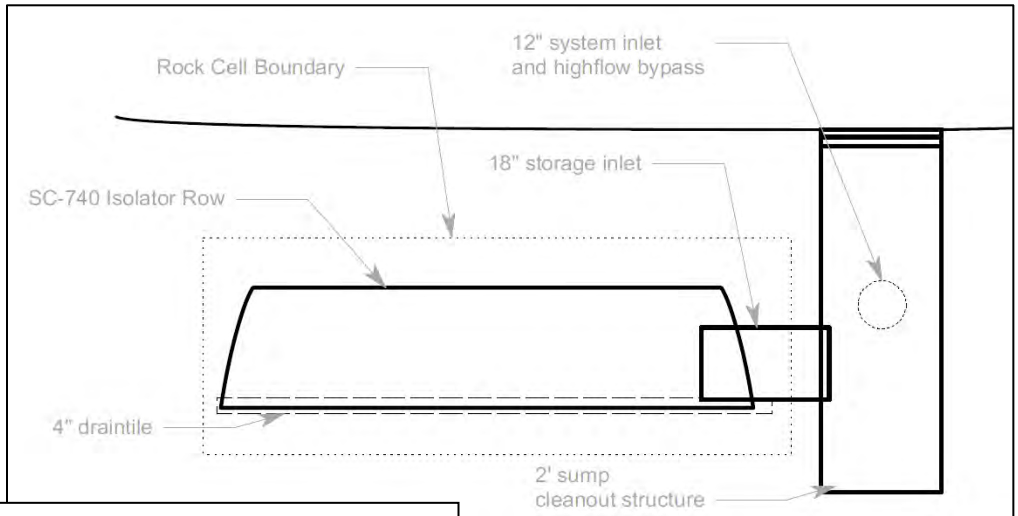
Isolator Row- Concept Layout



Isolator Row- Section CB to IsoRow

3.1 Methods

StormTech SC-740 Isolator Rows and Infiltration Chambers



Isolator Row- Section Cleanout to IsoRow

Model and Design Assumptions

The Saint Anthony Falls Laboratory recently reviewed test results from multiple organizations around the country that verify 70-95% TSS capture (depending on particle size distribution). For this report, we used a 85% TSS reduction as our MIDS Calculator model input (using "Other Device" in the model). This value allows for unforeseen variability in land cover, particle size distribution, maintenance practices, and system functionality.

Since the IsoRow inlet is fed from the bottom of the cell itself (for ease of cleanout), we assumed that a single row could reasonably hold about 50% of the inlet pipe depth before resuspension and backup issues occur. We chose an 18" inlet pipe to connect to the cell itself in order to maximize cell storage, although the inlet and high-flow bypass pipes are assumed to be 12" diameter to keep flow rates into the system under 2-3 cfs.

Catchment Profiles and Proposed BMP Summaries

Catchment – Pine Tree Trail

Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	14.7	6.4	44%	**8.30**
	TSS (lb/yr)	5,024	3,036.0	60%	**1988**
	Volume (acre-feet/yr)	7.88	1.8	23%	**6.10**
	BMP Type	Wet Pond			

EXISTING CATCHMENT SUMMARY

The Pine Tree Trail Catchment is 21.3 acres in size and is divided into two subcatchments. The western subcatchment is primarily woods and lawn with a small amount of impervious. This area all flows to the existing stormpond which overflows to the stormsewer and outlets to Lily Lake. The eastern half is primarily single family, medium density housing and has a higher than average impervious component. Native soils are classified as Urban Fill and infiltration rates vary from 0.1"-0.5" per hour, based on experience in the area.

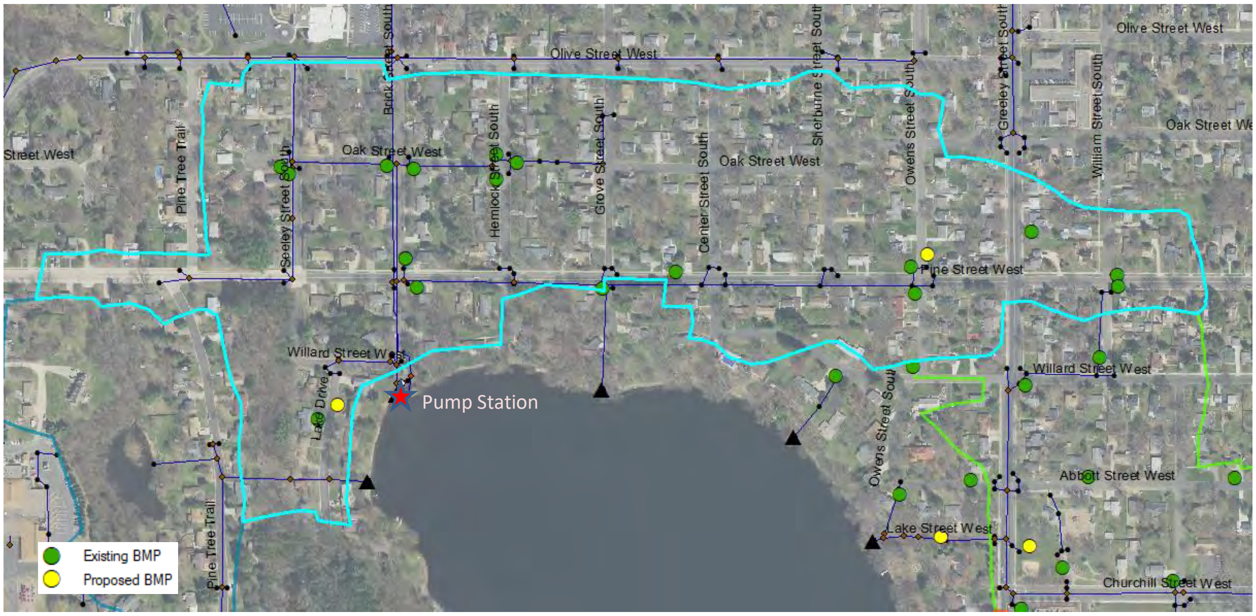
Targeted street sweeping of city streets and parking lots occur approximately twice annually. There are multiple small, natural depressions that add some volume storage for smaller rain events. The one large stormpond to the west of Pine Tree Trail is estimated to have 3' of dead storage and 1' of bounce with a 12" pipe outlet.

PROPOSED BMP SUMMARY

There is one Proposed BMP at 905 Pine tree Trail. It is a 300 sf Bioinfiltration Basin with a 4" underdrain that will be connected to the existing catchbasin. There is a gas line conflict with this basin footprint and coordination with the city and utility company will be necessary for relocation of the line.

Proposed Conditions		PROPOSED CONDITIONS		
		Proposed Load Reductions	Proposed Load Output	Percent Reduction
Treatment	TP (lb/yr)	0.72	7.58	9%
	TSS (lb/yr)	295	1693	15%
	Volume (acre-feet/yr)	0.43	5.67	7%
	BMP Type	1 curb cut raingarden		

Catchment – Pump Station



Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	55.2	10.5	7%	**44.67**
	TSS (lb/yr)	20,704	2,902.0	8%	**17802**
	Volume (acre-feet/yr)	31.40	0.1	0%	**31.34**
	BMP Type	14 curb cut raingardens, 3 isolator rows, 1 gallery			

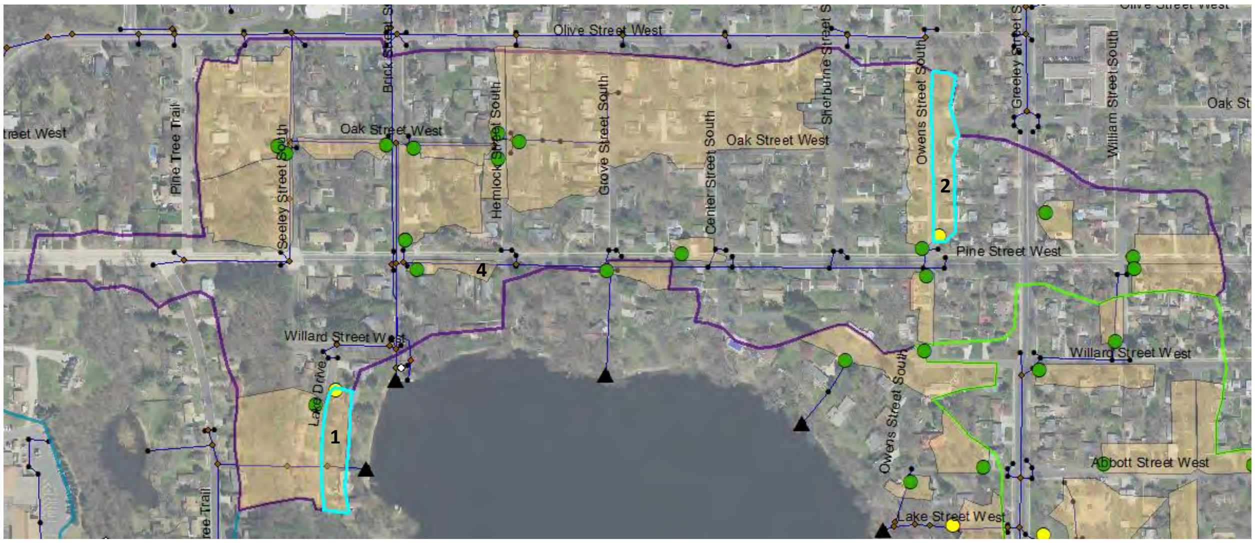
EXISTING CATCHMENT SUMMARY

The Pump Station Catchment is 66 acres in size was originally divided into two subcatchments in the previous subwatershed analysis. The two catchments were combined for this report since the monitoring data was taken from the outlet pipe near the pump station (after the two catchments join together in one pipe and outlet into Lily Lake). The land cover is fairly homogenous as medium density residential. The canopy is mature and the soils are all classified as Urban Fill. The general infiltration rate is 0.2”-0.5” per hour.

Targeted street sweeping of city streets and parking lots occur approximately twice annually. There are multiple small, natural depressions that add some volume storage for smaller rain events. There are 15 existing curb-cut raingardens and Stormtech Isolator Rows that exist in the neighborhood that have been installed at various points within the past 10 years. Their load reductions have been factored into the modelling of the existing conditions.

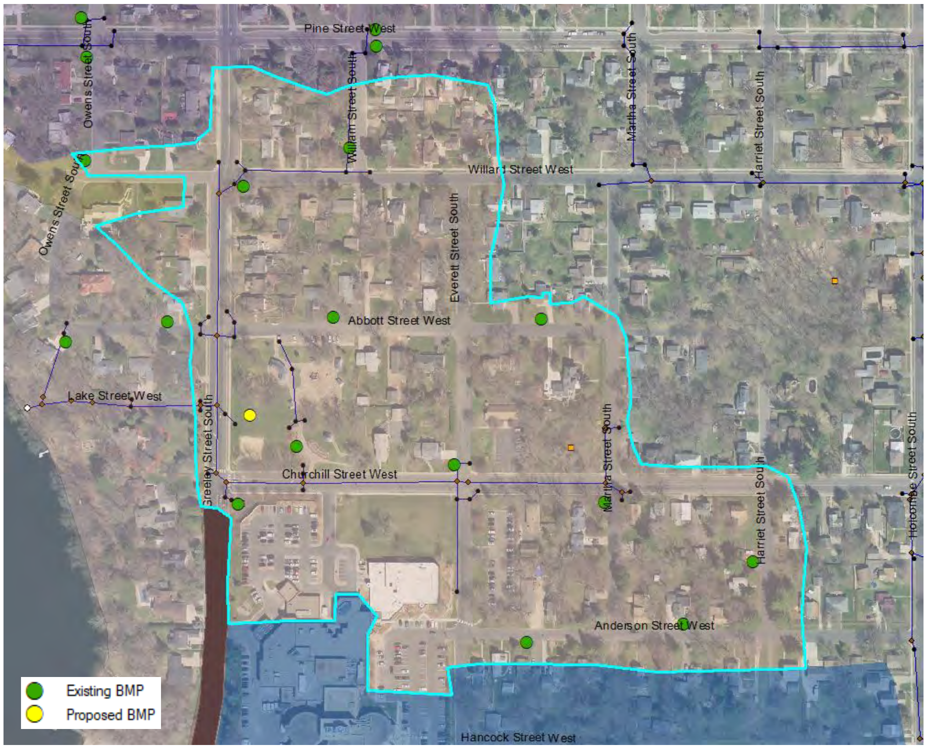
PROPOSED BMP SUMMARY

There are 2 Proposed BMPs. Practice 1 is a 300 sf Curb-cut Infiltration Basin with an underdrain and 12" ponding depth (612 Lake Drive). Practice 2 is a 400 sf Curb-cut Infiltration Basin with an underdrain and 12" ponding depth (1014 Owens St S).



Proposed Conditions		PROPOSED CONDITIONS		
		Proposed Load Reductions	Proposed Load Output	Percent Reduction
Treatment	TP (lb/yr)	2.15	42.52	5%
	TSS (lb/yr)	936	16866	5%
	Volume (acre-feet/yr)	0.92	30.42	3%
	BMP Type	2 Raingardens		

Catchment – Lake Street



Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	29.0	3.1	11%	**25.90**
	TSS (lb/yr)	12,198	1,338.0	11%	**10860**
	Volume (acre-feet/yr)	20.01	0.9	4%	**19.11**
	BMP Type	10 Curb Cut Raingardens, 2 Infiltration basins			

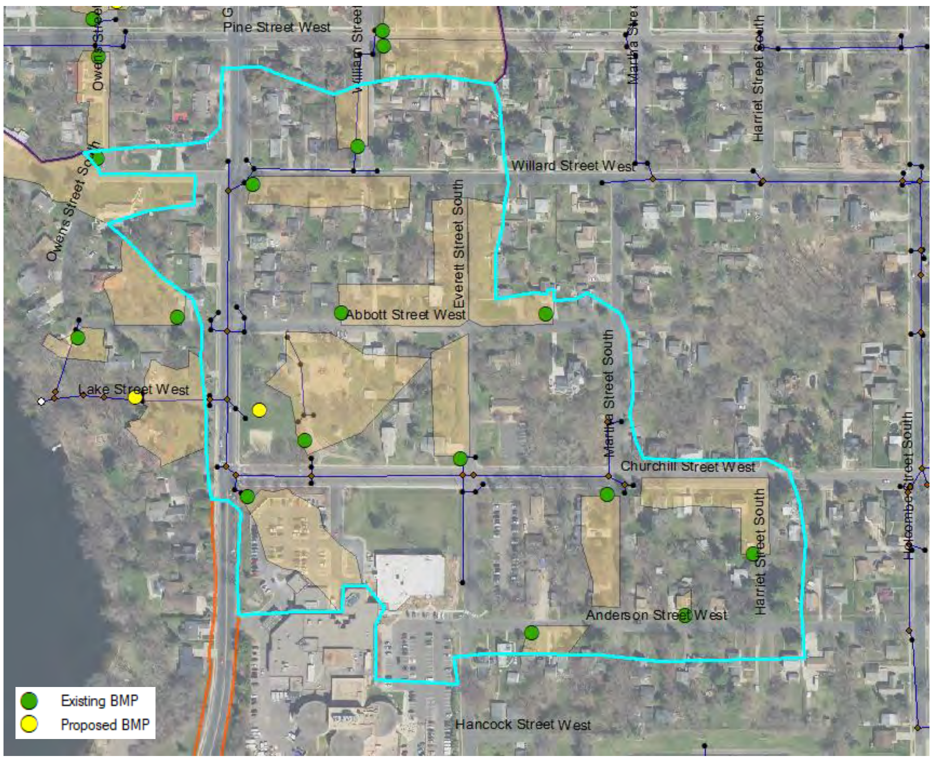
EXISTING CATCHMENT SUMMARY

The Lake Street Catchment is 33.3 acres in size. It is primarily composed of single family, medium density housing and has a higher than average impervious component. There is a hospital that gets some treatment before leaving the property and there is a larger infiltration basin in Washington Park.

Targeted street sweeping of city streets and parking lots occur approximately twice annually. There are multiple small and large natural depressions that add some volume storage for smaller rain events. There are also 10 existing curb-cut raingardens that exist in the neighborhood that have been installed at various points within the past 10 years. Their load reductions have been factored into the modelling of the existing conditions.

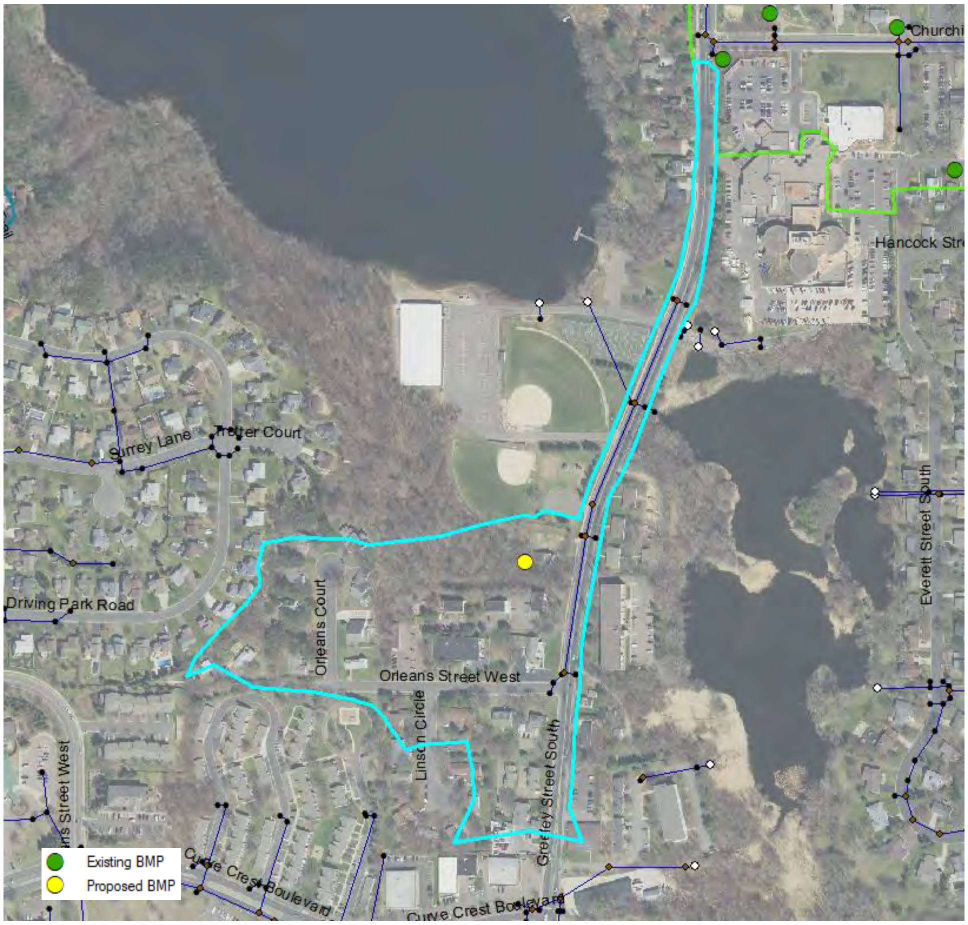
PROPOSED BMP SUMMARY

Two BMPs are proposed for this catchment. There is one proposed BMP at Washington Park. It is a 9,600 sf underground infiltration gallery that takes flow from 99% of the catchment. The system is designed to take low flows, while higher flows bypass to Lily Lake. The overall benefit of this practice will be to disconnect the entire catchment from the lake during all rain events less than 1.1 inches. The overall load reduction will be over 20 lbs. of TP per year, and will capture over 4 tons of sediment annually. The other BMP is a 400 sf infiltration basin at the end of Lake Street West. While this BMP is technically in the 'Direct Drainage' Catchment, it is being incorporated into the Lake St Catchment since its flow will combine with the Lake Street outlet before it enters Lily Lake. This BMP has a 0.63 lb/yr TP reduction.



Proposed Conditions		PROPOSED CONDITIONS		
		Proposed Load Reductions	Proposed Load Output	Percent Reduction
Treatment	TP (lb/yr)	20.71	5.19	80%
	TSS (lb/yr)	9615	1245	89%
	Volume (acre-feet/yr)	16.69	2.42	87%
	BMP Type	1 Infiltration Gallery, 1 Raingarden		

Catchment – Greeley Storm



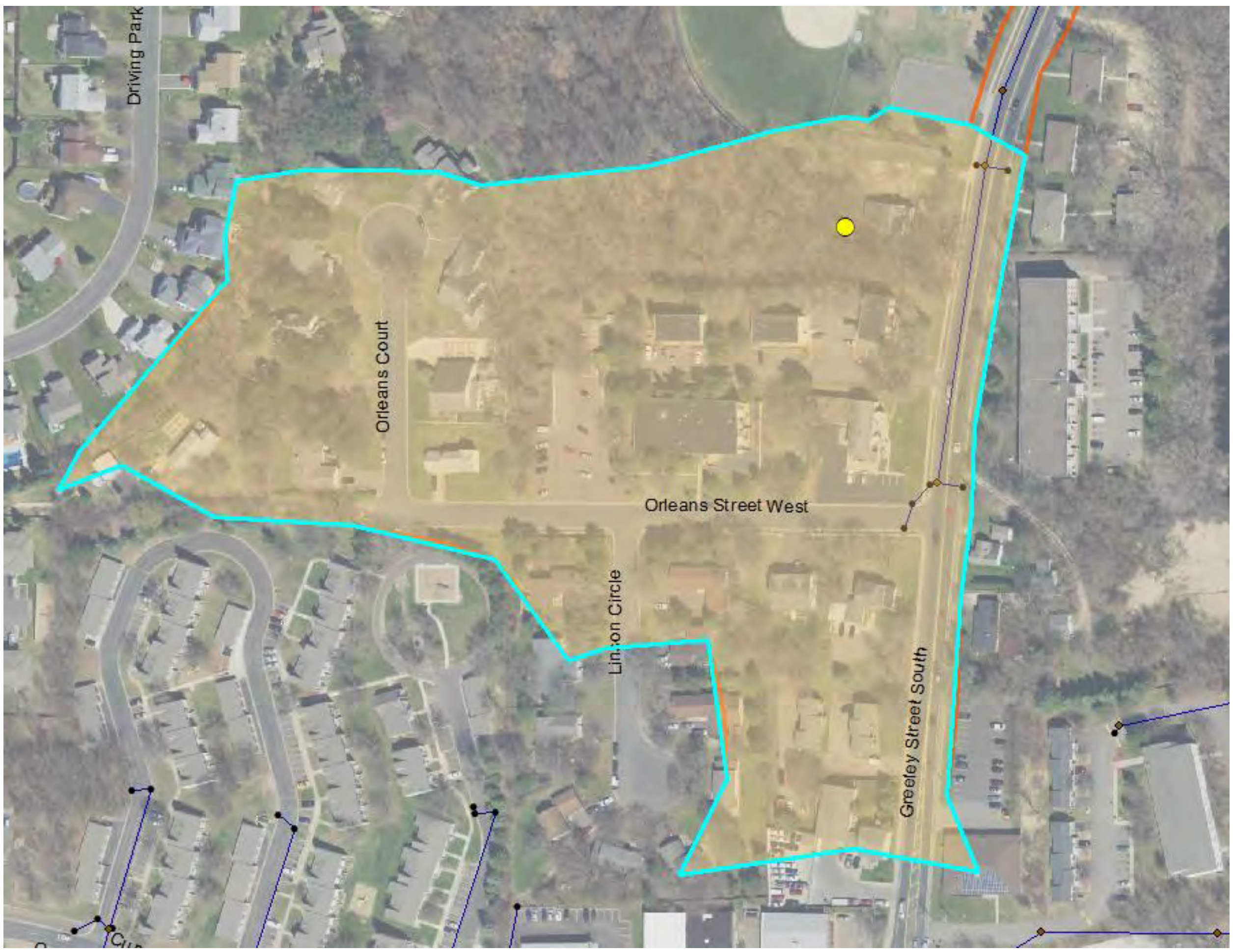
Existing Conditions		EXISTING CONDITIONS			
		Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	33.2	0.0	0%	**33.23**
	TSS (lb/yr)	5,968	0.0	0%	**9060**
	Volume (acre-feet/yr)	12.76	0.0	0%	**12.76**
	BMP Type	None			

EXISTING CATCHMENT SUMMARY

The Greeley Storm Catchment is 17.3 acres in size. The southern bulk of the catchment flows down Greeley Ave and combines with the overflow from Brick Pond (emptying into Lily Lake). This is a very 'flashy' catchment since the average slopes are often very steep. This contributes to the high loading that has been seen in the monitoring data from 2015 and 2016. Targeted street sweeping of city streets and parking lots occur approximately twice annually. There are no other notable practices that reduce pollutant loading to Lily Lake.

PROPOSED BMP SUMMARY

The proposed Infiltration Basin will be situated on the south edge of the park (after removal of the old structures). All flow will be diverted from Greeley Ave into the basin, and overflows will be via a separate overflow structure that routes remaining runoff back into the existing storm system. Native soils are a sandy gravel and should infiltrate in excess of 2.5” per hour. The average ponding depth is 24” (set by the overflow structure), but the emergency overflow depth of the basin is set at 3.4’. There will be 1.4’ of additional treatment volume available before the basin overflows. The WinSLAMM model shows that this 14,000 sf basin will capture rain events in excess of 2.4 inches and should perform well in even larger events.



Proposed Conditions		PROPOSED CONDITIONS		
		Proposed Load Reductions	Proposed Load Output	Percent Reduction
Treatment	TP (lb/yr)	30.18	3.05	91%
	TSS (lb/yr)	8257	803	91%
	Volume (acre-feet/yr)	11.50	1.26	90%
	BMP Type	Large Infiltration Basin at park		