Stonybrook Stormwater Retrofit Analysis

Prepared for the Coon Creek Watershed District

by the Anoka Conservation District

Funding provided in part by the Clean Water Fund from the Clean Water, Land, and Legacy Amendment

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Cover photo: The most upstream, open-channel section of Stonybrook located east of East River Road and west of the railroad tracks in the City of Fridley. The photo was taken facing downstream near the railroad tracks.

Table of Contents

List of Figures

List of Tables

Executive Summary

The Coon Creek Watershed District (CCWD) contracted the Anoka Conservation District (ACD) to complete this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects in the Stonybrook subwatershed. The Stonybrook subwatershed is located in the Cities of Fridley and Spring Lake Park and ultimately discharges to the Mississippi River. The CCWD specified volume reduction as a goal throughout the subwatershed given the well-documented history of stormwater drainage issues and flooding. The intent of this goal is for use in judging the overall impact of implementing BMPs in the study area.

This analysis is primarily intended to identify potential projects within the target area to reduce flooding throughout the subwatershed and improve water quality in the Mississippi through stormwater retrofits. Stormwater retrofits refer to best management practices (BMPs) that are added to an already developed landscape where little open space exists. The process is investigative and creative. Stormwater retrofits can be improperly judged by the total number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this SRA, both costs and pollutant reductions were estimated and used to calculate cost effectiveness for each potential retrofit identified.

Water quality benefits associated with the installation of each identified project were individually modeled using the Source Loading and Management Model for Windows (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 has detailed accounting of pollutant loading from various land uses, and allows the user to build a model “landscape”. WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user’s model for each storm.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Soils throughout the study area were classified as either sand or silt based on available soils information. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A.

The costs associated with project design, administration, promotion, land acquisition, opportunity costs, construction oversight, installation, and maintenance were estimated. The total costs over the assumed effective life of each project were then divided by the modeled benefits over the same time period to enable ranking by cost-effectiveness.

A variety of stormwater retrofit approaches were identified. They included:

- Bioretention,
- New stormwater pond opportunities or modification to an existing pond,
- Hydrodynamic separators, and
- Underground storage.

If all of the identified practices were installed, significant volume and pollutant reductions could be accomplished. However, funding limitations and landowner interest make this goal unlikely. Instead, it is recommended that projects be 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.

For each type of recommended retrofit, conceptual siting is provided in the project profiles section. The intent of these figures is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. In addition, many of the proposed retrofits (e.g. new ponds) will require engineered plan sets if selected. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners, both public and private.

Areas that drain to Stonybrook were delineated using available GIS subwatershed information and maps of stormwater conveyance features. Those areas were then divided into six smaller stormwater drainage areas, or catchments. Catchments were further divided into 50 subcatchments for modeling purposes. Base and existing conditions were modeled, including existing stormwater treatment practices. The total subwatershed analyzed for this project consisted of 914 acres, which based on WinSLAMM model results contribute an estimated 582 acre-feet of runoff, 573 pounds of phosphorus, and 207,517 pounds of total suspended solids annually to Stonybrook and subsequently the Mississippi River.

The tables in the Project Ranking and Selection section (pages 17 - 25) summarize potential projects ranked by cost effectiveness with respect to volume, TP, or TSS. Potential projects are organized from most cost effective to least based on volume or pollutant removed.

Installation of projects in series will result in lower total treatment than the simple sum of treatment achieved by the individual projects due to treatment train effects. Reported treatment levels are dependent upon optimal site selection and sizing. More detail about each project can be found in the catchment profile pages of this report. Projects that were deemed unfeasible due to prohibitive size, number, or expense were not included in this report.

Document Organization

This document is organized into five sections, plus references and appendices. Each section is briefly discussed below.

Background

The background section provides a brief description of the landscape characteristics within the study area.

Analytical Process and Elements

The analytical process and elements section overviews the procedures that were followed when analyzing the subwatershed. It explains the processes of retrofit scoping, desktop analysis, field investigation, modeling, cost/treatment analysis, project ranking, and project selection. Refer to Appendix A for additional detail on modeling methodology.

Project Ranking and Selection

The project ranking and selection section describes the methods and rationale for how projects were ranked. Local resource management professionals will be responsible to select and pursue projects, taking into consideration the many possible ways to prioritize projects. Several considerations in addition to project cost-effectiveness for prioritizing installation are included. Project funding opportunities may play a large role in project selection, design, and installation.

This section also ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by the amount of volume or pollutant removed by each project over 30 years. The final cost per unit treatment value includes installation and maintenance costs over the estimated life of the project. If a practice's effective life was expected to be less than 30 years, rehabilitation or reinstallation costs were included in the cost estimate. There are many possible ways to prioritize projects, and the lists provided in this report are merely a starting point.

BMP Descriptions

For each type of project included in this report, there is a description of the rationale for including that type of project, the modeling method employed, and the cost calculations used to estimate associated installation and maintenance expenses.

Catchment Profiles

The Stonybrook subwatershed was divided into six stormwater catchments which were assigned a unique identification number (i.e. ST-1 through ST-6) and further subdivided into 50 subcatchments for modeling purposes. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads under existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from the Cities of Spring Lake Park and Fridley. Small, site-specific practices (e.g. rain-leader disconnect rain gardens) were not included in the existing conditions model. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described in this section. Notable existing stormwater practices are explained, and their estimated effectiveness presented.

Potential Retrofits

Potential retrofits are presented for each catchment and include a description of the proposed BMP, cost effectiveness table including modeled volume and pollutant reductions, and an overview map showing the contributing drainage area for each BMP.

References

This section identifies various sources of information synthesized to produce the protocol used in this analysis.

Appendices

This section provides supplemental information and/or data used during the analysis.

Background

Many factors are considered when choosing which subwatershed to analyze for stormwater retrofits. Water quality monitoring data, non-degradation report modeling, and TMDL studies are just a few of the resources available to help determine which water bodies are a priority. Stormwater retrofit analyses supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the process also rank highly. For some communities a stormwater retrofit analysis complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

The Stonybrook subwatershed has been significantly altered from its natural condition. Begun first by farmers, then followed by urban developers, Stonybrook has been altered, channelized, and finally paved over and piped through much of its headwaters. Historical aerials dating back to the 1930's show an entirely agrarian society, with a large wetland complex in the western portion of the watershed and sand dunes to the east. At that time many of the historic wetlands were still intact, with exception to the Stonybrook stream corridor, which had already been drained and ditched.

Development in the area began in the 1940's and 1950's. By the 1970's, only the wetland complex between University Avenue and the Burlington Northern railroad tracks remained undeveloped. In time, the watershed would become completely developed, storm sewer pipes would be installed, and only the channel west of the railroad tracks would remain of the original creek.

The present-day Stonybrook watershed is bounded by Highway 10 to the northeast, Highway 65 to the east, and Osborne Road to the south. Stormwater generated within the subwatershed has very limited overland flow or storage. Most stormwater is intercepted quickly into stormwater catch basins and conveyed to a 72" storm sewer pipe draining from 78th Way, under the railroad tracks, and into the open channel east of East River Road. The open stream channel only extends about 200 yards to East River Road, where it is piped again for 175 yards, then is discharged back into another open channel prior to the stream's confluence with the Mississippi River (additional 125 yards).

Relatively recent rainfall events (July 16th and August 16th 2011) have overwhelmed the stormwater infrastructure near its confluence with the railroad tracks in the City of Fridley (i.e. near the intersection of 78th Way NE and Hickory St. NE) and resulted in street flooding and property damage. Previous hydrologic analysis has identified potential improvement options to increase the capacity of this system to convey stormwater runoff. More specifically, a drainage analysis completed of the Stonybrook subwatershed by WSB & Associates, Inc. for the City of Fridley in 2013 (WSB & Associates, Inc., 2013) determined that approximately 22 acre-feet of stormwater storage is needed to reduce flood potential within the industrial park near the intersection of Beech St. NE and 78th Way NE. However, potential upstream infiltration practices that could reduce volume or water quality improvement projects were not assessed. Therefore, volume reduction was identified by the CCWD as a priority. This SRA identifies and ranks cost effective volume reduction and water quality improvement projects throughout the Stonybrook subwatershed.

Stormwater runoff from impervious surfaces can carry a variety of pollutants. While stormwater treatment to remove these pollutants is adequate in some areas, many other areas were built prior to modern-day stormwater treatment technologies and requirements. This SRA is intended to identify potential projects throughout the Stonybrook subwatershed to reduce volume and pollutants associated with stormwater runoff.

The CCWD contracted the ACD to complete this SRA for the purpose of identifying and analyzing projects to reduce the volume and improve the quality of stormwater runoff from the Stonybrook subwatershed. Overall subwatershed loading of TP, TSS, and stormwater volume were estimated for subdivided drainage areas within the subwatershed. Potential retrofits were modeled to estimate each practice's capability for removing pollutants and reducing volume. Finally, each project was ranked based on the estimated cost effectiveness of the project to reduce volume or pollutants.

Analytical Process and Elements

This stormwater retrofit analysis is a watershed management tool to identify and prioritize potential stormwater retrofit projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent. The process used for this analysis is outlined in the following pages and was modified from the Center for Watershed Protection's Urban Stormwater Retrofit Practices, Manuals 2 and 3 (Schueler & Kitchell, 2005 and Schueler et al. 2007). Locally relevant design considerations were also incorporated into the process (Technical Documents, Minnesota Stormwater Manual, 2014).

Scoping includes determining the objectives of the retrofits (volume reduction, target pollutant, etc.) and the level of treatment desired. It involves meeting with local stormwater managers, city staff and watershed management organization members to determine the issues in the subwatershed. This step also helps to define preferred retrofit treatment options and retrofit performance criteria. In order to create a manageable area to analyze in large subwatersheds, a focus area may be determined.

In this analysis, the focus area was all areas that drain to Stonybrook and ultimately discharge to the Mississippi River. Included are areas of residential, commercial, industrial, and institutional land uses. The subwatershed was divided into six catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

The targeted pollutants for this study were volume, TP and TSS. Volume of stormwater was tracked throughout this study because it is necessary for pollutant loading calculations and potential retrofit project considerations. Table 1 describes the target pollutants and their role in water quality degradation. Projects that effectively reduce loading of multiple target pollutants can provide greater immediate and long-term benefits.

Table 1: Target Pollutants

Target Pollutant	Description
Total Phosphorus (TP)	Phosphorus is a nutrient essential to plant growth and is commonly the factor that limits the growth of plants in surface water bodies. TP is a combination of particulate phosphorus (PP), which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
Total Suspended Solids (TSS)	Very small mineral and organic particles that can be dispersed into the water column due to turbulent mixing. TSS loading can create turbid and cloudy water conditions and carry with it PP. As such, reductions in TSS will also result in TP reductions.
Volume	Higher runoff volumes and velocities can carry greater amounts of TSS to receiving water bodies. It can also exacerbate in-stream erosion, thereby increasing TSS loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading.

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 analyzed because of existing stormwater infrastructure or disconnection from the target water body. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS layers include: 2-foot or finer topography (Light Detection and Ranging [LiDAR] was used for this analysis), surface hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the stormwater drainage infrastructure (with invert elevations).

Field investigation is conducted after potential retrofits are identified in the desktop analysis to evaluate each site and identify additional opportunities. During the investigation, the drainage area and surface stormwater infrastructure mapping data are verified to the maximum extent practicable. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

Modeling involves assessing multiple scenarios to estimate pollutant loading and potential reductions by proposed retrofits. The newest version of WinSLAMM (version 10.1.1), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis because of the unique connectivity amongst the catchments identified in the Stonybrook subwatershed. Areas throughout the subwatershed are routed through multiple catchments before being discharged to the Mississippi River. This creates a network of stormwater treatment. Therefore, estimated volume and pollutant loads to the Mississippi River from any given catchment must take into consideration other treatment practices within the same network.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Specific model inputs (e.g. pollutant probability distribution, runoff coefficient, particulate solids concentration, particle residue delivery, and street delivery files) are detailed in Appendix A.

The initial step was to create a “base” model which estimates pollutant loading from each catchment in its present-day state without taking into consideration any existing stormwater treatment. To accurately model the land uses in each catchment, drainage area delineations were completed using GIS. The drainage areas were consolidated into six catchments using geographic information systems (specifically, ArcMap). Catchments were further subdivided into subcatchments for modeling purposes. Land use data (based on 2010 Metropolitan Council land use file) were used to calculate acreages of each land use type within each catchment. Soil types throughout the subwatershed were modeled as both sand and silt based on available soils information. 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.

Once the “base” model was established, an “existing conditions” model was created by incorporating notable existing stormwater treatment practices in the catchment for which data was available from the Cities of Spring Lake Park and Fridley (Figure 1). For example, street cleaning with mechanical or vacuum street sweepers, stormwater treatment ponds, and others were included in the “existing conditions” model if information was available.

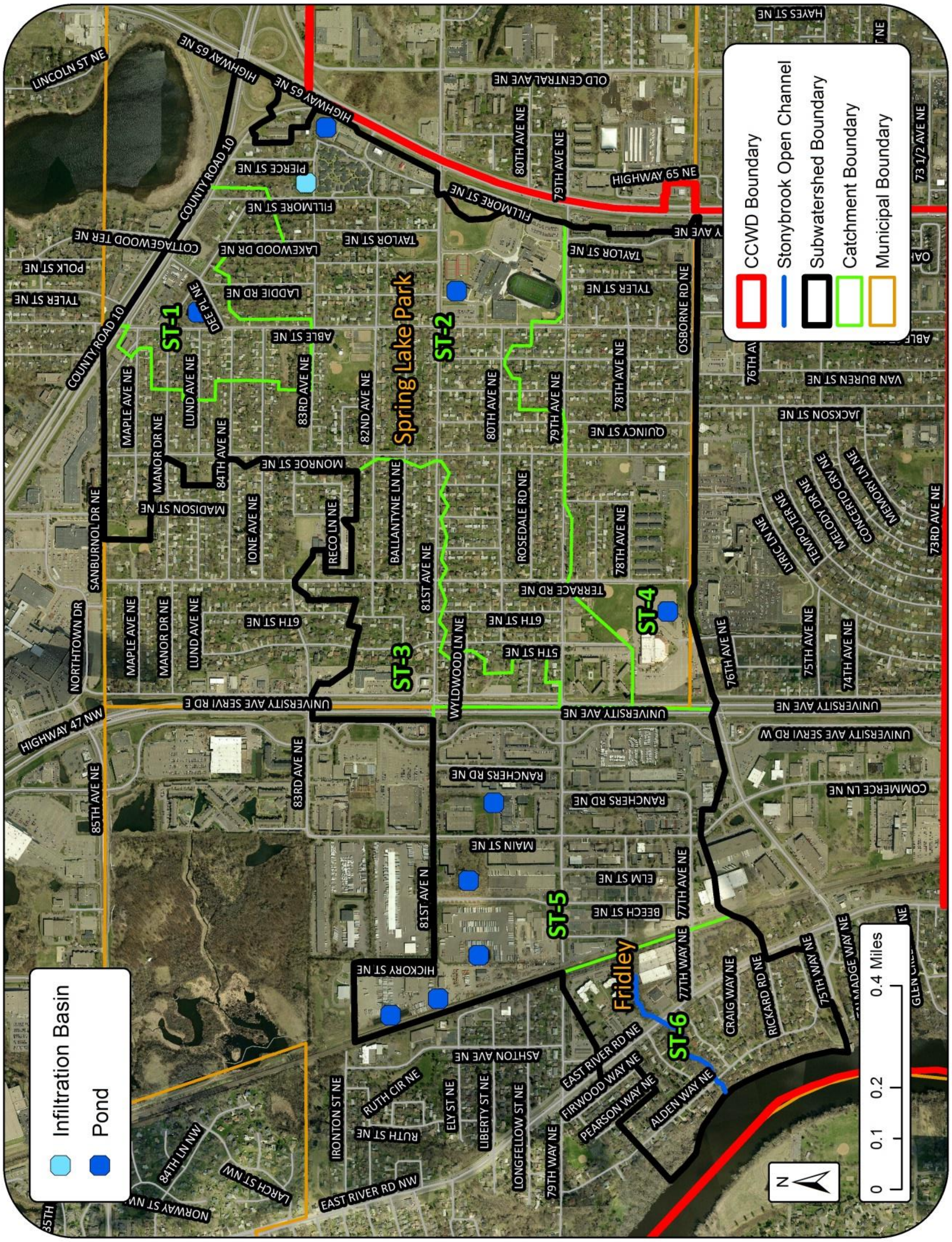


Figure 1: Subwatershed-wide map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the subwatershed.

Finally, each potential stormwater retrofit practice was added individually to the "existing conditions" model and pollutant reductions were estimated. 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. It is worth noting that each practice was modeled individually, and the benefits of projects may not be additive, especially if serving the same area (i.e. treatment train effects). Reported treatment levels are dependent upon optimal site selection and sizing. Additional information on the WinSLAMM models can be found in Appendix A.

Cost estimating is essential for the comparison and ranking of projects, development of work plans, and pursuit of grants and other funds. All estimates were developed using 2014 dollars. Costs throughout this report were estimated using a multitude of sources. Costs were derived from The Center for Watershed Protection's Urban Subwatershed Restoration Manuals (Schueler & Kitchell, 2005 and Schueler et al. 2007), recent installation costs, and cost estimates provided to the ACD by personal contacts. Cost estimates were annualized costs that incorporated the elements listed below over a 30-year period.

Project promotion and administration includes local staff efforts to reach out to landowners, administer related grants, and complete necessary administrative tasks.
Design includes site surveying, engineering, and construction oversight.
Land or easement acquisition cover the cost of purchasing property or the cost of obtaining necessary utility and access easements from landowners.
Construction calculations are project specific and may include all or some of the following; grading, erosion control, vegetation management, structures, mobilization, traffic control, equipment, soil disposal, and rock or other materials.
Maintenance includes annual inspections and minor site remediation such as vegetation management, structural outlet repair and cleaning, and washout repair.

In cases where promotion to landowners is important, such as rain gardens, those costs were included as well. In cases where multiple, similar projects are proposed in the same locality, promotion and administration costs were estimated using a non-linear relationship that accounted for savings with scale. 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 retrofit analysis, and therefore cost estimates account for only general site considerations.

Project ranking is essential to identify which projects may be pursued to achieve water quality goals. Project ranking tables are presented based on acre-feet of volume reduced, cost per pound of TP removed, and cost per 1,000 pounds of TSS removed.

Project selection involves considerations other than project ranking, including but not limited to total cost, treatment train effects, social acceptability, and political feasibility.

Project Ranking and Selection

The intent of this analysis is to provide the information necessary to enable local natural resource managers to successfully secure funding for the most cost-effective projects to achieve water quality goals. This analysis ranks potential projects by cost-effectiveness to facilitate project selection. There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Local resource management professionals will be responsible to select projects to pursue. Several considerations in addition to project cost-effectiveness for prioritizing installation are included.

Project Ranking

If all identified practices were installed (Figure 2), significant pollution reduction could be accomplished. However, funding limitations and landowner interest will be a limiting factor in implementation. The tables on the following pages rank all modeled projects by cost-effectiveness.

Projects were ranked in three ways:

1) Cost per acre-foot of volume reduced (Table 2 - Table 4),
2) Cost per pound of total phosphorus removed (Table 5 - Table 7), and
3) Cost per 1,000 pounds of total suspended solids removed (Table 8 - Table 10).

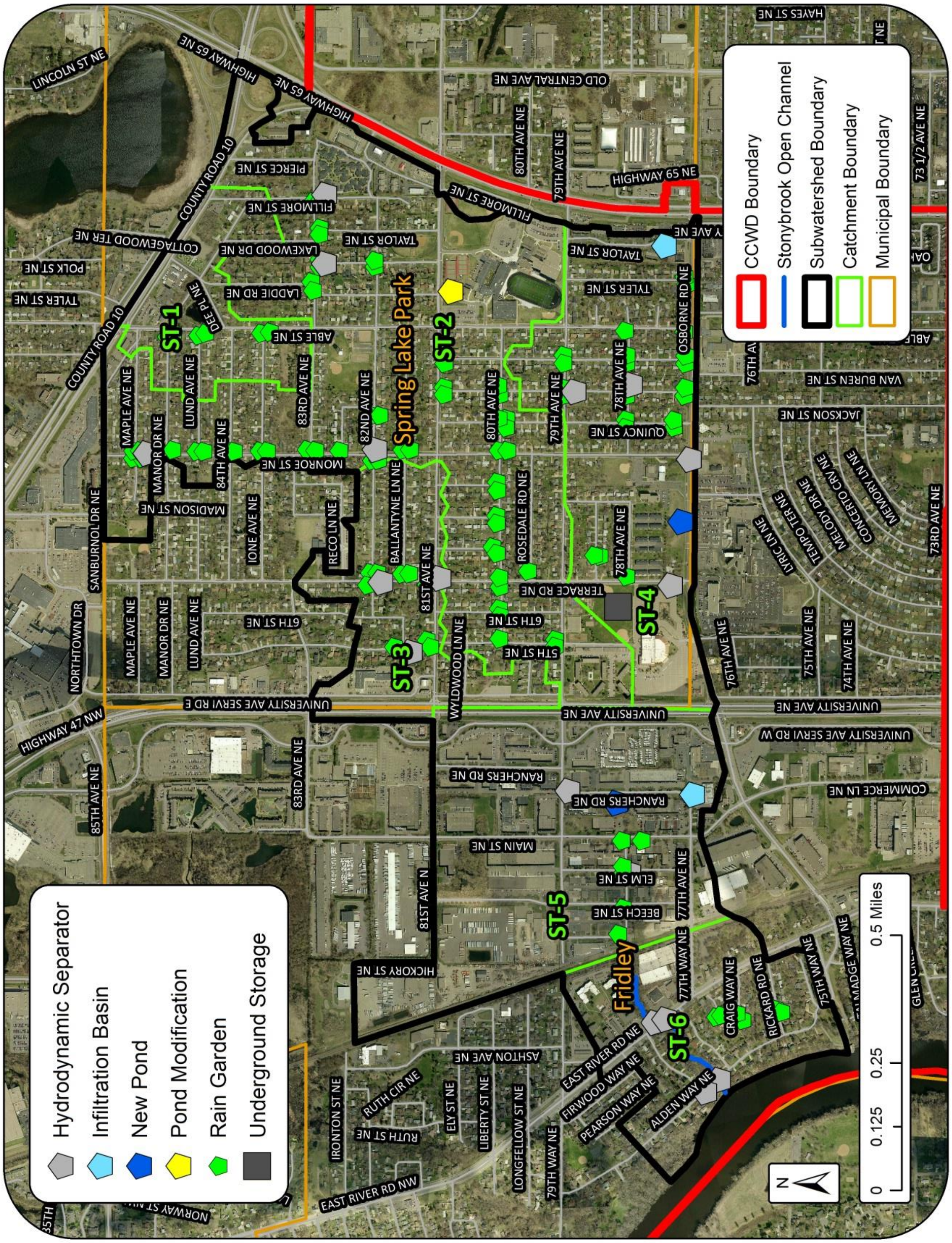


Figure 2: Subwatershed-wide map showing all proposed retrofits included in this report.

Table 2: Cost-effectiveness of retrofits with respect to volume reduction. Projects 1 - 10. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
1	5-E	74	Infiltration Basin	77th Way NE and Ranchers Rd. NE	ST-5	2.8	1,569	3.5	$41,296	$780	$614
2	4-G	67	Infiltration Basin	North of Osborne Rd. NE and Taylor St. NE	ST-4	2.8	956	3.2	$37,546	$780	$641
3	5-C	72	Curb-Cut Rain Gardens (1, 3, or 5)	Subcatchment South5-DD17	ST-5	0.8 - 3.4	464 - 1,952	0.87 - 3.63	$15,844 - $48,852	$225 - $1,125	$756 - $864
4	2-H	49	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment West1-DD4	ST-2	3.6 - 9.6	1,128 - 2,978	2.82 - 7.46	$40,600 - $106,616	$900 - $2,700	$798 - $838
5	4-E	65	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment East1-DD7	ST-4	3.3 - 8.7	1,126 - 2,963	2.80 - 7.37	$40,600 - $106,616	$900 - $2,700	$804 - $849
6	2-G	48	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East3-DD1	ST-2	1.6 - 4.1	571 - 1,525	1.47 - 3.90	$24,096 - $57,104	$450 - $1,350	$825 - $853
T7	2-E	46	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment North1-DD	ST-2	3.4 - 8.7	1,106 - 2,836	2.69 - 6.89	$40,600 - $106,616	$900 - $2,700	$839 - $908
T7	3-E	58	Curb-Cut Rain Gardens (1, 2, or 3)	Subcatchment West1-DD6	ST-3	1.0 - 2.7	380 - 1,013	0.80 - 2.09	$15,844 - $32,348	$225 - $675	$839 - $938
9	2-F	47	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East4-DD3	ST-2	1.9 - 4.9	582 - 1,535	1.40 - 3.67	$24,096 - $57,104	$450 - $1,350	$876 - $895
10	3-D	57	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment East1-DD5	ST-3	0.9 - 3.2	303 - 1,037	0.74 - 2.48	$15,844 - $40,600	$225 - $900	$909 - $1,025

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 3: Cost-effectiveness of retrofits with respect to volume reduction. Projects 11 - 20. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
11	1-A	39	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment WP1	ST-1	0.9 - 2.3	185 - 490	1.35 - 3.42	$24,096 - $57,104	$450 - $1,350	$926 - $951
12	6-F	82	Curb-Cut Rain Gardens (1 or 2)	Subcatchment South3-DD22	ST-6	0.8 - 1.5	269 - 485	0.64 - 1.17	$15,844 - $24,096	$225 - $450	$1,070 - $1,171
13	6-E	81	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment South2-DD20	ST-6	0.8 - 2.5	265 - 776	0.64 - 1.86	$15,844 - $40,600	$225 - $900	$1,114 - $1,211
14	2-J	51	Underground Storage	Terrace Park	ST-2	45.1	15,723	28.2	$884,246	$2,000	$1,115
T15	2-A	42	Hydrodynamic Device	Maple Ave. NE and Monroe St. NE	ST-2	0.9	377	0.0	$109,752	$840	N/A
T15	2-B	43	Hydrodynamic Device	82nd Ave. NE and Monroe St. NE	ST-2	0.6	235	0.0	$109,752	$840	N/A
T15	2-C	44	Hydrodynamic Device	83rd Ave. NE and Fillmore St. NE	ST-2	0.9	432	0.0	$109,752	$840	N/A
T15	2-D	45	Hydrodynamic Device	83rd Ave. NE and Polk St. NE	ST-2	0.6	237	0.0	$109,752	$840	N/A
T15	2-I	50	Pond Modification	Spring Lake Park High School Pond	ST-2	1.1	495	0.0	$17,460	$0	N/A
T15	3-A	54	Hydrodynamic Device	82nd Ave. NE and Terrace Rd. NE	ST-3	0.9	369	0.0	$109,752	$840	N/A

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 4: Cost-effectiveness of retrofits with respect to volume reduction. Projects 21 - 34. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
T15	3-B	55	Hydrodynamic Device	81st Ave. NE and Terrace Rd. NE	ST-3	0.4	164	0.0	$55,752	$840	N/A
T15	3-C	56	Hydrodynamic Device	Ballantyne Ln. NE and 5th St. NE	ST-3	0.8	296	0.0	$109,752	$840	N/A
T15	4-A	61	Hydrodynamic Device	79th Ave. NE and Jackson St. NE	ST-4	0.6	247	0.0	$109,752	$840	N/A
T15	4-B	62	Hydrodynamic Device	78th Ave. NE and Jackson St. NE	ST-4	0.4	159	0.0	$55,752	$840	N/A
T15	4-C	63	Hydrodynamic Device	Osborne Rd. NE and Monroe St. NE	ST-4	0.7	251	0.0	$109,752	$840	N/A
T15	4-D	64	Hydrodynamic Device	Osborne Rd. NE and Terrace Rd. NE	ST-4	1.6	634	0.0	$109,752	$840	N/A
T15	4-F	66	New Pond	North of Osborne Rd. west of Monroe St.	ST-4	26.5	11,031	0.0	$653,008	$1,341	N/A
T15	5-A	70	Hydrodynamic Device	79th Ave. NE and Ranchers Rd. NE	ST-5	1.4	939	0.0	$109,752	$840	N/A
T15	5-B	71	Hydrodynamic Device	78th Ave. NE and Elm St. NE	ST-5	0.5	392	0.0	$55,752	$840	N/A
T15	5-D	73	New Pond	West of Ranchers Rd. south of 79th Ave.	ST-5	9.3	6,010	0.0	$391,267	$627	N/A
T15	6-A	77	Hydrodynamic Device	East River Rd. NE and Stonybrook (north)	ST-6	0.2	105	0.0	$28,752	$840	N/A
T15	6-B	78	Hydrodynamic Device	East River Rd. NE and Stonybrook (south)	ST-6	0.8	494	0.0	$109,752	$840	N/A
T15	6-C	79	Hydrodynamic Device	Craigbrook Way NE and Alden Way NE	ST-6	0.6	238	0.0	$109,752	$840	N/A
T15	6-D	80	Hydrodynamic Device	Stonybrook Way NE and Alden Way NE	ST-6	0.7	278	0.0	$109,752	$840	N/A

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 5: Cost-effectiveness of retrofits with respect to TP reduction. Projects 1 - 10. TSS and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
1	2-I	50	Pond Modification - Riser	Spring Lake Park High School Pond	ST-2	1.1	495	0.0	$17,460	$0	$529
2	2-H	49	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment West1-DD4	ST-2	3.6 - 9.6	1,128 - 2,978	2.82 - 7.46	$40,600 - $106,616	$900 - $2,700	$626 - $651
3	2-F	47	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East4-DD3	ST-2	1.9 - 4.9	582 - 1,535	1.40 - 3.67	$24,096 - $57,104	$450 - $1,350	$644 - $664
4	3-E	58	Curb-Cut Rain Gardens (1, 2, or 3)	Subcatchment West1-DD6	ST-3	1.0 - 2.7	380 - 1,013	0.80 - 2.09	$15,844 - $32,348	$225 - $675	$649 - $753
5	2-E	46	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment North1-DD	ST-2	3.4 - 8.7	1,106 - 2,836	2.69 - 6.89	$40,600 - $106,616	$900 - $2,700	$663 - $719
6	4-E	65	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment East1-DD7	ST-4	3.3 - 8.7	1,126 - 2,963	2.80 - 7.37	$40,600 - $106,616	$900 - $2,700	$683 - $719
7	2-J	51	Underground Storage	Terrace Park	ST-2	45.1	15,723	28.2	$884,246	$2,000	$698
8	3-D	57	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment East1-DD5	ST-3	0.9 - 3.2	303 - 1,037	0.74 - 2.48	$15,844 - $40,600	$225 - $900	$704 - $837
9	4-G	67	Infiltration Basin	North of Osborne Rd. NE and Taylor St. NE	ST-4	2.8	956	3.2	$37,546	$780	$726
10	5-E	74	Infiltration Basin	77th Way NE and Ranchers Rd. NE	ST-5	2.8	1,569	3.5	$41,296	$780	$770

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 6: Cost-effectiveness of retrofits with respect to TP reduction. Projects 11 - 22. TSS and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
11	2-G	48	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East3-DD1	ST-2	1.6 - 4.1	571 - 1,525	1.47 - 3.90	$24,096 - $57,104	$450 - $1,350	$777 - $794
12	5-C	72	Curb-Cut Rain Gardens (1, 3, or 5)	Subcatchment South5-DD17	ST-5	0.8 - 3.4	464 - 1,952	0.87 - 3.63	$15,844 - $48,852	$225 - $1,125	$810 - $941
T13	6-E	81	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment South2-DD20	ST-6	0.8 - 2.5	265 - 776	0.64 - 1.86	$15,844 - $40,600	$225 - $900	$835 - $941
T13	6-F	82	Curb-Cut Rain Gardens (1 or 2)	Subcatchment South3-DD22	ST-6	0.8 - 1.5	269 - 485	0.64 - 1.17	$15,844 - $24,096	$225 - $450	$835 - $941
15	4-F	66	New Pond	North of Osborne Rd. west of Monroe St.	ST-4	26.5	11,031	0.0	$653,008	$1,341	$872
16	1-A	39	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment WP1	ST-1	0.9 - 2.3	185 - 490	1.35 - 3.42	$24,096 - $57,104	$450 - $1,350	$1,392 - $1,415
17	5-D	73	New Pond	West of Ranchers Rd. south of 79th Ave.	ST-5	9.3	6,010	0.0	$391,267	$627	$1,470
18	4-D	64	Hydrodynamic Device	Osborne Rd. NE and Terrace Rd. NE	ST-4	1.6	634	0.0	$109,752	$840	$2,812
19	5-A	70	Hydrodynamic Device	79th Ave. NE and Ranchers Rd. NE	ST-5	1.4	939	0.0	$109,752	$840	$3,213
T20	2-A	42	Hydrodynamic Device	Maple Ave. NE and Monroe St. NE	ST-2	0.9	377	0.0	$109,752	$840	$4,998
T20	2-C	44	Hydrodynamic Device	83rd Ave. NE and Fillmore St. NE	ST-2	0.9	432	0.0	$109,752	$840	$4,998
T20	3-A	54	Hydrodynamic Device	82nd Ave. NE and Terrace Rd. NE	ST-3	0.9	369	0.0	$109,752	$840	$4,998

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 7: Cost-effectiveness of retrofits with respect to TP reduction. Projects 23 - 34. TSS and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
23	5-B	71	Hydrodynamic Device	78th Ave. NE and Elm St. NE	ST-5	0.5	392	0.0	$55,752	$840	$5,397
T24	3-C	56	Hydrodynamic Device	Ballantyne Ln. NE and 5th St. NE	ST-3	0.8	296	0.0	$109,752	$840	$5,623
T24	6-B	78	Hydrodynamic Device	East River Rd. NE and Stonybrook (south)	ST-6	0.8	494	0.0	$109,752	$840	$5,623
T26	4-C	63	Hydrodynamic Device	Osborne Rd. NE and Monroe St. NE	ST-4	0.7	251	0.0	$109,752	$840	$6,426
T26	6-D	80	Hydrodynamic Device	Stonybrook Way NE and Alden Way NE	ST-6	0.7	278	0.0	$109,752	$840	$6,426
T28	3-B	55	Hydrodynamic Device	81st Ave. NE and Terrace Rd. NE	ST-3	0.4	164	0.0	$55,752	$840	$6,746
T28	4-B	62	Hydrodynamic Device	78th Ave. NE and Jackson St. NE	ST-4	0.4	159	0.0	$55,752	$840	$6,746
T30	2-B	43	Hydrodynamic Device	82nd Ave. NE and Monroe St. NE	ST-2	0.6	235	0.0	$109,752	$840	$7,497
T30	2-D	45	Hydrodynamic Device	83rd Ave. NE and Polk St. NE	ST-2	0.6	237	0.0	$109,752	$840	$7,497
T30	4-A	61	Hydrodynamic Device	79th Ave. NE and Jackson St. NE	ST-4	0.6	247	0.0	$109,752	$840	$7,497
T30	6-C	79	Hydrodynamic Device	Craigbrook Way NE and Alden Way NE	ST-6	0.6	238	0.0	$109,752	$840	$7,497
34	6-A	77	Hydrodynamic Device	East River Rd. NE and Stonybrook (north)	ST-6	0.2	105	0.0	$28,752	$840	$8,992

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 8: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 1 - 10. TP and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	2-I	50	Pond Modification	Spring Lake Park High School Pond	ST-2	1.1	495	0.0	$17,460	$0	$1,176
2	5-E	74	Infiltration Basin	77th Way NE and Ranchers Rd. NE	ST-5	2.8	1,569	3.5	$41,296	$780	$1,374
3	5-C	72	Curb-Cut Rain Gardens (1, 3, or 5)	Subcatchment South5-DD17	ST-5	0.8 - 3.4	464 - 1,952	0.87 - 3.63	$15,844 - $48,852	$225 - $1,125	$1,411 - $1,623
4	3-E	58	Curb-Cut Rain Gardens (1, 2, or 3)	Subcatchment West1-DD6	ST-3	1.0 - 2.7	380 - 1,013	0.80 - 2.09	$15,844 - $32,348	$225 - $675	$1,731 - $1,982
5	2-H	49	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment West1-DD4	ST-2	3.6 - 9.6	1,128 - 2,978	2.82 - 7.46	$40,600 - $106,616	$900 - $2,700	$1,998 - $2,100
6	4-E	65	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment East1-DD7	ST-4	3.3 - 8.7	1,126 - 2,963	2.80 - 7.37	$40,600 - $106,616	$900 - $2,700	$2,001 - $2,111
7	2-J	51	Underground Storage	Terrace Park	ST-2	45.1	15,723	28.2	$884,246	$2,000	$2,002
8	2-E	46	Curb-Cut Rain Gardens (4, 8, or 12)	Subcatchment North1-DD	ST-2	3.4 - 8.7	1,106 - 2,836	2.69 - 6.89	$40,600 - $106,616	$900 - $2,700	$2,037 - $2,205
9	2-F	47	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East4-DD3	ST-2	1.9 - 4.9	582 - 1,535	1.40 - 3.67	$24,096 - $57,104	$450 - $1,350	$2,086 - $2,153
10	4-F	66	New Pond	North of Osborne Rd. west of Monroe St.	ST-4	26.5	11,031	0.0	$653,008	$1,341	$2,095

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 9: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 11 - 20. TP and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
11	2-G	48	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment East3-DD1	ST-2	1.6 - 4.1	571 - 1,525	1.47 - 3.90	$24,096 - $57,104	$450 - $1,350	$2,110 - $2,195
12	4-G	67	Infiltration Basin	North of Osborne Rd. NE and Taylor St. NE	ST-4	2.8	956	3.2	$37,546	$780	$2,125
13	3-D	57	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment East1-DD5	ST-3	0.9 - 3.2	303 - 1,037	0.74 - 2.48	$15,844 - $40,600	$225 - $900	$2,173 - $2,486
14	5-D	73	New Pond	West of Ranchers Rd. south of 79th Ave.	ST-5	9.3	6,010	0.0	$391,267	$627	$2,274
15	6-F	82	Curb-Cut Rain Gardens (1 or 2)	Subcatchment South3-DD22	ST-6	0.8 - 1.5	269 - 485	0.64 - 1.17	$15,844 - $24,096	$225 - $450	$2,584 - $2,800
16	6-E	81	Curb-Cut Rain Gardens (1, 2, or 4)	Subcatchment South2-DD20	ST-6	0.8 - 2.5	265 - 776	0.64 - 1.86	$15,844 - $40,600	$225 - $900	$2,649 - $2,904
17	5-A	70	Hydrodynamic Device	79th Ave. NE and Ranchers Rd. NE	ST-5	1.4	939	0.0	$109,752	$840	$4,791
18	1-A	39	Curb-Cut Rain Gardens (2, 4, or 6)	Subcatchment WP1	ST-1	0.9 - 2.3	185 - 490	1.35 - 3.42	$24,096 - $57,104	$450 - $1,350	$6,627 - $6,774
19	5-B	71	Hydrodynamic Device	78th Ave. NE and Elm St. NE	ST-5	0.5	392	0.0	$55,752	$840	$6,884
20	4-D	64	Hydrodynamic Device	Osborne Rd. NE and Terrace Rd. NE	ST-4	1.6	634	0.0	$109,752	$840	$7,095

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Table 10: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 21 - 34. TP and volume reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost (2014 Dollars)	Estimated Annual Operations & Maintenance (2014 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
21	6-B	78	Hydrodynamic Device	East River Rd. NE and Stonybrook (south)	ST-6	0.8	494	0.0	$109,752	$840	$9,106
22	2-C	44	Hydrodynamic Device	83rd Ave. NE and Fillmore St. NE	ST-2	0.9	432	0.0	$109,752	$840	$10,413
23	2-A	42	Hydrodynamic Device	Maple Ave. NE and Monroe St. NE	ST-2	0.9	377	0.0	$109,752	$840	$11,932
24	3-A	54	Hydrodynamic Device	82nd Ave. NE and Terrace Rd. NE	ST-3	0.9	369	0.0	$109,752	$840	$12,191
25	3-C	56	Hydrodynamic Device	Ballantyne Ln. NE and 5th St. NE	ST-3	0.8	296	0.0	$109,752	$840	$15,197
26	6-D	80	Hydrodynamic Device	Stonybrook Way NE and Alden Way NE	ST-6	0.7	278	0.0	$109,752	$840	$16,181
27	3-B	55	Hydrodynamic Device	81st Ave. NE and Terrace Rd. NE	ST-3	0.4	164	0.0	$55,752	$840	$16,454
28	4-B	62	Hydrodynamic Device	78th Ave. NE and Jackson St. NE	ST-4	0.4	159	0.0	$55,752	$840	$16,971
29	6-A	77	Hydrodynamic Device	East River Rd. NE and Stonybrook (north)	ST-6	0.2	105	0.0	$28,752	$840	$17,128
30	4-C	63	Hydrodynamic Device	Osborne Rd. NE and Monroe St. NE	ST-4	0.7	251	0.0	$109,752	$840	$17,922
31	4-A	61	Hydrodynamic Device	79th Ave. NE and Jackson St. NE	ST-4	0.6	247	0.0	$109,752	$840	$18,212
32	6-C	79	Hydrodynamic Device	Craigbrook Way NE and Alden Way NE	ST-6	0.6	238	0.0	$109,752	$840	$18,901
33	2-D	45	Hydrodynamic Device	83rd Ave. NE and Polk St. NE	ST-2	0.6	237	0.0	$109,752	$840	$18,981
34	2-B	43	Hydrodynamic Device	82nd Ave. NE and Monroe St. NE	ST-2	0.6	235	0.0	$109,752	$840	$19,142

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TP Reduction)]

Project Selection

The combination of projects selected for pursuit could strive to achieve volume, TSS, and/or TP reductions in the most cost-effective manner possible. Several other factors affecting project installation decisions should be weighed by resource managers when selecting projects to pursue. These factors include but are not limited to the following:

- Total project costs
- Cumulative treatment
- Availability of funding
- Economies of scale
- Landowner willingness
- Project combinations with treatment train effects
- Non-target pollutant reductions
- Timing coordination with other projects to achieve cost savings
- Stakeholder input
- Number of parcels (landowners) involved
- Project visibility
- Educational value
- Long-term impacts on property values and public infrastructure

BMP Descriptions

BMP types proposed throughout the subwatershed are detailed in this section. This was done to reduce duplicative reporting. For each BMP type, the general method of modeling, assumptions made, and cost estimate considerations are described.

Project types included in the following sections are:

- Bioretention
- New Wet Retention Ponds
- Modification to an Existing Pond
- Hydrodynamic Devices
- Underground Storage

Bioretention

Bioretention is a BMP that uses soil and vegetation to treat stormwater runoff from roads, driveways, roof tops, and other impervious surfaces. Differing levels of volume and/or pollutant reductions can be achieved depending on the type of bioretention selected.

Bioretention can function as either filtration (biofiltration) or infiltration (bioinfiltration). Biofiltration BMPs are designed with a buried perforated drain tile that allows water in the basin to discharge to the stormwater drainage system after having been filtered through the soil. Bioinfiltration BMPs have no underdrain, ensuring that all water that enters the basins will either infiltrate into the soil or be evapotranspired into the air. Bioinfiltration provides 100% retention and treatment of captured stormwater, whereas biofiltration basins provide excellent removal of particulate contaminants but limited removal of dissolved contaminants, such as DP (Table 11).

Table 11: Matrix describing curb-cut rain garden efficacy for pollutant removal based on type.

Curb-cut Rain Garden Type	TSS Removal	PP Removal	DP Removal	Volume Reduction	Size of Area Treated	Site Selection and Design Notes
Bioinfiltration	High	High	High	High	High	Optimal sites are low enough in the landscape to capture most of the watershed but high enough to ensure adequate separation from the water table for treatment purposes. Higher soil infiltration rates allow for deeper basins and may eliminate the need for underdrains.
Biofiltration	High	Moderate	Low	Low	High	

The treatment efficacy of a particular bioretention project depends on many factors, including but not limited to the pollutant of concern, the quality of water entering the project, the intensity and duration of storm events, project size, position of the project in the landscape, existing downstream treatment, soil and vegetation characteristics, and project type (i.e. bioinfiltration or biofiltration). Optimally, new bioretention will capture water that would otherwise discharge into a priority waterbody untreated.

The volume and pollutant removal potential of each bioretention practice was estimated using WinSLAMM. In order to calculate cost-benefit, the cost of each project had to be estimated. To fully estimate the cost of project installation, labor costs for project outreach and promotion, project design, project administration, and project maintenance over the anticipated life of the practice were considered in addition to actual construction costs. If multiple projects were installed, cost savings could be achieved on the administration and promotion costs (and possibly the construction costs for a large and competitive bid).

Please note infiltration examples included in this section would require site specific investigations to verify soils are appropriate for infiltration. Also, infiltration practices proposed near or within wellhead protection areas (Appendix C) should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007).

Curb-cut Rain Gardens

Curb-cut rain gardens capture stormwater that is in roadside gutters and redirect it into shallow roadside basins. These curb-cut rain gardens can provide treatment for impervious surface runoff from one to many properties and can be located anywhere sufficient space is available. Because curb-cut rain gardens capture water that is already part of the stormwater drainage system, they are more likely to provide higher benefits. Generally, curb-cut rain gardens were proposed in areas without sufficient existing stormwater treatment and located immediately up-gradient of a catch basin serving a large drainage area. Bioinfiltration was solely proposed (as opposed to biofiltration) as the available soil information suggested infiltration rates could be sufficient to allow complete draw-down within 24-48 hours following a storm event (Figure 3: Rain garden before and during a rainfall event).

Figure 3: Rain garden before and during a rainfall event

All curb-cut rain gardens were presumed to have a 12” ponding depth, pretreatment, mulch, and perennial ornamental and native plants. The useful life of the project was assumed to be 30 years and so all costs are amortized over that time period. Additional costs were included for rehabilitation of the garden at years 10 and 20. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

Infiltration Basin

Infiltration basins function identically to the curb-cut rain gardens previously described in this bioretention section. However, these basins are proposed in locations where a large amount of space is available. This presents an opportunity to construct a large-scale (i.e. >1,000 sq-ft) infiltration basin. This would allow stormwater runoff to fill the basin and be filtered by the soil and vegetation.

Probable project cost includes installation of the project as well as promotion, administrative, and design costs, all in 2014 dollars. A reduced construction cost (i.e. \$15.00 per ft^2) relative to other bioretention practices was proposed for the infiltration basin because of assumed cost savings with a larger project. Furthermore, the large open spaces available at each of the proposed project locations could allow the basins to be constructed without retaining walls, which would result in a significant cost savings. Maintenance was assumed to be completed by city public works crews. Maintenance costs were also included for rehabilitation of the basin every 10 years for the life of the project.

New Wet Retention Ponds

If properly designed, wet retention ponds have controlled outflows to manage discharge rates and are sized to achieve predefined water quality goals. Wet retention ponds treat stormwater through a variety of processes, but primarily through sedimentation. Ponds are most often designed to contain a permanent pool storage depth; it is this permanent pool of water that separates the practice from most other stormwater BMPs, including detention ponds (Figure 4).

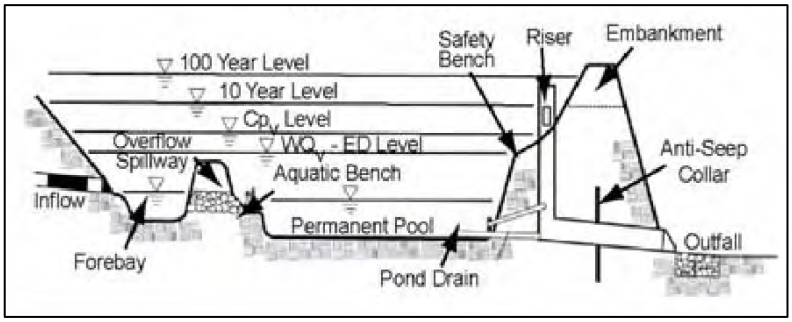


Figure 4: Schematic of a stormwater retention pond. Figure from the Urban Subwatershed Restoration Manual Series, Chapter 3: Urban Stormwater Retrofit Practices.

Wet retention pond depth generally ranges from 3-8' deep. If ponds are less than 3' deep, winds can increase mixing through the full water depth and resuspend sediments, thereby increasing turbidity. Scour may also occur during rain events following dry periods. If more than 8' deep, thermal stratification can occur creating a layer of low dissolved oxygen near the sediment that can release bound phosphorus. Above the permanent pool depth is the flood depth, which provides water quality treatment directly following storm events. Separating the permanent pool depth and the flood depth is the primary outlet control, which is often designed to control outflow rate. Configurations for the outlet control may include a V-notch or circular weir, multiple orifices, or a multiple-stage weir. Each of these can be configured within a skimmer structure or trash rack to provide additional treatment for larger, floatable items. Above the flood depth is the emergency control structure, which is available to bypass water from the largest rainfall events, such as the 100-year precipitation event. Ponds also often include a pretreatment practice, either a forebay or sedimentation basin adjacent to the pond or storm sewer sumps, hydrodynamic devices, or other basins upstream of the practice.

Outside of sedimentation, other important processes occurring in ponds are nutrient assimilation and evapotranspiration by plants. The addition of shoreline plants to pond designs has increased greatly since the 1980's because of the positive effects these plants were found to have for both water quality purposes and increasing terrestrial and aquatic wildlife habitat. The ability of the pond to regulate discharge rates should also be noted. This can reduce downstream in-channel erosion, thereby decreasing TSS and TP loading from within the channel.

With the multitude of considerations for these practices, ponds must be designed by professional engineers. This report provides a rudimentary description of ponding opportunities and cost estimates for project planning purposes. Ponds proposed in this analysis are designed and simulated within the water quality model WinSLAMM, which takes into account upland pollutant loading, pond bathymetry, and outlet control device(s) to estimate stormwater volume, TSS, and TP retention capacity. The model was run with and without the identified project and the difference in pollutant loading was calculated.

In order to calculate cost-benefit, the cost of each project had to be estimated. All new stormwater ponds were assumed to involve excavation and disposal of soil, installation of inlet and outlet control structures and emergency overflow, land acquisition, erosion control, and vegetation management. Additionally, project engineering, promotion, administration, construction oversight, and long-term maintenance (including annual inspections and removal of accumulated sediment/debris from the pretreatment area) had to be considered in order to capture the true cost of the effort. Complete pond dredging is not included in the long-term maintenance cost because project life is estimated to be 30 years. Load reduction estimates for these projects are noted in the Catchment Profiles section.

Modification to an Existing Pond

Developments prior to enactment of contemporary stormwater rules often included wet detention ponds which were frequently designed purely for flood control based on the land use, impervious cover, soils, and topography of the time. Changes to stormwater rules since the early 1970's have greatly altered the way ponds are designed.

Enactment of the National Pollution Discharge Elimination System (NPDES) in 1972 followed by research conducted by the Environmental Protection Agency in the early 1980's as part of the Nationwide Urban Runoff Program (NURP) set standards by which stormwater best management practices should be designed. Municipal Separate Storm Sewer System (MS4) guidelines issued in 1990 (affecting cities with more than 100,000 residents) and 1999 (for cities with less than 100,000 residents) required municipalities to obtain an NPDES permit and develop a plan for managing their stormwater.

Listed below are five strategies which exist for retrofitting a stormwater pond to increase pollutant retention (modified from *Urban Stormwater Retrofit Practices*):

- Excavate pond bottom to increase permanent pool storage
- Raise the embankment to increase flood pool storage
- Widen pond area to increase both permanent and flood pool storage
- Modify the riser
- Update pool geometry or add pretreatment (e.g. forebay)

These strategies can be employed separately or together to improve BMP effectiveness. Each strategy is limited by cost-effectiveness and constraints of space on the current site. Pond retrofits are preferable to most new BMPs as additional land usually does not need to be purchased, stormwater easements already exist, maintenance issues change little following project completion, and construction costs are greatly cheaper. There can also be a positive effect on reducing the rate of overflow from the pond, thereby reducing the risk for erosion (and thus further pollutant generation) downstream.

For this analysis, all existing ponds were modeled in the water quality model WinSLAMM to estimate their effectiveness based on best available information for pond characteristics and land use and soils.

Hydrodynamic Devices

In heavily urbanized settings such as the Cities of Spring Lake Park and Fridley, stormwater is immediately intercepted along roadway catch basins and conveyed rapidly via storm sewer pipes to its destination. Once stormwater is intercepted by catch basins, it can be very difficult to supply treatment without large end-of-pipe projects such as regional ponds. One of the possible solutions is the hydrodynamic device (Figure 5). These are installed in-line with the existing storm sewer network and can provide treatment for up to 10-15 acres of upland drainage. This practice applies some form of filtration, settling, or hydrodynamic separation to remove coarse sediment, litter, oil, and grease. These devices are particularly useful in small but highly urbanized drainage areas and can be used as pretreatment for other downstream stormwater BMPs.

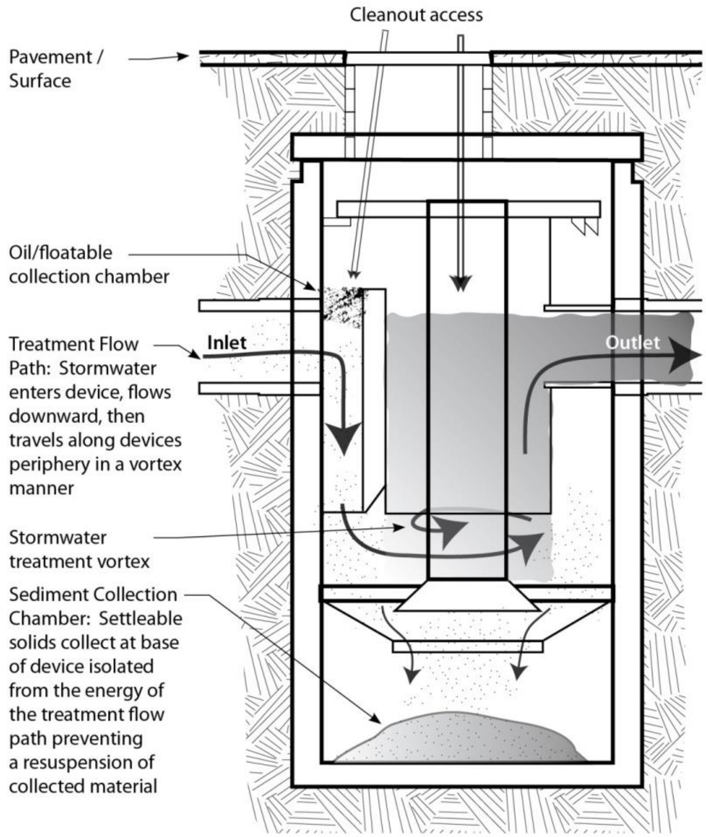


Figure 5: Schematic of a typical hydrodynamic device

Each device's pollutant removal potential was estimated using WinSLAMM. Devices were sized based on upstream drainage area to ensure peak flow does not exceed each device's design guidelines. For this analysis, Downstream Defender devices were modeled based on available information and to maintain continuity across other SRAs. Devices were proposed along particular storm sewer lines and often just upstream of intersections with another, larger line. Model results assume the device is receiving input from all nearby catch basins noted.

In order to calculate cost-benefit, the cost of each project had to be estimated. To fully estimate the cost of project installation, labor costs for project outreach, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual construction costs. Load reduction estimates for these projects are noted in the Catchment Profiles section.

Underground Storage

Similar to stormwater reuse, underground storage involves the capture and detention of stormwater from the existing storm sewer network to a large, below-grade device. Underground storage differs in that stored water is never returned to the surface for use. The device in which stormwater is detained is designed to allow for seepage of the stormwater into the ground. Therefore, these practices can often be cheaper than stormwater reuse practices as a pumping and filtering system is not needed.

For this analysis, a combination of aggregate rock and perforated corrugated metal pipes (CMP) were used to provide storage of the stormwater below ground elevation. The CMP is proposed in addition to the aggregate rock to increase the storage capacity of the practice (as water storage within the aggregate is only found in pore space). Stormwater could be delivered to the aggregate rock and CMP via stormwater catch basins along the existing storm sewer network. A grate at the top of the catch basin and sump at the bottom could provide pretreatment to the practice for large debris and sediment. The underground storage practice could also divert flow from the existing storm sewer network into large CMPs located underground.

Infiltration of the stored stormwater into the ground from the aggregate rock and perforated CMPs will capture particulate and dissolved stormwater pollutants, reduce high-flow runoff, and replenish local groundwater aquifers. Additional details for these practices, including assumed location, size, cost, and estimated reduction potential, are noted in the Catchment Profiles section.

Infiltration practices proposed near or within wellhead protection areas (Appendix C) should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007).

Catchment Profiles

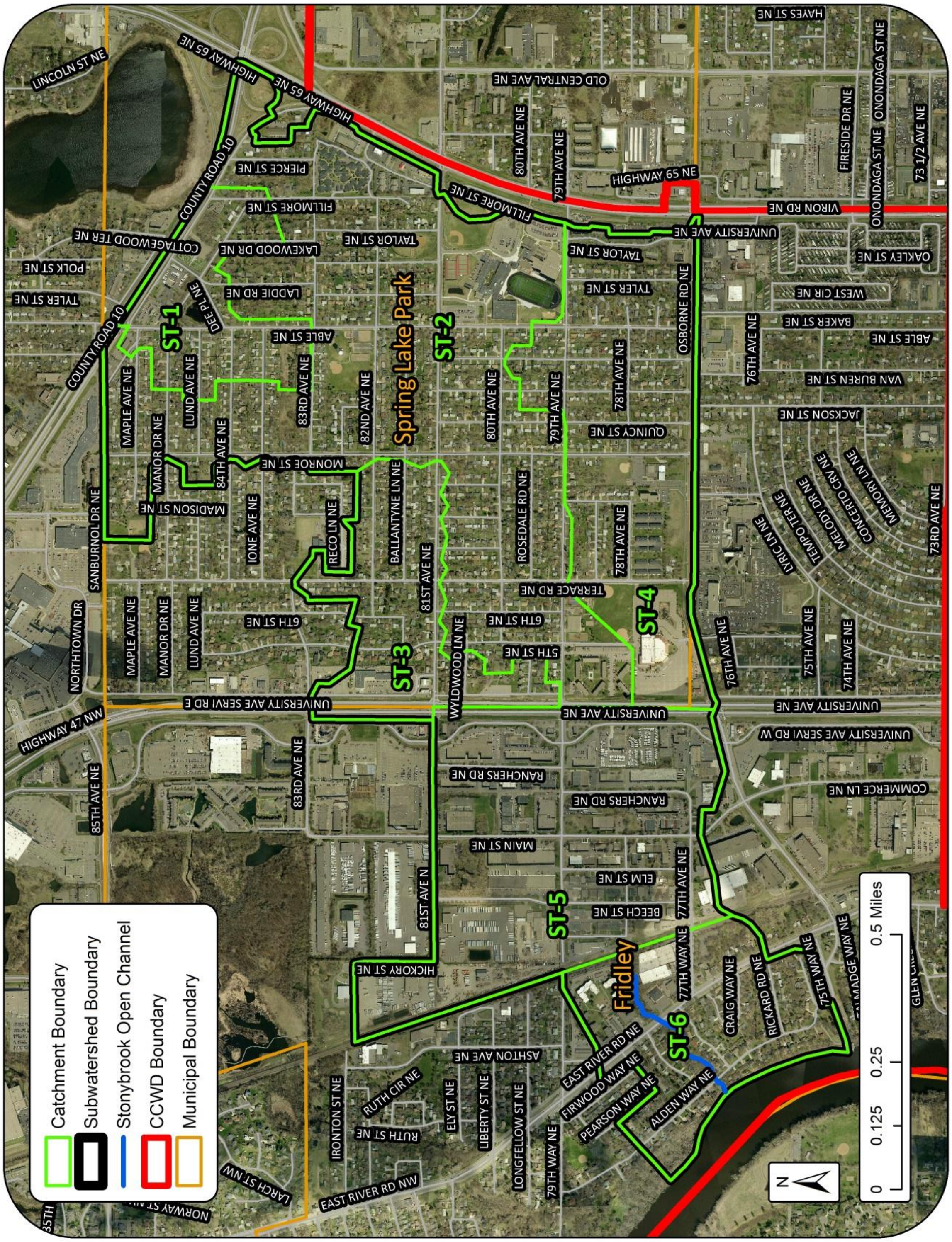
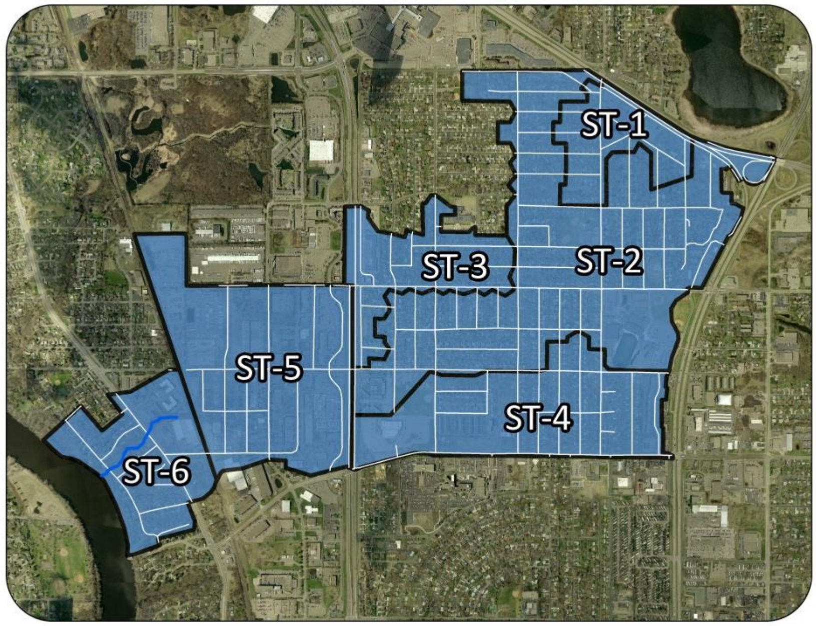


Figure 6: The 914 acre Stonybrook subwatershed was divided into 6 catchments for this analysis. Catchment profiles on the following pages provide additional information.

Subwatershed-Wide Summary

Catchment ID	Page
ST-1	37
ST-2	40
ST-3	52
ST-4	59
ST-5	68
ST-6	75

Existing Network Summary	
Acres	913.7
Dominant Land Cover	Residential
Volume (ac-ft/yr)	582
TP (lb/yr)	573.4
TSS (lb/yr)	207,517



SUBWATERSHED DRAINAGE SUMMARY

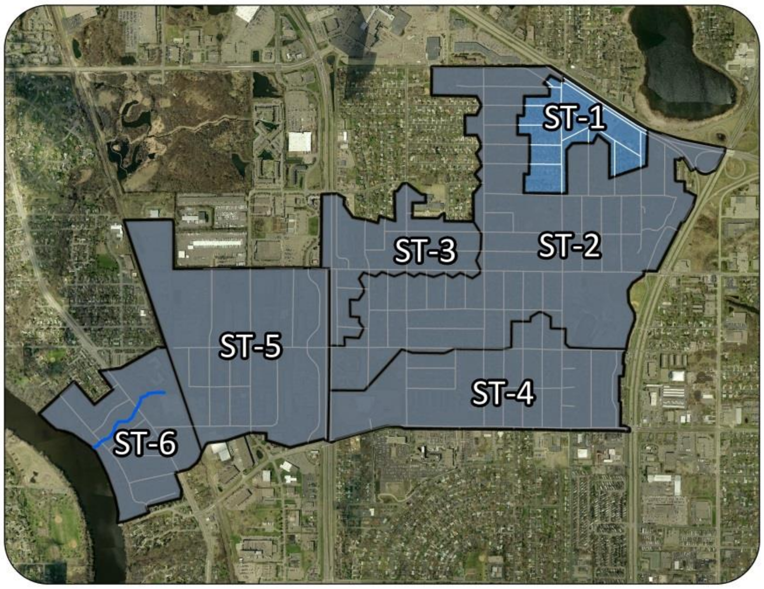
The Stonybrook subwatershed is comprised of six catchments (ST-1 through ST-6). Catchments ST-1 through ST-4 are located in the City of Spring Lake Park and catchments ST-5 and ST-6 are located in the City of Fridley. Stormwater runoff generated in the subwatershed largely flows from east to west where it discharges into the Mississippi River. Stonybrook is entirely piped, except for approximately 1,300 feet of open channel near the confluence with the Mississippi River. Land use throughout the subwatershed is predominantly residential in catchments ST-1, ST-2, ST-3, ST-4, and ST-6, whereas catchment ST-5 is dominated by industrial land use.

EXISTING STORMWATER TREATMENT

There is currently no existing regional stormwater treatment throughout the subwatershed (e.g. an inline stormwater pond). However, catchment-level BMPs exist throughout the subwatershed and are detailed in the following catchment profiles.

Catchment ST-1

Existing Catchment Summary	
Acres	56.9
Dominant Land Cover	Residential
Parcels	166
Volume (ac-ft/yr)	32.8
TP (lb/yr)	19.0
TSS (lb/yr)	4,514



CATCHMENT DESCRIPTION

Catchment ST-1 lies along the northern boundary of the Stonybrook subwatershed (County Road 10), and is completely within the city of Spring Lake Park. Land use within the catchment varies between commercial and industrial properties along County Road 10, Conde Park in the center, and single family residential lots throughout the remainder of the catchment.

Retrofits proposed in this catchment are farthest removed from the open channel section of Stonybrook. Nevertheless, volume reductions throughout the subwatershed will be beneficial for reducing in-channel erosion issues as well as reducing potential flooding issues.

EXISTING STORMWATER TREATMENT

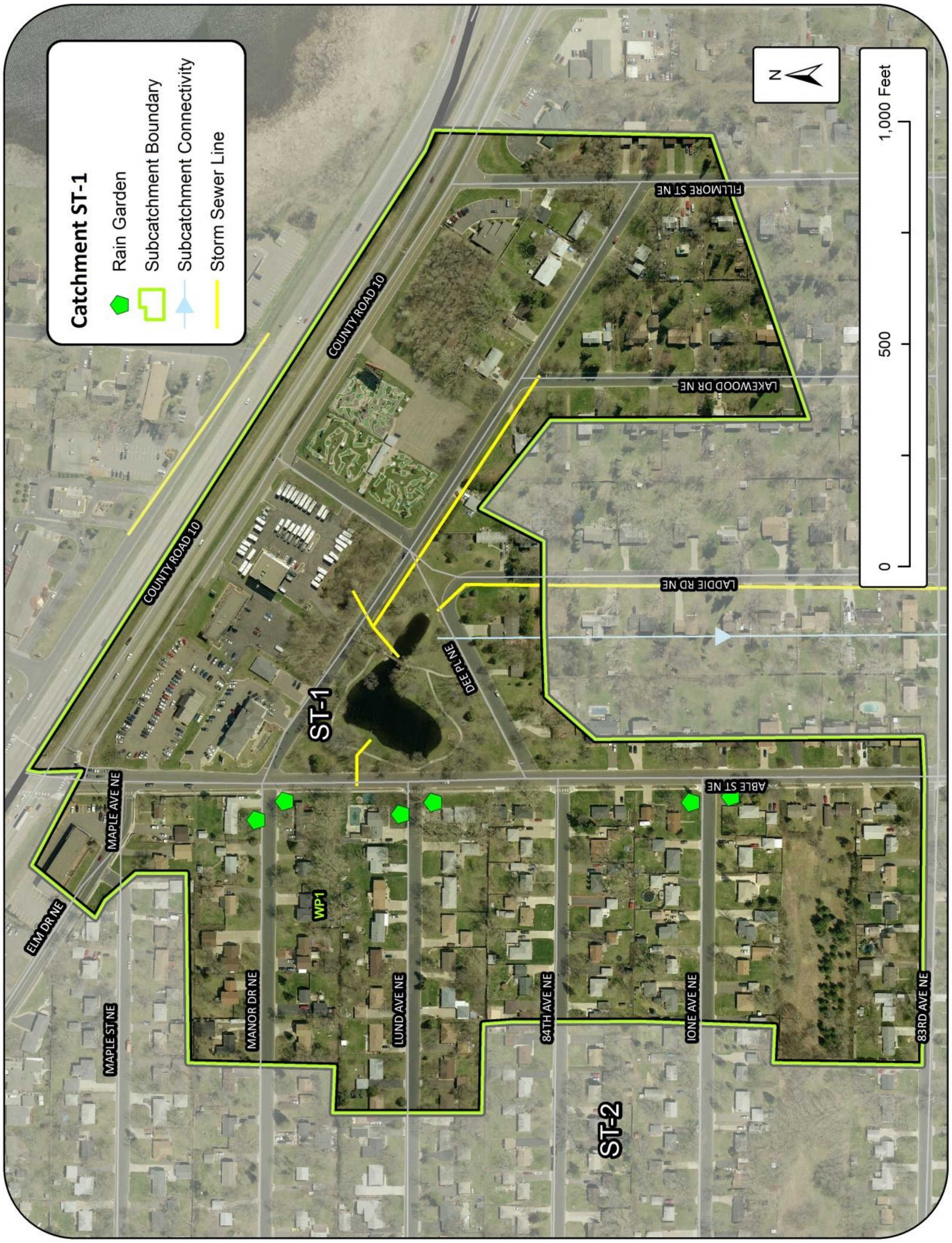
The entire catchment drains to a wet pond located within Conde Park. The pond overflows into the Stonybrook storm sewer network. Stormwater runoff through the residential properties is primarily overland, utilizing the existing storm sewer system only near the lake. Street cleaning is also provided by the City of Spring Lake Park in the spring and fall.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**Number of BMPs**	2			
	BMP Types	Conde Park Wet Pond and Street Cleaning			
	TP (lb/yr)	38.9	19.9	51%	**19.0**
	TSS (lb/yr)	13,442	8,928.0	66%	**4,514**
	Volume (acre-feet/yr)	32.8	0.0	0%	**32.8**

RETROFITS CONSIDERED BUT REJECTED

The pond within Conde Park was investigated for possible retrofit opportunities. The pond is approximately 0.7 acres and the contributing drainage area is 57 acres. Pond expansion and incorporation of an iron enhanced sand filter were considered as potential retrofits, but limited space in the park and an existing walking trail were prohibitive. In addition, hydrodynamic devices were not modeled in this catchment because all of the runoff already passes through the pond.

POTENTIAL RETROFITS



Project ID: 1-A

Curb-Cut Rain Gardens
Subcatchment: WP1

Drainage Area – 36.9 acres
Location – West of Able St. NE in ST-1
Property Ownership – Private
Site Specific Information – Stormwater runoff generated within the catchment is already treated by the stormwater pond. Rain gardens could be installed within the residential neighborhood to the west of Conde Park to better treat dissolved species of phosphorus, which stormwater ponds are much less able to treat (compared to phosphorus bound to sediment). The gardens could also reduce some of the downstream volume export to Stonybrook. Soils are also favorable through much of the catchment for infiltration practices. Considering typical landowner participation rates, scenarios with 2, 4, and 6 rain gardens were analyzed to treat the drainage area.

Curb-Cut Rain Garden

	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	2		4		6	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft	1,500	sq-ft
	TP (lb/yr)	0.90	4.7%	1.60	8.4%	2.30	12.1%
	TSS (lb/yr)	185	4.1%	340	7.5%	490	10.9%
	Volume (acre-feet/yr)	1.35	4.1%	2.43	7.4%	3.42	10.4%
Cost	**Administration & Promotion Costs***	$9,344		$11,096		$12,848	
	Design & Construction Costs**	$14,752		$29,504		$44,256	
	Total Estimated Project Cost (2014)	**$24,096**		**$40,600**		**$57,104**	
	Annual O&M***	$450		$900		$1,350	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,392**		**$1,408**		**$1,415**	
	30-yr Average Cost/1,000lb-TSS	**$6,774**		**$6,627**		**$6,640**	
	30-yr Average Cost/ac-ft Vol.	**$926**		**$926**		**$951**	

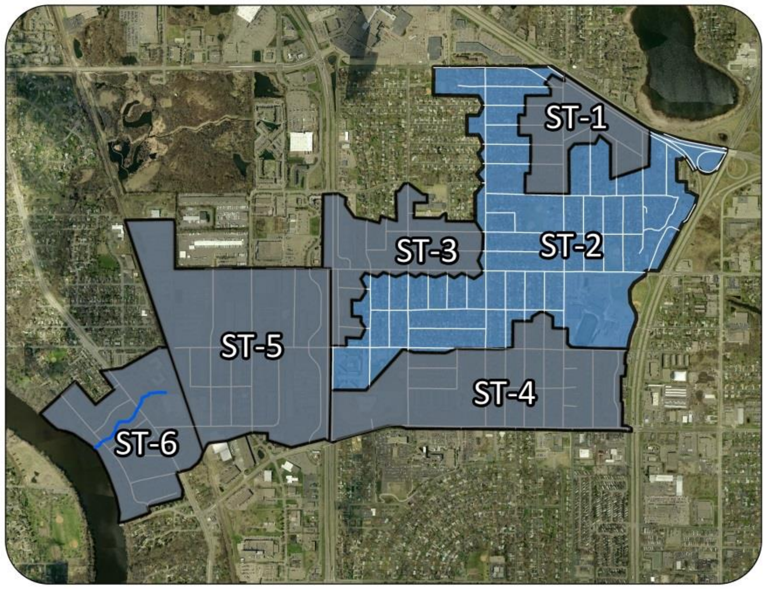
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment ST-2

Existing Catchment Summary	
Acres	338.1
Dominant Land Cover	Residential
Parcels	806
Volume (acre-feet/yr)	168.3
TP (lb/yr)	194.5
TSS (lb/yr)	58,001



CATCHMENT DESCRIPTION

Catchment ST-2 is the largest catchment in this analysis, spanning between University Avenue and Highway 65. This catchment is dominated by single family residential lots. Other land uses include multi-family properties, Spring Lake Park High School, Able and Terrace Parks, and commercial properties along Highway 65.

EXISTING STORMWATER TREATMENT

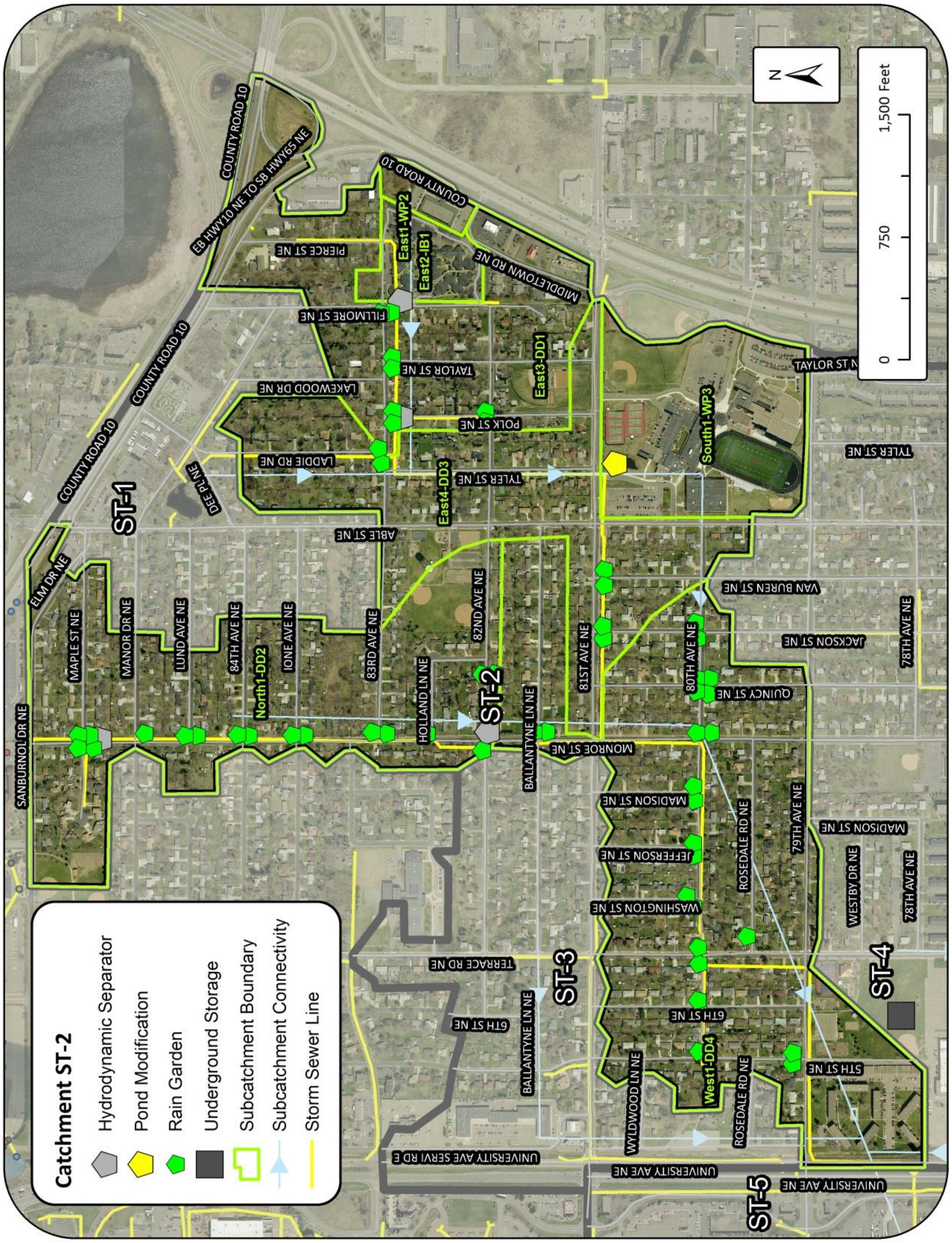
There are a limited number of stormwater BMP's within the catchment. These structural BMPs generally treat only the runoff generated within the property it was constructed upon. Wet ponds are located in the Spring Lake Park High School property and along the Highway 65 W Service Road. There is also an infiltration basin at the northeast corner of the intersection between Fillmore St. and 83rd Ave., which treats runoff generated within the multi-family units south of the BMP and discharges to the 83rd Ave. storm sewer line. In addition, street cleaning is completed twice annually by the City of Spring Lake Park.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	3			
	BMP Types	Spring Lake Park High School Pond, Fillmore St. and 83rd Ave. Infiltration Basin, and Street Cleaning			
	TP (lb/yr)	226.7	32.2	14%	**194.5**
	TSS (lb/yr)	72,286	14,285.0	20%	**58,001**
	Volume (acre-feet/yr)	174.2	5.9	3%	**168.3**

RETROFITS CONSIDERED BUT REJECTED

Large-scale pond or infiltration basin opportunities were considered, but the catchment is completely developed with little open space available for such practices. Open space in Able Park was also considered for BMPs. However, no stormwater infrastructure passes near the park for diversion and treatment of a larger contributing drainage area.

POTENTIAL RETROFITS



Project ID: 2-A

Maple Ave. NE & Monroe St. NE Hydrodynamic Device

Drainage Area – 16.7 acres
Location – Monroe St. NE between Maple Ave. NE and Manor Dr. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – Currently, stormwater runoff from the residential lots within this subcatchment discharges directly into the creek's storm sewer network without treatment. To provide treatment, a hydrodynamic device could be installed along the existing storm sewer line on Monroe St. A device at this intersection provides benefit due to the convergence of multiple storm sewer lines at a single location. Based on drainage area size and expected peak discharge, a 10 ft. diameter device was proposed.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.9	0.5%
	TSS (lb/yr)	377	0.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$11,932**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 2-B

82nd Ave. NE and Monroe St. NE Hydrodynamic Device

Drainage Area – 11.1 acres
Location – 82nd Ave. NE just east of Monroe St. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential lots and impervious space in Able Park. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. If feasible, this practice should be placed along the 82nd Ave. NE storm sewer line prior to its intersection with the Monroe St. NE line. The practice should not be placed along the Monroe St. NE line as expected peak discharge through the device would exceed structure capacity.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.6	0.3%
	TSS (lb/yr)	235	0.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$7,497**	
	30-yr Average Cost/1,000lb-TSS	**$19,142**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 2-C

83rd Ave. NE and Fillmore St. NE Hydrodynamic Device

Drainage Area – 12.0 acres
Location – Fillmore St. NE just south of 83rd Ave. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the residential and commercial properties within the subcatchment. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. If feasible, this practice should be placed along the Fillmore St. storm sewer line prior to its intersection with the 83rd Ave. line. The practice should not be placed along the 83rd Ave. line as expected peak discharge through the device would exceed structure capacity.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
Treatment	Total Size of BMPs	10	ft diameter
Treatment	TP (lb/yr)	0.9	0.5%
Treatment	TSS (lb/yr)	432	0.7%
Treatment	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
Cost	Design & Construction Costs**	$108,000	
Cost	Total Estimated Project Cost (2014)	**$109,752**	
Cost	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$4,998**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**$10,413**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**N/A**	

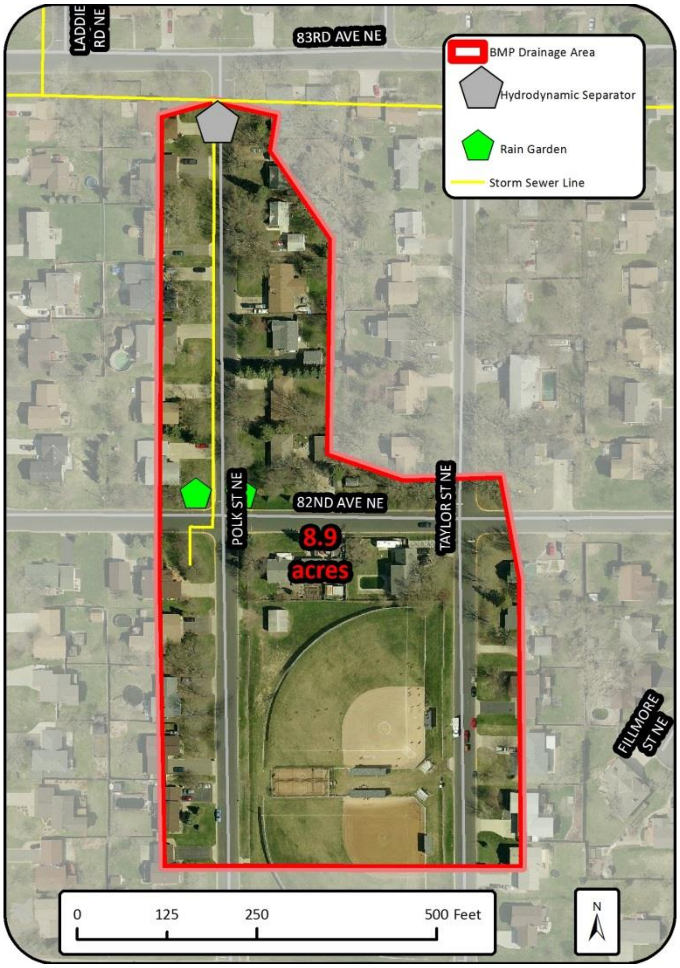
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 2-D

83rd Ave. NE and Polk St. NE
Hydrodynamic Device



Drainage Area – 8.9 acres
Location – Polk St. NE just south of 83rd Ave. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single family residential lots and portions of the Spring Lake Park High School softball fields. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. If feasible, this practice should be placed along the Polk St. NE storm sewer line prior to its intersection with the 83rd Ave. NE line. The practice should not be placed along the 83rd Ave. NE line as expected peak discharge through the device would exceed structure capacity.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.6	0.3%
	TSS (lb/yr)	237	0.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$7,497**	
	30-yr Average Cost/1,000lb-TSS	**$18,981**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 2-E

Curb-Cut Rain Gardens
Subcatchment: North1-DD

Drainage Area – 74.2 acres
Location – Throughout subcatchment North1-DD
Property Ownership – Private
Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 4, 8, and 12 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	4		8		12	
	Total Size of BMPs	1,000	sq-ft	2,000	sq-ft	3,000	sq-ft
	TP (lb/yr)	3.40	1.7%	6.20	3.2%	8.70	4.5%
	TSS (lb/yr)	1,106	1.9%	2,018	3.5%	2,836	4.9%
	Volume (acre-feet/yr)	2.69	1.6%	4.91	2.9%	6.89	4.1%
Cost	**Administration & Promotion Costs***		$11,096		$14,600		$18,104
	Design & Construction Costs**		$29,504		$59,008		$88,512
	Total Estimated Project Cost (2014)		**$40,600**		**$73,608**		**$106,616**
	Annual O&M***		$900		$1,800		$2,700
Efficiency	**30-yr Average Cost/lb-TP**	**$663**		**$686**		**$719**	
	30-yr Average Cost/1,000lb-TSS	**$2,037**		**$2,108**		**$2,205**	
	30-yr Average Cost/ac-ft Vol.	**$839**		**$866**		**$908**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

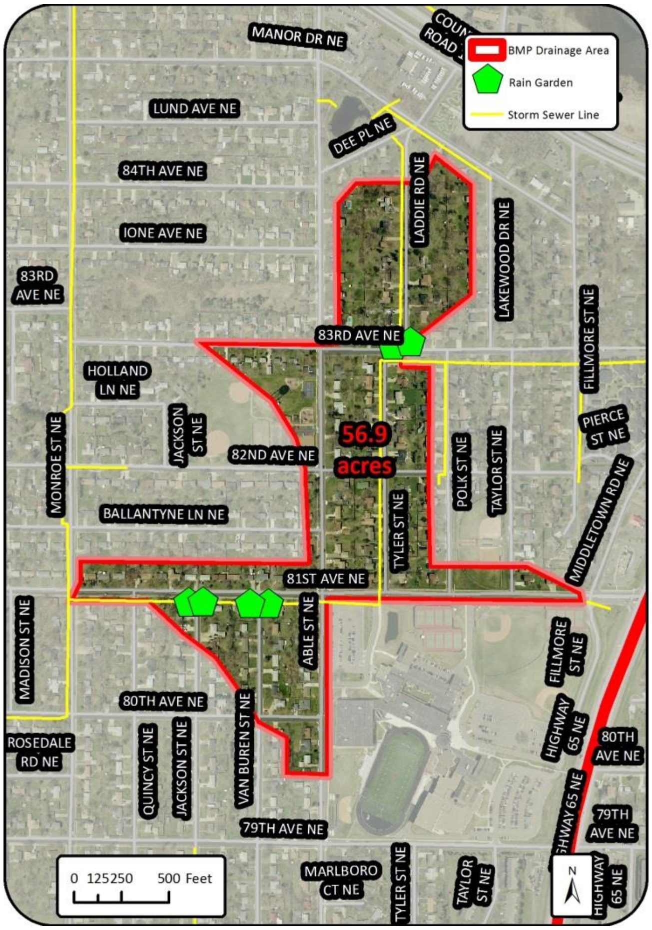
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-F

Curb-Cut Rain Gardens

Subcatchment: East4-DD3



Drainage Area – 56.9 acres
Location – Throughout subcatchment East4-DD3
Property Ownership – Private
Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 2, 4, and 6 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	2		4		6	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft	1,500	sq-ft
	TP (lb/yr)	1.90	1.0%	3.50	1.8%	4.90	2.5%
	TSS (lb/yr)	582	1.0%	1,080	1.9%	1,535	2.6%
	Volume (acre-feet/yr)	1.40	0.8%	2.57	1.5%	3.67	2.2%
Cost	**Administration & Promotion Costs***	$9,344		$11,096		$12,848	
	Design & Construction Costs**	$14,752		$29,504		$44,256	
	Total Estimated Project Cost (2014)	**$24,096**		**$40,600**		**$57,104**	
	Annual O&M***	$450		$900		$1,350	
Efficiency	**30-yr Average Cost/lb-TP**	**$660**		**$644**		**$664**	
	30-yr Average Cost/1,000lb-TSS	**$2,153**		**$2,086**		**$2,120**	
	30-yr Average Cost/ac-ft Vol.	**$895**		**$876**		**$886**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-G

Curb-Cut Rain Gardens

Subcatchment: East3-DD1

Drainage Area – 53.7 acres

Location – Throughout subcatchment East3-DD1

Property Ownership – Private

Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 2, 4, and 6 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	2		4		6	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft	1,500	sq-ft
	TP (lb/yr)	1.60	0.8%	2.90	1.5%	4.10	2.1%
	TSS (lb/yr)	571	1.0%	1,068	1.8%	1,525	2.6%
	Volume (acre-feet/yr)	1.47	0.9%	2.73	1.6%	3.90	2.3%
Cost	Administration & Promotion Costs*	$9,344		$11,096		$12,848	
	Design & Construction Costs**	$14,752		$29,504		$44,256	
	Total Estimated Project Cost (2014)	**$24,096**		**$40,600**		**$57,104**	
	Annual O&M***	$450		$900		$1,350	
Efficiency	30-yr Average Cost/lb-TP	**$783**		**$777**		**$794**	
	30-yr Average Cost/1,000lb-TSS	**$2,195**		**$2,110**		**$2,133**	
	30-yr Average Cost/ac-ft Vol.	**$853**		**$825**		**$834**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-H

Curb-Cut Rain Gardens

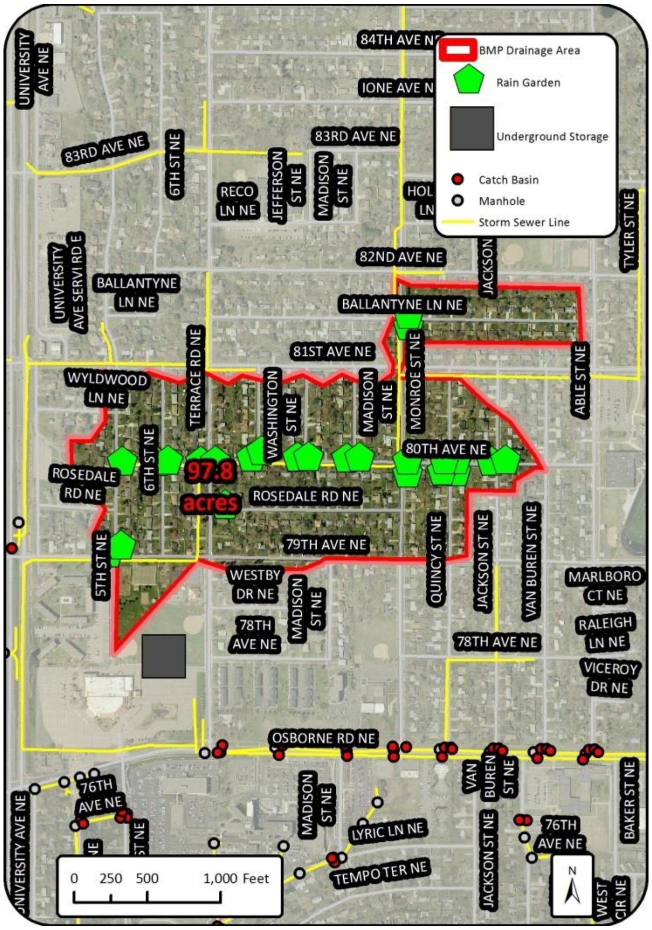
Subcatchment: West1-DD4

Drainage Area – 97.8 acres

Location – Throughout subcatchment West1-DD4

Property Ownership – Private

Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 4, 8, and 12 rain gardens were analyzed to treat the drainage area.



	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		8		12	
	Total Size of BMPs	1,000	sq-ft	2,000	sq-ft	3,000	sq-ft
	TP (lb/yr)	3.60	1.9%	6.70	3.4%	9.60	4.9%
	TSS (lb/yr)	1,128	1.9%	2,089	3.6%	2,978	5.1%
	Volume (acre-feet/yr)	2.82	1.7%	5.23	3.1%	7.46	4.4%
Cost	Administration & Promotion Costs*	$11,096		$14,600		$18,104	
	Design & Construction Costs**	$29,504		$59,008		$88,512	
	Total Estimated Project Cost (2014)	**$40,600**		**$73,608**		**$106,616**	
	Annual O&M***	$900		$1,800		$2,700	
Efficiency	30-yr Average Cost/lb-TP	**$626**		**$635**		**$651**	
	30-yr Average Cost/1,000lb-TSS	**$1,998**		**$2,036**		**$2,100**	
	30-yr Average Cost/ac-ft Vol.	**$798**		**$813**		**$838**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

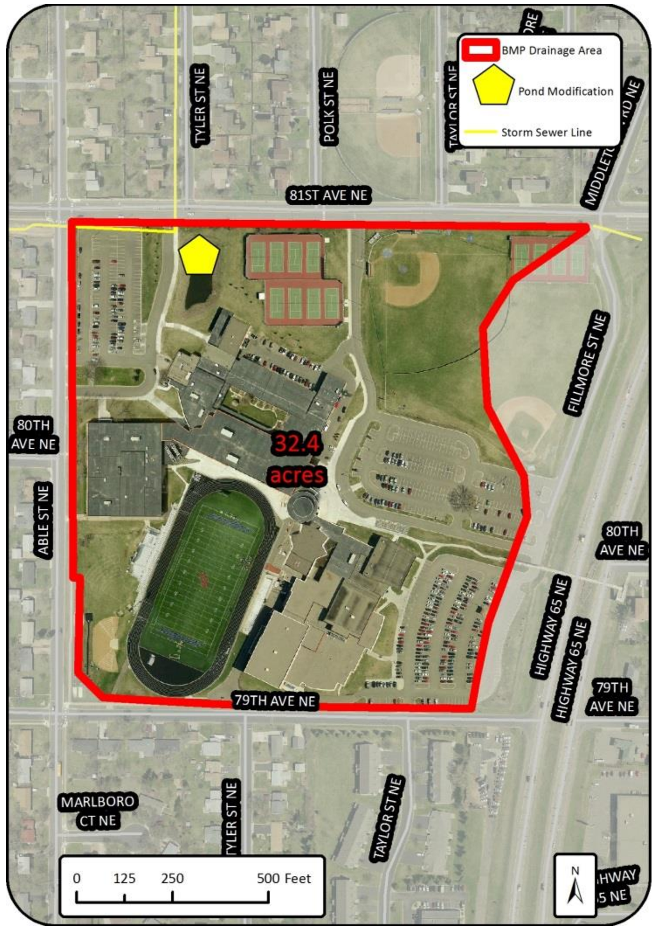
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-I

Pond Modification
Subcatchment: South1-WP3

Drainage Area – 32.4 acres
Location – Northwest corner of Spring Lake Park High School property
Property Ownership – Public (Spring Lake Park High School)
Site Specific Information – A pond modification was proposed for the existing stormwater pond located in the northeast corner of the Spring Lake Park High School property. The existing pond provides treatment for the campus. However, based on field observations and the available plan set, additional storage may be possible through the addition of a riser to the outlet structure. A 2 ft. riser was proposed.



	New Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	2	ft riser
	TP (lb/yr)	1.1	0.6%
	TSS (lb/yr)	495	0.9%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,460	
	Design & Construction Costs**	$16,000	
	Total Estimated Project Cost (2014)	**$17,460**	
	Annual O&M***	$0	
Efficiency	**30-yr Average Cost/lb-TP**	**$529**	
	30-yr Average Cost/1,000lb-TSS	**$1,176**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*20 hours at $73/hour
**See Appendix B for detailed cost information
***Assumes existing pond is already maintained

Project ID: 2-J

Underground Storage
Catchments ST-1 and ST-2

Drainage Area – 383.7 acres
Location – South central edge of Terrace Park
Property Ownership – Public (Spring Lake Park)
Site Specific Information – Please note the potential site is located within a wellhead protection area (Appendix C). The proposed location is within ST-4 to avoid the emergency response areas in the northeast and northwest corners of Terrace Park. A combination of aggregate rock and perforated corrugated metal pipe (CMP) could be installed underground to provide storage and treatment for stormwater runoff. Stormwater could be diverted to the aggregate rock and CMP in the northwest corner of Terrace Park from the east-west sewer line along 79th Ave. NE. Aggregate and pipe storage was estimated based on available space. Four, 200 ft. long 10 ft. diameter CMPs were proposed, which cumulatively provide 116,440 cu-ft. of storage.

	Underground Storage		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1	
	Total Size of BMPs	116,440	cu-ft
	TP (lb/yr)	45.1	21.1%
	TSS (lb/yr)	15,723	25.1%
	Volume (acre-feet/yr)	28.2	14.0%
Cost	Administration & Promotion Costs*	$5,840	
	Design & Construction Costs**	$878,406	
	Total Estimated Project Cost (2014)	**$884,246**	
	Annual O&M***	$2,000	
Efficiency	30-yr Average Cost/lb-TP	**$698**	
	30-yr Average Cost/1,000lb-TSS	**$2,002**	
	30-yr Average Cost/ac-ft Vol.	**$1,115**	

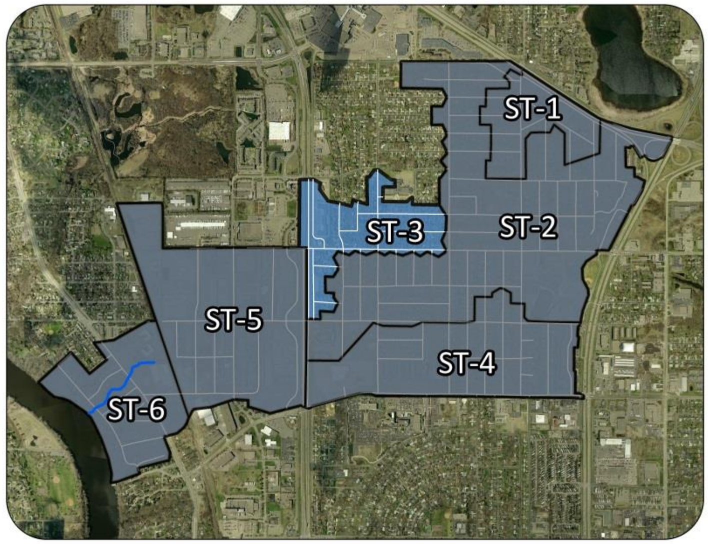
*80 hours at $73/hour

**See Appendix B for detailed cost information

***Includes cleaning of unit and disposal of sediment/debris

Catchment ST-3

Existing Catchment Summary	
Acres	78.2
Dominant Land Cover	Residential
Parcels	197
Volume (acre-feet/yr)	45.1
TP (lb/yr)	57.1
TSS (lb/yr)	18,410



CATCHMENT DESCRIPTION

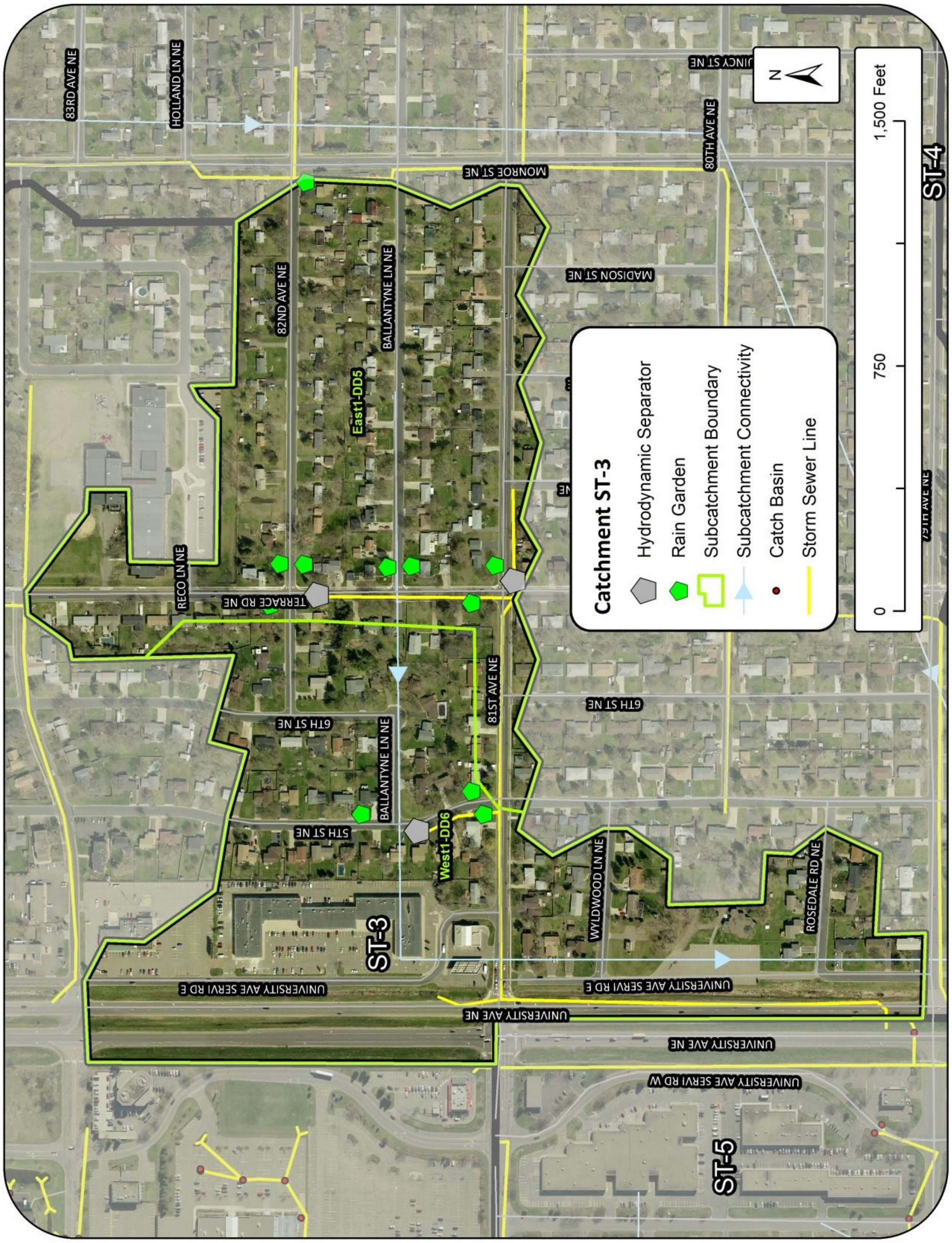
This catchment is bordered by University Ave. to the west and Monroe St. to the east. 81st Ave. bisects the catchment from east to west. Land use is primarily single family residential, but also includes commercial properties along University Ave. and a portion of Park Terrace Elementary School.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed twice per year by the City of Spring Lake Park. Stormwater runoff generated within ST-3 runs to a storm sewer line below 81st Ave. This line discharges into a ditch just east of University Ave.

	Existing Conditions	**Base Loading**	**Treatment**	**Net Treatment %**	**Existing Loading**
Treatment	**Number of BMPs**	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	60.7	3.6	6%	**57.1**
	TSS (lb/yr)	20,173	1,763.0	9%	**18,410**
	Volume (acre-feet/yr)	45.1	0.0	0%	**45.1**

POTENTIAL RETROFITS



Project ID: 3-A

82nd Ave. NE and Terrace Rd. NE Hydrodynamic Device

Drainage Area – 13.1 acres
Location – Terrace Rd. NE between 82nd Ave. NE and Ballantyne Ln. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – Currently, stormwater runoff from the residential lots and Park Terrace Elementary School property within this subcatchment discharges directly into the creek's storm sewer network without treatment. To provide for treatment, a hydrodynamic device could be installed along the existing storm sewer line on Terrace Rd. Based on drainage area size and expected peak discharge, a 10 ft. diameter device was proposed.

Hydrodynamic Device

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.9	1.6%
	TSS (lb/yr)	369	2.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$12,191**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 3-B

81st Ave. NE and Terrace Rd. NE Hydrodynamic Device

Drainage Area – 6.9 acres
Location – 81st Ave NE just east of Terrace Rd. NE
Property Ownership – Public (Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential properties to the east. Based on drainage area size and expected peak discharge, an 8 ft. diameter device was proposed. If feasible, this practice should be placed along the 81st Ave. storm sewer line prior to its intersection with the Terrace Rd. line. The practice should not be placed along the Terrace Rd. line as expected peak discharge would exceed structure capacity.

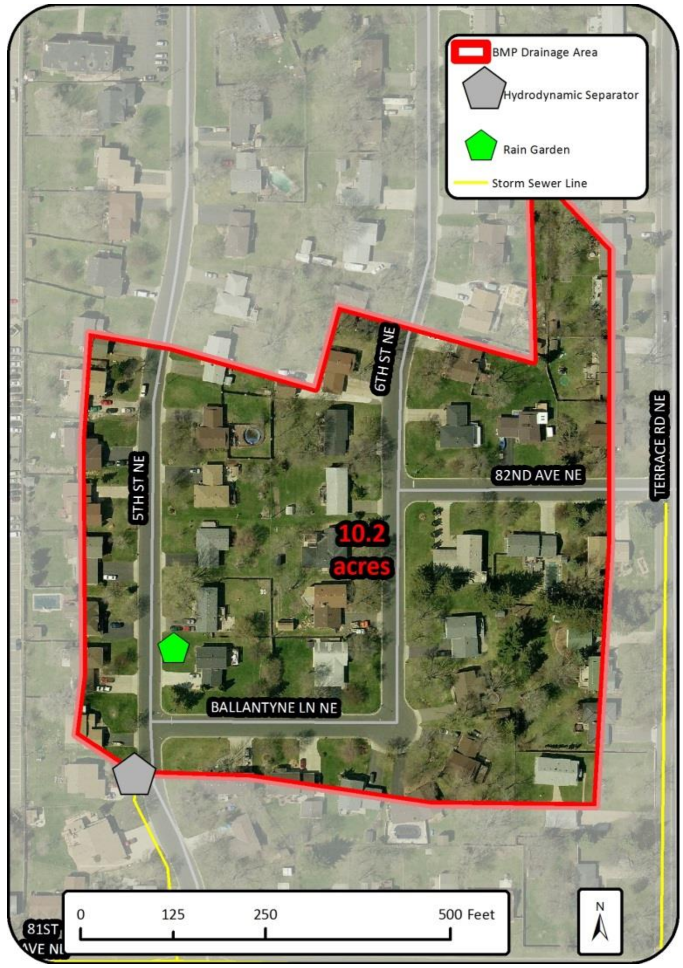
Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.4	0.7%
	TSS (lb/yr)	164	0.9%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2014)	**$55,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,746**	
	30-yr Average Cost/1,000lb-TSS	**$16,454**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 3-C

Ballantyne Ln. NE and 5th St. NE Hydrodynamic Device



Drainage Area – 10.2 acres
Location – 5th St. NE between Ballantyne Rd. NE and 81st Ave. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential properties within the subcatchment. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.8	1.4%
	TSS (lb/yr)	296	1.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,623**	
	30-yr Average Cost/1,000lb-TSS	**$15,197**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 3-D

Curb-Cut Rain Gardens

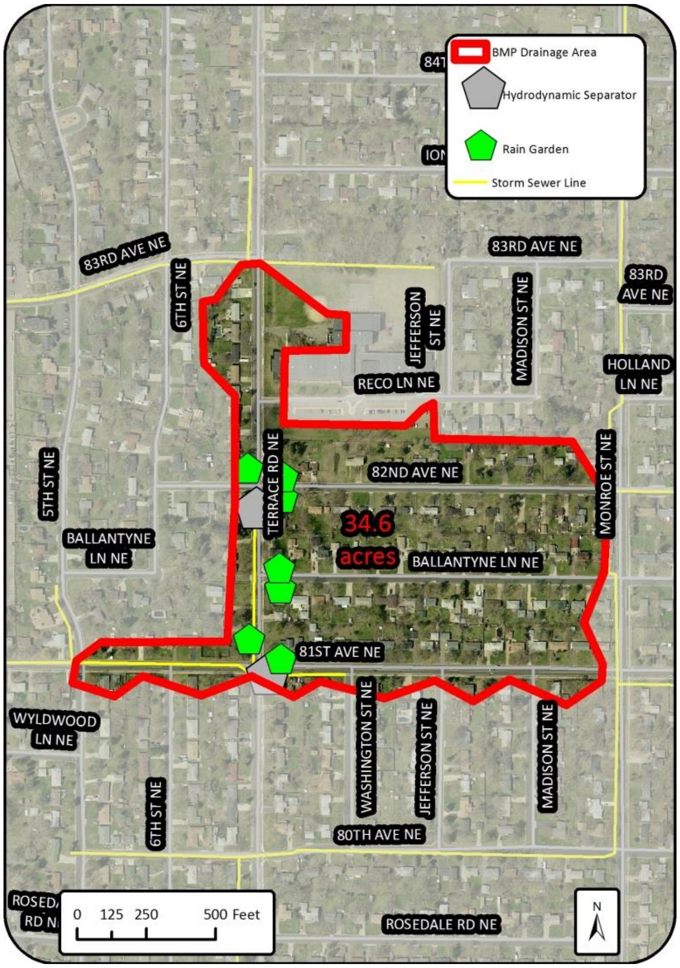
Subcatchment: East1-DD5

Drainage Area – 34.6 acres

Location – Throughout subcatchment East1-DD5

Property Ownership – Private

Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 1, 2, and 4 rain gardens were analyzed to treat the drainage area.



Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		2		4	
	Total Size of BMPs	250	sq-ft	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	0.90	1.6%	1.70	3.0%	3.20	5.6%
	TSS (lb/yr)	303	1.6%	566	3.1%	1,037	5.6%
	Volume (acre-feet/yr)	0.74	1.6%	1.35	3.0%	2.48	5.5%
Cost	Administration & Promotion Costs*	$8,468		$9,344		$11,096	
	Design & Construction Costs**	$7,376		$14,752		$29,504	
	Total Estimated Project Cost (2014)	**$15,844**		**$24,096**		**$40,600**	
	Annual O&M***	$225		$450		$900	
Efficiency	30-yr Average Cost/lb-TP	**$837**		**$737**		**$704**	
	30-yr Average Cost/1,000lb-TSS	**$2,486**		**$2,214**		**$2,173**	
	30-yr Average Cost/ac-ft Vol.	**$1,025**		**$926**		**$909**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

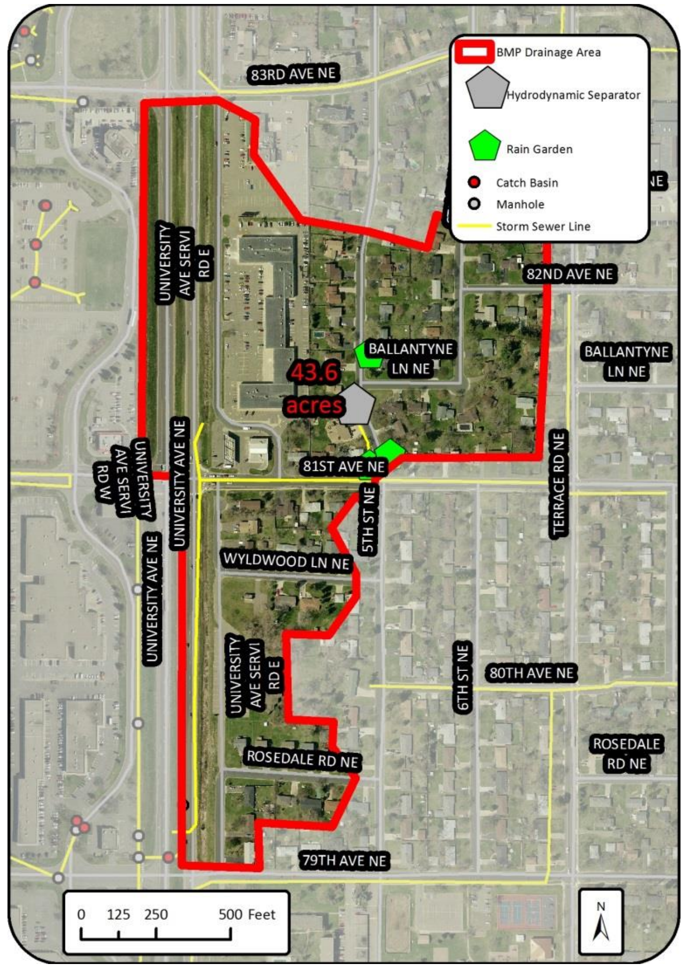
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 3-E

Curb-Cut Rain Gardens

Subcatchment: West1-DD6



Drainage Area – 43.6 acres
Location – Throughout subcatchment West1-DD6
Property Ownership – Private
Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 1, 2, and 3 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		2		3	
	Total Size of BMPs	250	sq-ft	500	sq-ft	750	sq-ft
	TP (lb/yr)	1.00	1.8%	1.90	3.3%	2.70	4.7%
	TSS (lb/yr)	380	2.1%	704	3.8%	1,013	5.5%
	Volume (acre-feet/yr)	0.80	1.8%	1.47	3.3%	2.09	4.6%
Cost	Administration & Promotion Costs*	$8,468		$9,344		$10,220	
	Design & Construction Costs**	$7,376		$14,752		$22,128	
	Total Estimated Project Cost (2014)	**$15,844**		**$24,096**		**$32,348**	
	Annual O&M***	$225		$450		$675	
Efficiency	**30-yr Average Cost/lb-TP**	**$753**		**$660**		**$649**	
	30-yr Average Cost/1,000lb-TSS	**$1,982**		**$1,780**		**$1,731**	
	30-yr Average Cost/ac-ft Vol.	**$938**		**$853**		**$839**	

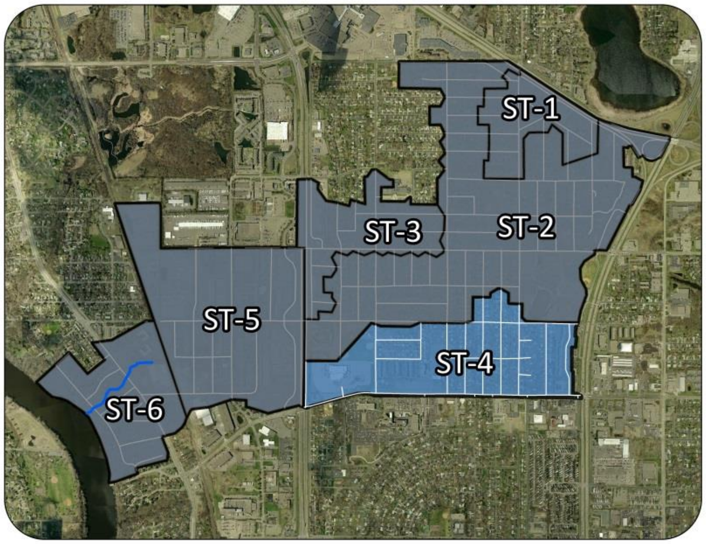
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment ST-4

Existing Catchment Summary	
Acres	150.1
Dominant Land Cover	Residential
Parcels	400
Volume (acre-feet/yr)	89.5
TP (lb/yr)	100.0
TSS (lb/yr)	31,268



CATCHMENT DESCRIPTION

Catchment ST-4, like catchment ST-2, spans urban property between University Ave. and Highway 65. The southern boundary of the catchment is Osborne Road. Land use in the catchment ranges widely, including commercial, charitable, single family residential, multi-family residential, park, and undeveloped open space.

EXISTING STORMWATER TREATMENT

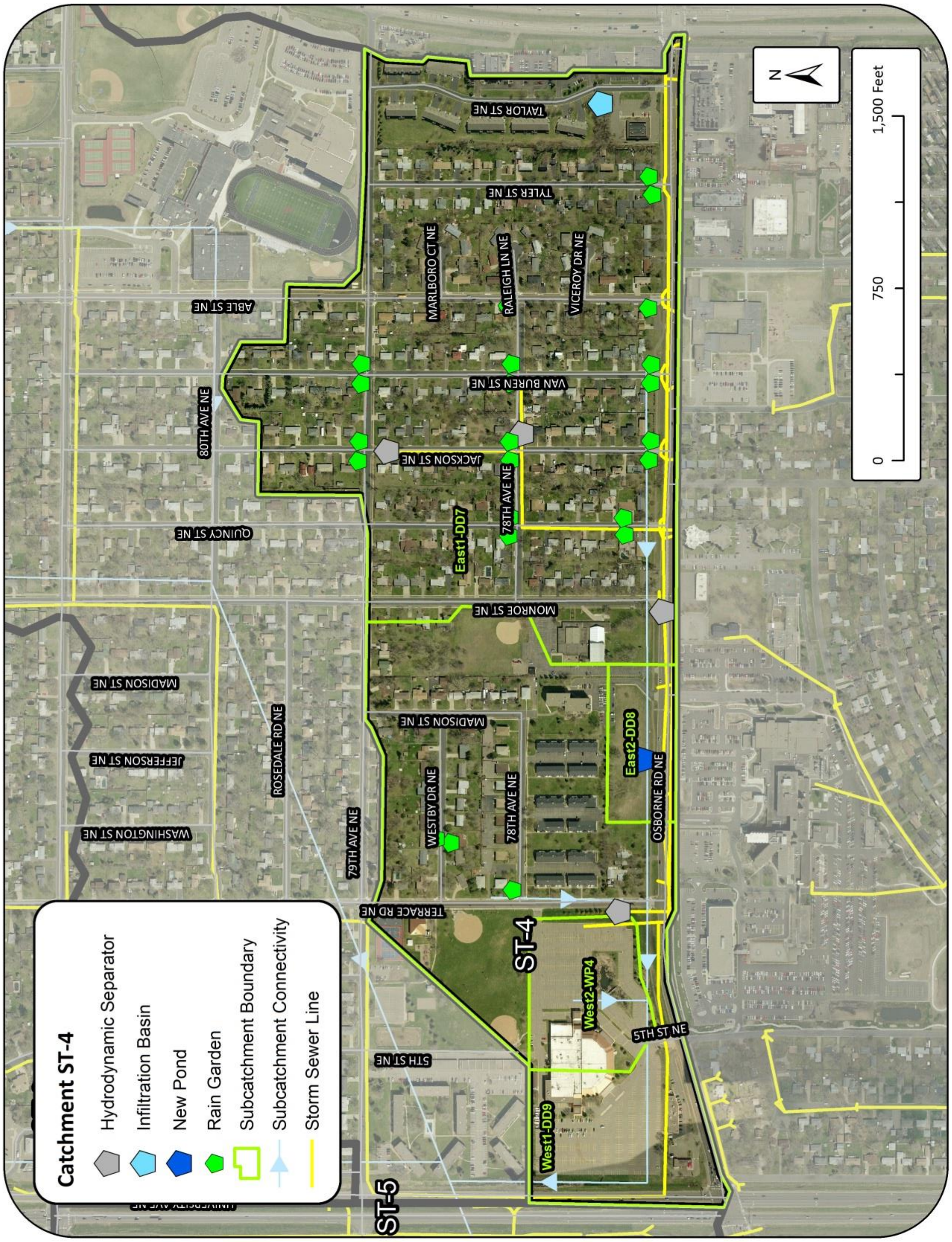
All stormwater runoff generated within the catchment runs to a storm sewer line below Osborne Road. This line discharges into a ditch just east of University Ave. This is the same ditch accepting runoff from both ST-2 and ST-3.

There is one structural BMP in the catchment, a wet pond located on and treating stormwater runoff from the Emmanuel Christian Center property. This pond appears to accept runoff from the eastern half of the parking lot and building. Runoff generated from the western portion of the property and building drains to the ditch along University Ave.

In addition, street cleaning is performed twice per year by the City of Spring Lake Park.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	Emanuel Christian Center Pond and Street Cleaning			
	TP (lb/yr)	111.4	11.4	10%	**100.0**
	TSS (lb/yr)	36,829	5,561.0	15%	**31,268**
	Volume (acre-feet/yr)	89.5	0.0	0%	**89.5**

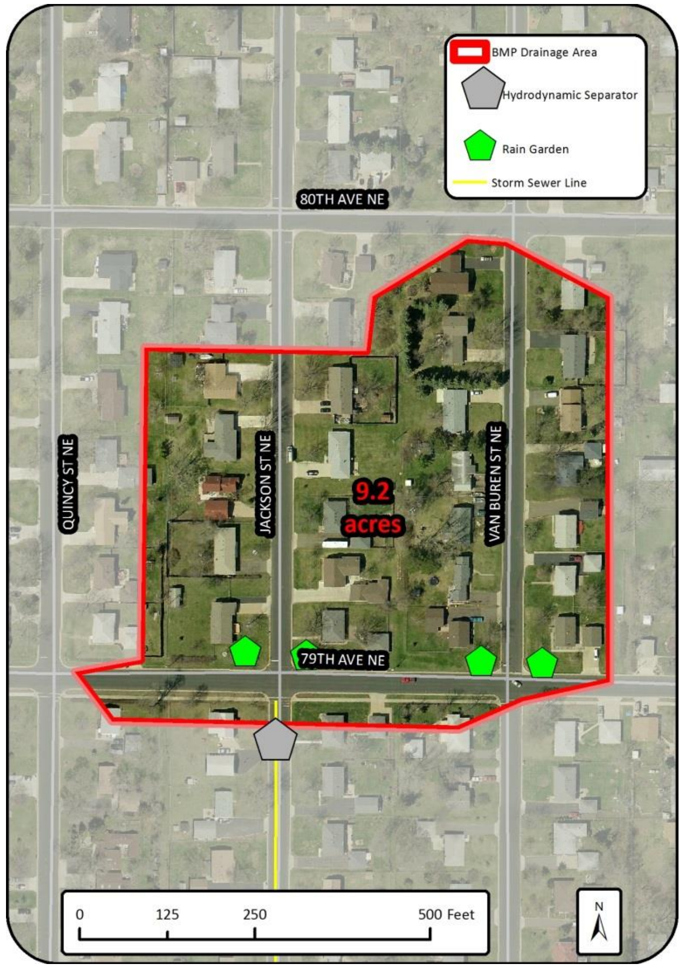
POTENTIAL RETROFITS



Project ID: 4-A

79th Ave. NE and Jackson St. NE Hydrodynamic Device

Drainage Area – 9.2 acres
Location – Jackson St. NE south of 79th Ave. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – Currently, stormwater runoff from the residential lots within this subcatchment discharges directly into the creek's storm sewer network without treatment. To provide treatment, a hydrodynamic device could be installed along the existing storm sewer line on Jackson St. NE. Based on drainage area size and expected peak discharge, a 10 ft. diameter device was proposed.



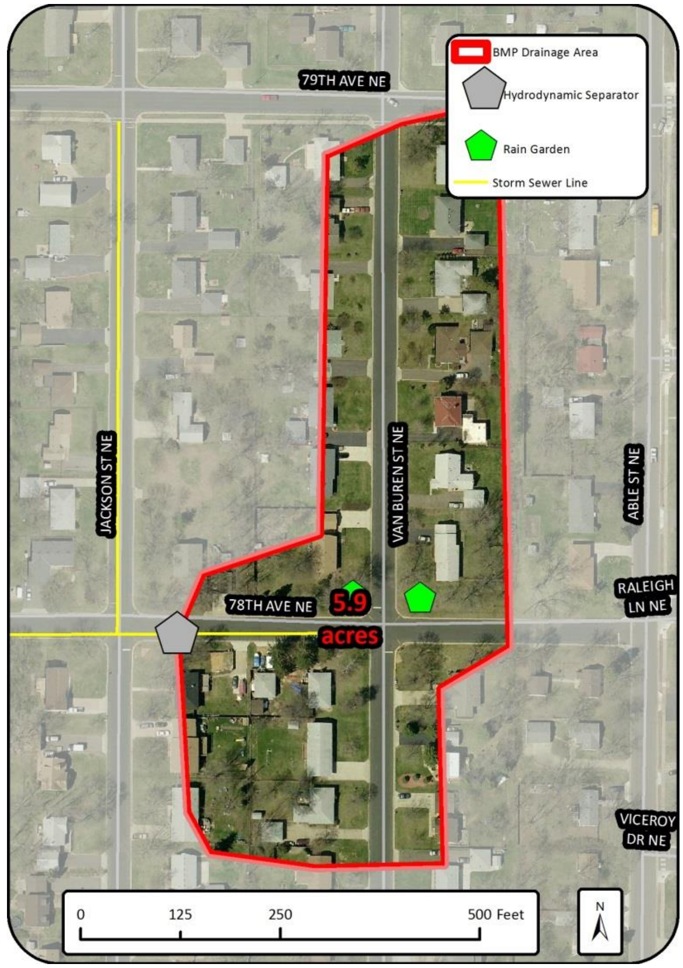
Hydrodynamic Device			
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.6	0.6%
	TSS (lb/yr)	247	0.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$7,497**	
	30-yr Average Cost/1,000lb-TSS	**$18,212**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 4-B

78th Ave. NE and Jackson St. NE Hydrodynamic Device

Drainage Area – 5.9 acres
Location – 79th Ave. NE between Jackson St. NE and Van Buren St. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential lots and impervious space along Van Buren St. NE and 79th Ave. NE. Based on drainage area size and expected peak discharge, an 8 ft. diameter device is proposed. If feasible, this practice should be placed along the 79nd Ave. storm sewer line prior to its intersection with the Jackson St. line. The practice should not be placed along the Jackson St. line as expected peak discharge would exceed structure capacity.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
Treatment	**Total Size of BMPs**	8	ft diameter
Treatment	**TP (lb/yr)**	0.4	0.4%
Treatment	**TSS (lb/yr)**	159	0.5%
Treatment	**Volume (acre-feet/yr)**	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
Cost	**Design & Construction Costs****	$54,000	
Cost	**Total Estimated Project Cost (2014)**	**$55,752**	
Cost	**Annual O&M*****	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,746**	
Efficiency	**30-yr Average Cost/1,000lb-TSS**	**$16,971**	
Efficiency	**30-yr Average Cost/ac-ft Vol.**	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

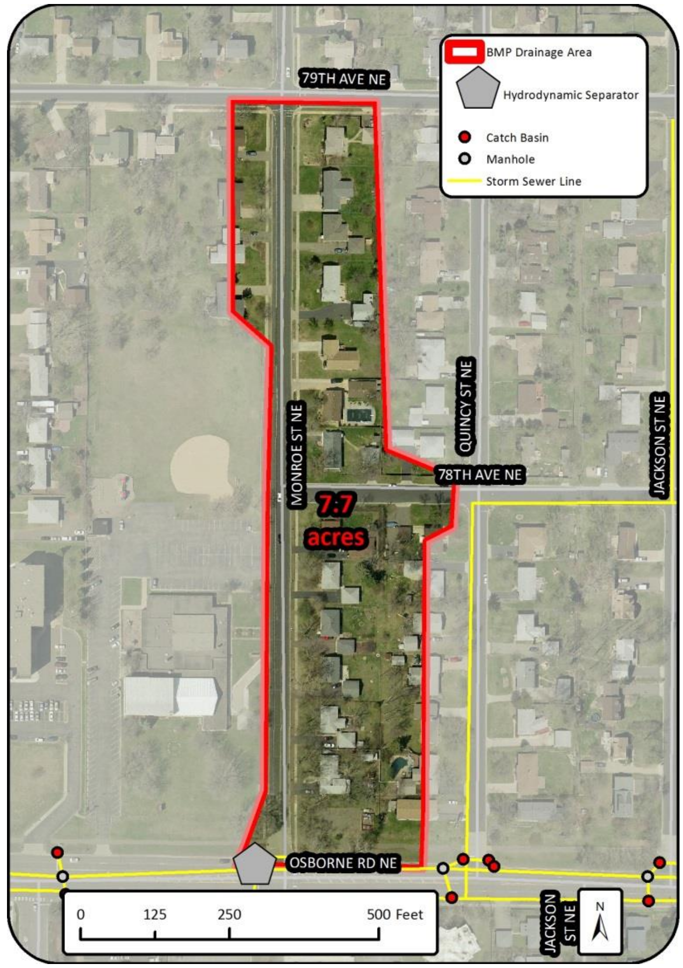
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 4-C

Osborne Rd. NE and Monroe St. NE Hydrodynamic Device

Drainage Area – 7.7 acres
Location – Monroe St. NE at its intersection with Osborne Rd. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the residential properties within the subcatchment. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. If feasible, this practice should be placed downstream of the catch basins at the corner of Osborne Rd. and Monroe St., to ensure sufficient drainage along Monroe St. reaches the device. The values listed in the table below assume runoff from both catch basins at the corner of Osborne Rd. and Monroe St. pass through the device.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.7	0.7%
	TSS (lb/yr)	251	0.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,426**	
	30-yr Average Cost/1,000lb-TSS	**$17,922**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 4-D

Osborne Rd. NE and Terrace Rd. NE Hydrodynamic Device

Drainage Area – 31.2 acres
Location – Terrace Rd. NE north of Osborne Rd. NE
Property Ownership – Public (City of Spring Lake Park)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single family residential lots and portions of Terrace Park and the baseball field west of Monroe St. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. The drainage area is very large for a hydrodynamic device, but much of the catchment (9.25 acres) is pervious park space.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.6	1.6%
	TSS (lb/yr)	634	2.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,812**	
	30-yr Average Cost/1,000lb-TSS	**$7,095**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 4-E

Curb-Cut Rain Gardens

Subcatchment: East1-DD7

Drainage Area – 87.9 acres

Location – Throughout subcatchment East1-DD7

Property Ownership – Private

Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 4, 8, and 12 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	4		8		12	
	Total Size of BMPs	1,000	sq-ft	2,000	sq-ft	3,000	sq-ft
	TP (lb/yr)	3.30	3.3%	6.10	6.1%	8.70	8.7%
	TSS (lb/yr)	1,126	3.6%	2,085	6.7%	2,963	9.5%
	Volume (acre-feet/yr)	2.80	3.1%	5.19	5.8%	7.37	8.2%
Cost	Administration & Promotion Costs*		$11,096		$14,600		$18,104
	Design & Construction Costs**		$29,504		$59,008		$88,512
	Total Estimated Project Cost (2014)		**$40,600**		**$73,608**		**$106,616**
	Annual O&M***		$900		$1,800		$2,700
Efficiency	30-yr Average Cost/lb-TP	**$683**		**$697**		**$719**	
	30-yr Average Cost/1,000lb-TSS	**$2,001**		**$2,040**		**$2,111**	
	30-yr Average Cost/ac-ft Vol.	**$804**		**$820**		**$849**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 4-F

New Pond

Drainage Area –92.6 acres
Location – Undeveloped space along Osborne Rd. between Terrace Rd. and Monroe St.
Property Ownership – Private
Site Specific Information – Up to two acres of undeveloped space is available along Osborne Rd. for the installation of a new stormwater pond. Due to the estimated pollutants generated upstream, a new wet pond is proposed. This pond will treat the full drainage area upstream, 92.7 acres, by diverting the existing storm sewer line running along Osborne Rd. into the pond. The pond outlet would need to be reconnected to this line downstream of the practice. This pond, although designed as a water quality BMP, will also reduce peak discharges downstream by retaining water within the practice.

	New Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	4.45	ac-ft
	TP (lb/yr)	26.5	26.5%
	TSS (lb/yr)	11,031	35.3%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,840	
	Design & Construction Costs**	$647,168	
	Total Estimated Project Cost (2014)	**$653,008**	
	Annual O&M***	$1,341	
Efficiency	**30-yr Average Cost/lb-TP**	**$872**	
	30-yr Average Cost/1,000lb-TSS	**$2,095**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*80 hours at $73/hour

**See Appendix B for detailed cost information

***$1,000/acre of pond surface area - Annual inspection and sediment/debris removal from pretreatment area

Project ID: 4-G

Infiltration basin

Subcatchment: East1-DD7-IB2

Drainage Area – 5.2 acres
Location – Taylor St. north of Osborne Rd.
Property Ownership – Private
Site Specific Information – Up to a quarter acre of open space exists on private property along Taylor St. NE to install a curb-cut infiltration basin. The basin would treat stormwater runoff from the town home properties to the north. The basin could be designed to fill to a 1' depth, then overflow along the gutter line to reduce the risk of flooding neighboring properties. Similar to rain gardens, native plant species could also be included to improve the aesthetic quality of the practice. It was assumed that landowner cooperation would allow for installation. Therefore, no additional costs were included for property acquisition.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	2,250	sq-ft
	TP (lb/yr)	2.8	2.8%
	TSS (lb/yr)	956	3.1%
	Volume (acre-feet/yr)	3.2	3.5%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$34,626	
	Total Estimated Project Cost (2014)	**$37,546**	
	Annual O&M***	$780	
Efficiency	30-yr Average Cost/lb-TP	**$726**	
	30-yr Average Cost/1,000lb-TSS	**$2,125**	
	30-yr Average Cost/ac-ft Vol.	**$641**	

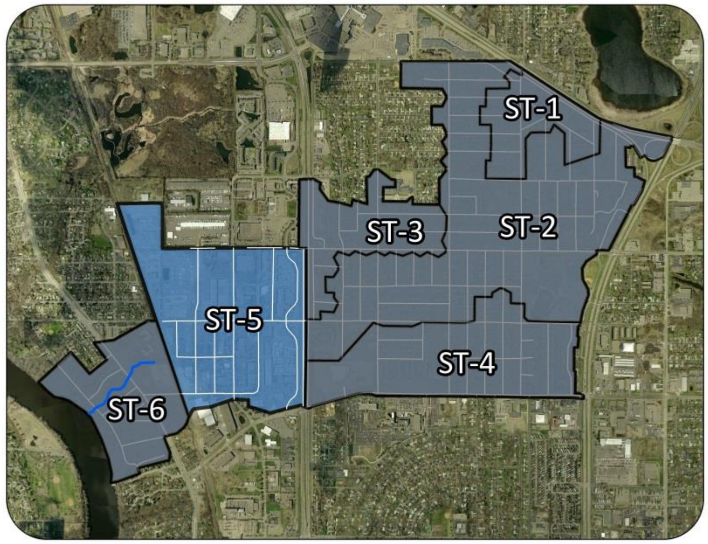
*40 hours at $73/hour

**($15/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation) + ($630/year for routine maintenance [9 hours at $70/hour])

Catchment ST-5

Existing Catchment Summary	
Acres	192.7
Dominant Land Cover	Industrial
Parcels	108
Volume (acre-feet/yr)	193.7
TP (lb/yr)	148.2
TSS (lb/yr)	75,161



CATCHMENT DESCRIPTION
Catchment ST-5 is an industrial and commercial area bounded by University Ave. to the east and the Burlington Northern railroad tracks to the west. The area has had a history of street and parking lot flooding during large storm events, likely due to the high amount of impervious cover and generally hydric soils. Stonybrook is piped through this catchment, daylighting downstream in ST-6.

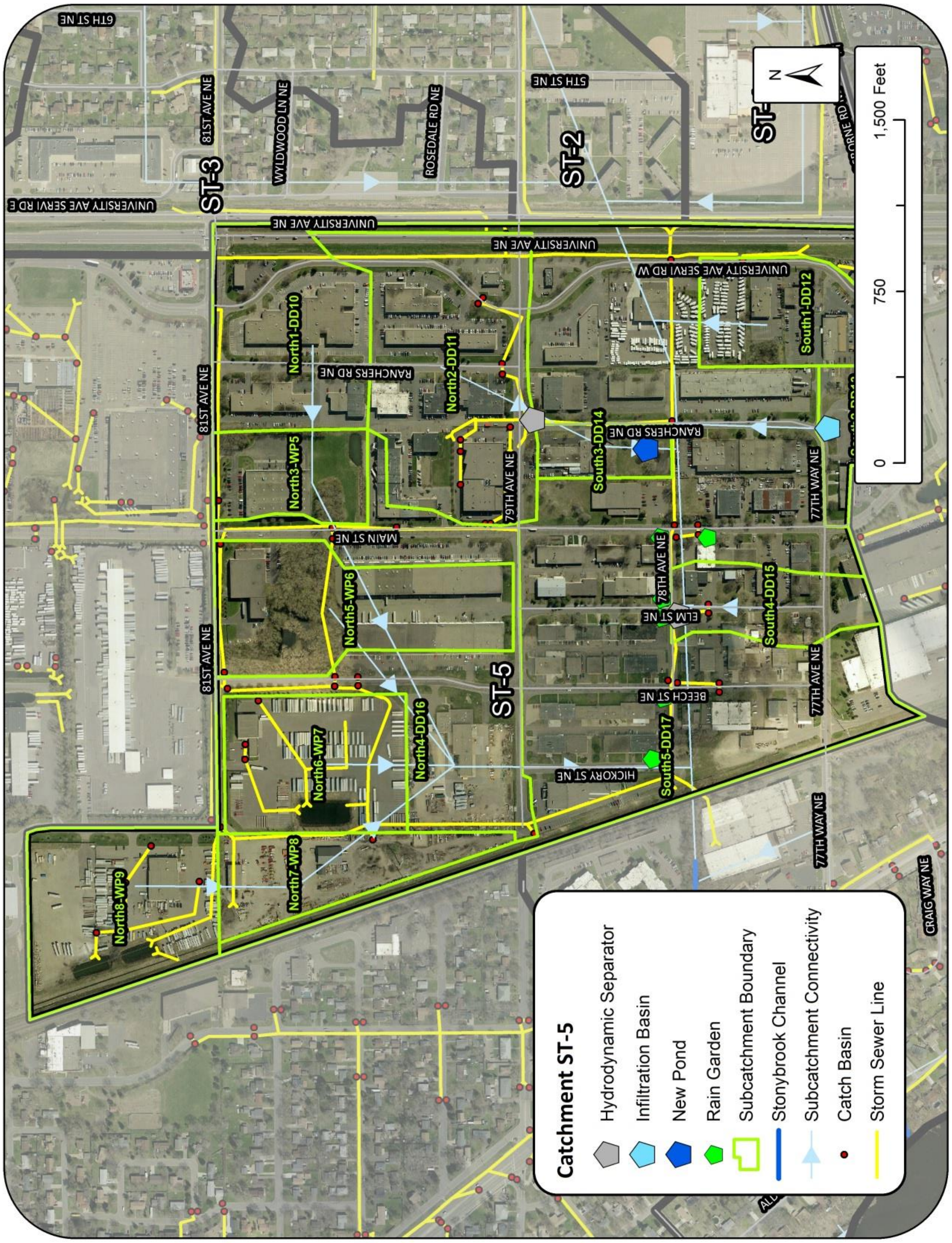
EXISTING STORMWATER TREATMENT
Stormwater generated within the catchment is directed to a 72" storm sewer pipe running from east to west under 78th Ave. This pipe discharges into the Stonybrook channel approximately 200 ft. west of the railroad tracks.

There are currently 5 wet ponds in the catchment, each treating runoff from the property they were constructed upon. The properties for these ponds are all located in the northern portion of the catchment along 81st Ave. and Hickory St.

In addition, street cleaning is performed four times per year by the City of Fridley.

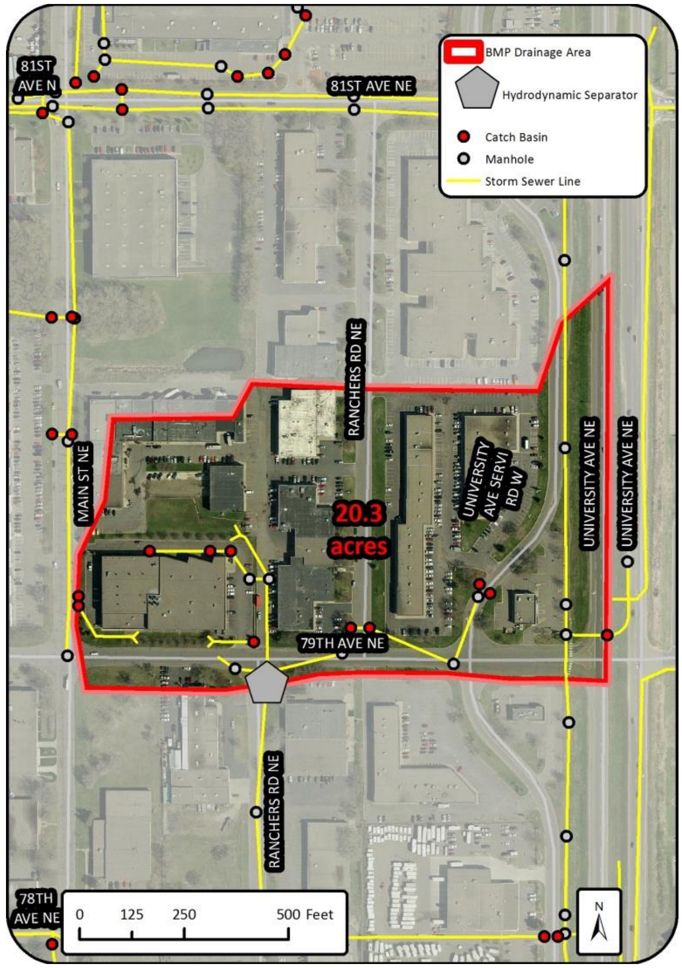
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	6			
	BMP Types	5 Private Stormwater Ponds and Street Cleaning			
	TP (lb/yr)	176.3	28.1	16%	**148.2**
	TSS (lb/yr)	96,470	21,309.0	22%	**75,161**
	Volume (acre-feet/yr)	193.7	0.0	0%	**193.7**

POTENTIAL RETROFITS



Project ID: 5-A

79th Ave. NE and Ranchers Rd. NE Hydrodynamic Device



Drainage Area – 20.3 acres
Location – Intersection of Rancher's Rd. NE and 79th Ave. NE
Property Ownership – Public (City of Fridley)
Site Specific Information – Currently, stormwater runoff from this subcatchment discharges directly into the storm sewer network without treatment. A hydrodynamic device could be installed along the existing storm sewer line on Rancher's St. Based on drainage area size and expected peak discharge, a 10 ft. diameter device was proposed. If feasible, this device should be installed south of 79th Ave. such that input from the 79th Ave. storm sewer line as well as the line draining the commercial properties north of Ranchers Rd. are all treated. Values listed in the table assume both of these storm sewer lines are treated.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.4	0.9%
	TSS (lb/yr)	939	1.2%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,213**	
	30-yr Average Cost/1,000lb-TSS	**$4,791**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

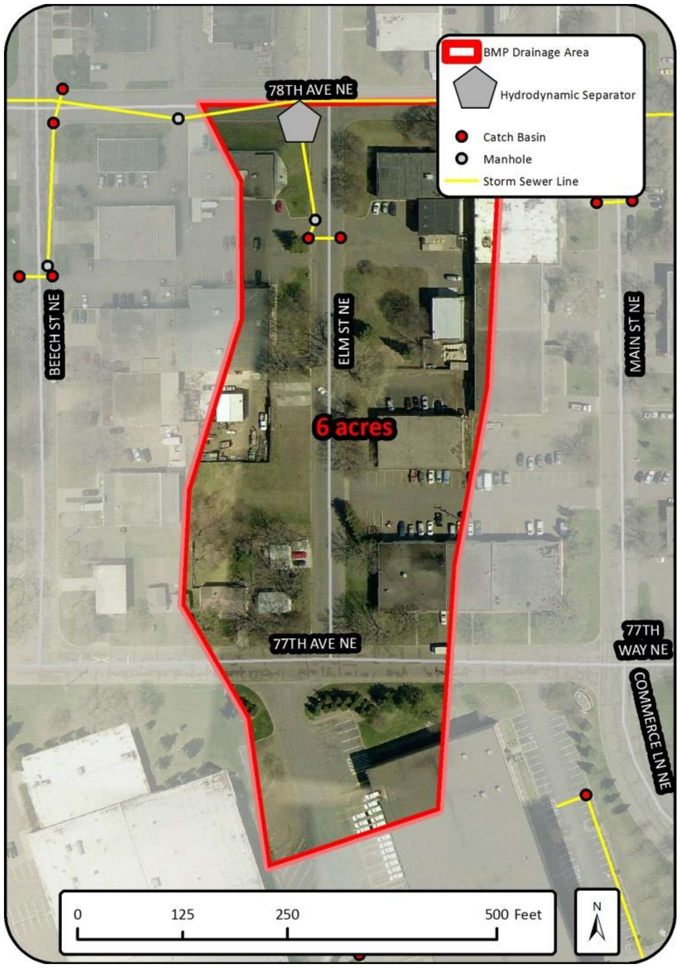
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 5-B

78th Ave. NE and Elm St. NE
Hydrodynamic Device



Drainage Area – 6.0 acres
Location – Intersection of Elm St. NE and 78th Ave. NE
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed along Elm St. and 77th Ave. Based on drainage area size and expected peak discharge, a 6 ft. diameter device was proposed. This practice should be placed along the Elm St. storm sewer line prior to its intersection with the 78th Ave. line. The practice should not be placed along the 78th Ave. line as expected peak discharge would exceed structure capacity. If this location is infeasible, similar reduction benefits could be achieved on two adjacent streets south of 78th Ave.: Beech St. and Main St. Each has a predominantly industrial land use, similar percentage of impervious space, and contributing drainage area of 5-6 acres.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.5	0.3%
	TSS (lb/yr)	392	0.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2014)	**$55,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$5,397**	
	30-yr Average Cost/1,000lb-TSS	**$6,884**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

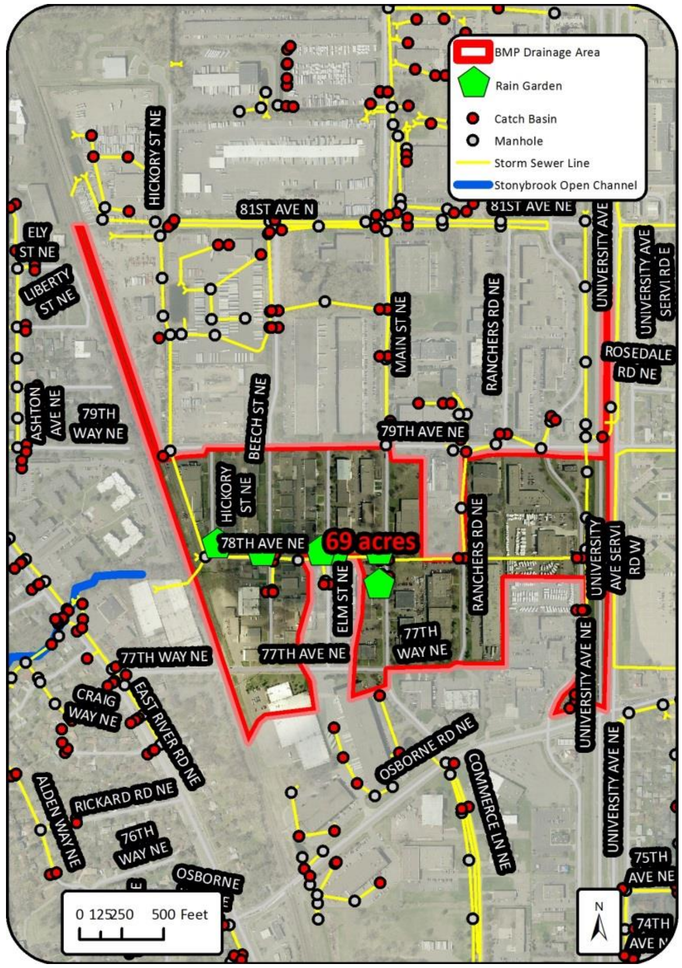
*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 5-C

Curb-Cut Rain Gardens

Subcatchment: South5-DD17

Drainage Area – 69.0 acres
Location – Throughout subcatchment South5-DD17
Property Ownership – Private
Site Specific Information – – Currently, stormwater runoff generated within the catchment flows untreated into the Stonybrook storm sewer network. As these gardens are proposed for commercial properties, gauging landowner interest is very difficult. To be conservative, scenarios with 1, 3, or 5 rain gardens were analyzed. Soils should be tested prior to installation to determine soil type and potential infiltration rates. If necessary (or feasible), an underdrain could be installed to ensure ponding time is less than 48 hours.



	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		3		5	
	Total Size of BMPs	250	sq-ft	750	sq-ft	1,250	sq-ft
	TP (lb/yr)	0.80	0.5%	2.10	1.4%	3.40	2.3%
	TSS (lb/yr)	464	0.6%	1,238	1.6%	1,952	2.6%
	Volume (acre-feet/yr)	0.87	0.5%	2.32	1.2%	3.63	1.9%
Cost	Administration & Promotion Costs*	$8,468		$10,220		$11,972	
	Design & Construction Costs**	$7,376		$22,128		$36,880	
	Total Estimated Project Cost (2014)	**$15,844**		**$32,348**		**$48,852**	
	Annual O&M***	$225		$675		$1,125	
Efficiency	30-yr Average Cost/lb-TP	**$941**		**$835**		**$810**	
	30-yr Average Cost/1,000lb-TSS	**$1,623**		**$1,416**		**$1,411**	
	30-yr Average Cost/ac-ft Vol.	**$864**		**$756**		**$759**	

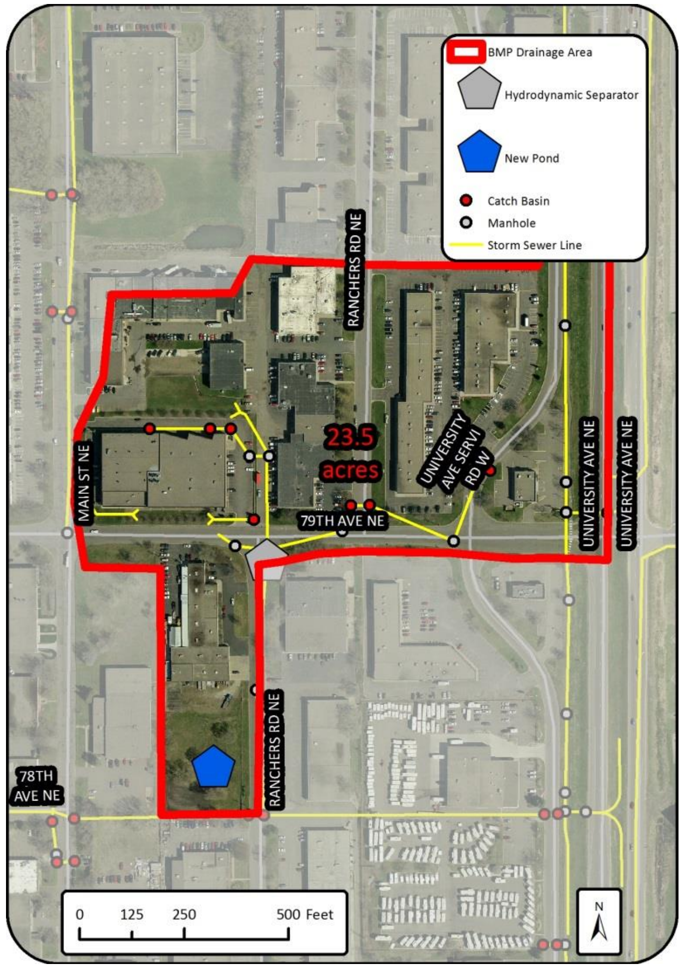
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 5-D

New Pond



Drainage Area – 23.5 acres
Location – Open space west of Ranchers Rd. between 79th Ave. and 77th Ave.
Property Ownership – Private
Site Specific Information – Undeveloped space is available within the industrial park on private property. The pond would require modifying the storm sewer line running south under Ranchers Rd. to become the new pond inlet. Up to 1.2 acres is available for the pond footprint. To treat the drainage area, pond storage should be approximately 1.0 ac-ft (assuming 1,800 cu-ft of storage per acre of contributing drainage area). Therefore, a 1.22 ac-ft pond was modeled. This pond, although designed as a water quality BMP, will also reduce peak discharge by retaining water within the practice.

	New Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1	
	Total Size of BMPs	1.22	ac-ft
	TP (lb/yr)	9.3	6.3%
	TSS (lb/yr)	6,010	8.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$5,840	
	Design & Construction Costs**	$385,427	
	Total Estimated Project Cost (2014)	**$391,267**	
	Annual O&M***	$627	
Efficiency	30-yr Average Cost/lb-TP	**$1,470**	
	30-yr Average Cost/1,000lb-TSS	**$2,274**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*80 hours at $73/hour

**See Appendix B for detailed cost information

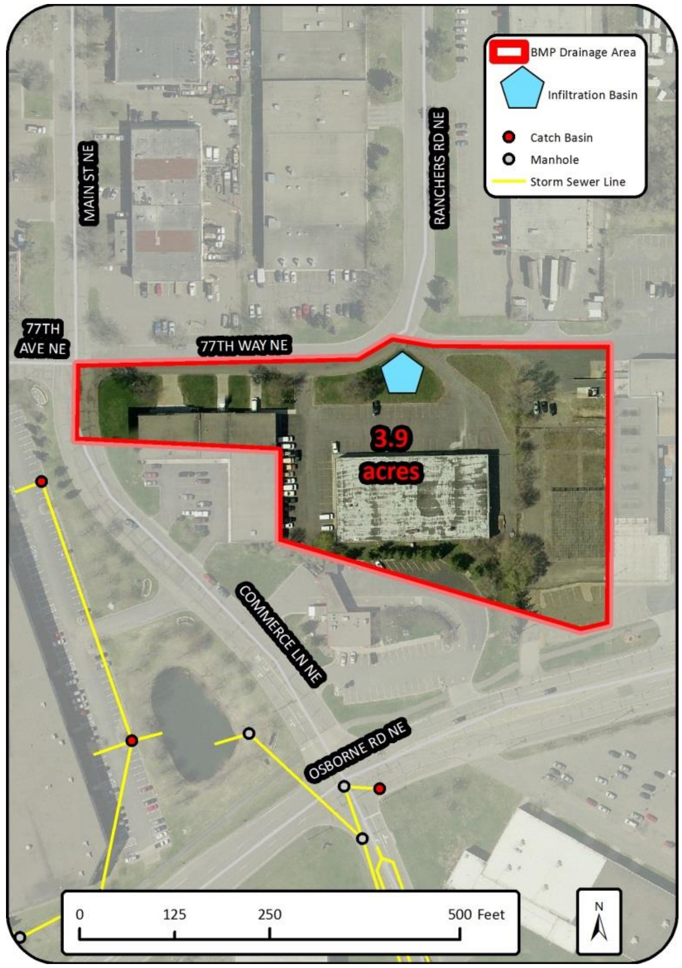
***$1,000/acre of pond surface area - Annual inspection and sediment/debris removal from pretreatment area

Project ID: 5-E

Infiltration Basin

Subcatchment: South2-DD13

Drainage Area – 3.9 acres
Location – Southeast corner of 77th Way and Ranchers Rd. intersection
Property Ownership – Private
Site Specific Information – An opportunity exists to install a curb-cut infiltration basin along 77th Way at its intersection with Rancher's Rd. Based on the drainage area and space available, an infiltration basin with a top area of 2,500 sq-ft is proposed. The basin could be designed to fill to a 1' depth, then overflow along the gutter line to reduce the risk of flooding neighboring properties. It was assumed that landowner cooperation would allow for installation. Therefore, no additional costs were included for property acquisition.



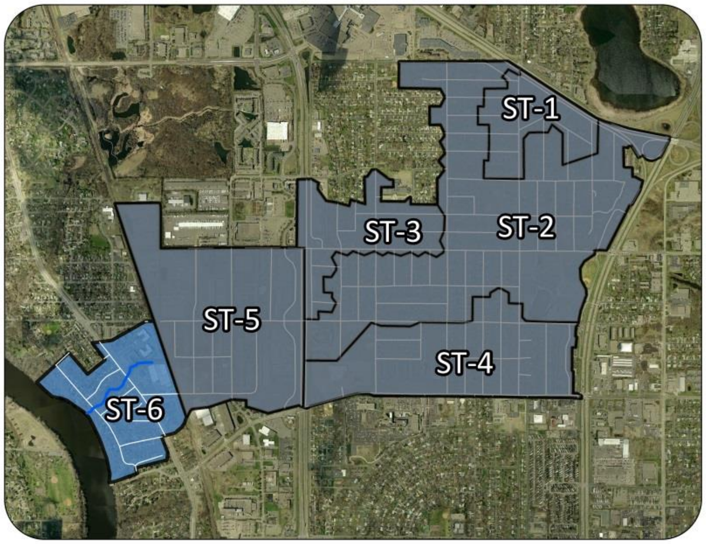
Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	2,500	sq-ft
	TP (lb/yr)	2.8	1.9%
	TSS (lb/yr)	1,569	2.1%
	Volume (acre-feet/yr)	3.5	1.8%
Cost	Administration & Promotion Costs*		$2,920
	Design & Construction Costs**		$38,376
	Total Estimated Project Cost (2014)		**$41,296**
	Annual O&M***		$780
Efficiency	30-yr Average Cost/lb-TP	**$770**	
	30-yr Average Cost/1,000lb-TSS	**$1,374**	
	30-yr Average Cost/ac-ft Vol.	**$614**	

*40 hours at $73/hour
**($15/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)
***Per BMP: ($150/year for 10-year rehabilitation) + ($630/year for routine maintenance [9 hours at $70/hour])

Catchment ST-6

Existing Catchment Summary	
Acres	82.9
Dominant Land Cover	Residential
Parcels	167
Volume (acre-feet/yr)	52.5
TP (lb/yr)	54.6
TSS (lb/yr)	20,163



CATCHMENT DESCRIPTION

This catchment lies west of the Burlington Northern railroad tracks and is the westernmost catchment in the subwatershed. Stonybrook daylights from the storm sewer network in this catchment and follows a highly incised channel to its confluence with the Mississippi River. Land use throughout the catchment is predominantly single family residential west of East River Road. East of East River Road is a mix of both single and multi-family residential properties along with several industrial and commercial lots.

EXISTING STORMWATER TREATMENT

The primary stormwater treatment in the catchment is street cleaning, performed four times per year by the City of Fridley. Stormwater runoff is conveyed overland or through the storm sewer lines on East River Road, Craig Way, and Alden Way and discharges directly into Stonybrook.

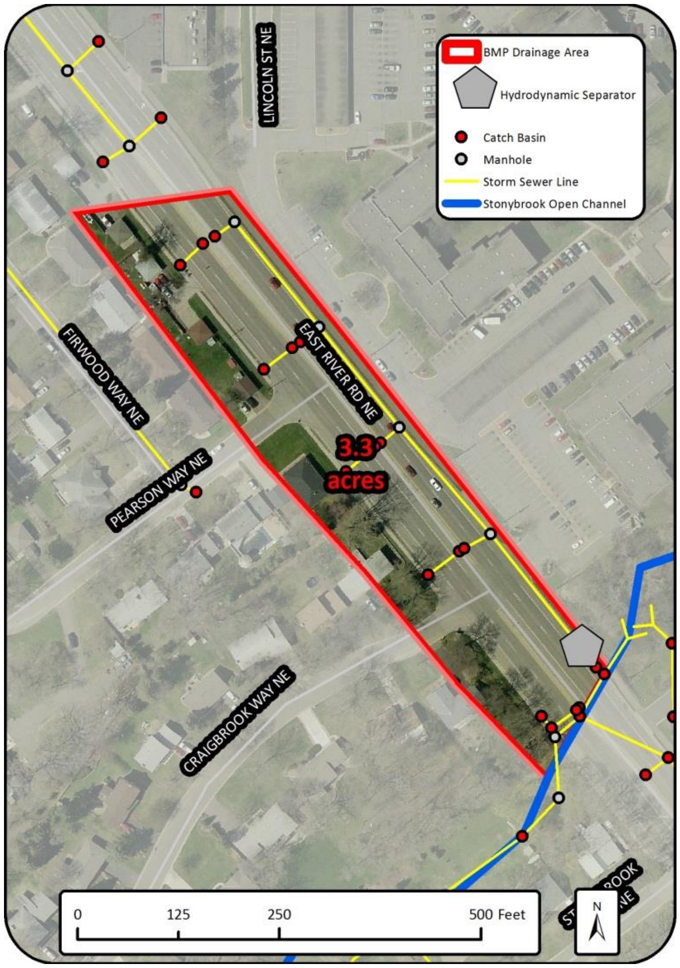
Please note subcatchment “West1-Disconnect” was not included in the WinSLAMM model. It was excluded because it discharges directly to the Mississippi River and does not enter Stonybrook. The subcatchment is largely comprised of residential property halves adjacent to the Mississippi River.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	59.0	4.4	7%	**54.6**
	TSS (lb/yr)	22,258	2,095.0	9%	**20,163**
	Volume (acre-feet/yr)	52.5	0.0	0%	**52.5**

POTENTIAL RETROFITS

Project ID: 6-A

East River Rd. NE and Stonybrook Hydrodynamic Device



Drainage Area – 3.3 acres
Location – East River Road at Stonybrook (north of creek)
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line on Jackson St. Based on drainage area size and expected peak discharge, a 6 ft. diameter device was proposed. Although this catchment is quite small, most of the drainage area is East River Road, a four-lane highway that generates high amounts of roadway pollutants.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	6	ft diameter
	TP (lb/yr)	0.2	0.4%
	TSS (lb/yr)	105	0.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$27,000	
	Total Estimated Project Cost (2014)	**$28,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$8,992**	
	30-yr Average Cost/1,000lb-TSS	**$17,128**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

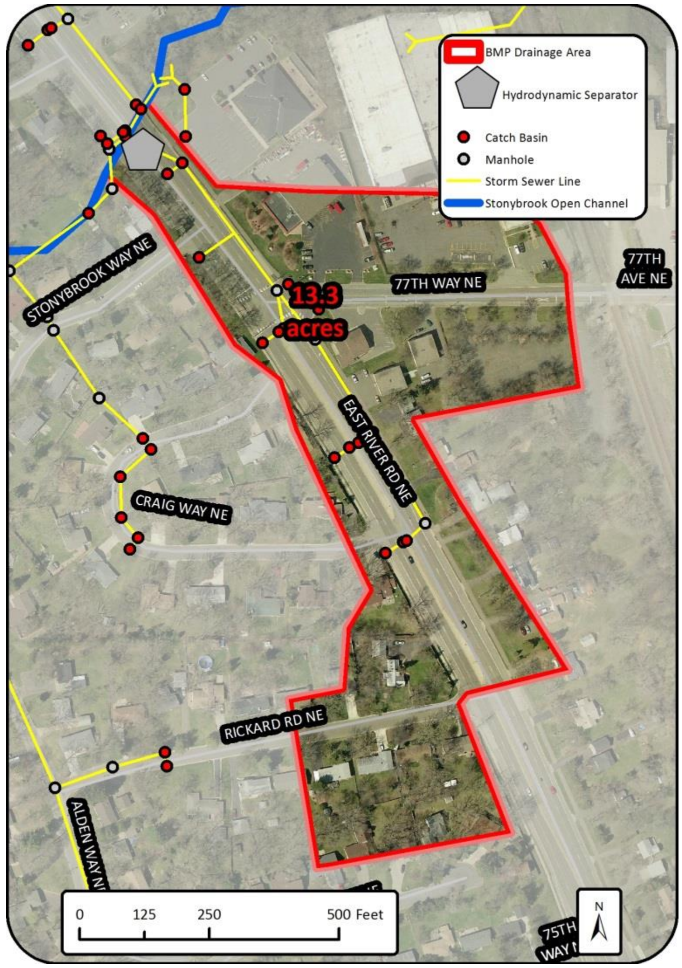
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 6-B

East River Rd. NE and Stonybrook Hydrodynamic Device



Drainage Area – 13.3 acres
Location – East River Road at Stonybrook (south of creek)
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential and commercial lots along East River Road and 77th Way. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. Values listed in the table assume the device is placed just upstream of the storm sewer discharge to the creek.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.8	1.5%
	TSS (lb/yr)	494	2.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$5,623**	
	30-yr Average Cost/1,000lb-TSS	**$9,106**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: (24 hours at $73/hour)
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)
***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 6-C

Craigbrook Way NE and Alden Way NE Hydrodynamic Device

Drainage Area – 10.5 acres
Location – Intersection of Craigbrook Way and Alden Way
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential lots along Craigbrook Way and Alden Way. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. Values listed in the table assume the device only treats stormwater from catch basins located at the intersection of Craigbrook Way and Alden Way.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.6	1.1%
	TSS (lb/yr)	238	1.2%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$7,497**	
	30-yr Average Cost/1,000lb-TSS	**$18,901**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

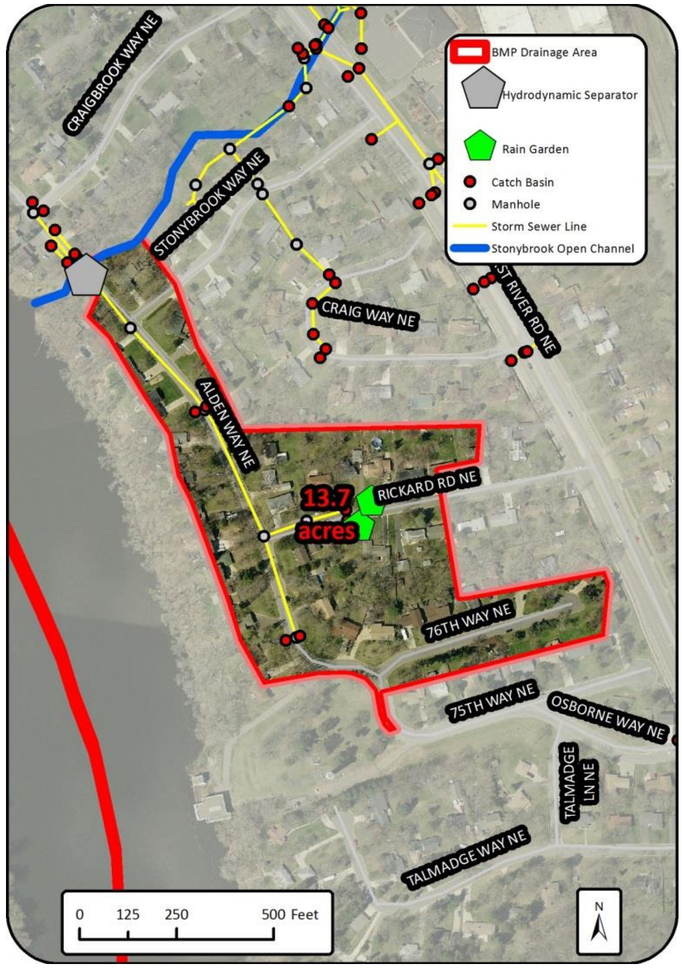
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 6-D

Stonybrook Way NE and Alden Way NE Hydrodynamic Device



Drainage Area – 13.7 acres
Location – 79th Ave between Jackson St. and Van Buren St.
Property Ownership – Public (City of Fridley)
Site Specific Information – A hydrodynamic device could be installed along the existing storm sewer line to treat the single-family residential properties along Alden Way, Rickard Rd., and 76th Way. Based on drainage area size and expected peak discharge, a 10 ft. diameter device is proposed. To maximize treatment area, the device should be installed along Alden Way near its intersection with the creek.

Hydrodynamic Device			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.7	1.3%
	TSS (lb/yr)	278	1.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2014)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,426**	
	30-yr Average Cost/1,000lb-TSS	**$16,181**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

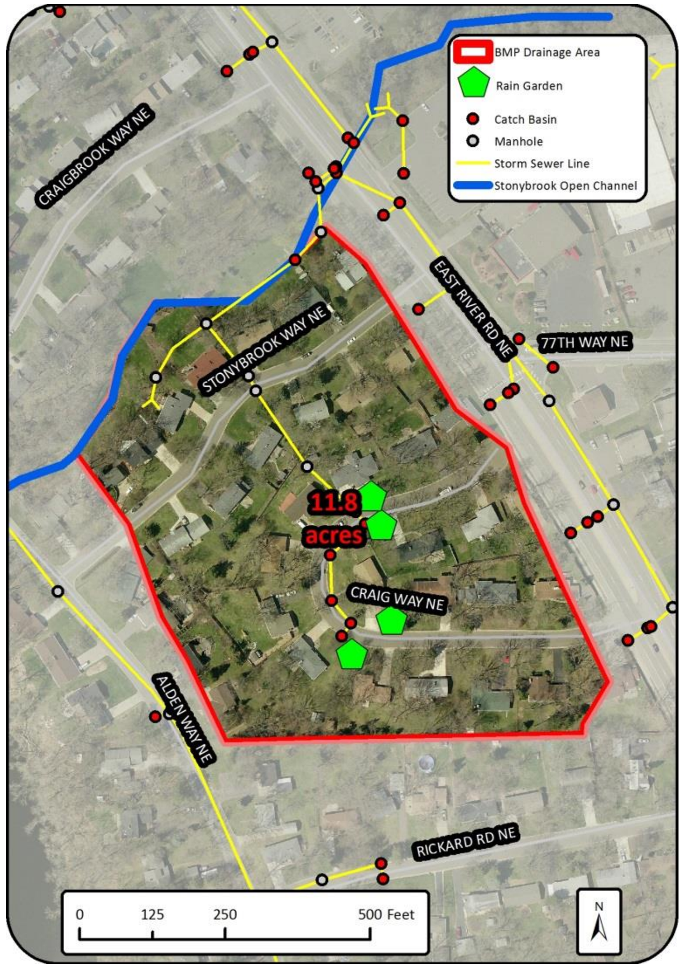
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

***Per BMP: (4 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 6-E

Curb-Cut Rain Gardens
Subcatchment: South2-DD20



Drainage Area – 11.8 acres
Location – Throughout subcatchment South2-DD20
Property Ownership – Private
Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 1, 2, and 4 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		2		4	
	Total Size of BMPs	250	sq-ft	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	0.80	1.5%	1.50	2.7%	2.50	4.6%
	TSS (lb/yr)	265	1.3%	473	2.3%	776	3.8%
	Volume (acre-feet/yr)	0.64	1.2%	1.13	2.1%	1.86	3.5%
Cost	Administration & Promotion Costs*	$8,468		$9,344		$11,096	
	Design & Construction Costs**	$7,376		$14,752		$29,504	
	Total Estimated Project Cost (2014)	**$15,844**		**$24,096**		**$40,600**	
	Annual O&M***	$225		$450		$900	
Efficiency	30-yr Average Cost/lb-TP	**$941**		**$835**		**$901**	
	30-yr Average Cost/1,000lb-TSS	**$2,842**		**$2,649**		**$2,904**	
	30-yr Average Cost/ac-ft Vol.	**$1,171**		**$1,114**		**$1,211**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

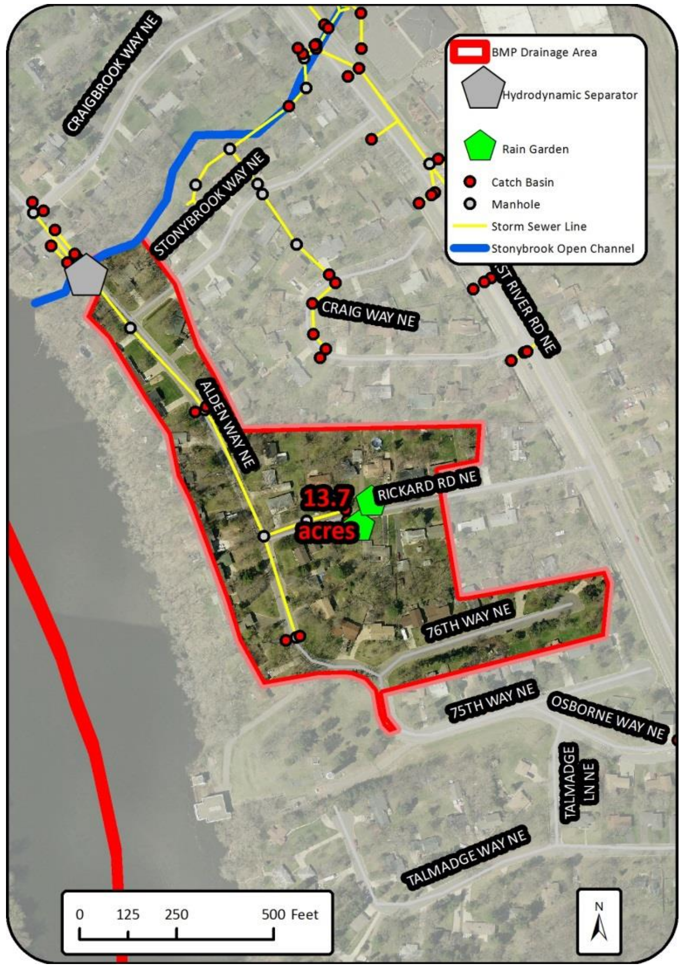
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 6-F

Curb-Cut Rain Gardens

Subcatchment: South3-DD22



Drainage Area – 13.7 acres

Location – Throughout subcatchment South3-DD22

Property Ownership – Private

Site Specific Information – Currently, stormwater runoff generated within the subcatchment flows untreated into the Stonybrook storm sewer network. Curb-cut rain gardens are proposed because soils were mapped as favorable for infiltration practices. Considering typical landowner participation rates, scenarios with 1 and 2 rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden				
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1		2	
	Total Size of BMPs	250	sq-ft	500	sq-ft
	TP (lb/yr)	0.80	1.5%	1.50	2.7%
	TSS (lb/yr)	269	1.3%	485	2.4%
	Volume (acre-feet/yr)	0.64	1.2%	1.17	2.2%
Cost	Administration & Promotion Costs*	$8,468		$9,344	
	Design & Construction Costs**	$7,376		$14,752	
	Total Estimated Project Cost (2014)	**$15,844**		**$24,096**	
	Annual O&M***	$225		$450	
Efficiency	30-yr Average Cost/lb-TP	**$941**		**$835**	
	30-yr Average Cost/1,000lb-TSS	**$2,800**		**$2,584**	
	30-yr Average Cost/ac-ft Vol.	**$1,171**		**$1,070**	

*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

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Appendix A – Modeling Methods

The following sections include WinSLAMM model details for each type of best management practice modeled for this analysis. The sections are separated into general WinSLAMM model inputs, existing conditions, and proposed conditions.

WinSLAMM

Pollutant and volume reductions were estimated using the stormwater model Source Load and Management Model for Windows (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 has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape". WinSLAMM uses rainfall and temperature data from a typical year (1959 data from Minneapolis for this analysis), routing stormwater through the user's model for each storm. WinSLAMM version 10.1.1 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 12.

Table 12: General WinSLAMM Model Inputs (i.e. Current File Data)

Parameter	File/Method
Land use acreage	ArcMap, Metropolitan Council 2010 Land Use
Precipitation/Temperature Data	Minneapolis 1959 – best approximation of a typical year
Winter season	Included in model. Winter dates are 11-4 to 3-13.
Pollutant probability distribution	WI_GEO01.ppd
Runoff coefficient file	WI_SL06 Dec06.rsv
Particulate solids concentration file	WI_AVG01.psc
Particle residue delivery file	WI_DLV01.prr
Street delivery files	WI files for each land use

Existing Conditions

Existing stormwater BMPs were included in the WinSLAMM model for which information was available from either the City of Spring Lake Park or the City of Fridley. The practices listed below were included in the existing conditions model.

Infiltration Basins

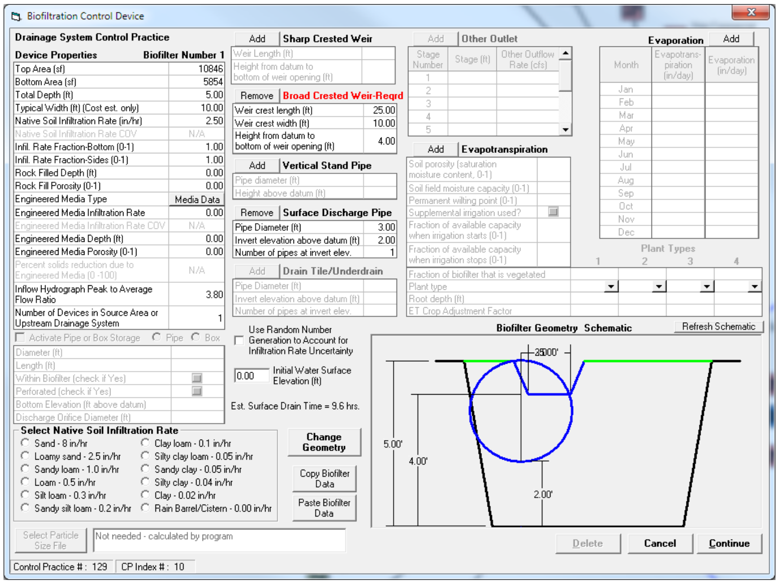

Figure 7: Infiltration basin IB1 in catchment ST-2 WinSLAMM model inputs

Stormwater Ponds

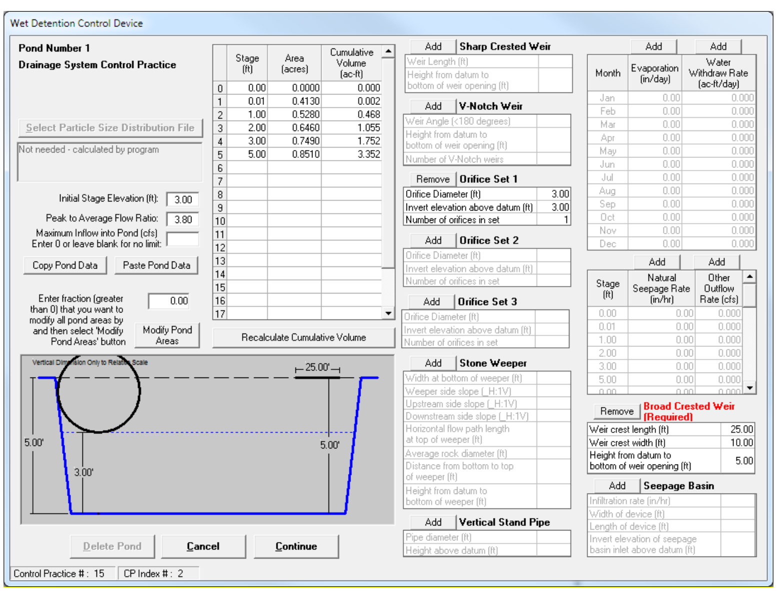

Figure 8: Wet pond WP1 in catchment ST-1 WinSLAMM model inputs

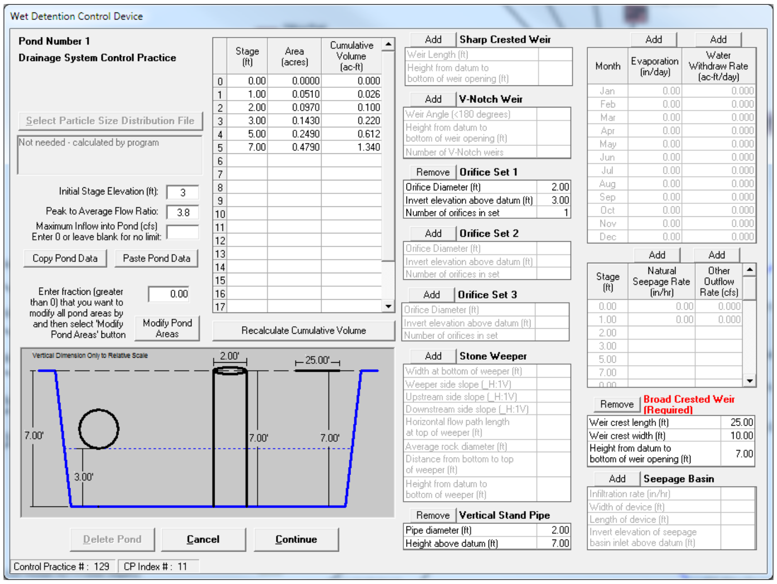

Figure 9: Wet pond WP2 in catchment ST-2 WinSLAMM model inputs

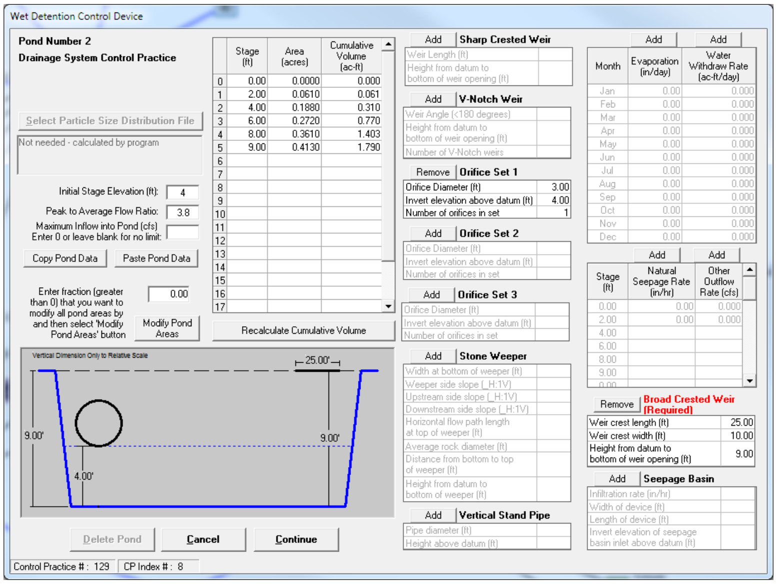

Figure 10: Wet pond WP3 in catchment ST-2 WinSLAMM model inputs

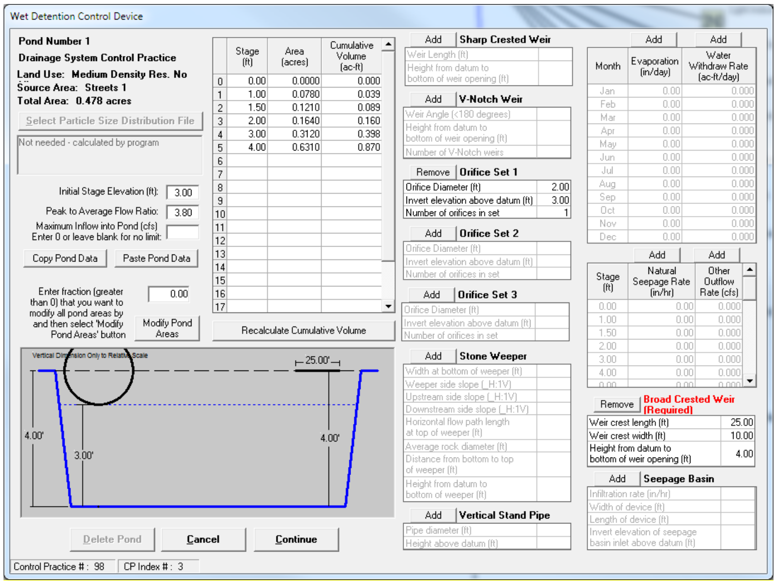

Figure 11: Wet pond WP4 in catchment ST-4 WinSLAMM model inputs.

An outlet for this pond was not identified in the field. However, rather than simply remove this contributing drainage area from the WinSLAMM model, thereby assuming 100% treatment of volume and pollutants, a 2 ft. diameter outlet with an invert elevation 3 ft. above the pond bottom was modeled.

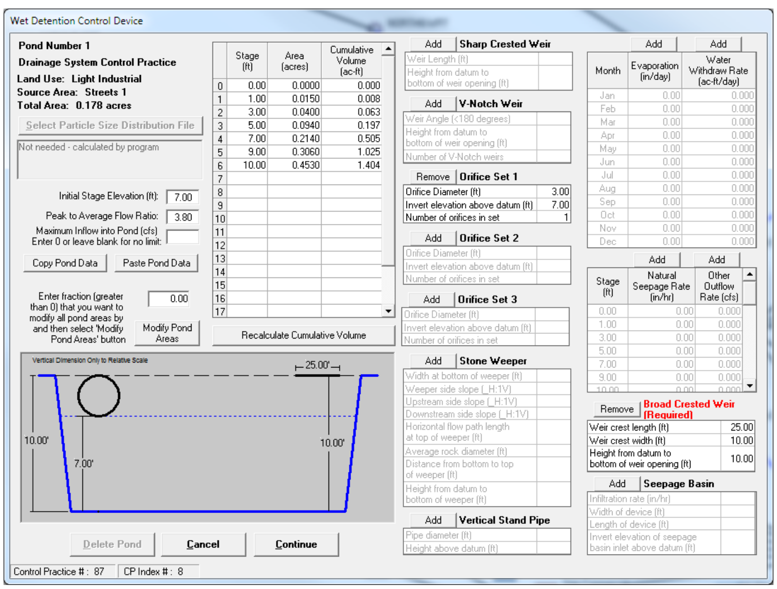

Figure 12: Wet pond WP5 in catchment ST-5 WinSLAMM model inputs.

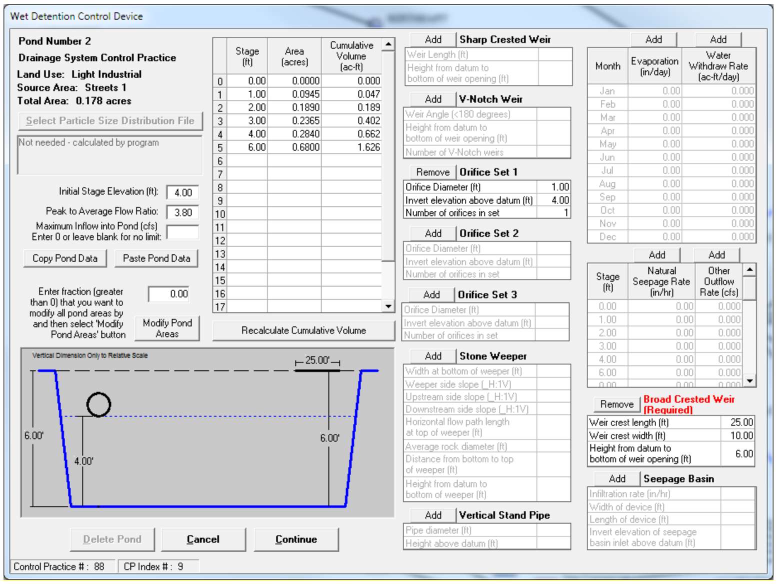

Figure 13: Wet pond WP6 in catchment ST-5 WinSLAMM model inputs.

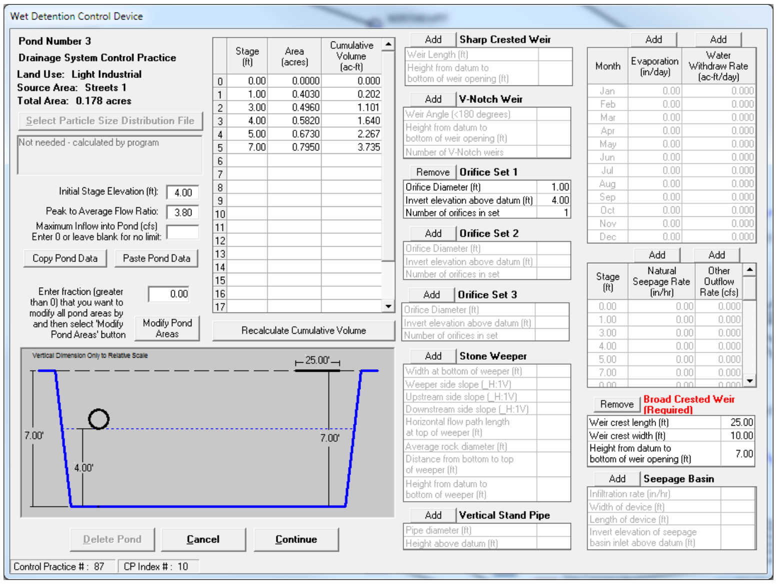

Figure 14: Wet pond WP7 in catchment ST-5 WinSLAMM model inputs.

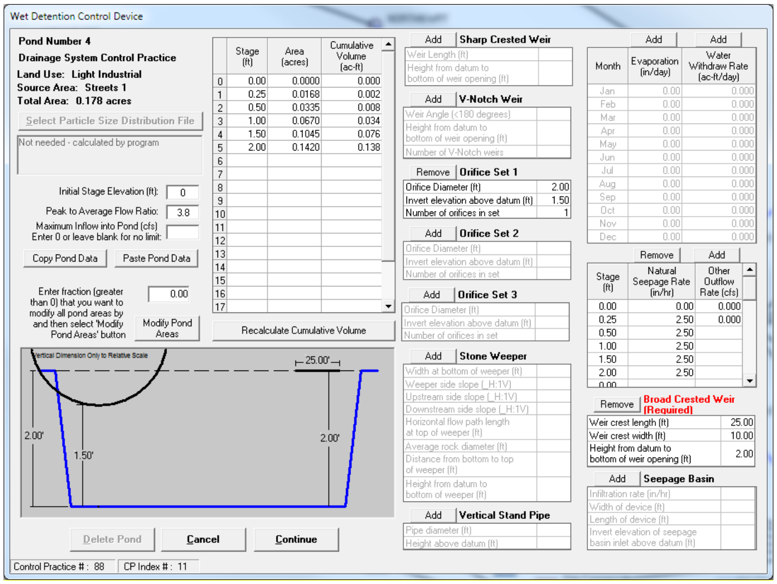

Figure 15: Wet pond WP8 in catchment ST-5 WinSLAMM model inputs.

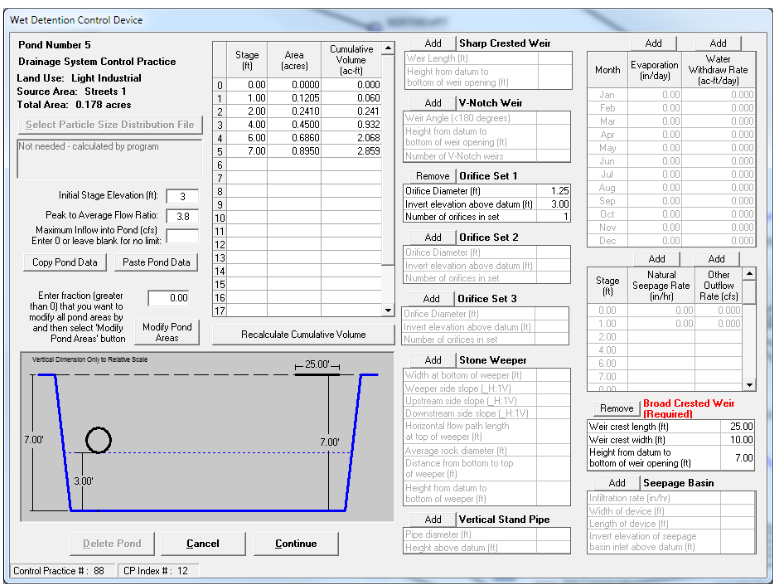

Figure 16: Wet pond WP9 in catchment ST-5 WinSLAMM model inputs.

Street Cleaning

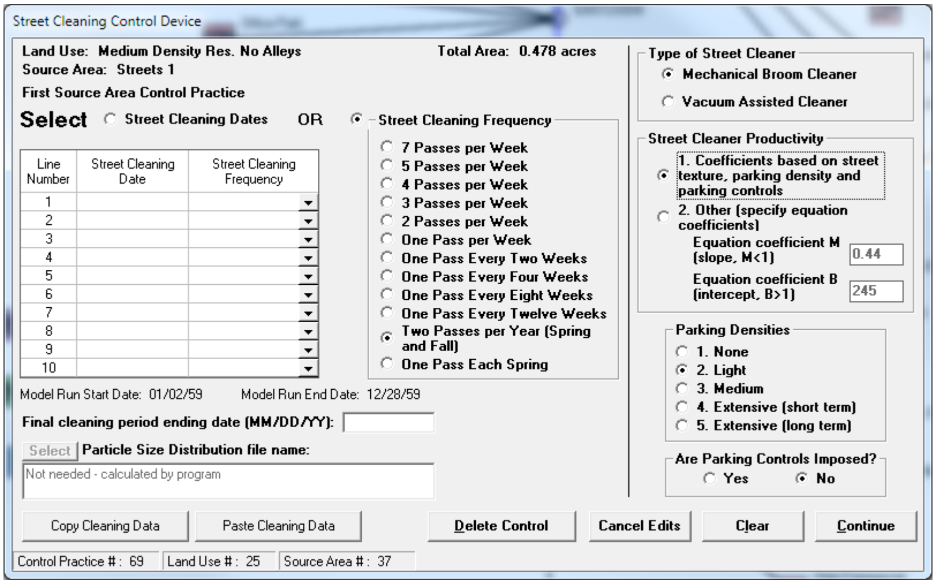

Figure 17: Street Cleaning (City of Spring Lake Park) WinSLAMM model inputs

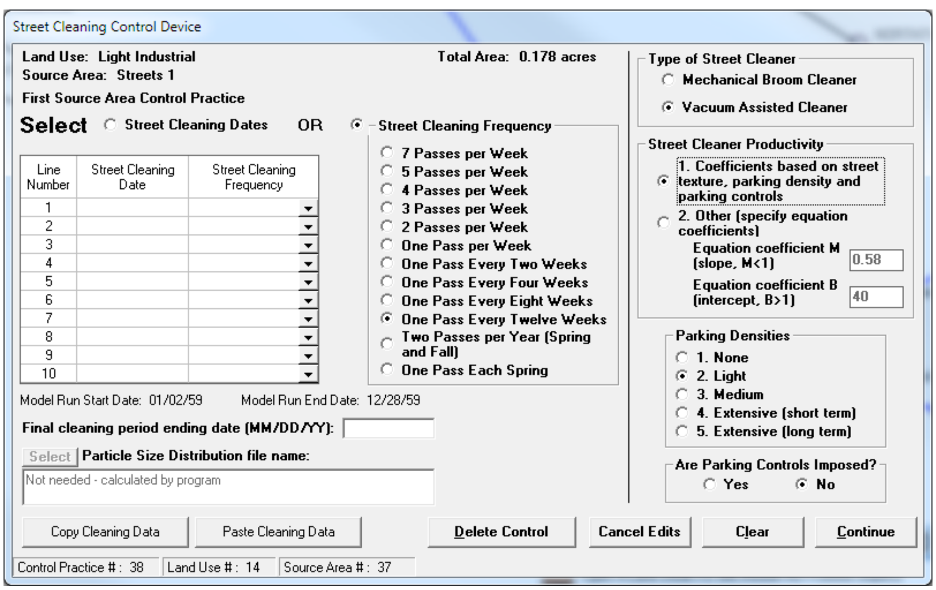

Figure 18: Street Cleaning (City of Fridley) WinSLAMM model inputs

Proposed Conditions

Curb-Cut Rain Garden

Curb-cut rain gardens were modeled as drainage area control practices within WinSLAMM. Table 13 describes specific input parameters for rain gardens in the WinSLAMM model. Figure 19 shows the WinSLAMM biofiltration parameter input screen.

Table 13: WinSLAMM Input Parameters for Curb-Cut Rain Gardens

Parameter	Unit	Value
Top Area	sq-ft	varies
Bottom Area	sq-ft	Varies
Total Depth	ft	1.5
Native Soil Infiltration Rate	in/hr	2.5
Infiltration Rate Fraction-Bottom (0-1)	-	1
Infiltration Rate Fraction-Sides (0-1)	-	1
Rock Filled Depth	ft	N/A
Rock Fill Porosity (0-1)	-	N/A
Engineered Media Infiltration Rate	in/hr	N/A
Engineered Media Depth	ft	N/A
Engineerd Media Porosity (0-1)	-	N/A
Inflow Hydrograph Peak to Average Flow Ratio	-	3.8
Broad Crested Weir Length	ft	3.0
Broad Crested Weir Width	ft	0.5
Height From Datum to Bottom of Weir Opening	ft	1.0
Underdrain Pipe Diameter	ft	N/A
Underdrain Invert Elevation Above Datum	ft	N/A
Number of pipes at invert elevation	-	N/A

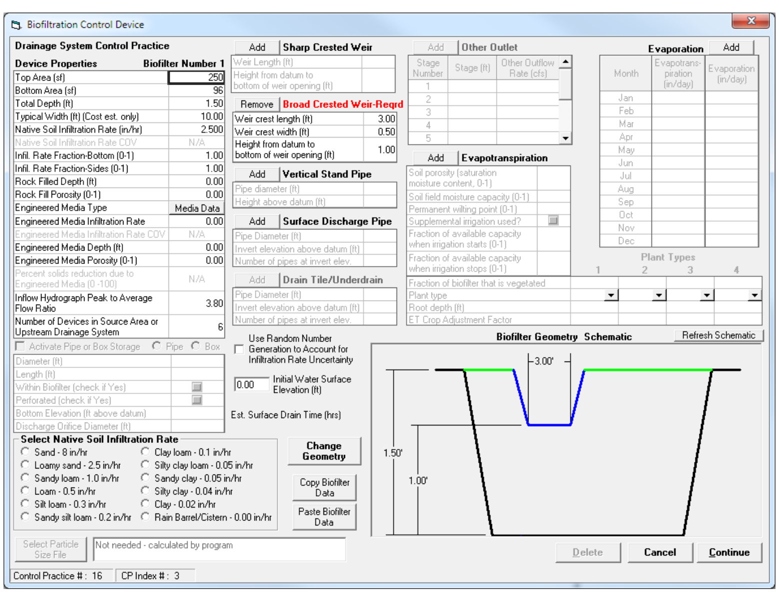

Figure 19: Bioinfiltration Control Practice Input Screen: Curb-cut Rain Garden (WinSLAMM)

Infiltration Basin

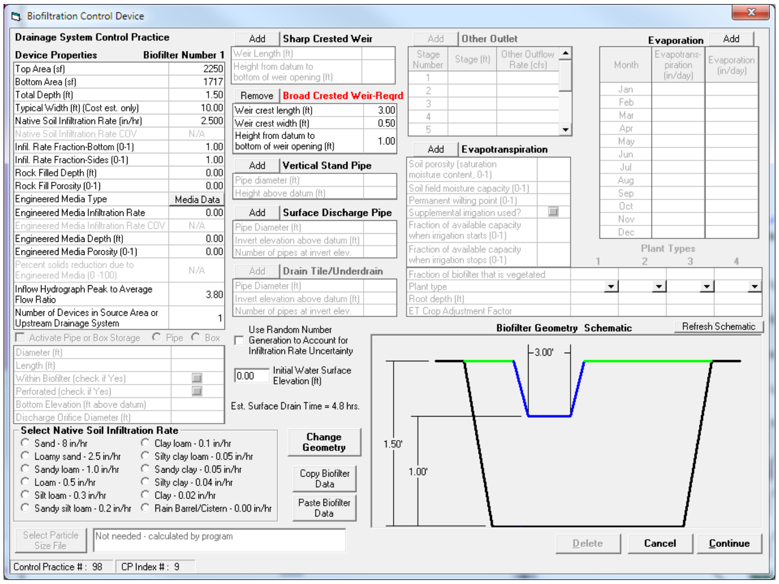

Figure 20: Infiltration basin (Catchment ST-4) WinSLAMM model inputs

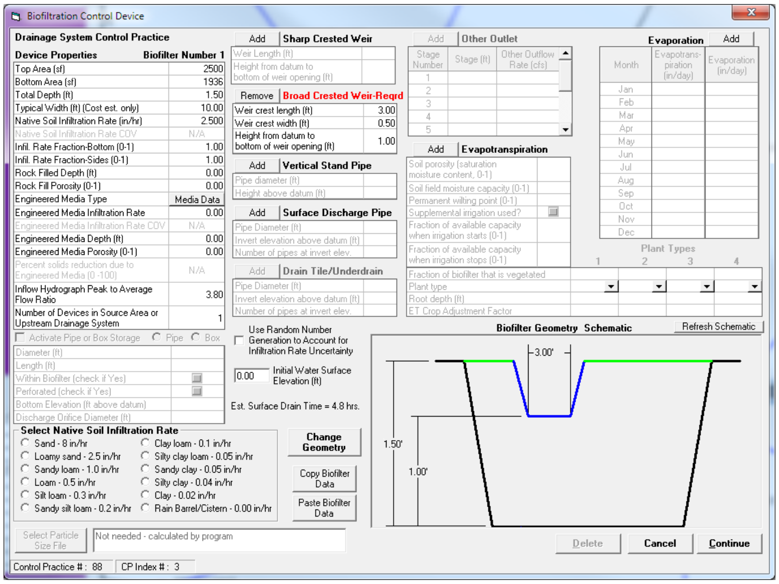

Figure 21: Infiltration basin (Catchment ST-5) WinSLAMM model inputs

Hydrodynamic Device

Table 14: Hydrodynamic Device Sizing Criteria

Drainage Area (acres)	Peak Q (cfs)	Hydrodynamic Device Diameter (ft)
1	1.97	4
2	3.90	6
3	5.83	6
4	7.77	6
5	9.72	8
6	11.68	8
7	13.65	8
≥8	15.63	10

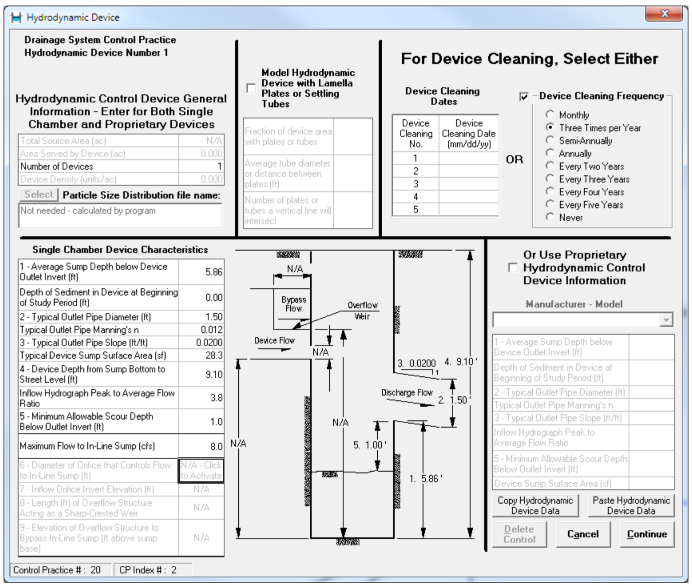

Figure 22: Hydrodynamic Device (6' diam.) WinSLAMM model inputs

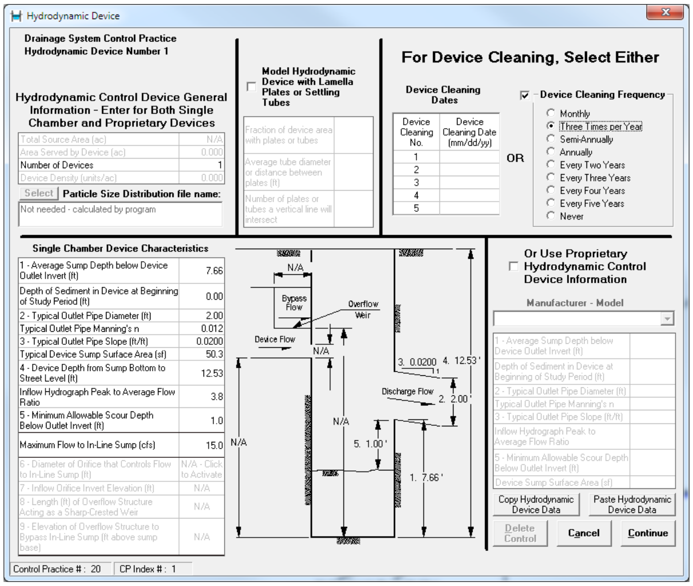

Figure 23: Hydrodynamic Device (8' diam.) WinSLAMM model inputs

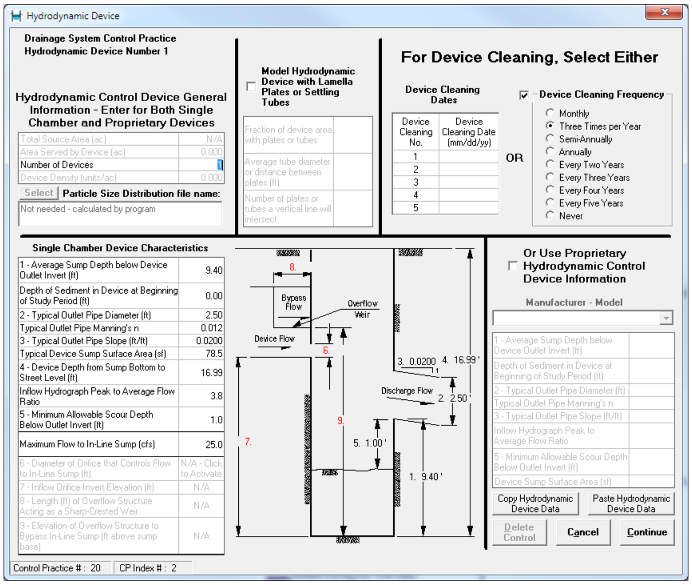

Figure 24: Hydrodynamic Device (10' diam.) WinSLAMM model inputs

Pond Modification and New Ponds

Ponds were proposed in the landscape where sufficient drainage area could sustain a permanent pool of water (MPCA, 2014). Ponds were proposed following guidance from the Minnesota Pollution Control Agency, in which depths are equal to or less than 8-10' to prohibit stratification and at least 1,800 cu-ft. of pond storage is available for each acre of contributing drainage area.

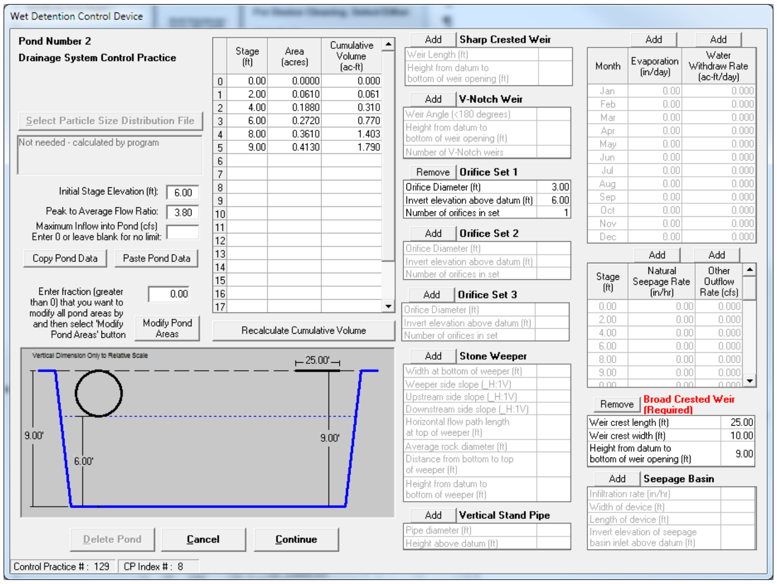

Figure 25: Catchment ST-2 pond modification (2 ft. riser) WinSLAMM model inputs

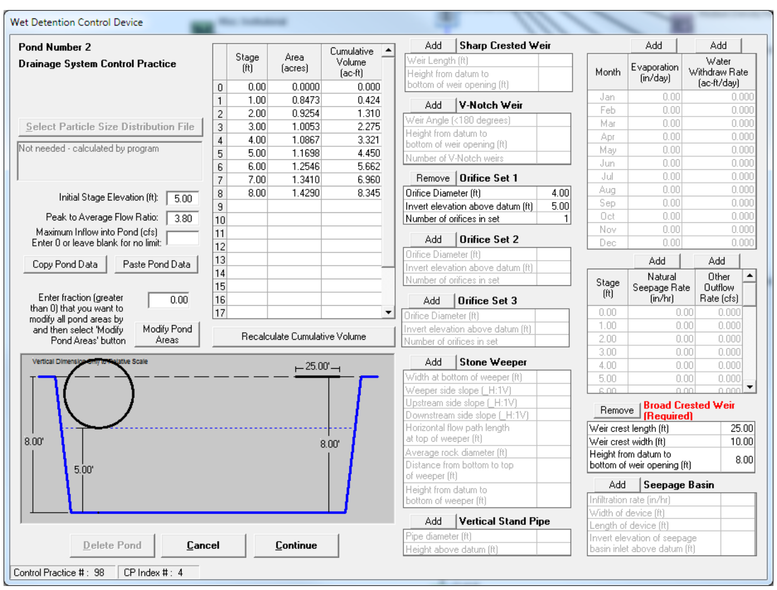

Figure 26: Catchment ST-4 new pond WinSLAMM model inputs

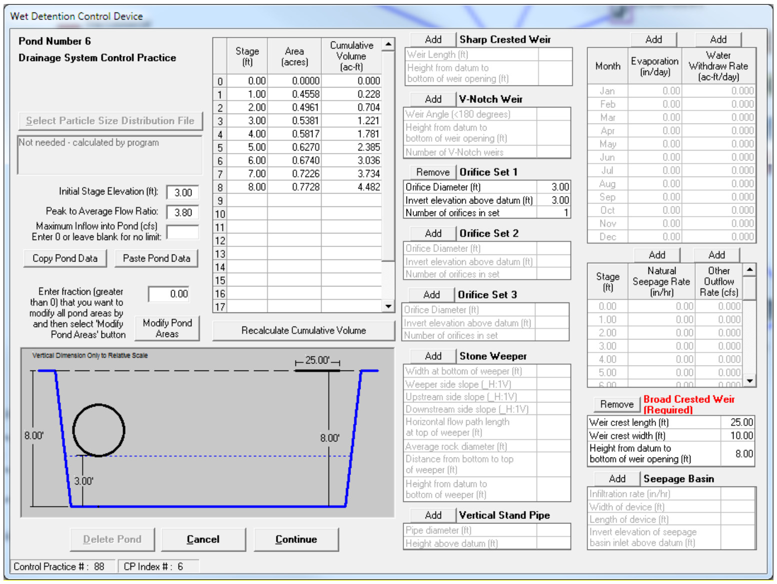

Figure 27: Catchment ST-5 new pond WinSLAMM model inputs

Underground Storage

The CMP is proposed in addition to the aggregate rock to increase the storage capacity of the practice (as water storage within the aggregate is only found in pore space). The aggregate and pipe concept proposed for the project are based on designs in the *Technical Memorandum: Analysis and Evaluation for Shared, Stacked-Function, Green Infrastructure* prepared for the City of St. Paul by SRF Consulting and amended to meet site considerations for residential neighborhoods in the research area.

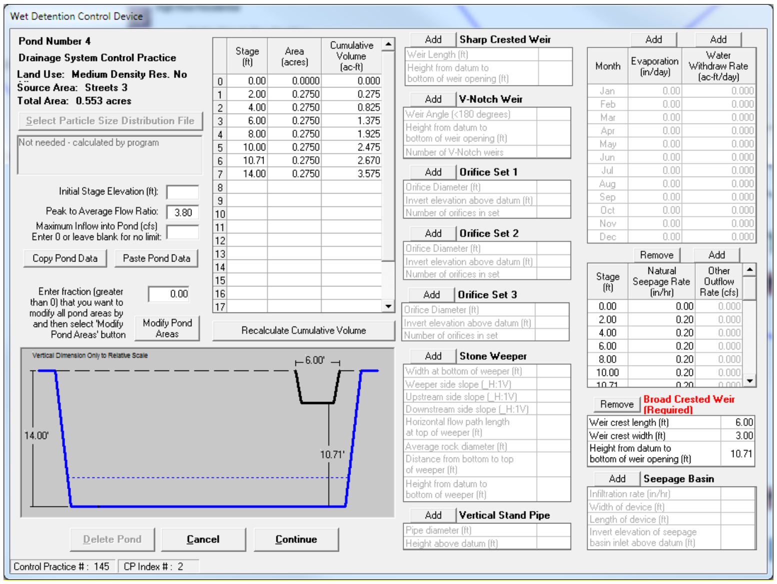

Figure 28: Underground Storage (Catchment ST-2) WinSLAMM model inputs

Appendix B – Project Cost Estimates

Introduction

The ‘Cost Estimates’ section on page 14 explains the elements of cost that were considered and the assumptions that were made. In addition, each project type concludes with budget assumptions listed in the footnotes. This appendix is a compilation of tables that shows in greater detail the calculations made and quantities used to arrive at the cost estimates for practices where the information provided elsewhere in the document is insufficient to reconstruct the budget. This section includes ponds and underground storage.

Pond Modification and New Ponds

Table 15: Catchment ST-2 – Pond Modification (2 ft. riser)

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 5,000.00	1	$ 5,000.00
Mobilization	Each	$ 1,000.00	1	$ 1,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 16,000.00

Table 16: Catchment ST-4 – New Pond

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 25,000.00	1	$ 25,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition	Each	$ 344,700.00	1	$ 344,700.00
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 12.50	14,597	$ 182,468.00
Outlet Control Structure	Each	$ 20,000.00	1	$ 20,000.00
Existing Infrastructure Retrofit	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
		Total for project =		$ 647,168.00

Table 17: Catchment ST-5 – New Pond

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 25,000.00	1	$ 25,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Land Acquisition	Each	$ 202,900.00	1	$ 202,900.00
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 12.50	5,002	$ 62,526.75
Outlet Control Structure	Each	$ 20,000.00	1	$ 20,000.00
Existing Infrastructure Retrofit	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
		Total for project =		$ 385,426.75

Underground Storage

Table 18: Catchment ST-2 –Underground Storage

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 50,000.00	1	$ 50,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
Site Prep	Each	$ 25,000.00	1	$ 25,000.00
Excavation	cu-yards	$ 12.50	9,600	$ 120,000.00
CMP	linear-ft	$ 500.00	800	$ 400,000.00
Rock Aggregate	cu-yards	$ 35.00	6,240	$ 218,406.43
Existing Infrastructure Retrofit and Pretreatment	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration	Each	$ 5,000.00	1	$ 5,000.00
		Total for project =		$ 878,406.43

Appendix C – Wellhead Protection Areas