Pleasure Creek Stormwater Retrofit Analysis

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

COON CREEK WATERSHED DISTRICT

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Cover photo: Pleasure Creek just north of the intersection between 86th Ave. NW and Mississippi River Blvd. NW, approximately 1,300 feet upstream of its confluence with the Mississippi River.

Disclaimer: This report identifies and ranks identified BMPs for the Pleasure Creek subwatershed at the time of printing. This list of practices is not all-inclusive and does not preclude adding additional priority BMPs in the future. An updated copy of the report shall be housed at either the Anoka Conservation District or the Coon Creek Watershed District.

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Executive Summary

This study provides recommendations for cost effectively improving treatment of stormwater draining to Pleasure Creek. Pleasure Creek is located within the Coon Creek Watershed District, and flows through southwestern Blaine and southern Coon Rapids. The creek serves as drainage for a 1,694 acre urban area, and is the primary stormwater conveyance. Both because of its own local importance, and because it discharges into the Mississippi River, water quality in Pleasure Creek is a priority. Improved stormwater treatment is a means for significant water quality improvement in the creek. Pleasure Creek is designated as a state "impaired" water for failing to meet invertebrate biota expectations. The stream also has other water quality problems including high dissolved pollutants, suspended solids, and E. coli that have not yet been designated by the state as "impairments." Stormwater runoff is a major source of these pollutants.

This report presents stormwater retrofitting projects that will improve water quality, and ranks projects in order of cost effectiveness. Stormwater retrofitting refers to adding stormwater treatment to an already built-up area, where little open land exists. This process is investigative and creative. Stormwater retrofitting success is sometimes improperly judged by the number of projects installed or by comparing costs alone. Those approaches neglect to consider how much pollution is removed per dollar spent. In this stormwater analysis we estimated both costs and pollutant reductions, and used them to calculate cost effectiveness of each possible project.

This report's modeling and numeric pollutant reduction results are for suspended solids, with secondary analysis of phosphorus, though dissolved pollutants and E. coli are also of importance and considered in non-numeric ways. Robust computer models for suspended solids and phosphorus exist. Models are weak at estimating bacterial and dissolved pollutant reductions (outside of nutrients). While we do select stormwater treatment practices that are effective at treating these pollutants, we cannot present numeric reductions with high confidence. The report contains discussion throughout about why certain retrofits are recommended for multi-pollutant treatment.

Monitoring data was examined to gain a sense of the magnitude of pollutant reductions needed to meet state water quality standards. Preliminary analysis based on in-stream water quality monitoring found that a 29.2% reduction in total suspended solids (TSS) and a 14.0% reduction in total phosphorus (TP) are necessary for samples in exceedance of the state standards. These percentages were set as the reduction goal for these pollutants across the subwatershed. Based on existing conditions, including present-day land use and installed stormwater BMPs, these percentages correspond to annual loadings of 28,206 lbs-TSS and 61.6 lbs-TP. No numeric goals were proposed for bacteria, but infiltration practices, known to be the most effective at removing bacteria, were targeted above other practices where possible. Adaptive management, where plans are revised after each round of projects, is appropriate.

This report is organized by stormwater catchment or drainage area. There are nine neighborhood-level catchments discussed. For each, the water quality modeling software WinSLAMM was used to estimate volume and pollutant loads from the landscape in three scenarios: base (no stormwater treatment), existing (present-day stormwater treatment), and proposed (with proposed stormwater retrofits). The 1,694 acres draining to Pleasure Creek contribute an estimated 861.6 ac-ft of stormwater runoff, 512.2 lbs-TP, and 118,230 lbs-TSS each year.

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

- Maintenance of, or alterations to, existing stormwater treatment,
- New stormwater pond opportunities,
- Curb-cut rain gardens,
- Iron-enhanced sand filter retention pond benches,
- Enhanced street cleaning,
- Hydrodynamic devices,
- Stormwater redirection, and
- Streambank stabilizations.

A total of 34 practices were proposed in this analysis. These projects were ranked by their cost-effectiveness, or their ability to remove stormwater pollutants at the lowest cost. Tables ranking projects based on their cost-effectiveness can be found in the *Project Ranking and Selection* section of this report. To achieve the proposed goal of reducing TP loading in Pleasure Creek by 61.6 lbs (14.0%), a suite of projects were selected which reach the goal at the lowest cost possible. The suite includes these projects:

Table 1: Projects needed to reach the proposed TP goal

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	$50,420	$750	$135
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	$50,420	$750	$135
3	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	$50,420	$750	$215
T4	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	$30,420	$350	$257
T4	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	$30,420	$350	$257
7	9-H	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	$30,420	$350	$426
13	9-A	106	Curb-Cut Rain Gardens (2)	Multiple	PC-9	1.3	$24,096	$450	$823

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

Combined, these projects permanently remove 62.4 lbs-TP from the Pleasure Creek system at a cost of $266,616 for project administration, promotion, and installation and $3,750 in annual operations and maintenance. Assuming each project has a 30-year lifetime, total cost for the practices (excluding inflation) is expected to be $329,116.

A subset of this suite, projects 9-I and 9-J, are able to reach the proposed goal of 28,206 lbs-TSS (29.2% TSS loading), as shown in the table below:

Table 2: Projects needed to reach the proposed TSS goal

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TSS Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	22,500	$50,420	$750	$108
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	22,500	$50,420	$750	$108

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

The projects noted in the tables above, along with 27 others, are described in detail in the *Catchment Profiles* pages. Conceptual sketches or photos of recommended stormwater retrofitting projects are provided within this report. The intent 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. wet ponds) will require more detailed feasibility studies and engineered plan sets if selected. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property.

The tables on the next pages summarize potential projects. Potential projects are organized from most cost effective to least, based on cost per pound of TSS removed. Installation of projects in series will result in lower total treatment than the simple sum of treatment across 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 infeasible due to prohibitive size, number, or cost to justify installation are not included in this report.

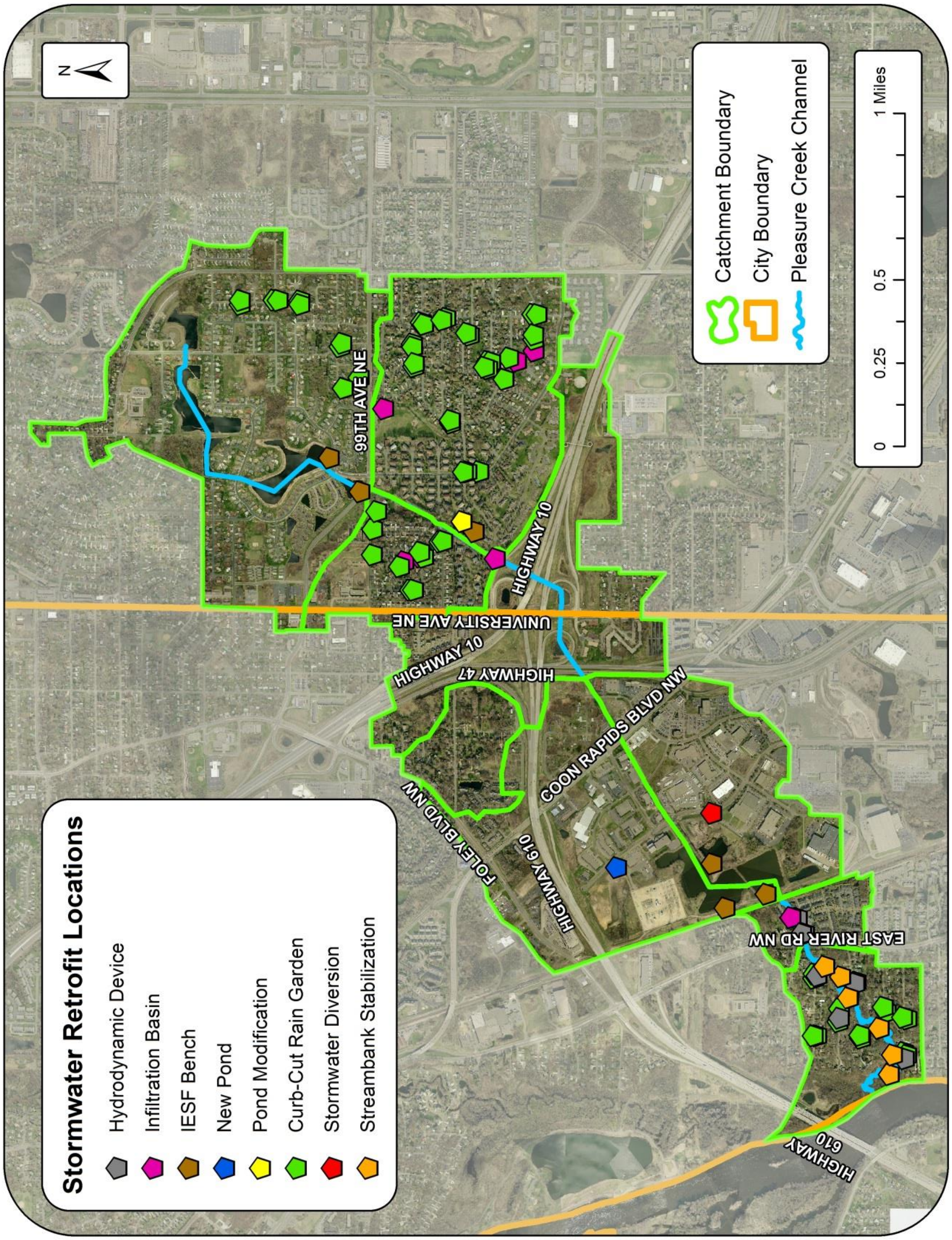


Figure 1: Subwatershed-wide map showing all proposed retrofits included in this report.

Table 3: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 1 - 17. 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$108
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$108
3	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	14,063	0.0	$50,420	$750	$173
T4	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$208
T4	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$208
6	9-H	112	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	3,938	0.0	$30,420	$350	$346
7	9-A	105	Curb-Cut Rain Gardens	Multiple	PC-9	1.3-7.6	418-2,394	1.3-7.6	$24,096-$106,616	$450-$2,700	$2,612-$2,998
8	2-D	63	Infiltration Basin	96th Ln. DP	PC-2	2.5	633	4.6	$48,796	$275	$3,004
9	2-C	62	Infiltration Basin	Swan Park (South)	PC-2	2.1	477	2.8	$41,296	$275	$3,462
10	3-D	71	Infiltration Basin	Cloverleaf Park	PC-3	0.5-1.5	99-321	0.7-2.1	$103,796-$203,796	$275	$4,712-$7,470
11	8-A	96	Infiltration Basin	Norway St. North DP-IB	PC-8	0.2-0.4	69-111	0.2-0.3	$12,896	$225	$5,900-$9,491
12	9-F	110	Enhanced Street Cleaning	Multiple	PC-9	1.7-3.3	718-1,422	0.0	$4,268-$13,529	N/A	$5,944-$9,514
13	2-B	61	Infiltration Basin	Swan Park (North)	PC-2	1.0	233	1.4	$33,796	$275	$6,015
14	2-A	60	Curb-Cut Rain Gardens	Multiple	PC-2	1.2-2.8	268-67	2.1-4.4	$32,348-$73,608	$675-$1,800	$6,542-$6678
15	3-C	70	Infiltration Basin	Van Buren Park (North)	PC-3	1.1-2.1	243-498	1.8-3.7	$48,796-$93,796	$275	$6,830-$7,825
16	3-B	69	Infiltration Basin	Van Buren Park (South)	PC-3	1.1-2.0	243-485	1.8-3.4	$48,796-$93,796	$275	$7,013-$7,825
17	1-B	53	Curb-Cut Rain Gardens	Pond 310	PC-1	0.8-1.5	159-305	1.2-2.1	$24,096-$40,600	$450-$900	$7,388-$7,882

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 4: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 18 - 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
18	8-E	100	Enhanced Street Cleaning	Multiple	PC-8	0.9-1.7	376-728	0.0	$2,864-$7,495	N/A	$7,436-$10,295
19	3-A	68	Curb-Cut Rain Gardens	Multiple	PC-3	2.9-5.2	657-1,228	4.8-8.5	$90,112-$172,632	$2,250-$4,500	$7,997-$8,493
20	9-D	108	Hydrodynamic Device	88th Ave. DP	PC-9	0.9	354	0.0	$109,752	$840	$12,707
21	6-A	84	New Pond	Foley Blvd DP	PC-6	2.0	755	0.0	$265,650	$1,300	$13,450
22	9-E	109	Hydrodynamic Device	86th Ave DP	PC-9	0.9	334	0.0	$109,752	$840	$13,468
23	8-D	99	Hydrodynamic Device	East River Road South DP	PC-8	0.4	186	0.0	$55,752	$840	$14,508
24	3-E	73	Pond Modification	Pond 304	PC-3	4.9	1,531	0.0	$655,840-$1,360,840	$450	$14,573-$29,922
25	8-B	97	Hydrodynamic Device	Norway St. South DP	PC-8	0.7	300	0.0	$109,752	$840	$14,995
26	9-C	107	Hydrodynamic Device	87th Lane DP	PC-9	0.6	237	0.0	$109,752	$840	$18,981
27	9-B	106	Hydrodynamic Device	88th Lane DP	PC-9	0.3	131	0.0	$55,752	$840	$20,598
28	8-C	98	Hydrodynamic Device	East River Road North DP	PC-8	0.5	197	0.0	$109,752	$840	$22,835
29	1-A	52	Curb-Cut Rain Gardens	Pond 302	PC-1	0.5-1.2	12-71	1.4-3.2	$24,096-$57,104	$450-$1,350	$45,823-$104,433
T30	1-C	55	IESF Bench	Pond 303	PC-1	17.1	0	0.0	$208,210	$1,377	N/A
T30	1-D	56	IESF Bench	Pond 310	PC-1	13.8	0	0.0	$162,450	$918	N/A
T30	3-F	75	IESF Bench	Pond 304	PC-3	13.7	0	0.0	$259,050	$1,837	N/A
T30	6-B	85	IESF Bench	Multiple	PC-6 and PC-7	28.3-71.3	0	0.0	$321,795-$729,375	$2,066-$5,395	N/A
T30	7-A	91	IESF Bench (with Stormwater Diversion)	Industrial Park Pond	PC-7	4.2-8.1	0	0.0	$293,050-$351,510	$2,296	N/A

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

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 chosen and 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 its given lifetime, usually 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.

Lastly, water quality goals are detailed in this section, as well as a project list capable of reaching any proposed goals.

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 Pleasure Creek subwatershed was divided into nine stormwater catchments which were assigned a unique identification number (i.e. PC-1 through PC-9) and further subdivided into 57 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, dominant land cover, and parcels. A second table lists the estimated annual pollutant and volume loads under base and existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from the Cities of Blaine and Coon Rapids. 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.

Abbreviations

Listed below are some abbreviations used frequently throughout the text:

ACD: Anoka Conservation District
BMP: Best Management Practice
DP: Discharge Point
GIS: Geographic Information Systems
IESF: Iron-Enhanced Sand Filter
MNDOT or DOT: Minnesota Department of Transportation
MPCA: Minnesota Pollution Control Agency
MS4: Municipal Separate Storm Sewer System
NPDES: National Pollutant Discharge Elimination System
TP: Total Phosphorus
TSS: Total Suspended Solids
WinSLAMM: Source Loading and Management Model for Windows

Background

Pleasure Creek, and its surrounding subwatershed, has been altered highly over the last century. Historical aerials dating back to the 1930's and 1940's show an agrarian society which had already drained many, but not all, of the pre-development wetlands. By this time Pleasure Creek had already been channelized as a drainage ditch for nearby agricultural fields. Much of the upland areas of the subwatershed still had many of the woody wetlands that had dominated the landscape of Anoka County prior to settlement. Through the 1950's and 1960's development in the suburbs grew rapidly. This led to the replacement of farms, forests, and wetlands with single-family residential lots. Continued development in the area from the 1970's to the present saw increases in commercial properties and interstates through the central portion of the catchment, along with additional development north of 99th Ave. NE.

Any initial installation of stormwater infrastructure from the 1950's through the 1980's focused primarily on flood mitigation. Over the last 30 years stormwater infrastructure throughout the subwatershed has been bolstered, but many areas still see little to no treatment prior to discharge into the creek. Notably, the construction of 17 acres of in-line stormwater ponds (defined throughout the report as the "Pleasure Creek Ponds") east of the Burlington Northern railroad tracks provides treatment to greater than 90% of the subwatershed. Additional areas of stormwater detainment include the eleven ponds and one infiltration basin upstream of 99th Ave. NE, the seven ponds in the Highway 10/610 corridor, and other assorted BMPs (including, grass swales, a wetland, and other ponds) scattered throughout the subwatershed. Unfortunately, these practices are unable to keep water quality within the creek above state standards.

Pleasure Creek is currently designated as an "impaired" waterbody for failing to meet invertebrate biota expectations. The stream also has other water quality problems including high dissolved pollutants, suspended solids, and E. coli that have not yet been designated by the State as "impairments." Conductivity (which is a measure of the concentration of ions in the water) and chloride measurements are continually some of the highest for streams measured within Anoka County (ACD 2014). For the most recent data available, median values for TSS and TP are below proposed state standards of 30 mg/L and 100 µg/L, respectively, but during storm events these values often exceed standards (ACD 2014).

The CCWD contracted the ACD to complete this SRA for the purpose of identifying and analyzing projects to reduce pollutant loading to the creek. Overall subwatershed loading of TSS, TP, 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 pollutants or volume.

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 and Reduction Goals determine 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 Pleasure Creek and ultimately discharge to the Mississippi River. Included are areas of residential, commercial, industrial, institutional, and freeway land uses. The subwatershed was divided into nine catchments using a combination of existing subwatershed mapping data, stormwater infrastructure maps, and observed topography.

Targeted pollutants in this study (Table 5) were determined by reviewing the most recent monitoring data available for Pleasure Creek. Water quality samples found to be in exceedance of state standards were evaluated to determine the percent reduction needed to bring each sample into compliance. These individual reductions were then averaged within each flow regime of the flow duration curve (as exceedance was most often found outside baseflow and small storm events). Finally, a reduction percentage across all storm events was estimated by weighting each flow regime to flow frequency and then summing across all flow regimes. This analysis found that TSS and TP loading to the creek would need to be reduced by 29.1% and 14.0%, respectively, to comply with standards. Projects were studied based on their ability to cost-effectively treat either TP or TSS. Volume reductions were also investigated as it is likely that in-stream erosion from high volume inputs leads to additional TSS and TP loading.

Table 5: 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, 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), 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 Pleasure Creek 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 wasteload 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 geographic information systems (GIS). The drainage areas were consolidated into nine catchments using GIS (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 Blaine and Coon Rapids (Figure 2). 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.

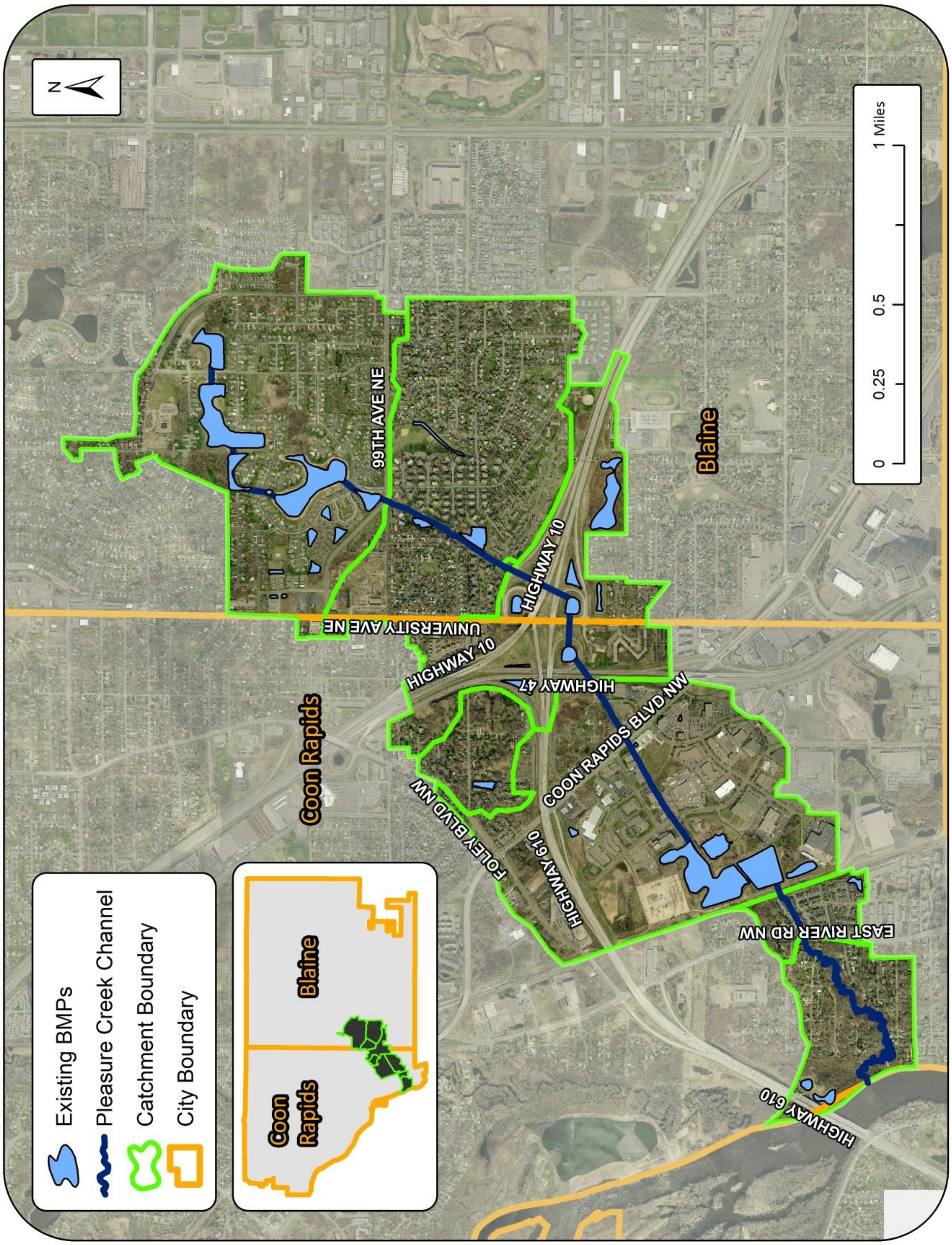


Figure 2: Subwatershed-wide map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the subwatershed.

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 2015 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) and updated based on 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. Any project goals, such as a pollutant reduction target, are detailed. Project(s) needed to reach this goal are listed and discussed.

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 3), 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. Please note this list only ranks identified BMPs for the Pleasure Creek subwatershed at the time of printing. This list of practices is not all-inclusive and does not preclude adding additional priority BMPs in the future. An updated copy of the report shall be housed at the ACD and/or CCWD offices.

Projects were ranked in three ways:

1) Cost per 1,000 pounds of total suspended solids removed (Table 6 -Table 7),
2) Cost per pound of total phosphorus removed (Table 8 - Table 9), and
3) Cost per acre-foot of volume reduced (Table 10 - Table 11).

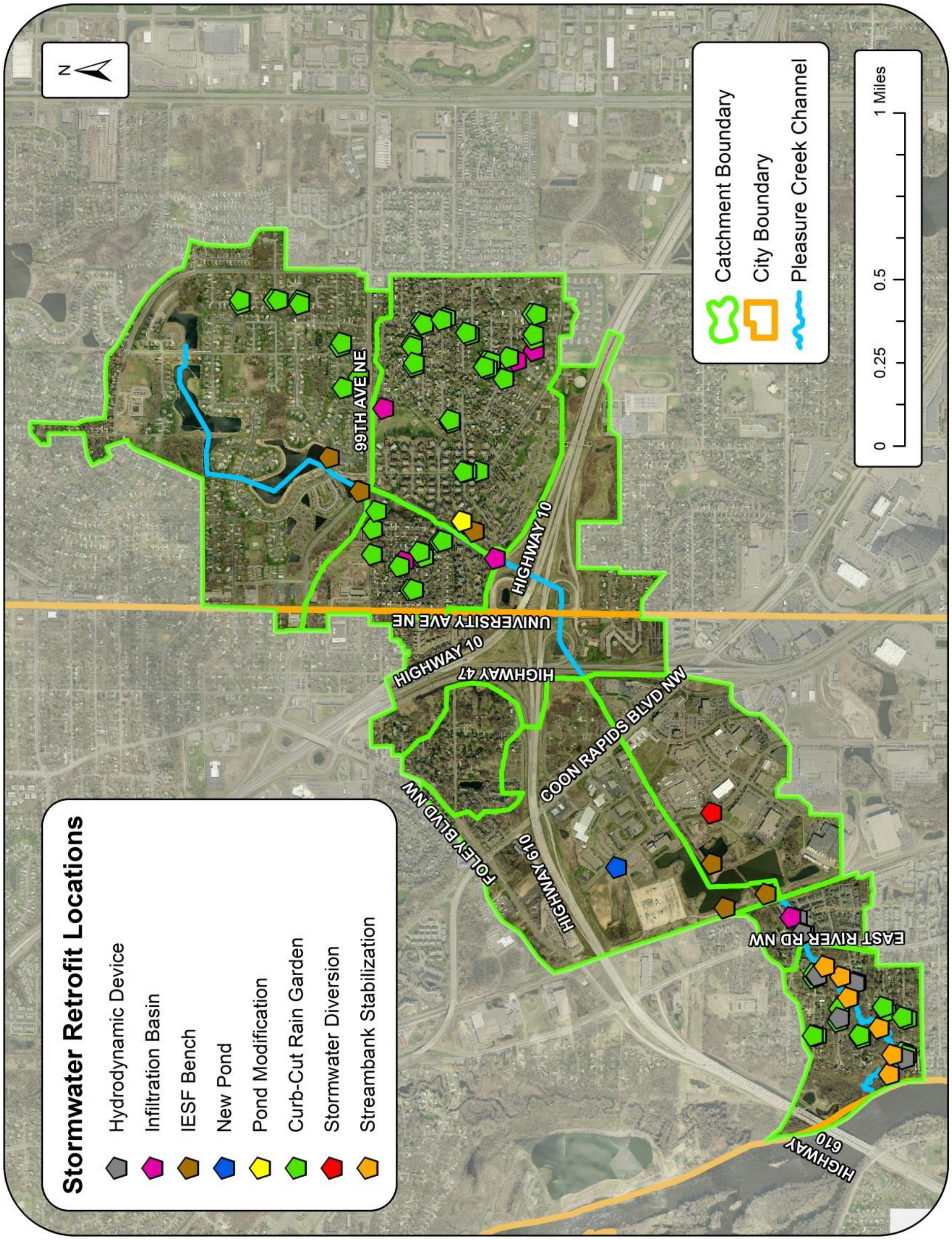


Figure 3: Subwatershed-wide map showing all proposed retrofits included in this report.

Table 6: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 1 - 17. 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$108
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$108
3	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	14,063	0.0	$50,420	$750	$173
T4	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$208
T4	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$208
6	9-H	112	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	3,938	0.0	$30,420	$350	$346
7	9-A	105	Curb-Cut Rain Gardens	Multiple	PC-9	1.3-7.6	418-2,394	1.3-7.6	$24,096-$106,616	$450-$2,700	$2,612-$2,998
8	2-D	63	Infiltration Basin	96th Ln. DP	PC-2	2.5	633	4.6	$48,796	$275	$3,004
9	2-C	62	Infiltration Basin	Swan Park (South)	PC-2	2.1	477	2.8	$41,296	$275	$3,462
10	3-D	71	Infiltration Basin	Cloverleaf Park	PC-3	0.5-1.5	99-321	0.7-2.1	$103,796-$203,796	$275	$4,712-$7,470
11	8-A	96	Infiltration Basin	Norway St. North DP-IB	PC-8	0.2-0.4	69-111	0.2-0.3	$12,896	$225	$5,900-$9,491
12	9-F	110	Enhanced Street Cleaning	Multiple	PC-9	1.7-3.3	718-1,422	0.0	$4,268-$13,529	N/A	$5,944-$9,514
13	2-B	61	Infiltration Basin	Swan Park (North)	PC-2	1.0	233	1.4	$33,796	$275	$6,015
14	2-A	60	Curb-Cut Rain Gardens	Multiple	PC-2	1.2-2.8	268-67	2.1-4.4	$32,348-$73,608	$675-$1,800	$6,542-$6678
15	3-C	70	Infiltration Basin	Van Buren Park (North)	PC-3	1.1-2.1	243-498	1.8-3.7	$48,796-$93,796	$275	$6,830-$7,825
16	3-B	69	Infiltration Basin	Van Buren Park (South)	PC-3	1.1-2.0	243-485	1.8-3.4	$48,796-$93,796	$275	$7,013-$7,825
17	1-B	53	Curb-Cut Rain Gardens	Pond 310	PC-1	0.8-1.5	159-305	1.2-2.1	$24,096-$40,600	$450-$900	$7,388-$7,882

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 7: Cost-effectiveness of retrofits with respect to TSS reduction. Projects 18 - 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
18	8-E	100	Enhanced Street Cleaning	Multiple	PC-8	0.9-1.7	376-728	0.0	$2,864-$7,495	N/A	$7,436-$10,295
19	3-A	68	Curb-Cut Rain Gardens	Multiple	PC-3	2.9-5.2	657-1,228	4.8-8.5	$90,112-$172,632	$2,250-$4,500	$7,997-$8,493
20	9-D	108	Hydrodynamic Device	88th Ave. DP	PC-9	0.9	354	0.0	$109,752	$840	$12,707
21	6-A	84	New Pond	Foley Blvd DP	PC-6	2.0	755	0.0	$265,650	$1,300	$13,450
22	9-E	109	Hydrodynamic Device	86th Ave DP	PC-9	0.9	334	0.0	$109,752	$840	$13,468
23	8-D	99	Hydrodynamic Device	East River Road South DP	PC-8	0.4	186	0.0	$55,752	$840	$14,508
24	3-E	73	Pond Modification	Pond 304	PC-3	4.9	1,531	0.0	$655,840-$1,360,840	$450	$14,573-$29,922
25	8-B	97	Hydrodynamic Device	Norway St. South DP	PC-8	0.7	300	0.0	$109,752	$840	$14,995
26	9-C	107	Hydrodynamic Device	87th Lane DP	PC-9	0.6	237	0.0	$109,752	$840	$18,981
27	9-B	106	Hydrodynamic Device	88th Lane DP	PC-9	0.3	131	0.0	$55,752	$840	$20,598
28	8-C	98	Hydrodynamic Device	East River Road North DP	PC-8	0.5	197	0.0	$109,752	$840	$22,835
29	1-A	52	Curb-Cut Rain Gardens	Pond 302	PC-1	0.5-1.2	12-71	1.4-3.2	$24,096-$57,104	$450-$1,350	$45,823-$104,433
T30	1-C	55	IESF Bench	Pond 303	PC-1	17.1	0	0.0	$208,210	$1,377	N/A
T30	1-D	56	IESF Bench	Pond 310	PC-1	13.8	0	0.0	$162,450	$918	N/A
T30	3-F	75	IESF Bench	Pond 304	PC-3	13.7	0	0.0	$259,050	$1,837	N/A
T30	6-B	85	IESF Bench	Multiple	PC-6 and PC-7	28.3-71.3	0	0.0	$321,795-$729,375	$2,066-$5,395	N/A
T30	7-A	91	IESF Bench (with Stormwater Diversion)	Industrial Park Pond	PC-7	4.2-8.1	0	0.0	$293,050-$351,510	$2,296	N/A

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Table 8: Cost-effectiveness of retrofits with respect to TP reduction. Projects 1 - 17. 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$135
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$50,420	$750	$135
3	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	14,063	0.0	$50,420	$750	$215
T4	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$257
T4	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$30,420	$350	$257
6	6-B	85	IESF Bench	Multiple	PC-6 and PC-7	28.3-71.3	0	0.0	$321,795-$729,375	$2,066-$5,395	$417-$452
7	9-H	112	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	3,938	0.0	$30,420	$350	$426
8	1-D	56	IESF Bench	Pond 310	PC-1	13.8	0	0.0	$162,450	$918	$459
9	1-C	55	IESF Bench	Pond 303	PC-1	17.1	0	0.0	$208,210	$1,377	$486
10	2-D	63	Infiltration Basin	96th Ln. DP	PC-2	2.5	633	4.6	$48,796	$275	$761
11	3-F	75	IESF Bench	Pond 304	PC-3	13.7	0	0.0	$259,050	$1,837	$764
12	2-C	62	Infiltration Basin	Swan Park (South)	PC-2	2.1	477	2.8	$41,296	$275	$786
13	9-A	105	Curb-Cut Rain Gardens	Multiple	PC-9	1.3-7.6	418-2,394	1.3-7.6	$24,096-$106,616	$450-$2,700	$823-$964
14	2-B	61	Infiltration Basin	Swan Park (North)	PC-2	1.0	233	1.4	$33,796	$275	$1,402
15	2-A	60	Curb-Cut Rain Gardens	Multiple	PC-2	1.2-2.8	268-67	2.1-4.4	$32,348-$73,608	$675-$1,800	$1,461-$1,549
16	1-B	53	Curb-Cut Rain Gardens	Pond 310	PC-1	0.8-1.5	159-305	1.2-2.1	$24,096-$40,600	$450-$900	$1,502-$1,567
17	3-C	70	Infiltration Basin	Van Buren Park (North)	PC-3	1.1-2.1	243-498	1.8-3.7	$48,796-$93,796	$275	$1,620-$1,729

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

Table 9: Cost-effectiveness of retrofits with respect to TP reduction. Projects 18 - 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
18	8-A	96	Infiltration Basin	Norway St. North DP-IB	PC-8	0.2-0.4	69-111	0.2-0.3	$12,896	$225	$1,637-$2,924
19	3-B	69	Infiltration Basin	Van Buren Park (South)	PC-3	1.1-2.0	243-485	1.8-3.4	$48,796-$93,796	$275	$1,701-$1,729
20	7-A	91	IESF Bench (with Stormwater Diversion)	Industrial Park Pond	PC-7	4.2-8.1	0	0.0	$293,050-$351,510	$2,296	$1,730-$2,872
21	3-A	68	Curb-Cut Rain Gardens	Multiple	PC-3	2.9-5.2	657-1,228	4.8-8.5	$90,112-$172,632	$2,250-$4,500	$1,812-$1,972
22	1-A	52	Curb-Cut Rain Gardens	Pond 302	PC-1	0.5-1.2	12-71	1.4-3.2	$24,096-$57,104	$450-$1,350	$2,506-$2,817
23	9-F	110	Enhanced Street Cleaning	Multiple	PC-9	1.7-3.3	718-1,422	0.0	$4,268-$13,529	N/A	$2,511-$4,100
24	8-E	100	Enhanced Street Cleaning	Multiple	PC-8	0.9-1.7	376-728	0.0	$2,864-$7,495	N/A	$3,182-$4,409
25	3-E	73	Pond Modification	Pond 304	PC-3	4.9	1,531	0.0	$655,840-$1,360,840	$450	$4,553-$9,349
26	3-D	71	Infiltration Basin	Cloverleaf Park	PC-3	0.5-1.5	99-321	0.7-2.1	$103,796-$203,796	$275	$4,712-$7,470
T27	9-D	108	Hydrodynamic Device	88th Ave. DP	PC-9	0.9	354	0.0	$109,752	$840	$4,998
T27	9-E	109	Hydrodynamic Device	86th Ave DP	PC-9	0.9	334	0.0	$109,752	$840	$4,998
29	6-A	84	New Pond	Foley Blvd DP	PC-6	2.0	755	0.0	$265,650	$1,300	$5,078
30	8-B	97	Hydrodynamic Device	Norway St. South DP	PC-8	0.7	300	0.0	$109,752	$840	$6,426
31	8-D	99	Hydrodynamic Device	East River Road South DP	PC-8	0.4	186	0.0	$55,752	$840	$6,746
32	9-C	107	Hydrodynamic Device	87th Lane DP	PC-9	0.6	237	0.0	$109,752	$840	$7,497
33	9-B	106	Hydrodynamic Device	88th Lane DP	PC-9	0.3	131	0.0	$55,752	$840	$8,995
34	8-C	98	Hydrodynamic Device	East River Road North DP	PC-8	0.5	197	0.0	$109,752	$840	$8,997

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

Table 10: Cost-effectiveness of retrofits with respect to volume reduction. Projects 1 - 17. TSS and TP 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
1	2-D	63	Infiltration Basin	96th Ln. DP	PC-2	2.5	633	4.6	$48,796	$275	$413
2	2-C	62	Infiltration Basin	Swan Park (South)	PC-2	2.1	477	2.8	$41,296	$275	$590
3	9-A	105	Curb-Cut Rain Gardens	Multiple	PC-9	1.3-7.6	418-2,394	1.3-7.6	$24,096-$106,616	$450-$2,700	$823-$1,139
4	2-A	60	Curb-Cut Rain Gardens	Multiple	PC-2	1.2-2.8	268-67	2.1-4.4	$32,348-$73,608	$675-$1,800	$835-$967
5	1-A	52	Curb-Cut Rain Gardens	Pond 302	PC-1	0.5-1.2	12-71	1.4-3.2	$24,096-$57,104	$450-$1,350	$895-$1,017
6	3-C	70	Infiltration Basin	Van Buren Park (North)	PC-3	1.1-2.1	243-498	1.8-3.7	$48,796-$93,796	$275	$919-$1,056
7	3-B	69	Infiltration Basin	Van Buren Park (South)	PC-3	1.1-2.0	243-485	1.8-3.4	$48,796-$93,796	$275	$1,000-$1,056
8	2-B	61	Infiltration Basin	Swan Park (North)	PC-2	1.0	233	1.4	$33,796	$275	$1,001
9	1-B	53	Curb-Cut Rain Gardens	Pond 310	PC-1	0.8-1.5	159-305	1.2-2.1	$24,096-$40,600	$450-$900	$1,044-$1,073
10	3-A	68	Curb-Cut Rain Gardens	Multiple	PC-3	2.9-5.2	657-1,228	4.8-8.5	$90,112-$172,632	$2,250-$4,500	$1,095-$1,212
11	8-A	96	Infiltration Basin	Norway St. North DP-IB	PC-8	0.2-0.4	69-111	0.2-0.3	$12,896	$225	$2,183-$2,924
12	3-D	71	Infiltration Basin	Cloverleaf Park	PC-3	0.5-1.5	99-321	0.7-2.1	$103,796-$203,796	$275	$3,366-$5,336
T13	1-C	55	IESF Bench	Pond 303	PC-1	17.1	0	0.0	$208,210	$1,377	N/A
T13	1-D	56	IESF Bench	Pond 310	PC-1	13.8	0	0.0	$162,450	$918	N/A
T13	3-E	73	Pond Modification	Pond 304	PC-3	4.9	1,531	0.0	$655,840-$1,360,840	$450	N/A
T13	3-F	75	IESF Bench	Pond 304	PC-3	13.7	0	0.0	$259,050	$1,837	N/A
T13	6-A	84	New Pond	Foley Blvd DP	PC-6	2.0	755	0.0	$265,650	$1,300	N/A

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

Table 11: Cost-effectiveness of retrofits with respect to volume reduction. Projects 18 - 34. TSS and TP 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 (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ ac-ft Vol./year (30-year)
T13	6-B	85	IESF Bench	Multiple	PC-6 and PC-7	28.3-71.3	0	0.0	$321,795-$729,375	$2,066-$5,395	N/A
T13	7-A	91	IESF Bench (with Stormwater Diversion)	Industrial Park Pond	PC-7	4.2-8.1	0	0.0	$293,050-$351,510	$2,296	N/A
T13	8-B	97	Hydrodynamic Device	Norway St. South DP	PC-8	0.7	300	0.0	$109,752	$840	N/A
T13	8-C	98	Hydrodynamic Device	East River Road North DP	PC-8	0.5	197	0.0	$109,752	$840	N/A
T13	8-D	99	Hydrodynamic Device	East River Road South DP	PC-8	0.4	186	0.0	$55,752	$840	N/A
T13	8-E	100	Enhanced Street Cleaning	Multiple	PC-8	0.9-1.7	376-728	0.0	$2,864-$7,495	N/A	N/A
T13	9-B	106	Hydrodynamic Device	88th Lane DP	PC-9	0.3	131	0.0	$55,752	$840	N/A
T13	9-C	107	Hydrodynamic Device	87th Lane DP	PC-9	0.6	237	0.0	$109,752	$840	N/A
T13	9-D	108	Hydrodynamic Device	88th Ave. DP	PC-9	0.9	354	0.0	$109,752	$840	N/A
T13	9-E	109	Hydrodynamic Device	86th Ave DP	PC-9	0.9	334	0.0	$109,752	$840	N/A
T13	9-F	110	Enhanced Street Cleaning	Multiple	PC-9	1.7-3.3	718-1,422	0.0	$4,268-$13,529	N/A	N/A
T13	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$20,170	$350	N/A
T13	9-H	112	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	3,938	0.0	$20,170	$350	N/A
T13	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$26,170	$750	N/A
T13	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	22,500	0.0	$26,170	$750	N/A
T13	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	14,063	0.0	$26,170	$750	N/A
T13	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	6,563	0.0	$20,170	$350	N/A

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

To determine which projects to pursue, Coon Creek Watershed District analyzed water quality samples taken in Pleasure Creek to establish which pollutants needed to be addressed. This methodology is listed in detail in the *Analytical Process and Elements* section.

Results of this analysis set the TSS reduction goal at 29.1% and TP reduction goal at 14.0%. Using WinSLAMM model results based on existing conditions we find these percentages are 28,206 lbs for TSS and 61.6 lbs for TP. The TSS goal could be reached through the installation of the following projects:

Table 12: Projects needed to reach the proposed TSS goal

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TSS Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	22,500	$50,420	$750	$108
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	22,500	$50,420	$750	$108

[1] [(Probable Project Cost) + 30*(Annual O&M)] / [30*(Annual TSS Reduction/1,000)]

Installing both of these projects would result in 45,000 lbs-TSS removal. Direct (design and construction) and indirect (promotion and administration) costs for these projects are proposed to be $100,840, with an additional $1,500 per year in estimated operations and maintenance costs. Assuming a 30-year project lifetime for each of these projects, total cost (excluding inflation) is expected to be approximately $145,840.

To reach the proposed goal of 61.6 lbs-TP (14.0% TP loading), the following projects could be installed:

Table 13: Projects needed to reach the proposed TP goal

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	Probable Project Cost (2015 Dollars)	Estimated Annual Operations & Maintenance (2015 Dollars)	Estimated cost/ lb-TP/year (30-year)[1]
T1	9-I	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	$50,420	$750	$135
T1	9-J	114	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	18.0	$50,420	$750	$135
3	9-K	115	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	11.3	$50,420	$750	$215
T4	9-G	111	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	$30,420	$350	$257
T4	9-L	116	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	5.3	$30,420	$350	$257
7	9-H	113	Streambank Stabilization	Direct-to-Creek PC-9	PC-9	3.2	$30,420	$350	$426
13	9-A	106	Curb-Cut Rain Gardens (2)	Multiple	PC-9	1.3	$24,096	$450	$823

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

These projects include the two listed in Table 12 plus five others. Installing all seven of the projects as proposed in Table 13 would result in 62.4 lbs-TP removal. Direct (design and construction) and indirect (promotion and administration) costs for these projects are proposed to be $266,616, with an additional $3,750 per year in estimated operations and maintenance costs. Assuming a 30-year project lifetime for each of these projects, total cost (excluding inflation) is expected to be approximately $329,116.

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
- Enhanced street cleaning
- Hydrodynamic devices
- Iron-enhanced sand filter pond bench
- New wet retention ponds
- Pond maintenance and modifications
- Stormwater diversion
- Streambank stabilization

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 dissolved phosphorus (Table 14).

Table 14: Matrix describing curb-cut rain garden efficacy for pollutant removal based on type. 'PP' is particulate phosphorus. 'DP' is dissolved phosphorus.

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.

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 4: Rain garden before and during a rainfall event).

Figure 4: 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. usually >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 2015 dollars. A reduced construction cost (i.e. $10.00-15.00 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.

Enhanced Street Cleaning

Urban streets often act as the first conduit for stormwater before it reaches storm catch basins and sewer systems. Because of this, streets are often left with debris, sediment, and other pollutants following precipitation events. For both aesthetic and environmental reasons, municipalities and other entities have been cleaning streets for hundreds of years to remove these items. Since the early 1990's, municipalities have been regulated under the NPDES program to improve storm water treatment prior to discharge into local waterbodies. Since that time municipal governments have often utilized street cleaning as a cost-effective option for improving stormwater treatment.

Street cleaning is most often performed by one of two types of vehicles:

Mechanical Sweeper: primarily removes debris and coarse sediments through sweeping with a gutter broom, most common sweeper used nationwide, least costly to purchase but has highest annual maintenance costs

Vacuum-Assisted Sweeper: Utilizes a strong vacuum to remove coarse and fine sediments in addition to the gutter broom; this unit is able to remove particles often wedged within cracks and breaks in pavement, more costly to purchase than a mechanical sweeper but has lower annual maintenance costs.

Many cities pursue a street cleaning frequency of sweeping twice per year, generally following spring snowmelt and just before snowfall in late fall. This removes sediments and debris during two of the most opportune times to sweep, but neglects events during the year which still have the capacity to carry pollutants onto the roadway. These pollutants can be transported to storm sewer catch basins during precipitation events long before the next sweep. Increasing the frequency of passes on each city street could be an option for capturing more pollutants before they reach the storm sewer system. For this analysis, the process of increasing street cleaning frequency to capture additional pollutants has been termed "enhanced" street cleaning.

Frequency of cleaning should depend on a number of items, including primarily land use type, but also soil characteristics, roadway structure (e.g. curb and gutter), and traffic patterns. One of the more comprehensive analyses performed within the Twin Cities metropolitan area was for the Ramsey-Washington Metro Watershed Management Organization (Schilling, 2005a & Schilling, 2005b), which proposed street cleaning frequencies of 6-9 passes per year for residential land uses and "hot spot areas," 9-16 passes per year for arterial roadways and streets in commercial and heavy industrial land uses, and biweekly to twice weekly passes per year for the central business district. These were found to be the most cost-effective strategies based on survey results and an analysis of other city's cleaning approaches. Within this analysis we did not pursue land use-specific cleanings. Instead, the increase in street cleaning frequency was applied evenly across all land use types.

Pollutant treatment based on street cleaning frequency was determined using the water quality modeling software WinSLAMM. Both cities within the Pleasure Creek subwatershed, Blaine and Coon Rapids, already have a street cleaning program. Blaine employs two regenerative-air, vacuum-assisted street sweepers which sweep every street at least twice per year. Coon Rapids utilizes one mechanical sweeper and one vacuum-assisted sweeper. In addition, Coon Rapids often contracts additional companies (utilizing mechanical sweepers) to assist in sweeping. This ensures at least two passes on each street during spring/summer and at least two passes on each street during fall. To determine existing pollutant removal from these programs, WinSLAMM was utilized with the following scenarios:

Table 15: Existing municipal street cleaning frequencies for all cities in the Pleasure Creek subwatershed

City	Sweeper Type	Street Cleaning Frequency (WinSLAMM Model Input)
Blaine	Vacuum-Assisted	Two passes per year (spring and fall)
Coon Rapids	Mechanical	One pass every 12 weeks

Street cleaning was modeled at the subcatchment-scale within WinSLAMM. Only one cleaning frequency and sweeper type was modeled for each subcatchment. As some subcatchments straddled municipal boundaries, the city with the largest geographical area within each subcatchment was used for model input. Thus, if a particular subcatchment was 75% within Blaine and 25% within Coon Rapids, Blaine's street cleaning schedule was used for the entire subcatchment. Coon Rapids utilizes both sweeper technologies, vacuum-assisted and mechanical, but was modeled within WinSLAMM only as 'mechanical' due to modeling constraints.

To determine the impact of enhanced street cleaning schedules, the number of passes per year were increased to match those proposed in Schilling (2005b; although not land use specific). The number of passes per year for each urban street was determined based on the frequency in the following table, and is limited to the frequencies available within the WinSLAMM model:

Table 16: Street Cleaning frequencies available as WinSLAMM model inputs

Street Sweeping Frequency	Number of passes per year
Once every 4 weeks	8
Once every 2 weeks	17
Once every week	34

Proposed frequencies were also modeled at the subcatchment-scale. Benefits were determined in addition to existing BMPs in the landscape, including current street cleaning schedules.

Enhanced street cleaning was modeled for all catchments in the Pleasure Creek subwatershed, but only proposed in this report within catchments PC-8 and PC-9. This is because most sediments and sediment-bound phosphorus picked up by street cleaning devices in Catchments PC-1 through PC-7 are already being removed by catchment-specific stormwater ponds (particularly in PC-1 and PC-3) and the Pleasure Creek Ponds. Downstream of the Pleasure Creek Ponds no treatment exists, providing enhanced street cleaning the opportunity to become a cost-effective option for treating pollutants.

In order to calculate cost-benefit, the cost of each project had to be estimated. To fully estimate the cost of increasing cleaning frequency, costs including fuel, worker time, and additional depreciation must be included. Costs determined in Schilling (2005a), based on cleaning frequency, were used during the cost-benefit analysis and are listed in the table below (cost values are for dollars/curb-mile/year). Load reduction estimates for these projects are noted in the Catchment Profiles section.

Table 17: Cost estimates based on cleaning frequency as found in Schilling, 2005a

Sweeper Type	Sweeping Frequency					
	Weekly	Bi-weekly	Monthly	Four times per year	Twice per year	Annual
Mechanical	$2,235	$1,120	$520	$170	$90	$45
Vacuum	$1,260	$630	$290	$100	$50	$25

A 'curb mile' is the length of curb in miles a street sweeper travels while it cleans. In most cases this number represents the length of street multiplied by two to account for curb on either side of the street. Curb mile length was estimated using WinSLAMM standard land uses as opposed to the actual length (as measured in GIS) in each subcatchment to gauge cost-benefit more accurately.

Hydrodynamic Devices

In heavily urbanized settings such as the Cities of Blaine and Coon Rapids, 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.

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.

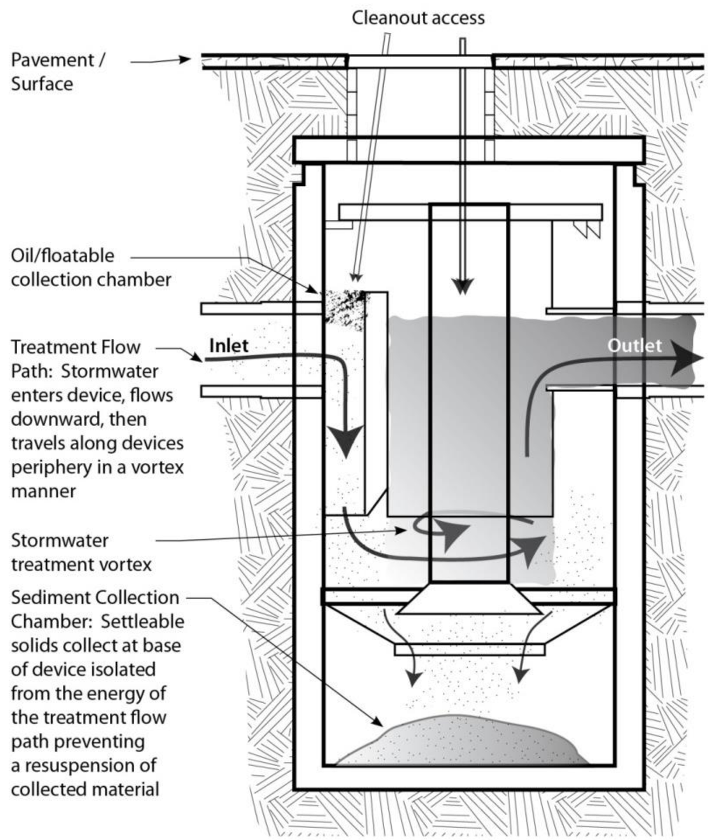


Figure 5: Schematic of a typical hydrodynamic device

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.

Iron-Enhanced Sand Filter Pond Bench

Wet retention ponds, although very effective in treating stormwater for suspended sediment and nutrients bound to sediment, have shown a limited ability at retaining dissolved species of nutrients. This is most notable for phosphorus. Median values for pollutant removal percentage by wet retention ponds are 84% for TSS and 50% for TP (Technical Documents, 2014). For the case of phosphorus, dissolved species typically constitute 40-50% of TP in urban stream systems, but only 34% (median efficiency; Weiss et al., 2005) of dissolved phosphorus is treated by the pond. Thus, a majority of the phosphorus escaping wet retention ponds is in dissolved form. This has important effects downstream as dissolved phosphorus is a readily available nutrient for algal uptake in waterbodies and can be a main cause for nutrient eutrophication.

To augment dissolved phosphorus retention in existing stormwater ponds, an iron-enhanced sand filter (IESF) bench can be retrofit along the pond bank nearest the outlet. The IESF bench relies on the properties of iron to bind dissolved phosphorus as it passes through an iron-rich medium. Depending on topographic characteristics of the installation site, IESF benches can rely on gravitational flow and natural water level fluctuation, or water pumping to hydrate the IESF. IESF benches must be designed to prevent anoxic conditions in the filter medium because such conditions will release the bound phosphorus. Because IESFs are intended to remove dissolved phosphorus and not organic phosphorus, they are typically constructed just downstream of stormwater ponds, minimizing the amount of suspended solids that could compromise their efficacy and drastically increase maintenance. As an alternative to an IESF bench, a ferric-chloride injection system could be installed to bind dissolved phosphorus into a flocculent, which would settle in the bottom of the pond.

Figure 6 shows an IESF bench that is installed at an elevation slightly above the normal water level of the pond so that following a storm event the increase in depth of the pond would be first diverted to the IESF bench. The filter would have drain tile installed along the base of the trench and would outlet downstream of the current pond outlet. Large storm events that overwhelm the IESF bench's capacity would exit the pond via the existing outlet.

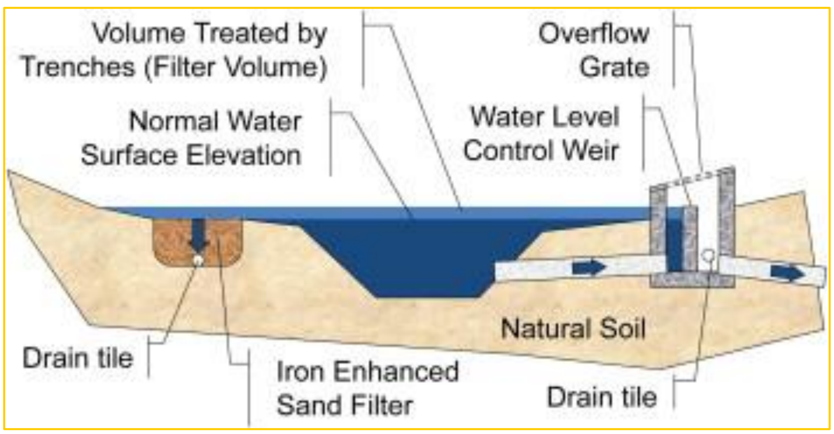


Figure 6: Iron-Enhanced Sand Filter Concept (Erickson & Gulliver, 2010)

Benefits for stormwater ponds were modeled utilizing WinSLAMM. WinSLAMM is able to calculate flow through constructed features such as rain gardens with underdrains, soil amendments, and controlled overflow elevations. An IESF bench works much the same way. Storm event based discharge volumes and dissolved phosphorus concentrations estimated by WinSLAMM after construction of the pond were entered into WinSLAMM as inputs into the IESF bench (baseflow, if pond is installed in-line, was discounted as it would bypass the IESF). Various iterations of

IESF benches were modeled to identify an optimal treatment level compared to construction costs. A detailed account of the methodologies used is included in *Appendix A*. To account for the dissolved phosphorus treated by the IESF bench, an additional 80% dissolved phosphorus removal was assumed for each IESF bench in addition to any removal by the pond. This value is based on laboratory and field tests performed by the University of Minnesota (Erickson & Gulliver, 2010) and assumes only removal of dissolved phosphorus species within the device. Load reduction estimates for these projects are noted in the *Catchment Profiles* sections.

In order to calculate cost-benefit, the cost of each project had to be estimated. IESF bench projects were assumed to involve some excavation and disposal of soil, land acquisition (if not already publically-owned), erosion control, vegetation management, and other necessary construction costs. Additionally, project engineering, promotion, administration, construction oversight, and long-term maintenance had to be considered in order to capture the true cost of the effort. Costs for each of these items were projected based on IESF practices installed within Anoka County during 2015. IESF material costs were estimated to be $15.00 per sq-ft. This value aggregates costs for installation and materials, including an impermeable liner, iron filings, rip rap, erosion control fabric, drain tile, and coarse and/or fine aggregate fill. Annual maintenance costs were estimated to be $10,000 per acre of IESF based on information received from local private consulting firms.

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 7).

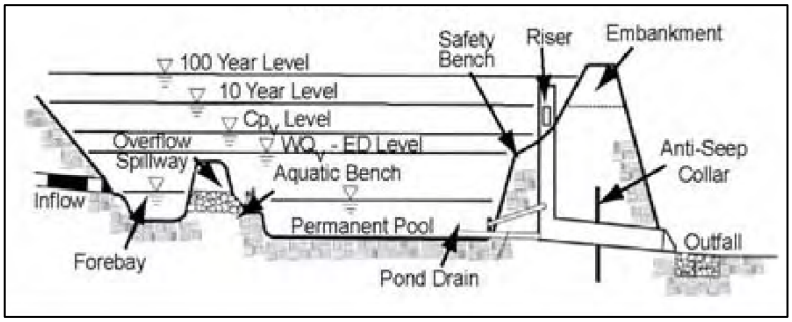


Figure 7: Schematic of a stormwater retention pond. Figure from the Urban Subwatershed Restoration Manual Series, Chapter 3: Urban Stormwater Retrofit Practices.

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.

Pond Maintenance and Modifications

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 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. 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. One proposed modification, excavating the pond bottom to increase storage, often has a very wide range in expected cost due to the nature of the excavated soil. If the soil has been contaminated and requires landfilling, the cost for disposal can quickly lead to a doubling in project cost. For this reason, projects which include the excavation of ponds have been priced based on the following criteria:

- Management Level 1: Dredged pond soil is suitable for use or reuse on properties with a residential or recreational use
- Management Level 2: Dredged pond soil is suitable for use or reuse on properties with an industrial use
- Management Level 3: Dredged pond soil is considered significantly contaminated and must be managed specifically for the contaminants present

Costs within each of these levels can even range widely, but were estimated to be \$20/cu-yd., \$35/cu-yd., and \$50/cu-yd. for levels 1, 2, and 3, respectively. Additional costs associated with specific projects are listed in *Appendix B*.

Stormwater Diversions

Stormwater conveyance at the time of development in many cities focused solely on flooding issues. Or, in many cases, when water quality treatment is sought it is done only on the property under construction. The stormwater retrofit approach allows for a more complete look at stormwater infrastructure and treatment, and often opportunities arise where connecting and/or rerouting stormwater to an existing treatment practice can more cost-effectively improve treatment as compared to building a new practice. These opportunities are sought above others as it takes advantage of existing infrastructure and resources.

One such opportunity was pursued in this analysis in PC-7, described in detail in Project 7-A on page 91. In this case the storm sewer along Evergreen Blvd. could be rerouted to the Industrial Park pond adjacent to the Pleasure Creek Ponds, where an IESF bench could potentially increase dissolved phosphorus retention capacity.

Streambank Stabilizations

Increasing impervious surface in the upstream drainage areas of a watershed can cause higher peak flows which threaten the stability of downstream bank channels. Sustained high flows lead to unstable banks with toe erosion and bank sloughing. The sediment lost from the bank is carried downstream, bringing with it nutrients such as phosphorus as well as other pollutants commonly found in soil. Streambank stabilizations are projects which focus on ensuring that both (i) the toe of the slope is reinforced to ensure undercutting no longer occurs and (ii) upland bank sloughing is repaired and protected from future erosion.

Streambank stabilization designs vary greatly depending on the location and severity of erosion, soil texture, vegetative cover, contributing watershed size, slope and land use characteristics, site access, and cultural features. The first element of a streambank stabilization is to secure the toe of the slope. This is often done using large boulder or rip rap, often buried into the soil to prohibit downcutting. Above the creek channel additional actions can be taken to protect and maintain bank structure, including erosion control mats/fabric and the planting of deep-rooted vegetation. Other in-channel stream restoration structures can also be included in the design to provide grade stabilization or to divert flow from a cut bank to the main channel. Grade stabilization structures include cross vanes and w-weirs. Restoration structures which divert flow velocity from the bank to the main channel include rock vanes, bendway weirs, J-hooks, and root wads among others.

Engineered designs are critical to ensure the practices are suitable for anticipated water velocities and volumes, soil types, and other characteristics previously mentioned. Costs vary greatly depending on the engineered practice as well as site access, regulatory requirements, and the size of the treatment area.

A ditch inspection of Pleasure Creek was completed by CCWD in May 2012. This inspection identified nine reaches of the creek illustrating erosion that needed to be addressed in the near future. Three of these sites have been stabilized as of the completion of this report. The remaining six project sites have been evaluated in this analysis to determine their pollutant contribution to Pleasure Creek, the cost to complete and maintain the project, and the cost-effectiveness of the effort.

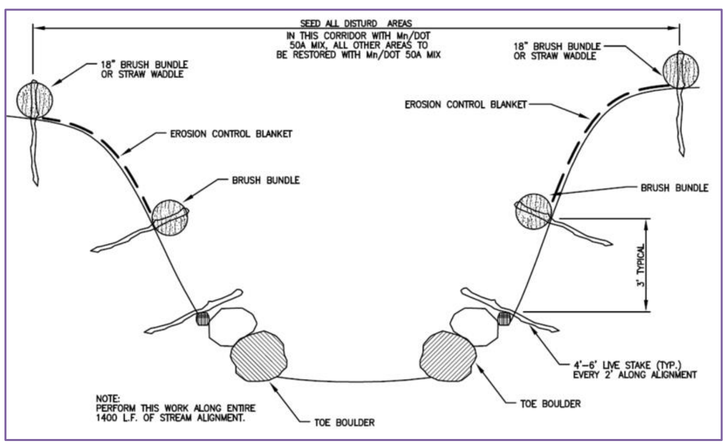


Figure 8: Various Stabilization Practices Cross Section

Instances of erosion were classified according to severity along each distinct stream segment. Erosion severity determinations and voided soil volumes were estimated utilizing RAP-M (Windhorn, R. D., 2000). TSS and TP reduction estimates were based on the Board of Water and Soil Resources Pollution Reduction Estimator which estimates loading based on a correlation between voided sediment volume and type with soil density averages and phosphorus concentrations. *Appendix A* includes more detail on modeling methods.

To estimate overall project cost and impact, cost-benefit, installation cost, annual maintenance, as well as project promotion, design, and administration were all determined. Installation cost was estimated at $500.00 per linear foot, which includes costs for mobilization, clearing, grubbing, common excavation and disposal, stabilization of channel and bank, water control, and site restoration. All streambank stabilization projects are assumed to include Class 3 rip rap in the channel and erosion control fabric along the upper bank. This estimate does not include any costs for in-stream structures for flow diversion or grade control. The estimate also ignores any costs to acquire the land, either through an easement or an outright sale, as landowner participation in the project is expected based on prior experience in this neighborhood. Total cost over the 30-year anticipated project life was divided by the total reduction in stormwater pollutants over the same time span.

Catchment Profiles

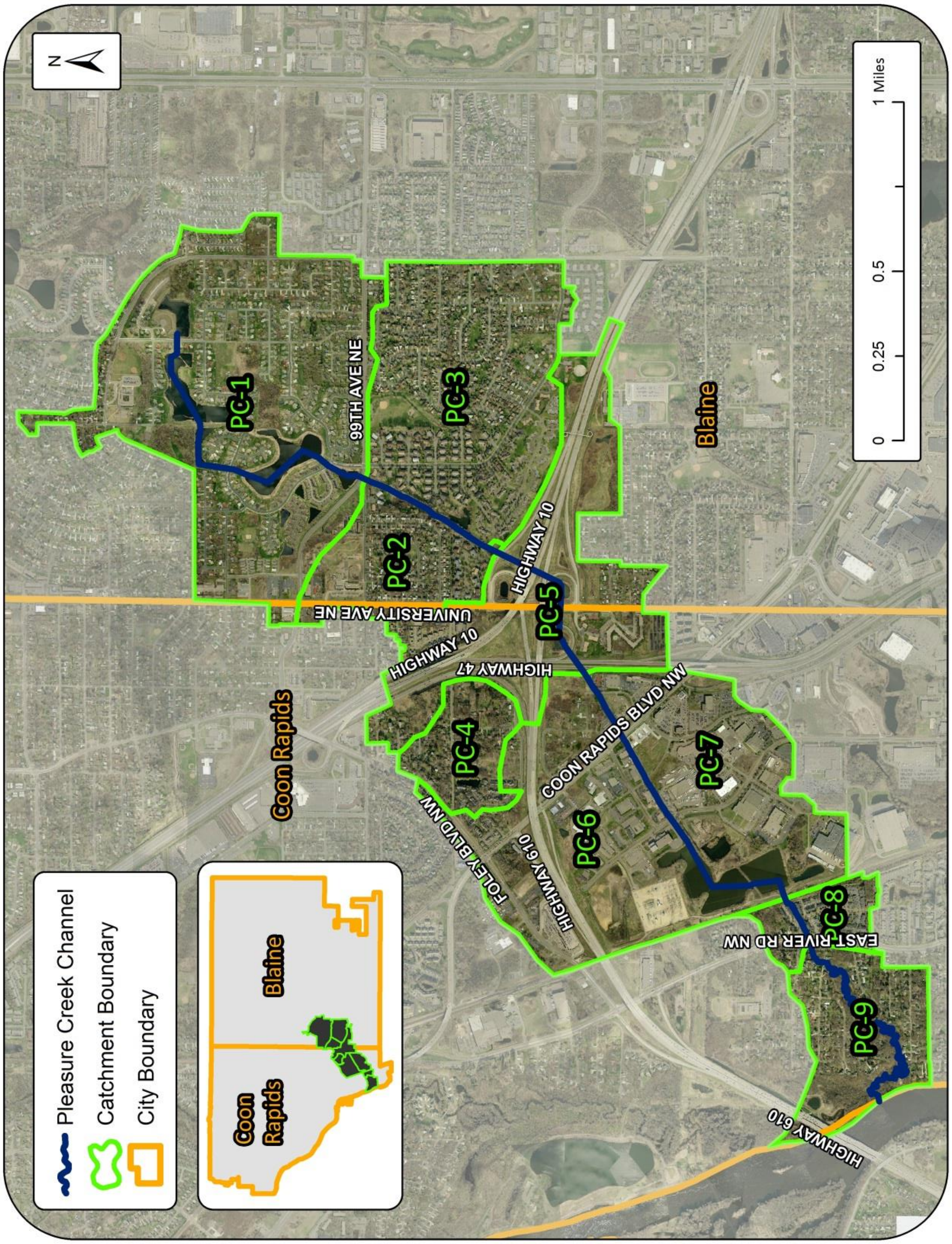
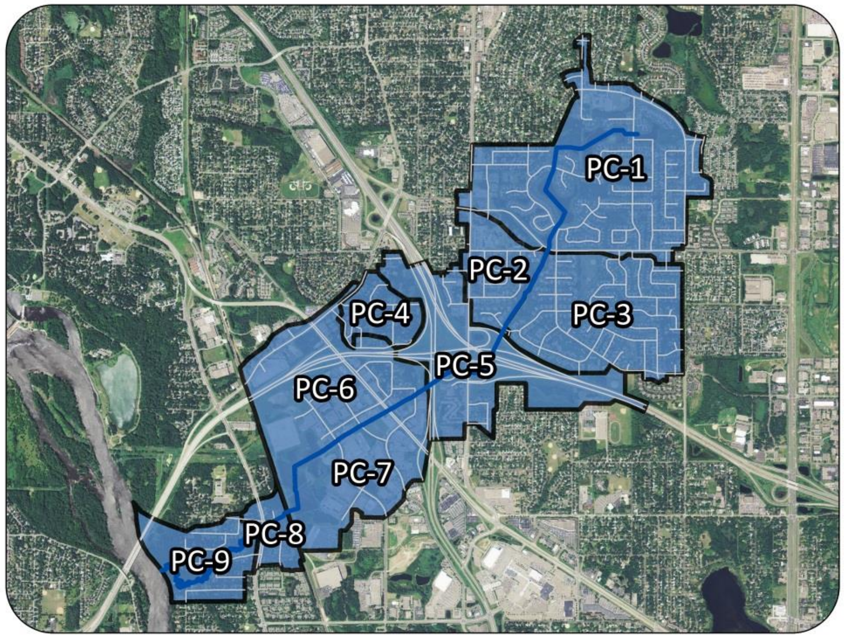


Figure 9: The 1,694 acre Pleasure Creek subwatershed was divided into 9 catchments for this analysis. Catchment profiles on the following pages provide additional information.

Subwatershed-Wide Summary

Catchment ID	Page
PC-1	48
PC-2	57
PC-3	64
PC-4	76
PC-5	78
PC-6	80
PC-7	87
PC-8	93
PC-9	101



Existing Network Summary	
Acres	1,694
Dominant Land Cover	Residential
Volume (ac-ft/yr)	861.6
TP (lb/yr)	512.2
TSS (lb/yr)	118,230

SUBWATERSHED DRAINAGE SUMMARY

The Pleasure Creek subwatershed is comprised of nine catchments, PC-1 through PC-9. Catchments PC-1, PC-2, and PC-3 lie primarily within the City of Blaine whereas catchments PC-4 and PC-6 through PC-9 lie completely within the City of Coon Rapids. Catchment PC-5, which contains the Highway 10/610 freeway corridor, straddles the municipal boundary.

The subwatershed is highly developed, with little remaining undeveloped space. The upper (PC-1 through PC-3) and lower (PC-8 and PC-9) catchments are primarily residential properties. The middle catchments (PC-4 through PC-7) are a mix of land uses between residential, freeway, commercial, and industrial. The creek begins at the outfall of the ponds in PC-1, just south of 99th Ave. NE, and flows to its confluence with the Mississippi River in the southwestern end of the subwatershed.

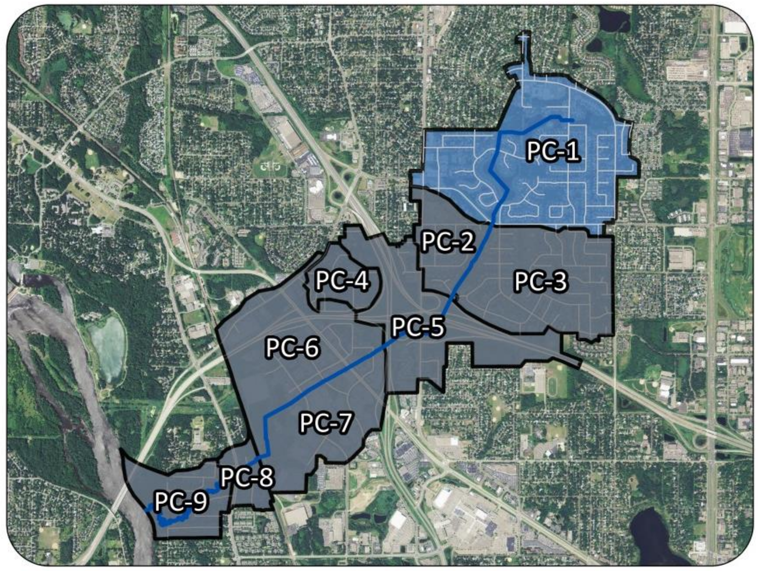
EXISTING STORMWATER TREATMENT

Stormwater runoff in the Pleasure Creek subwatershed has limited overland flow paths due to the large network of storm sewers throughout the Cities of Blaine and Coon Rapids. In many cases, water intercepted by the storm sewer system discharges into a stormwater BMP prior to reaching the creek. A total of 31 structural stormwater BMPs are scattered throughout the subwatershed and were significant enough in size to be modeled within this analysis. Over one third are in PC-1, including eleven stormwater ponds, an infiltration basin, and grass swale. An additional nine (seven ponds, a grass swale, and a wetland) are in PC-5 and treat runoff from both the interstates and neighboring properties. Four of the BMPs are in-line with the creek south of 99th Avenue, providing some treatment to all properties upstream of the practice. These include two ponds in PC-5 and the Pleasure Creek Ponds in Catchments PC-6 and PC-7. All 31 BMPs are shown in Figure 2. An additional 7 BMPs are also shown in the map but were not modeled, either because no significant storm sewer inputs were found or not enough information was provided to include them during analysis. Each of these BMPs, along with those modeled within WinSLAMM, are noted in the Existing Stormwater Treatment section of each Catchment Profile.

A cultural practice provided throughout the subwatershed is street cleaning, performed by the Cities of Coon Rapids and Blaine. Coon Rapids employs primarily mechanical sweepers, which clean the streets four times annually. The City of Blaine utilizes vacuum sweepers, which clean the streets at least twice annually. Blaine’s sweeping was modeled as only occurring twice annually to ensure estimates for pollutant removal from this practice were not overestimated.

Catchment PC-1

Existing Catchment Summary	
Acres	434.2
Dominant Land Cover	Residential
Parcels	952



CATCHMENT DESCRIPTION

This catchment is bounded by University Ave. NE to the west, 99th Ave. NE to the south, Fillmore Pl. NE to the east and Territorial Rd. NE to the north. It consists primarily of single-family residential lots with some businesses along University Ave. NE, multi-family units, and Madison Elementary School.

EXISTING STORMWATER TREATMENT

Stormwater runoff generated within the catchment is directed to a set of 11 stormwater retention ponds, an infiltration basin and grass swale running north to south through the center of the catchment. Three separate series of ponds drain into Pond 303 and subsequently pond 310 (see map on following page). Pond connectivity is (beginning with the most upstream pond) 302-301-318-316-303, 314-313-303, and 311-312-303. Pond 310, the outlet for all stormwater generated within the catchment, accepts overflow from Pond 303 and stormwater runoff from single-family lots to the east. The pond drains into a storm sewer south of 99th Ave. NE. This pipe then enters the open channel section of Pleasure Creek south of 99th Ave. NE. Pond information within the catchment is summarized in *Appendix A* and also in the schematic below.

In addition to the 11 wet retention ponds in the catchment, roadway catch basins draining the residential and commercial lots along 102nd Ln. NE, 103rd Ave. NE, and 6th St. NE outlet into a 230 foot long grass swale in President Park. The swale is hydrologically connected to pond 314 and the subsequent in-series ponds downstream. Stormwater runoff from University Ave. NE commercial properties and multi-family units along 3rd St. NE drains into a stormwater pond and infiltration basin located west of 3rd St. NE and south of 102nd Ln. NE. Because of the high outlet elevation of these structures, this portion of the catchment rarely overflows, with most runoff either infiltrating or evaporating within one of these two BMPs.

Lastly, street cleaning is performed at least twice annually by the City of Blaine.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments drains to the Pleasure Creek Ponds, which supply stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

PROPOSED RETROFITS OVERVIEW

Stormwater ponds and the grass swale sufficiently treat this catchment for TSS. On the other hand, stormwater ponds provide limited to no treatment for dissolved pollutants, which can also lead to degrading water quality and stream impairments. Therefore, retrofits were chosen based on feasibility and treatment capability for dissolved species. Curb-cut rain gardens were proposed in the single-family residential neighborhood where soils were favorable for an infiltration practice. IESF benches were proposed for two of the stormwater ponds in the catchment. These filters will provide additional treatment for dissolved species.

RETROFITS CONSIDERED BUT REJECTED

The series of stormwater ponds running the length of the catchment are well-sized for the drainage area. The ponds cover 7.4% of the total catchment land area, well above the 1-3% coverage recommended by the Minnesota Stormwater Manual and the Pollution Control Agency (MPCA, 2014). These ponds already sufficiently treat TSS pollution from within the catchment, so no pond modifications were proposed within the catchment.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

POTENTIAL RETROFITS

Project ID: 1-A

Curb-Cut Rain Gardens
Pond 302 Subcatchment

Drainage Area – 73.4 acres
Location – Throughout subcatchment Pond 302
Property Ownership – Private
Site Specific Information – Stormwater runoff generated within the catchment is already treated by the stormwater retention pond 302. Rain gardens could be installed within the residential neighborhood south of the pond to better treat dissolved species of phosphorus, which stormwater ponds are much less able to treat (compared to phosphorus bound to sediment). Soils are also favorable through much of the southern portion of the subcatchment 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)	0.5	0.1%	0.8	0.2%	1.2	0.3%
	TSS (lb/yr)	12	0.0%	45	0.0%	71	0.1%
	Volume (acre-feet/yr)	1.4	0.2%	2.5	0.3%	3.2	0.4%
Cost	Administration & Promotion Costs*	$9,344		$11,096		$12,848	
	Design & Construction Costs**	$14,752		$29,504		$44,256	
	Total Estimated Project Cost (2015)	**$24,096**		**$40,600**		**$57,104**	
	Annual O&M***	$450		$900		$1,350	
Efficiency	30-yr Average Cost/lb-TP	**$2,506**		**$2,817**		**$2,711**	
	30-yr Average Cost/1,000lb-TSS	**$104,433**		**$50,074**		**$45,823**	
	30-yr Average Cost/ac-ft Vol.	**$895**		**$901**		**$1,017**	

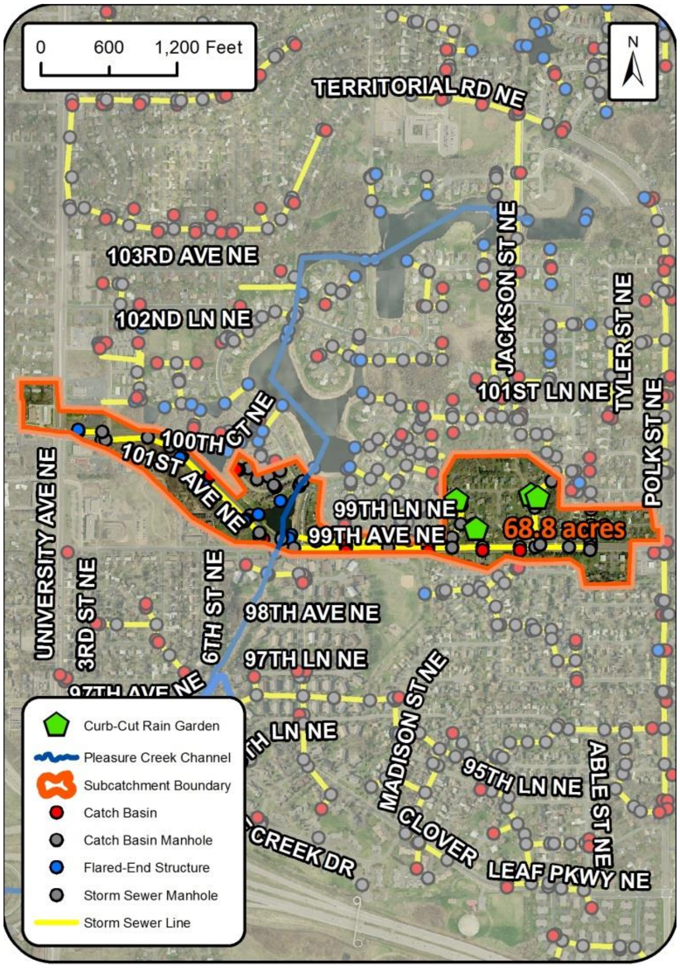
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**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: 1-B

Curb-Cut Rain Gardens
Pond 310 Subcatchment



Drainage Area – 68.8 acres
Location – Throughout eastern portion of subcatchment Pond 310
Property Ownership – Private
Site Specific Information – Stormwater runoff generated within the catchment is already treated by the stormwater retention pond 310. Rain gardens could be installed within the residential neighborhood east of the pond and north of 99th Ave. NE (see map on following page) to better treat dissolved species of phosphorus, which stormwater ponds are much less able to treat. Soils in this subcatchment should be tested prior to installing projects as drained hydric soils do exist throughout most of the subcatchment; the gardens may require underdrains. Considering typical landowner participation rates, scenarios with 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
Treatment	Number of BMPs	2		4	
	Total Size of BMPs	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	0.8	0.2%	1.5	0.3%
	TSS (lb/yr)	159	0.2%	305	0.3%
	Volume (acre-feet/yr)	1.2	0.1%	2.1	0.3%
Cost	Administration & Promotion Costs*	$9,344		$11,096	
	Design & Construction Costs**	$14,752		$29,504	
	Total Estimated Project Cost (2015)	**$24,096**		**$40,600**	
	Annual O&M***	$450		$900	
Efficiency	30-yr Average Cost/lb-TP	**$1,567**		**$1,502**	
	30-yr Average Cost/1,000lb-TSS	**$7,882**		**$7,388**	
	30-yr Average Cost/ac-ft Vol.	**$1,044**		**$1,073**	

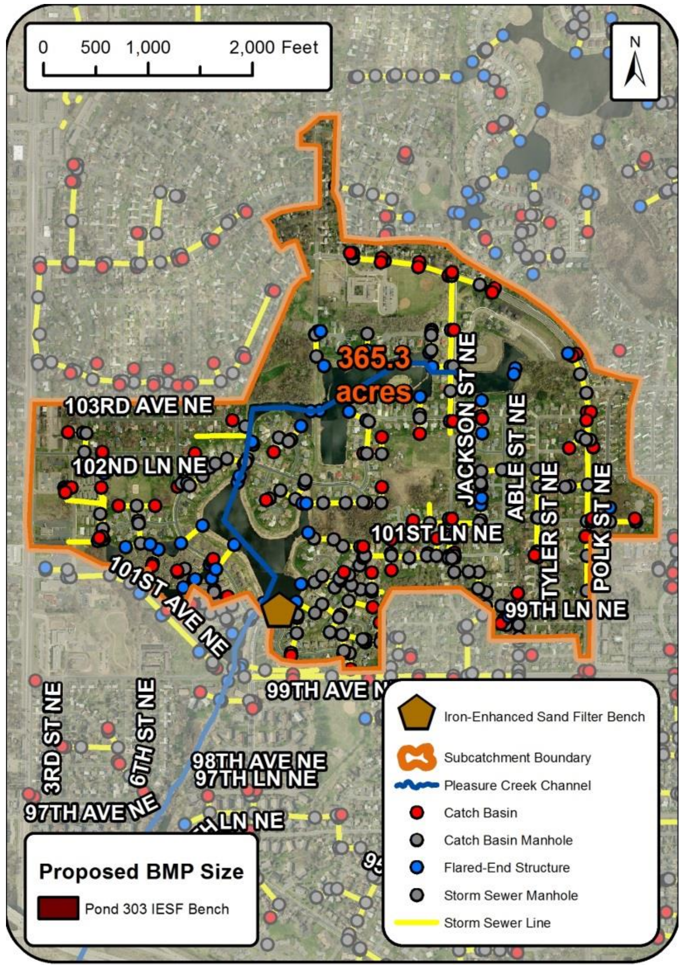
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

**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: 1-C

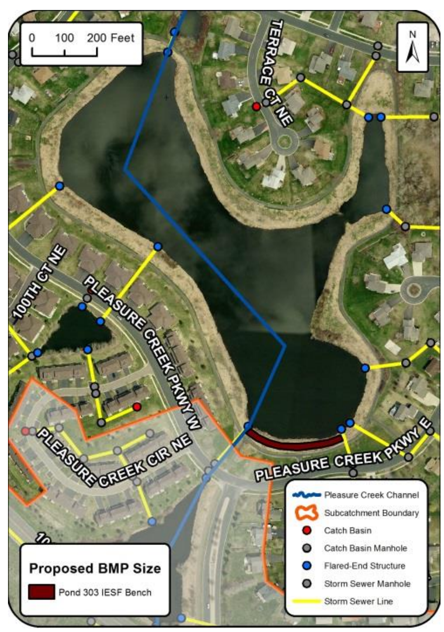
IESF Bench
Pond 303 Subcatchment



Drainage Area – 365.3 acres
Location – Along southern shore of Pond 303
Property Ownership – Public (City of Blaine)
Site Specific Information – An IESF bench was proposed as an improvement to the existing pond (Pond 303). The pond currently provides treatment through retention and settling. However, the addition of an IESF will increase removal of dissolved phosphorus. This location was chosen due to (1) ease of access along Pleasure Creek Parkway for maintenance, (2) its proximity to the existing outlet, and (3) its location in relation to upstream ponds that drain to it. The IESF was sized to 6,000 sq-ft based on available space between existing storm sewer pipes and the roadway. Detailed cost estimates for the project are listed in *Appendix B*.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	6,000	sq-ft
	TP (lb/yr)	17.1	3.9%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$3,650	
	Design & Construction Costs**	$204,560	
	Total Estimated Project Cost (2015)	**$208,210**	
	Annual O&M***	$1,377	
Efficiency	**30-yr Average Cost/lb-TP**	**$486**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

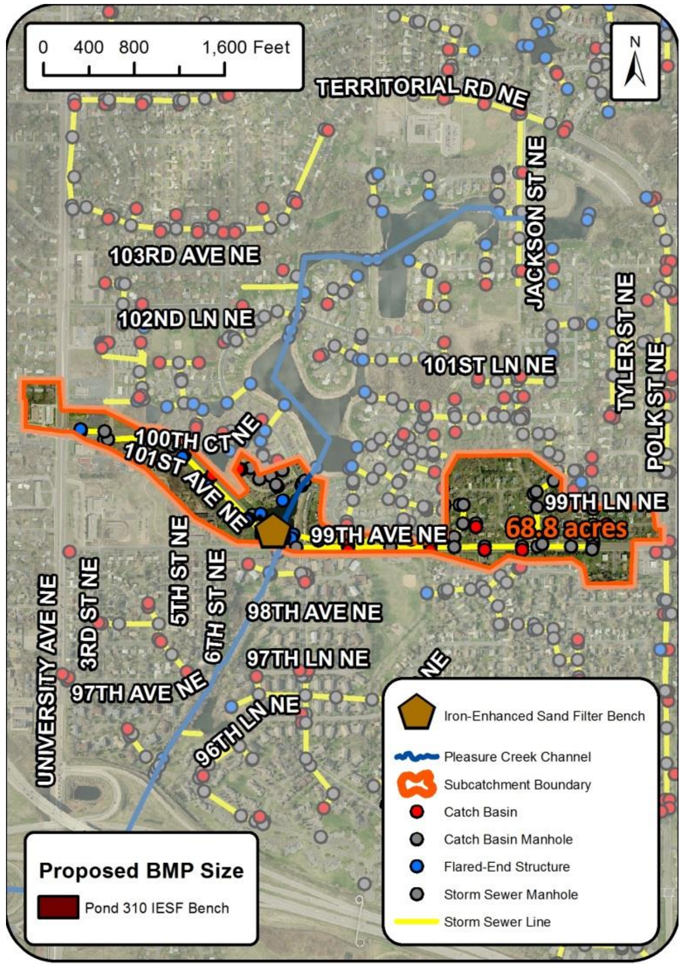
*Indirect Cost: 50 hours at $73/hour
**Direct Cost: See Appendix B for detailed cost information
***$10,000/acre for IESF



Project ID: 1-D

IESF Bench

Pond 310 Subcatchment



Drainage Area – 434.2 acres
Location – Along southwestern shore of Pond 310
Property Ownership – Public (City of Blaine)
Site Specific Information – An IESF bench was proposed as an improvement to the existing pond (Pond 310). The pond currently provides treatment through retention and settling. However, the addition of an IESF will increase removal of dissolved phosphorus. The project is proposed on the southwestern shore of the pond, as opposed to the eastern shore, to more easily tie into the existing outflow pipe without conflicts with other existing storm sewer pipe inlets to the pond. The IESF was sized to 4,000 sq-ft based on available space between existing storm sewer pipes and the roadway. Detailed cost estimates for the project are listed in *Appendix B*.

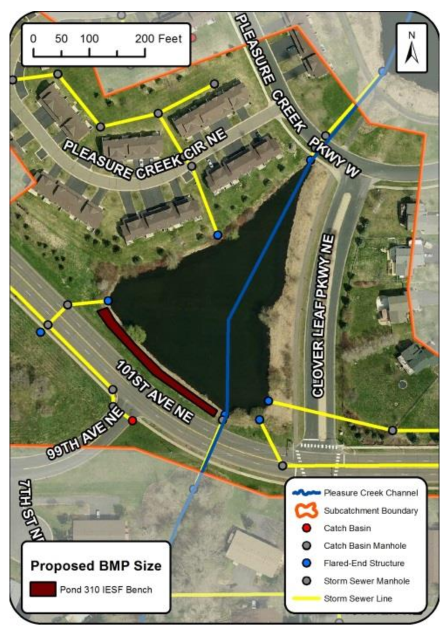
IESF Bench

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	4,000	sq-ft
	TP (lb/yr)	13.8	3.1%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$3,650	
	Design & Construction Costs**	$158,800	
	Total Estimated Project Cost (2015)	**$162,450**	
	Annual O&M***	$918	
Efficiency	30-yr Average Cost/lb-TP	**$459**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 50 hours at $73/hour

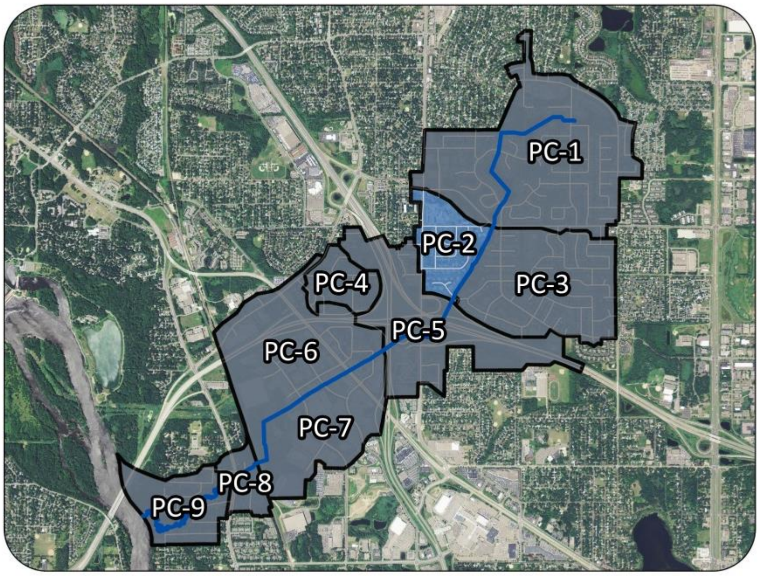
**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF



Catchment PC-2

Existing Catchment Summary	
Acres	94.0
Dominant Land Cover	Residential
Parcels	286



CATCHMENT DESCRIPTION

Catchment PC-2 consists of a mix between single-family residential, multi-family residential, and commercial properties in both the cities of Blaine and Coon Rapids. The subcatchment is bounded by Highway 10 to the south and west and Pleasure Creek to the east. All runoff within this catchment drains from the north and west to the south and east directly into Pleasure Creek. There are 3 main stormwater sewer discharge points into the creek, located (from north to south) along 7th St. NE, 97th Ave. NE and 96th Ln. NE.

EXISTING STORMWATER TREATMENT

No existing structural stormwater treatment exists in this catchment. There is an offline wetland (named the '7th St Wetland') along the creek between 7th St. NE and 6th St. NE which accepts overland runoff from backyards and stream flow during some storm events. This feature was not modeled as it is not connected with the existing stormwater infrastructure. The only form of stormwater treatment is street cleaning performed at least twice annually by the City of Blaine.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each catchment ultimately drains to the Please Creek Ponds, which supplies stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

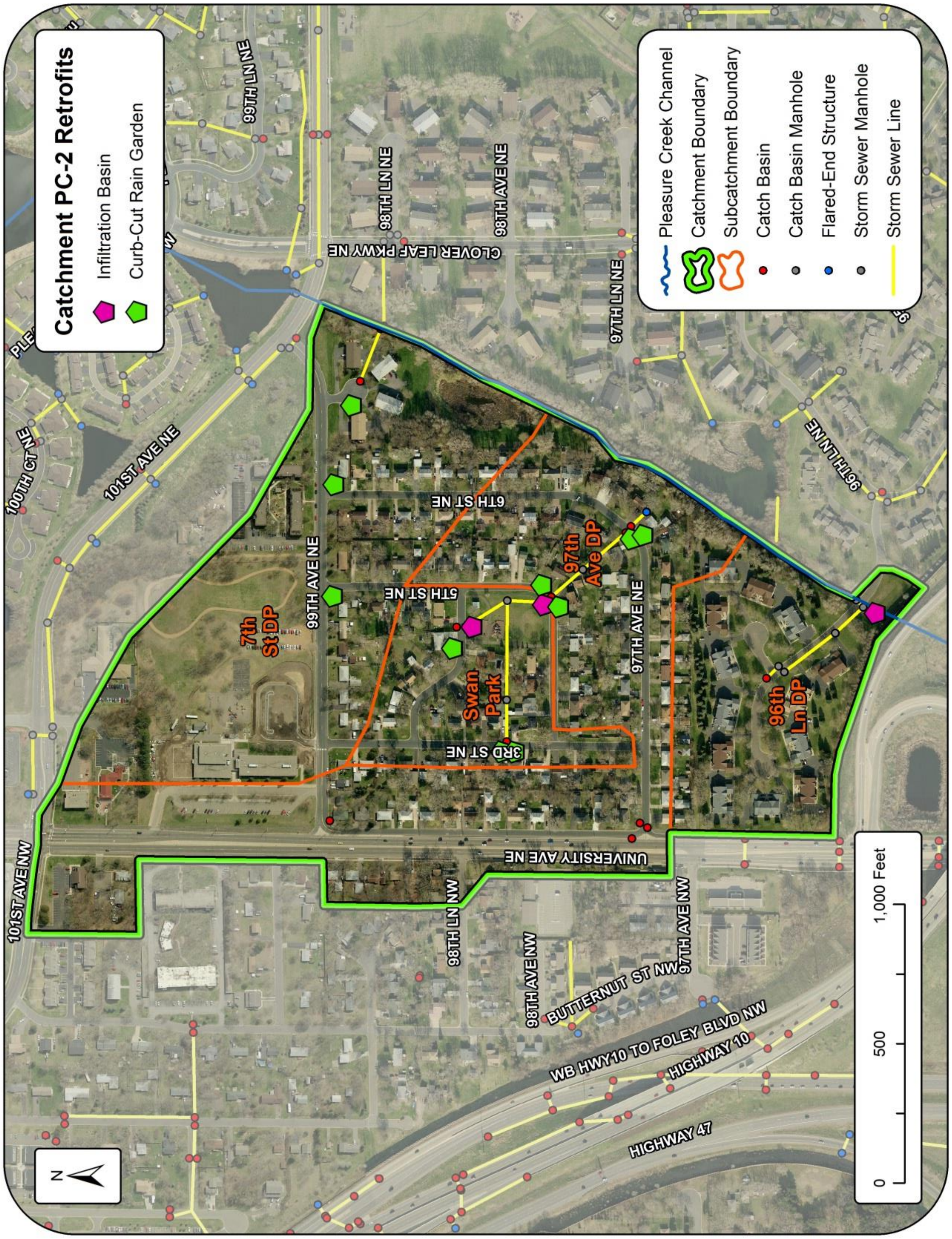
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

RETROFITS CONSIDERED BUT REJECTED

Hydrodynamic devices were studied in this catchment but found to be cost-prohibitive for removing either TSS or TP, likely because TSS and TSS-bound TP are already being retained downstream in the Pleasure Creek Ponds.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

POTENTIAL RETROFITS



Project ID: 2-A

Curb-Cut Rain Gardens
Catchment PC-2

Drainage Area – 94.0 acres
Location – Throughout catchment PC-2
Property Ownership – Private
Site Specific Information – Currently, street cleaning is the only BMP that treats stormwater within the catchment. Rain gardens could be installed within the residential neighborhood south of 99th Ave. NE to treat both TSS and TP. Soils in this subcatchment should be tested prior to installing projects as drained hydric soils do exist in the eastern portion of the catchment near Pleasure Creek; the rain gardens may require underdrains. Considering typical landowner participation rates, scenarios with 3, 6, and 8 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	3		6		8	
	Total Size of BMPs	750	sq-ft	1,500	sq-ft	2,000	sq-ft
	TP (lb/yr)	1.2	0.3%	2.1	0.5%	2.8	0.6%
	TSS (lb/yr)	268	0.3%	497	0.5%	637	0.7%
	Volume (acre-feet/yr)	2.1	0.3%	3.4	0.4%	4.4	0.5%
Cost	Administration & Promotion Costs*	$10,220		$12,848		$14,600	
	Design & Construction Costs**	$22,128		$44,256		$59,008	
	Total Estimated Project Cost (2015)	**$32,348**		**$57,104**		**$73,608**	
	Annual O&M***	$675		$1,350		$1,800	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,461**		**$1,549**		**$1,519**	
	30-yr Average Cost/1,000lb-TSS	**$6,542**		**$6,546**		**$6,678**	
	30-yr Average Cost/ac-ft Vol.	**$835**		**$957**		**$967**	

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

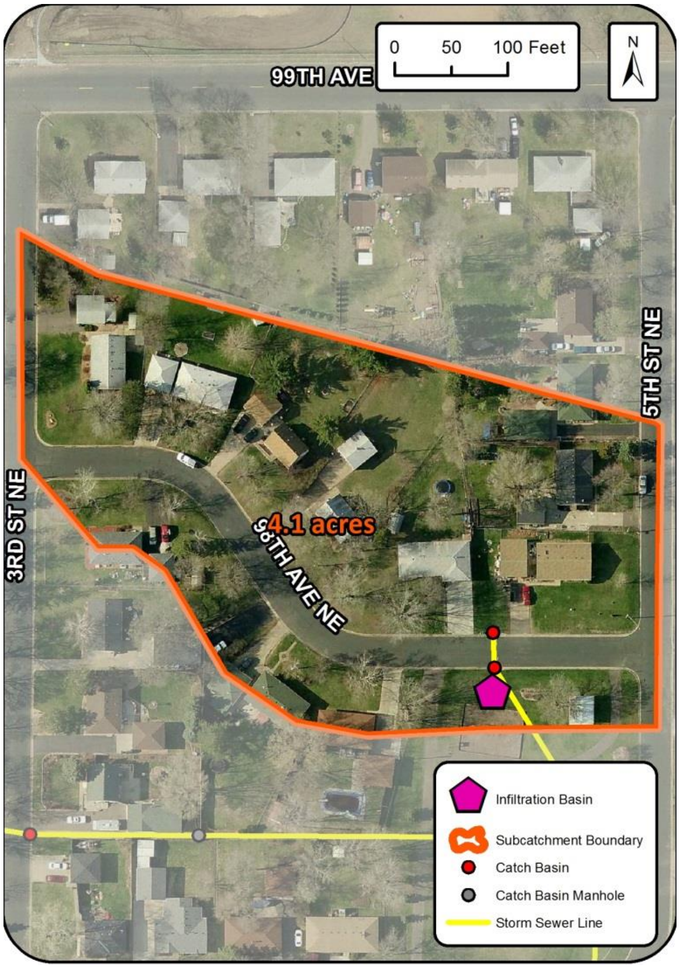
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 2-B

Infiltration Basin
Swan Park Subcatchment (North)

Drainage Area – 4.1 acres (to only the northern site in Swan Park along 98th Ave. NE)
Location – North side of Swan Park along 98th Ave. NE
Property Ownership – Public (City of Blaine)
Site Specific Information – Open public space is available south of 98th Ave. NE to daylight a storm sewer pipe to allow for on-site infiltration of stormwater. A 2,000 sq-ft infiltration basin was proposed based on available space. A more detailed feasibility analysis will be required in order to assess the depth of the pipe and options for daylighting.



Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	2,000	sq-ft
	TP (lb/yr)	1.0	0.2%
	TSS (lb/yr)	233	0.2%
	Volume (acre-feet/yr)	1.4	0.2%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$30,876	
	Total Estimated Project Cost (2015)	**$33,796**	
	Annual O&M***	$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,402**	
	30-yr Average Cost/1,000lb-TSS	**$6,015**	
	30-yr Average Cost/ac-ft Vol.	**$1,001**	

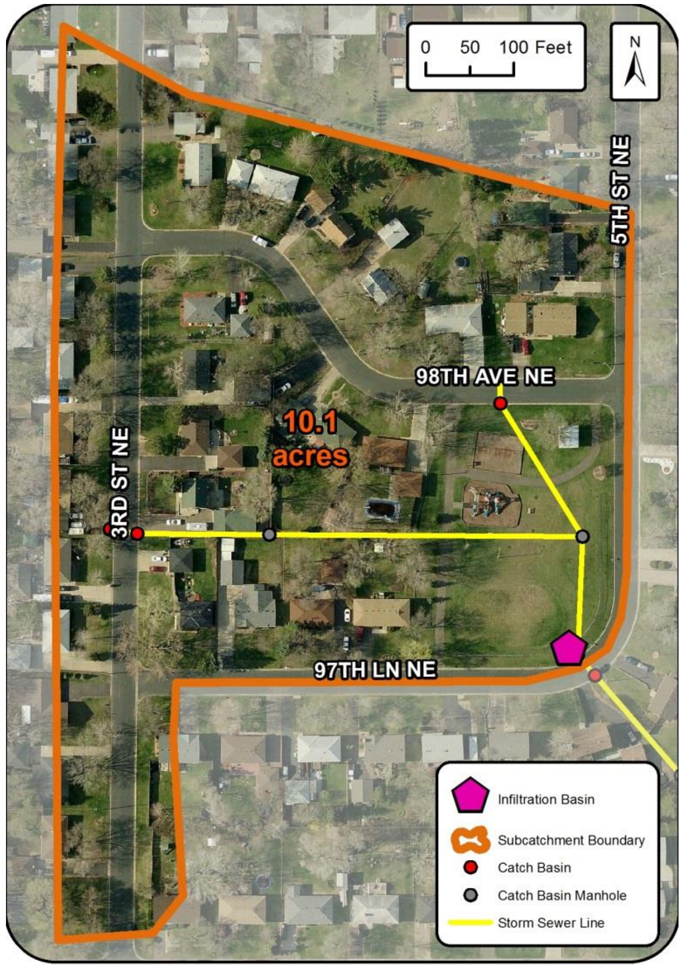
*Indirect Cost: 40 hours at $73/hour

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

***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-C

Infiltration Basin
Swan Park Subcatchment (North+South)



Drainage Area – 10.1 acres
Location – South side of Swan Park along 97th Ln. NE
Property Ownership – Public (City of Blaine)
Site Specific Information – Open public space is available north of 97th Ln. NE to daylight a storm sewer pipe to allow for on-site infiltration of stormwater. A 2,500 sq-ft infiltration basin was proposed based on available space. A more detailed feasibility analysis will be required in order to assess the depth of the pipe and options for daylighting.

	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	2,500	sq-ft
	TP (lb/yr)	2.1	0.5%
	TSS (lb/yr)	477	0.5%
	Volume (acre-feet/yr)	2.8	0.3%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$38,376	
	Total Estimated Project Cost (2014)	**$41,296**	
	Annual O&M***	$275	
Efficiency	**30-yr Average Cost/lb-TP**	**$786**	
	30-yr Average Cost/1,000lb-TSS	**$3,462**	
	30-yr Average Cost/ac-ft Vol.	**$590**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($15/sq-ft for materials and labor) + (12 hours at $73/hour for design)
***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 2-D

Infiltration Basin
96th Lane DP Subcatchment

Drainage Area – 15.1 acres
Location – In open space south of 96th Ln. NE
Property Ownership – Public (MNDOT)
Site Specific Information –A 3,000 sq-ft infiltration basin was proposed to treat multi-family residential runoff draining to 96th Ln. NE. The existing storm sewer pipe would be disconnected and discharged into open space between 96th Ln. NE and the Highway 10 corridor.

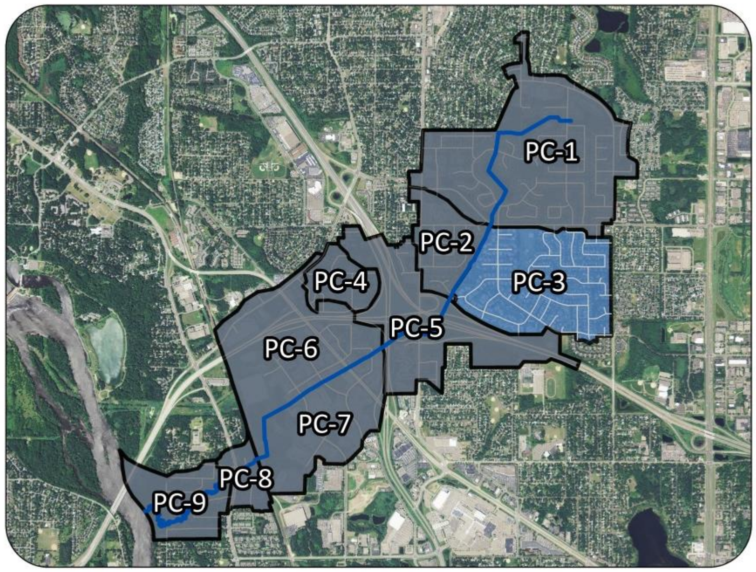
Due to the hydric soils in the vicinity of this site, the basin was modeled with a ponding depth of only 6”. Ponding depth should be determined based on soil tests at the site to ensure a maximum ponding time of no longer than 48 hours.

	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	3,000	sq-ft
	TP (lb/yr)	2.5	0.6%
	TSS (lb/yr)	633	0.7%
	Volume (acre-feet/yr)	4.6	0.6%
Cost	**Administration & Promotion Costs***		$2,920
	Design & Construction Costs**		$45,876
	Total Estimated Project Cost (2015)		**$48,796**
	Annual O&M***		$275
Efficiency	**30-yr Average Cost/lb-TP**	**$761**	
	30-yr Average Cost/1,000lb-TSS	**$3,004**	
	30-yr Average Cost/ac-ft Vol.	**$413**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($15/sq-ft for materials and labor) + (12 hours at $73/hour for design)
***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Catchment PC-3

Existing Catchment Summary	
Acres	262.1
Dominant Land Cover	Residential
Parcels	995



CATCHMENT DESCRIPTION

Catchment PC-3 consists of single family residential lots in the eastern portion of the subcatchment with multi-family units in the western and southern portions and along 99th Ave. NE and Clover Leaf Parkway NE. There are two parks in the subcatchment, Cloverleaf and Van Buren. The catchment is bounded by Tyler St. NE to the east and Pleasure Creek to the west.

EXISTING STORMWATER TREATMENT

Runoff generated within this catchment is directed into one of three stormwater sewer lines. The first drains the eastern and southern portions of the catchment and outlets into a stormwater pond along Pleasure Creek, Pond 304. Overflow from this pond outlets directly into the creek and is one of two Pleasure Creek discharge points within the catchment. The second stormwater line drains the northeastern portion of the catchment and outlets into Cloverleaf Park, where it follows over 1,000 feet of ditching and outlets into the first line (and subsequently Pond 304). The third sewer line accepts roadway and residential runoff along Cloverleaf Parkway NE and 98th Ln. NE and is the second discharge point into the creek within the catchment.

Lastly, street cleaning is performed catchment-wide at least twice annually by the City of Blaine.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments ultimately drains to the Please Creek Ponds, which supply stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

PROPOSED RETROFITS OVERVIEW

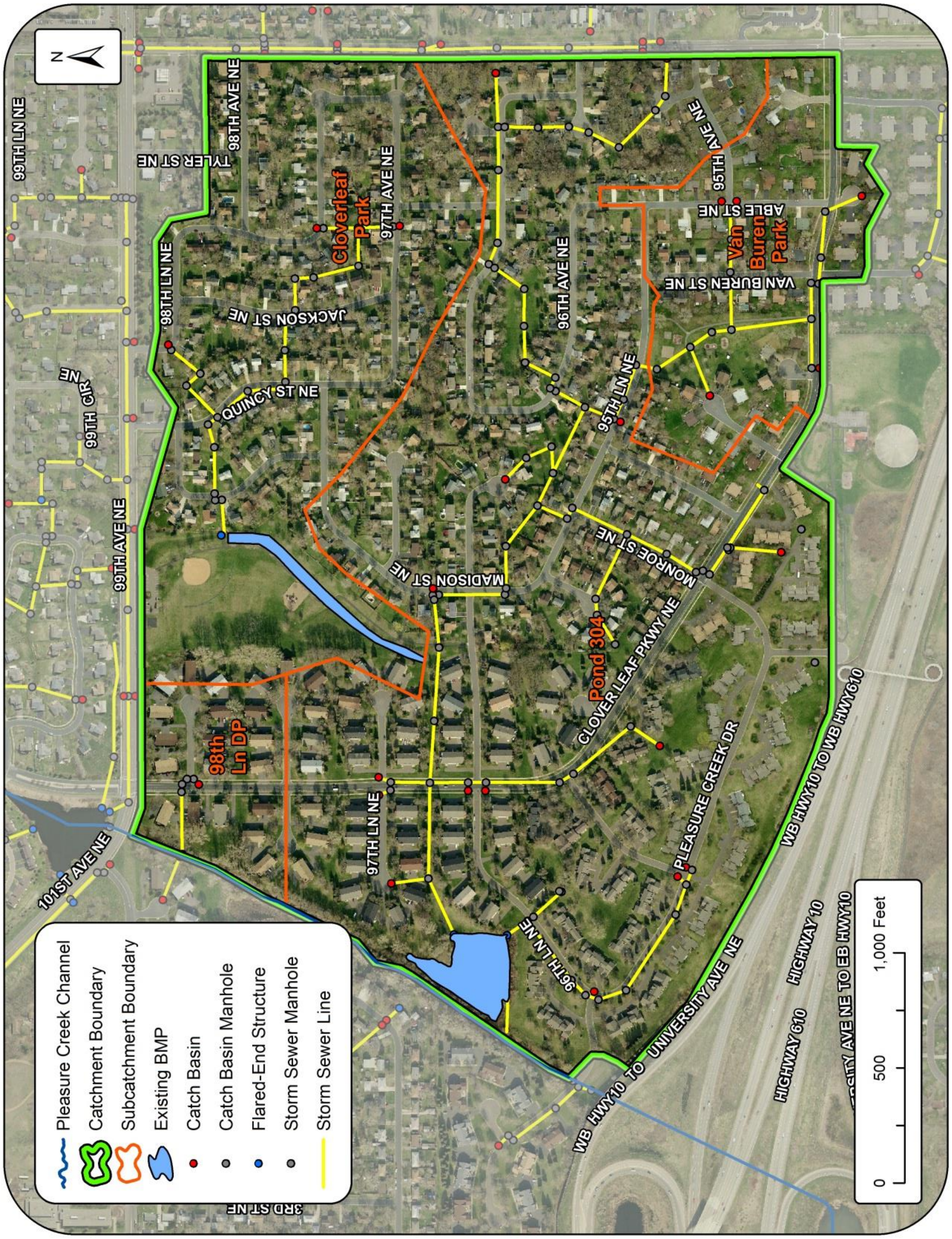
Infiltration and filtration practices were the focus of retrofits in this catchment and were proposed to augment the removal of TSS, as well as increase the removal of dissolved species. Up to 25 rain gardens were proposed throughout the single family and multi-family residential lots. Three infiltration basins were proposed in city parks, two in Van Buren Park and one in Cloverleaf Park. Lastly retrofits to Pond 304 along Pleasure Creek were proposed to increase functionality of the pond, including an IESF bench and an increase in pond volume.

PROPOSED RETROFITS CONSIDERED BUT REJECTED

Five hydrodynamic device locations were analyzed throughout catchment PC-3 to relieve Pond 304 and the Pleasure Creek Ponds by retaining upstream TSS and TP. Model results found none of the devices removed more than 20 lbs-TSS/year or 0.2 lbs-TP/year above what the ponds were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive.

Installation of a new pond in Cloverleaf Park was explored but was not included as a proposed retrofit due to (1) the number of in-line ponds downstream of this location and (2) the possibility for additional ponding along the swale on the eastern side of the property (proposed in Project 3-D). In addition, the footprint of the new pond would have limited the green space available in this park.

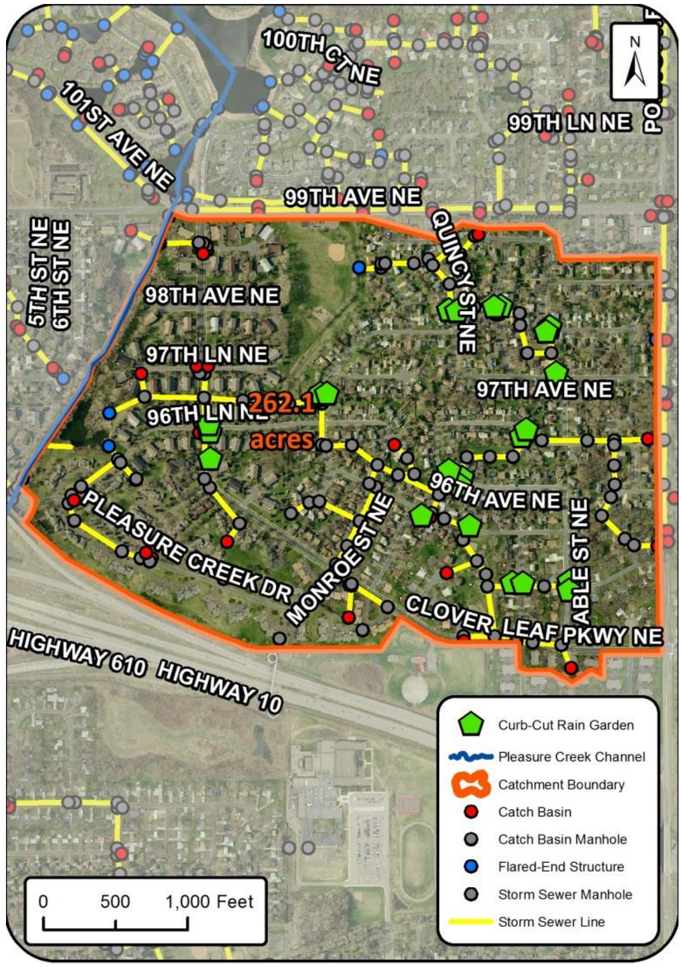
CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS

Project ID: 3-A

Curb-Cut Rain Gardens
Catchment PC-3



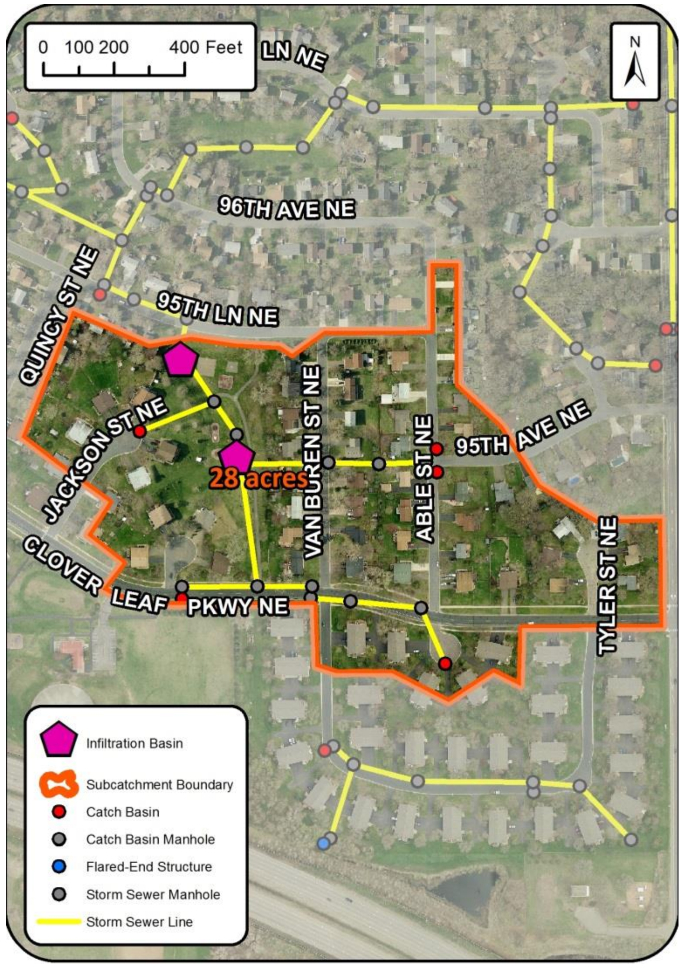
Drainage Area – 262.1 acres
Location – Throughout catchment PC-3
Property Ownership – Private
Site Specific Information – Stormwater runoff generated within the catchment is already treated by the stormwater retention pond 304. Rain gardens could be installed within the residential neighborhood east of the pond to better treat dissolved species of phosphorus, which stormwater ponds are much less able to treat (compared to phosphorus bound to sediment). Up to 25 optimal sites were found through desktop analysis. Considering typical landowner participation rates, scenarios with 10, 15, and 20 rain gardens were analyzed to treat the drainage area. Note that some proposed garden sites are located near or within wellhead protection areas. Infiltration on the sites should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007; *Appendix C*).

	Curb-Cut Rain Garden						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	10		15		20	
	Total Size of BMPs	2,500	sq-ft	3,750	sq-ft	5,000	sq-ft
	TP (lb/yr)	2.9	0.7%	4.0	0.9%	5.2	1.2%
	TSS (lb/yr)	657	0.7%	913	0.9%	1,228	1.3%
	Volume (acre-feet/yr)	4.8	0.6%	6.4	0.8%	8.5	1.1%
Cost	Administration & Promotion Costs*	$16,352		$20,732		$25,112	
	Design & Construction Costs**	$73,760		$110,640		$147,520	
	Total Estimated Project Cost (2015)	**$90,112**		**$131,372**		**$172,632**	
	Annual O&M***	$2,250		$3,375		$4,500	
Efficiency	30-yr Average Cost/lb-TP	**$1,812**		**$1,939**		**$1,972**	
	30-yr Average Cost/1,000lb-TSS	**$7,997**		**$8,493**		**$8,350**	
	30-yr Average Cost/ac-ft Vol.	**$1,095**		**$1,212**		**$1,206**	

*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-B

Infiltration Basin (South Option, 18.8 acres) Van Buren Park Subcatchment



Drainage Area – 18.8 acres (excluding northern portion of park)
Location – Van Buren Park
Property Ownership – Public (City of Blaine)
Site Specific Information – Open space is available within Van Buren Park for the installation of an infiltration basin. A storm sewer line running the length of the park could be daylighted to provide treatment of TSS and TP. To maximize treatment, the practice should be sited such that the storm sewer line treating Van Buren St. NE and Able St. NE can also input into the practice (southern purple icon in map). Pollutant reduction values in the table below assume a ponding depth of 6" as local native soils are predominantly hydric. This proposed site is also within a City of Blaine wellhead protection area. Infiltration on this site should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007; *Appendix C*).

	Infiltration Basin				
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1		1	
	Total Size of BMPs	3,000	sq-ft	6,000	sq-ft
	TP (lb/yr)	1.1	0.3%	2.0	0.5%
	TSS (lb/yr)	243	0.3%	485	0.5%
	Volume (acre-feet/yr)	1.8	0.2%	3.4	0.4%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$45,876		$90,876	
	Total Estimated Project Cost (2014)	**$48,796**		**$93,796**	
	Annual O&M***	$275		$275	
Efficiency	30-yr Average Cost/lb-TP	**$1,729**		**$1,701**	
	30-yr Average Cost/1,000lb-TSS	**$7,825**		**$7,013**	
	30-yr Average Cost/ac-ft Vol.	**$1,056**		**$1,000**	

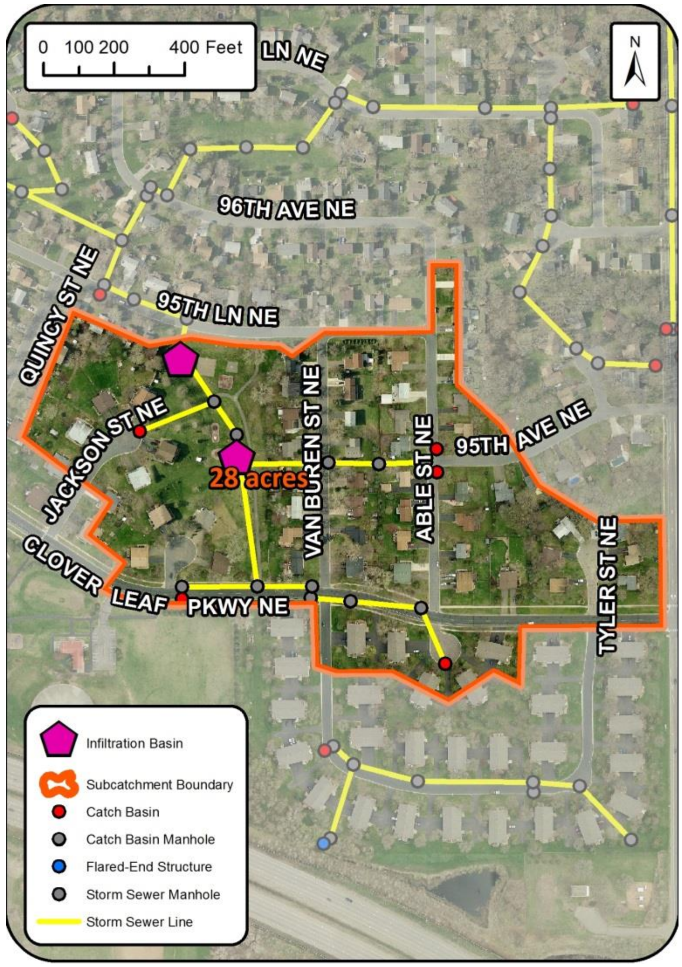
*Indirect Cost: 40 hours at $73/hour

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

***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 3-C

Infiltration Basin (North Option, 28 acres) Van Buren Park Subcatchment



Drainage Area – 28.0 acres
Location – Van Buren Park
Property Ownership – Public (City of Blaine)
Site Specific Information – Open space is available within Van Buren Park for the installation of an infiltration basin. A storm sewer line running the length of the park could be daylighted to provide treatment of TSS and TP. To maximize treatment, the practice should be sited such that the storm sewer line treating Jackson St. can also input into the practice. Pollutant reduction values in the table below assume a ponding depth of 6” as local native soils are predominantly hydric. This proposed site is also within a City of Blaine wellhead protection area. Infiltration on this site should be evaluated using the procedure established by the Minnesota Department of Health (MDH, 2007; *Appendix C*).

	Infiltration Basin				
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		1	
	Total Size of BMPs	3,000	sq-ft	6,000	sq-ft
	TP (lb/yr)	1.1	0.3%	2.1	0.5%
	TSS (lb/yr)	243	0.3%	498	0.5%
	Volume (acre-feet/yr)	1.8	0.2%	3.7	0.5%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$45,876		$90,876	
	Total Estimated Project Cost (2015)	**$48,796**		**$93,796**	
	Annual O&M***	$275		$275	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,729**		**$1,620**	
	30-yr Average Cost/1,000lb-TSS	**$7,825**		**$6,830**	
	30-yr Average Cost/ac-ft Vol.	**$1,056**		**$919**	

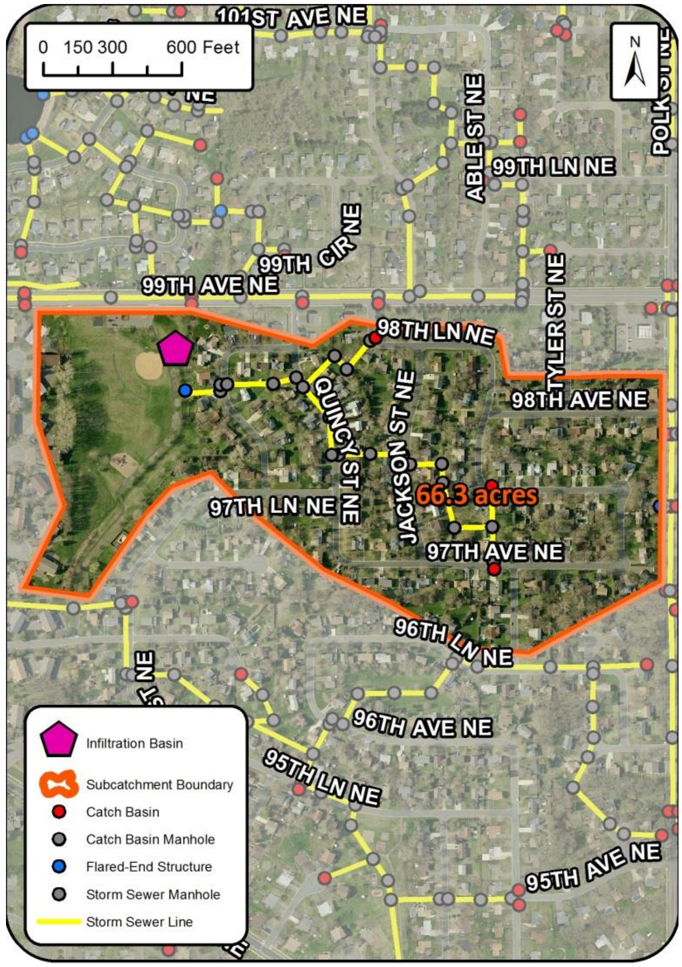
*Indirect Cost: 40 hours at $73/hour

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

***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 3-D

Infiltration Basin
Cloverleaf Park Subcatchment



Drainage Area – 66.3 acres
Location – Northeastern corner of Cloverleaf Park
Property Ownership – Public (City of Blaine)
Site Specific Information – Currently some storage is available in a depression south of 99th Ave. NE for stormwater discharging from the 36” storm sewer pipe into Cloverleaf Park, although most stormwater is diverted to the south and never enters the depression. An expansion of this storage is proposed which will also include a direct input from the 36” pipe. Native soil infiltration rates should be tested prior to installation to establish a basin ponding depth which ensures dry out within 48 hours. Two distinct basin sizes were modeled, each with only a 6” ponding depth due to native hydric soils throughout the park property. Details are provided on the following page.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		1	
	Total Size of BMPs	10,000	sq-ft	20,000	sq-ft
	TP (lb/yr)	0.5	0.1%	1.5	0.3%
	TSS (lb/yr)	99	0.1%	321	0.3%
	Volume (acre-feet/yr)	0.7	0.1%	2.1	0.3%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$100,876		$200,876	
	Total Estimated Project Cost (2015)	**$103,796**		**$203,796**	
	Annual O&M***	$275		$275	
Efficiency	30-yr Average Cost/lb-TP	**$7,470**		**$4,712**	
	30-yr Average Cost/1,000lb-TSS	**$37,726**		**$22,019**	
	30-yr Average Cost/ac-ft Vol.	**$5,336**		**$3,366**	

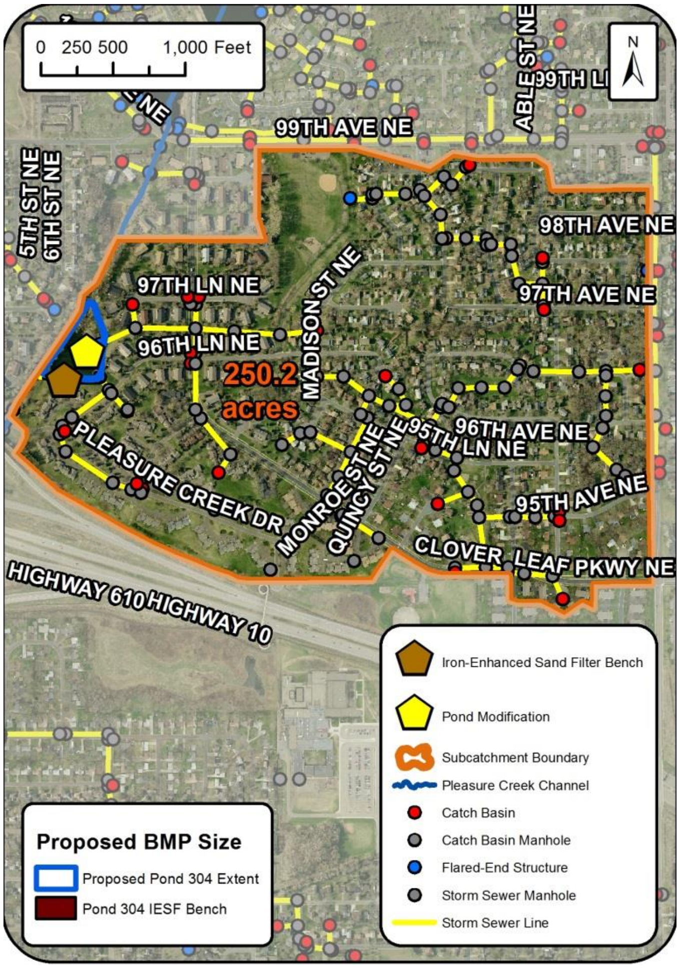
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($10/sq-ft for materials and labor) + (12 hours at $73/hour for design)

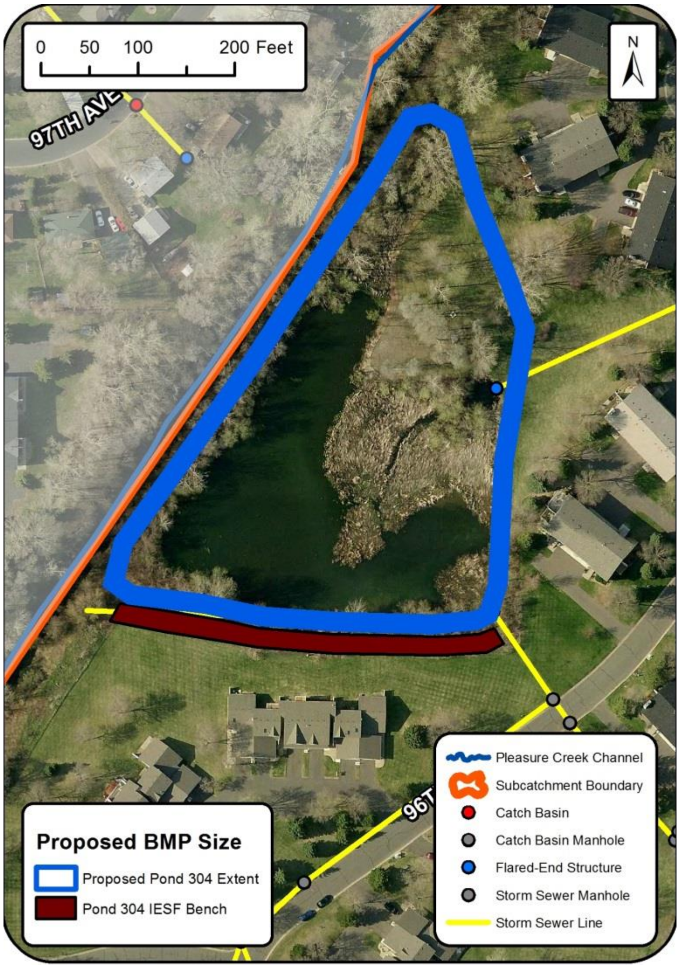
***($200/year for rehabilitations at years 10 and 20) + ($75/year for routine maintenance)

Project ID: 3-E

Pond Modification
Pond 304 Subcatchment



Drainage Area – 250.2 acres
Location – Pond 304
Property Ownership – Private
Site Specific Information – The existing pond receiving drainage from most of catchment PC-3 is currently undersized to treat the contributing drainage area (MPCA, 2014). An expansion and dredging of the pond is recommended to increase the permanent pool storage, thereby promoting sediment settling and phosphorus retention. Proposed increases in pond storage will increase permanent pool surface area from 1.5 acres to 3.3 acres and average ponding depth from 2.6 ft. to 6 ft. The table on the following page gives pollutant reduction and cost estimates based on pond Management Level for the pond maintenance only (i.e. excluding the IESF bench). Please see the *BMP Descriptions* section titled *Pond Maintenance and Modifications* for additional information on this practice.



Pond Maintenance

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Pond Management Level	1		2		3	
	Amount of Soil Excavated	23,500	cu-yards	23,500	cu-yards	23,500	cu-yards
	TP (lb/yr)	4.9	1.1%	4.9	1.1%	4.9	1.1%
	TSS (lb/yr)	1,531	1.6%	1,531	1.6%	1,531	1.6%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$5,840		$5,840		$5,840	
	Design & Construction Costs**	$650,000		$1,002,500		$1,355,000	
	Total Estimated Project Cost (2015)	**$655,840**		**$1,008,340**		**$1,360,840**	
	Annual O&M***	$450		$450		$450	
Efficiency	30-yr Average Cost/lb-TP	**$4,553**		**$6,951**		**$9,349**	
	30-yr Average Cost/1,000lb-TSS	**$14,573**		**$22,248**		**$29,922**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

*Indirect Cost: 80 hours at $73/hour

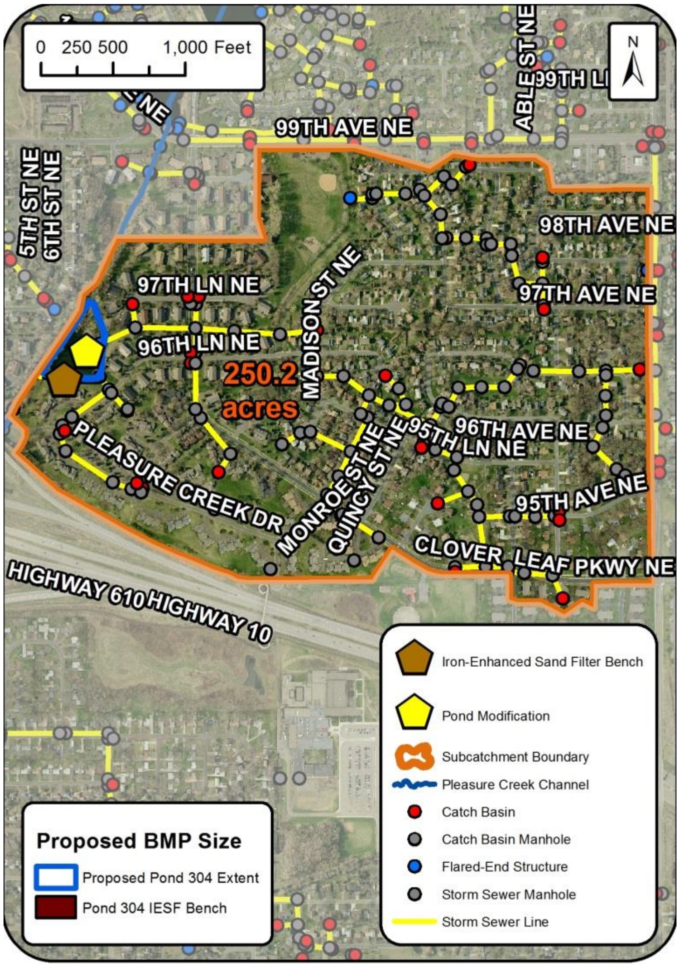
**Direct Cost: See Appendix B for detailed cost information

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

Project ID: 3-F

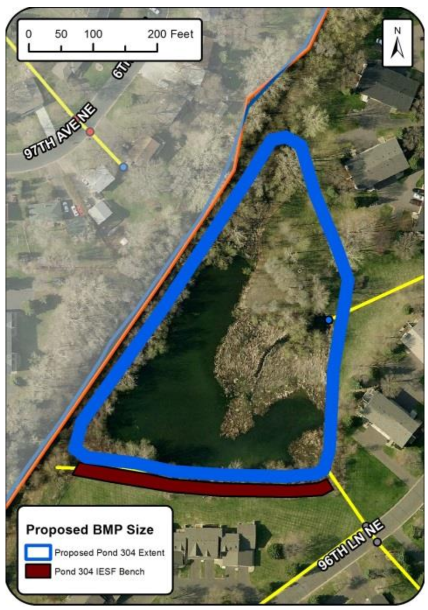
IESF Bench
Pond 304 Subcatchment

Drainage Area –250.2 acres
Location – Along southern shore of Pond 304
Property Ownership – Private
Site Specific Information – A pond modification is proposed in Project 3-E to increase storage in Pond 304. To help retain additional dissolved phosphorus, which is less effectively treated within most pond systems, an IESF bench is also proposed. The IESF was sized based on the space available, and will tie into the existing storm sewer outlet directly into Pleasure Creek. Pollutant reduction values in the table below assume pond storage is increased as proposed in Project 3-E.



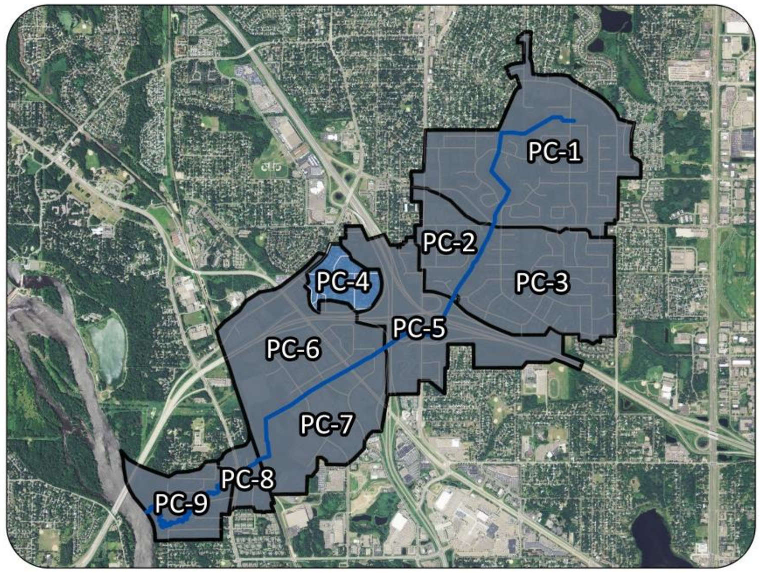
	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	Number of BMPs	1	
	Total Size of BMPs	8,000	sq-ft
	TP (lb/yr)	13.7	3.1%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$3,650	
	Design & Construction Costs**	$255,400	
	Total Estimated Project Cost (2015)	**$259,050**	
	Annual O&M***	$1,837	
Efficiency	30-yr Average Cost/lb-TP	**$764**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 50 hours at $73/hour
**Direct Cost: See Appendix B for detailed cost information
***$10,000/acre for IESF



Catchment PC-4

Existing Catchment Summary	
Acres	59.6
Dominant Land Cover	Residential
Parcels	149



CATCHMENT DESCRIPTION

Catchment PC-4 lies completely within the City of Coon Rapids and is a mix of single family and multi-family residential lots. The catchment is bounded by Mason Park and 95th Lane to the south and southwest, Foley Blvd to the northwest, 98th Lane to the north, and the Highway 610 corridor to the east.

EXISTING STORMWATER TREATMENT

All stormwater runoff within this catchment drains to either (1) a stormwater pond in the northwestern corner of Mason Park or (2) into natural depressions and ditches in the undeveloped area within the catchment. The Mason Park stormwater pond drains to the south, discharging into Pleasure Creek upstream of the Pleasure Creek Ponds.

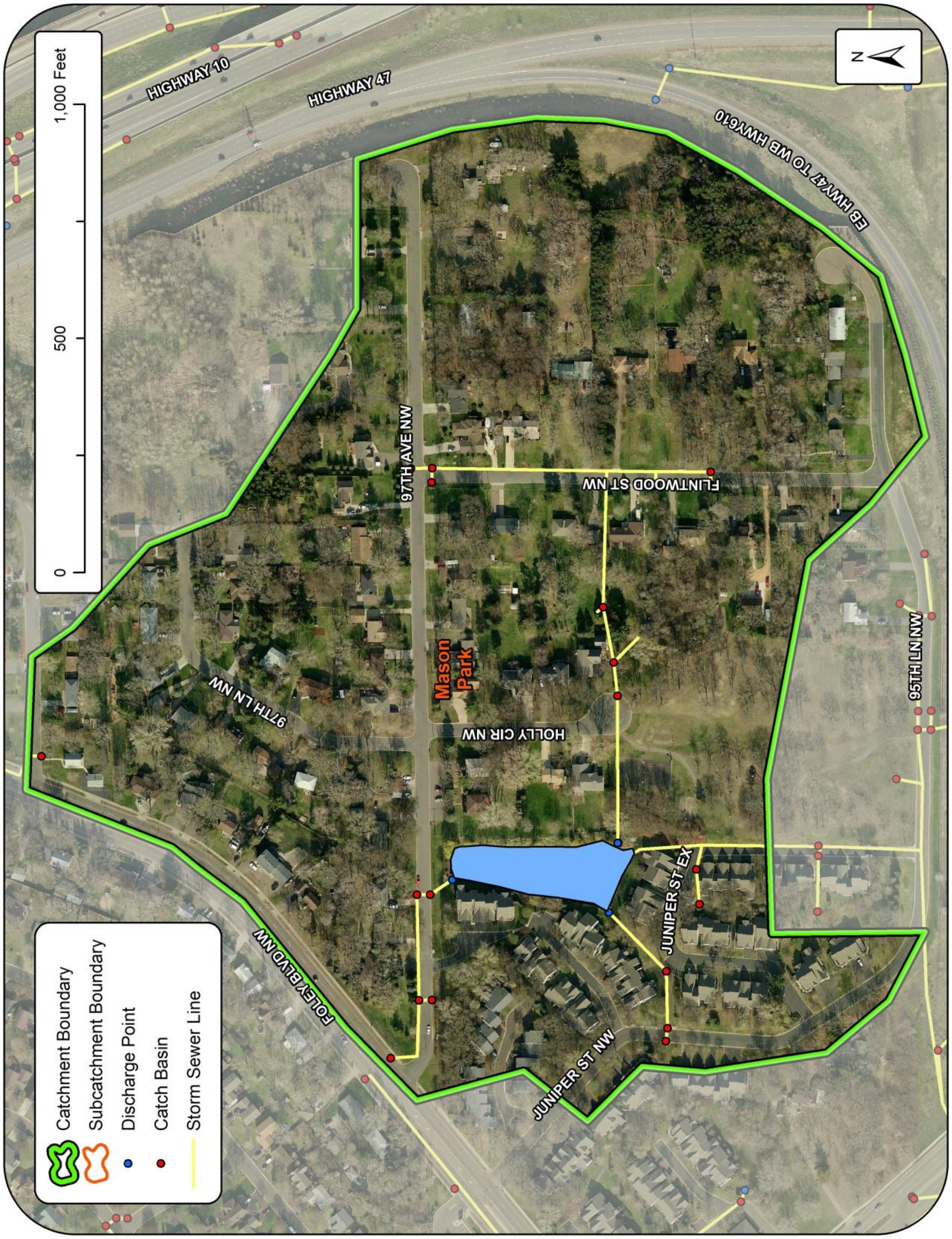
Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments ultimately discharges to the Please Creek Ponds, which provide stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

PROPOSED RETROFITS CONSIDERED BUT REJECTED

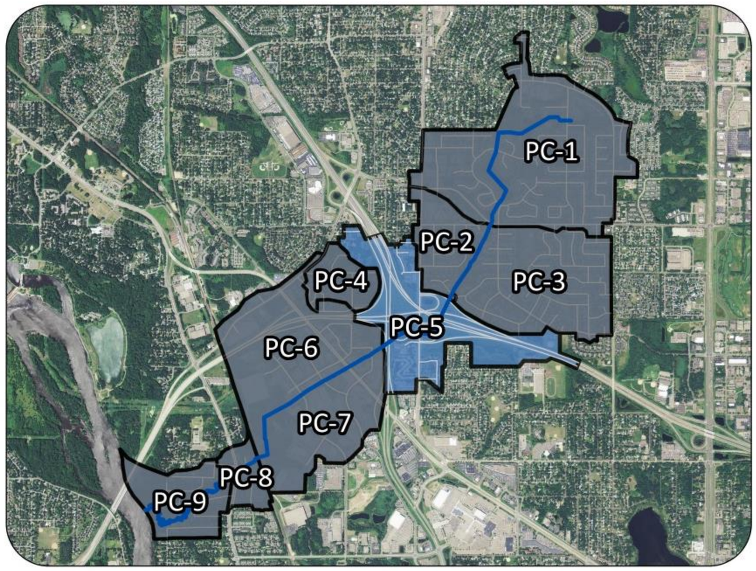
No retrofits were proposed for this catchment. The catchment is less impervious (36.5% of land area) than much of the surrounding subwatershed. In addition, the stormwater pond in Mason Park is well-sized for its drainage area at 1.3% of catchment area and more than 1,800 ft^3 of storage per acre of runoff (MPCA, 2014).

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



Catchment PC-5

Existing Catchment Summary	
Acres	248.6
Dominant Land Cover	Freeway
Parcels	216



CATCHMENT DESCRIPTION
Catchment PC-5 spans the Highway 10/610 corridor, along with two residential neighborhoods flanking University Ave. NE north and south of Highway 10. Both residential neighborhoods have multi-family units and single family residential homes. Pleasure Creek bisects the catchment, running from north to south through a 48" storm sewer line and into the Minnesota Department of Transportation (DOT) ponds 3 and 4, before discharging out of DOT pond 3 into the creek channel west of Highway 47.

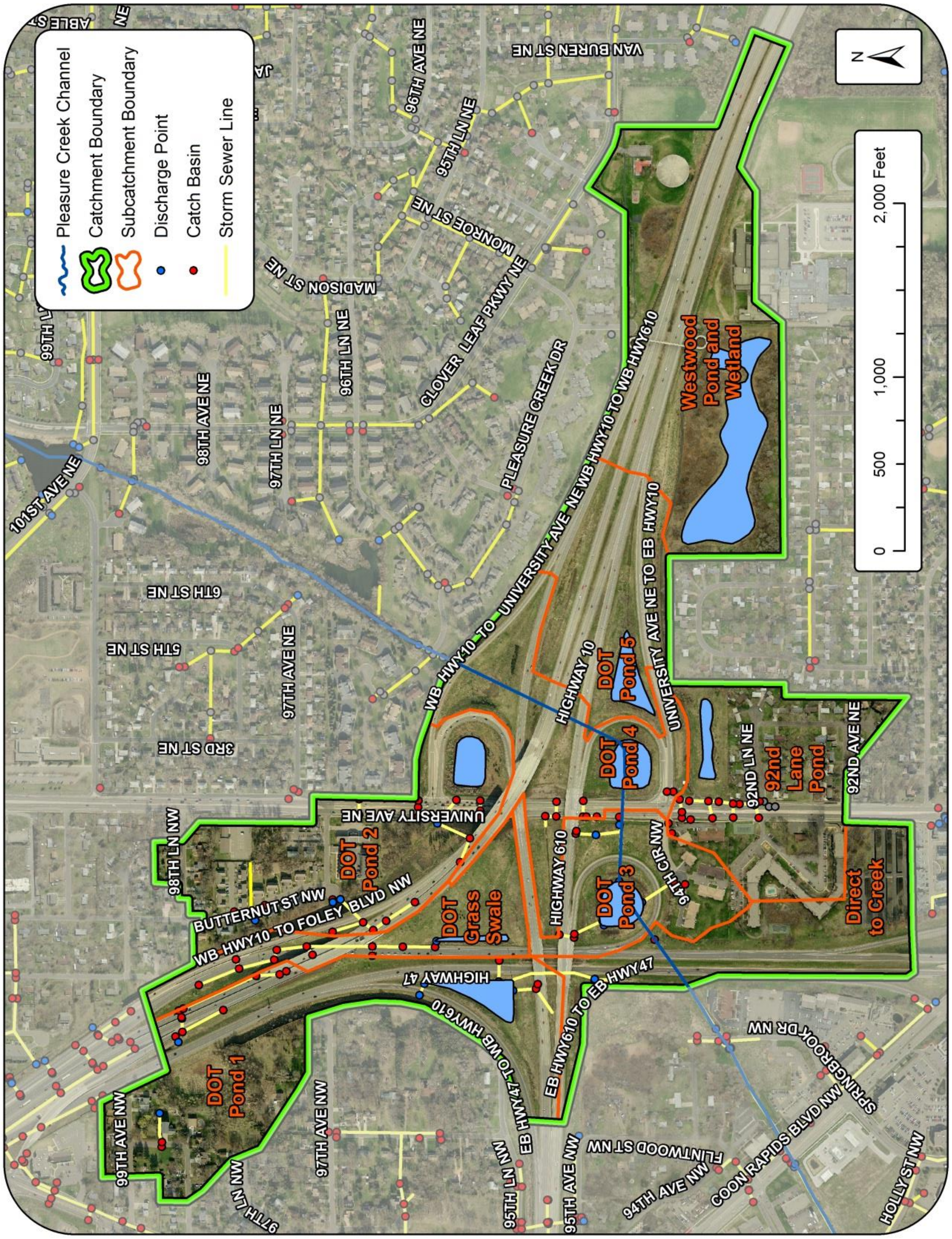
EXISTING STORMWATER TREATMENT
Stormwater runoff generated within this catchment is well treated, with six stormwater ponds, a wetland, and a grass swale treating interstate runoff and a seventh pond treating runoff from the residential neighborhood.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments ultimately discharges to the Please Creek Ponds, which supply stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

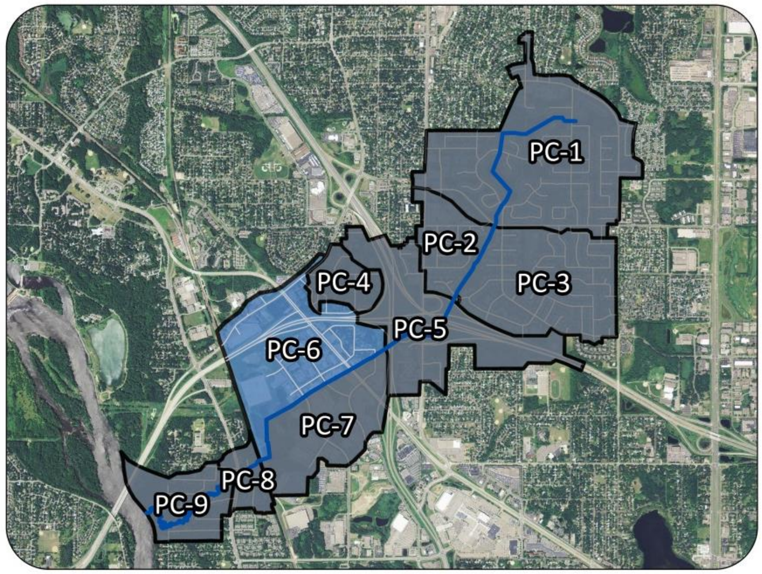
PROPOSED RETROFITS CONSIDERED BUT REJECTED
Due to the well-sized stormwater ponds and the large pervious space throughout the Highway 10/610 corridor, no retrofits were proposed within this catchment. Even throughout the residential neighborhoods with curb and gutter, most stormwater is provided with some treatment prior to discharging into the creek.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



Catchment PC-6

Existing Catchment Summary	
Acres	260.5
Dominant Land Cover	Commercial
Parcels	177



CATCHMENT DESCRIPTION

Catchment PC-6 is the most diverse of the catchments examined in this analysis in terms of land use, which range from multi-family and single family residential lots in the east, to commercial properties along Coon Rapids Blvd. NW, the Highway 610 corridor and a park-and-ride in the north, and industrial and undeveloped lots in the south and west. Pleasure Creek runs along the southeastern boundary of the catchment.

EXISTING STORMWATER TREATMENT

Currently, three ponds in this catchment treat stormwater runoff. One of these, located on the InTown Suites property, has a relatively small contributing drainage area and provides limited catchment-wide treatment. The second and third ponds, the Pleasure Creek Ponds, are in-line with the creek and treat all upstream drainage in the subwatershed, including all of PC-6 and PC-7. These two ponds are separated by an earthen berm; three, in parallel, culverts connect the two ponds during large precipitation events.

Lastly, street cleaning is performed catchment-wide by the City of Coon Rapids at least three times annually.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments ultimately discharges to the Please Creek Ponds, which supply stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

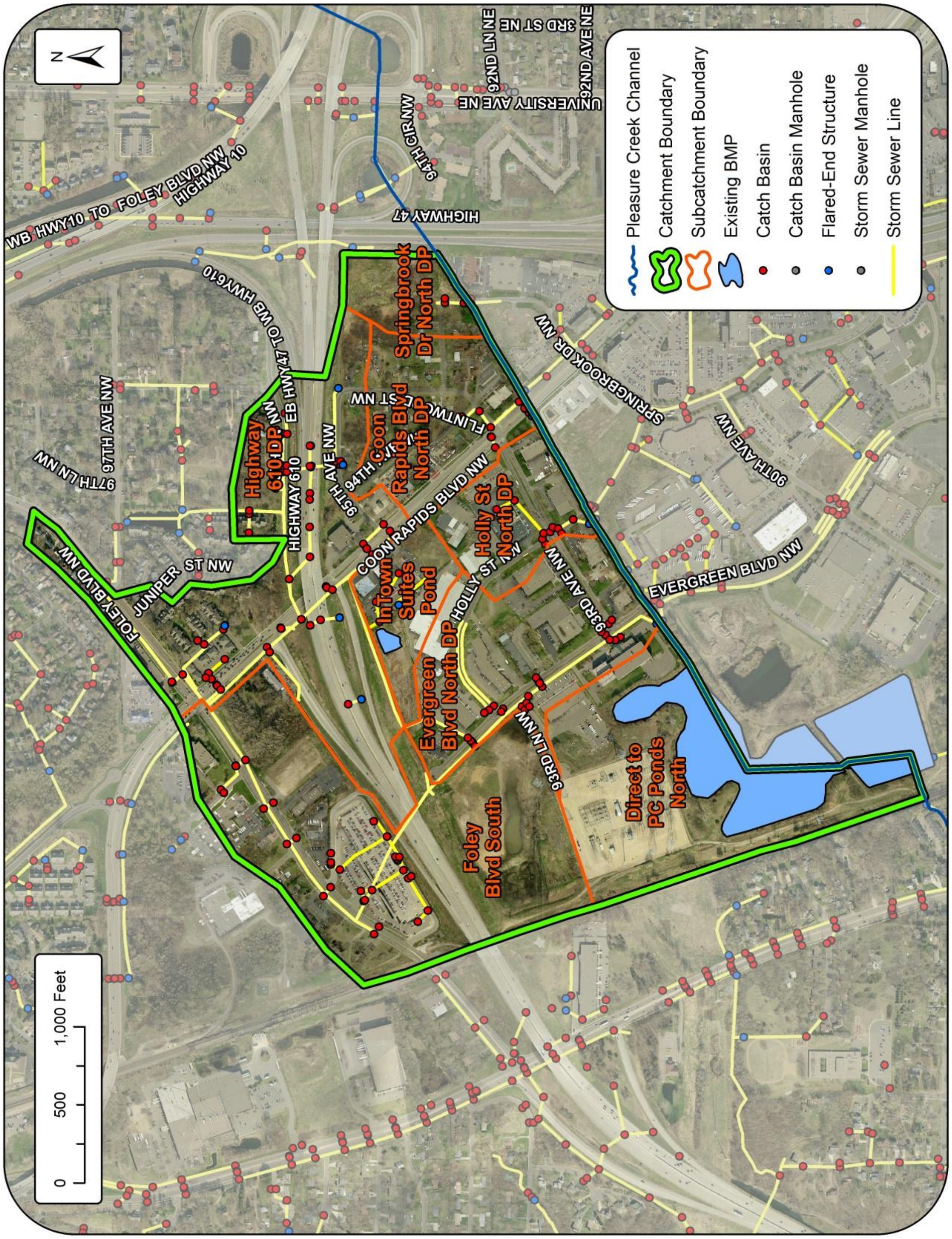
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

PROPOSED RETROFITS OVERVIEW
Two projects were proposed in the catchment, including a new pond built along Evergreen Blvd. NW south of Highway 610 and a pair of IESF benches along the Pleasure Creek Ponds.

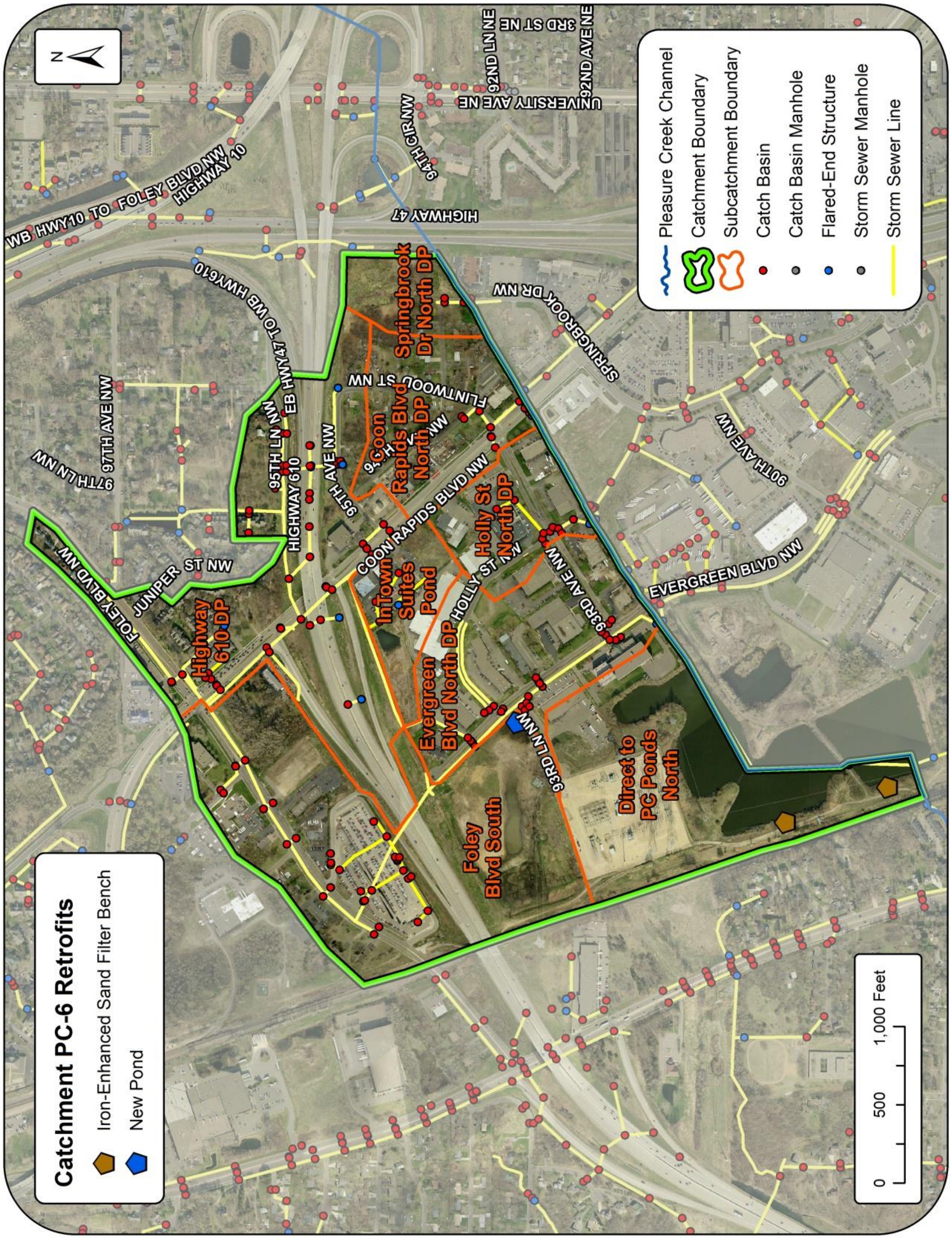
PROPOSED RETROFITS CONSIDERED BUT REJECTED
Hydrodynamic devices were explored at multiple locations throughout the catchment to help retain upstream TSS and TP prior to discharge into the Pleasure Creek Ponds. Model results within the catchment found none of the devices removed more than 10 lbs-TSS/year or 0.1 lbs-TP/year above what the ponds were already treating. Considering their cost, such little pollutant retention made these devices cost-prohibitive.

No retrofits were proposed in the residential neighborhood north of Coon Rapids Blvd. Each lot is relatively low density, with less impervious surface than most properties throughout the catchment. Roadways lack curb and gutter, which promotes infiltration prior to stormwater reaching catch basins. In addition, any stormwater that does reach catch basins (and subsequently Pleasure Creek) is treated by the Pleasure Creek Ponds downstream.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 6-A

New Pond

Foley Blvd DP Subcatchment

Drainage Area – 66.6 acres

Location – On undeveloped property on the northwestern corner of the Evergreen Blvd. NW and 93rd Ln. NW intersection

Property Ownership – Public (Anoka County Regional Railroad Authority)

Site Specific Information –A new pond is proposed to supplement treatment provided by the Pleasure Creek Ponds downstream. The pond was sized to treat upstream drainage per MPCA sizing requirement for TSS and TP (MPCA, 2014). The potential extent of the pond is shown on the map to the right. At normal water level, the pond would cover 1.3 acres and detain 5.3 ac-ft of water volume.

	New Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	1.3	acres
	TP (lb/yr)	2.0	0.5%
	TSS (lb/yr)	755	0.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$3,650	
	Design & Construction Costs**	$262,000	
	Total Estimated Project Cost (2015)	**$265,650**	
	Annual O&M***	$1,300	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,078**	
	30-yr Average Cost/1,000lb-TSS	**$13,450**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 50 hours at $73/hour

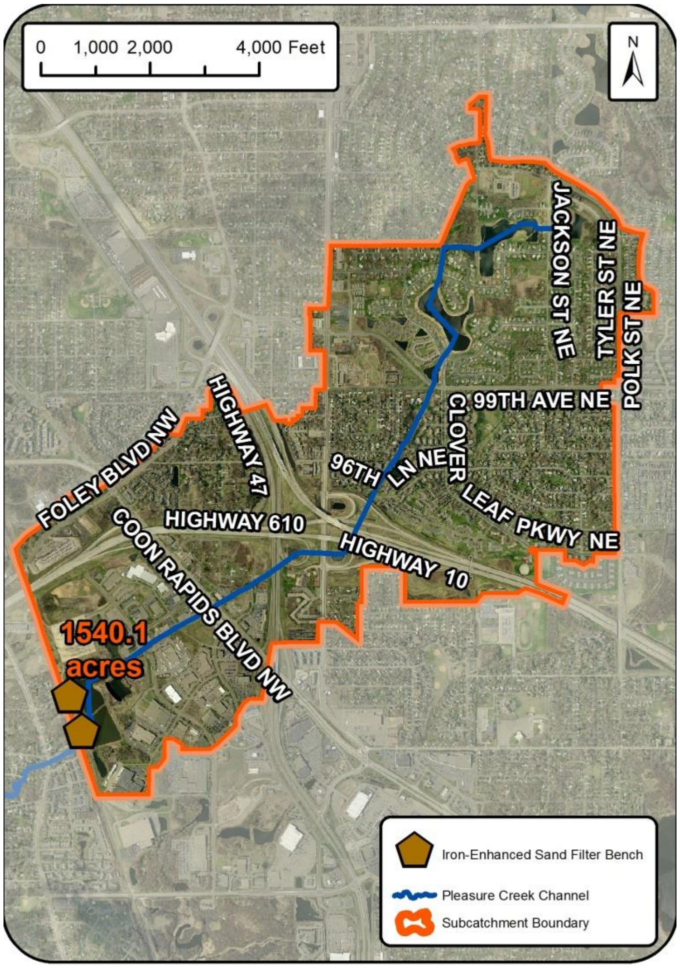
**Direct Cost: See Appendix B for detailed cost information

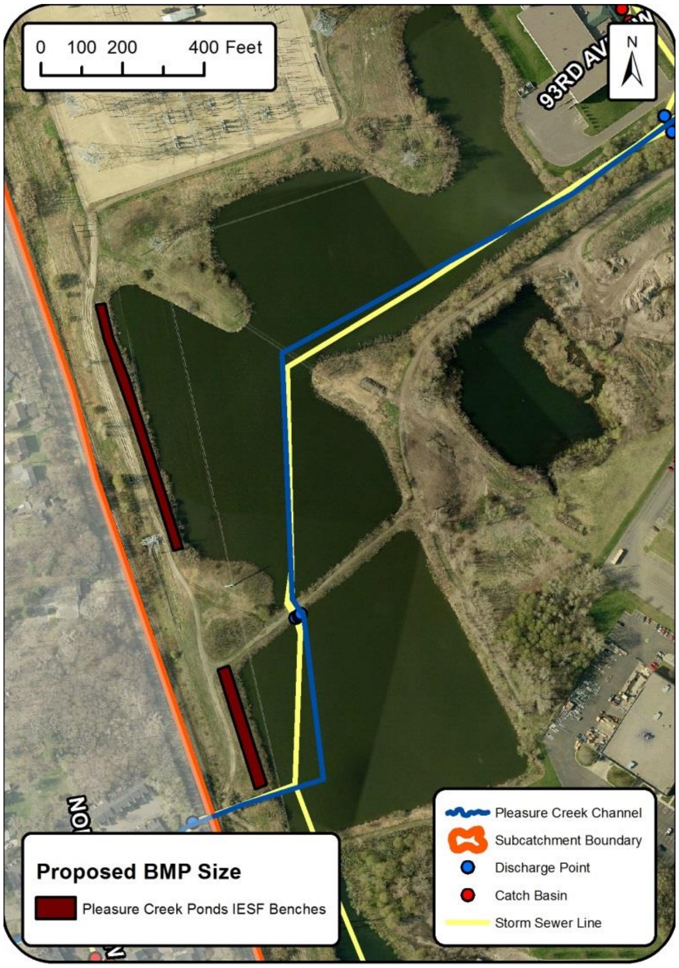
***$1,000/acre - Annual inspection and sediment/debris removal from pretreatment area

Project ID: 6-B

IESF Bench
Catchments PC-6-PC7

Drainage Area – 1,540.1 acres (including all upstream subcatchments)
Location – Along western shores of both Pleasure Creek Ponds
Property Ownership – Public (MNDOT)
Site Specific Information – Pleasure Creek Ponds provide treatment through settling and retention to TSS and TSS-bound TP for all upstream drainage. Dissolved phosphorus, though, can more easily travel through the pond system untreated. IESF benches are proposed along the western shore of both in-line Pleasure Creek Ponds. Pollutant reduction values listed in the table below are for (1) a single bench only along the northern pond, (2) a single bench only along the southern pond, and (3) two benches, one along each pond.





	IESF Bench						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Adjacent Pond(s)**	North PC Pond		South PC Pond		Both PC Ponds	
	Total Size of BMPs	14,500	sq-ft	9,000	sq-ft	23,500	sq-ft
	TP (lb/yr)	43.0	9.8%	28.3	6.4%	71.3	16.2%
	TSS (lb/yr)	0	0.0%	0	0.0%	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475		$5,475		$5,475	
	Design & Construction Costs**	$442,500		$316,320		$723,900	
	Total Estimated Project Cost (2015)	**$447,975**		**$321,795**		**$729,375**	
	Annual O&M***	$3,329		$2,066		$5,395	
Efficiency	**30-yr Average Cost/lb-TP**	**$425**		**$452**		**$417**	
	30-yr Average Cost/1,000lb-TSS	**N/A**		**N/A**		**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

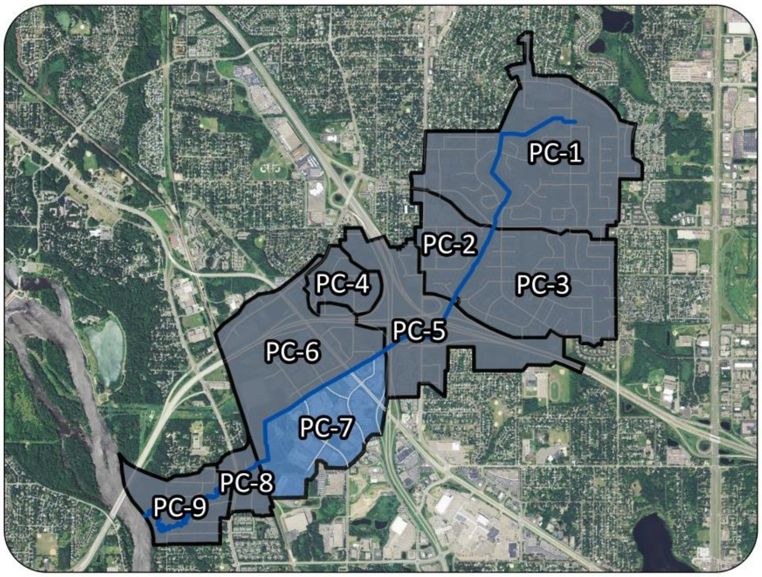
*Indirect Cost: 75 hours at $73/hour

**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF

Catchment PC-7

Existing Catchment Summary	
Acres	181.1
Dominant Land Cover	Commercial
Parcels	88



CATCHMENT DESCRIPTION

This catchment is primarily large industrial properties, with a mix of office and commercial space along Coon Rapids Blvd. NW. The western portion of the catchment is undeveloped, including the southern portion of the Pleasure Creek Ponds and another municipal pond. Pleasure Creek runs from east to west along the northern boundary of the catchment. Soils are generally hydric throughout the catchment.

EXISTING STORMWATER TREATMENT

Five retention ponds (two private and three municipal) provide the primary form of stormwater treatment in the catchment. The Green Bay Packaging facility and Kwik Trip each have their own private pond. The municipal ponds are the two Pleasure Creek Ponds and a third pond to the southeast treating runoff from industrial facilities in the southern portion of the catchment. The Pleasure Creek Ponds discharge into a 96” RCP under the Burlington Northern railroad tracks and into the Pleasure Creek channel west of the tracks.

Two small ponds are also located within the catchment but were not included in this analysis as their treatment areas were inconclusive based on municipal stormwater data and field surveys. The first pond is located along Coon Rapids Blvd. NW, west of Highway 47. The pond could potentially treat businesses and parking lots but access to the property restricted field investigation. Municipal storm sewer data show no connection. The second pond is located within a commercial district bounded by Springbrook Dr. NW, Coon Rapids Blvd. NW and Highway 47 and has no obvious input from the stormwater infrastructure.

Street cleaning is also conducted catchment-wide by the City of Coon Rapids at least three times annually.

Listed below are network-level base and existing loading for catchments PC-1 to PC-7. Each of these catchments ultimately discharges to the Please Creek Ponds, which supply stormwater treatment to over 1,500 acres of the Pleasure Creek subwatershed.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	33			
	BMP Types	26 Wet Ponds, 3 Grass Swales, 2 Wetlands, Infiltration Basin, Street Cleaning			
	TP (lb/yr)	1213.0	773.1	64%	**439.9**
	TSS (lb/yr)	443,654	346,741	78%	**96,913**
	Volume (acre-feet/yr)	858.4	57.6	7%	**800.8**

PROPOSED RETROFITS OVERVIEW

Similar to PC-6, retrofits were proposed to reduce the strain placed on the Pleasure Creek Ponds by reducing the suspended sediment load. A pond modification and stormwater diversion were proposed for the municipal pond southeast of the Pleasure Creek Ponds. The stormwater diversion would break the stormwater line from its existing track (discharging along Evergreen Blvd. into the Pleasure Creek Ponds) and outlet it into the municipal pond. An iron-enhanced sand bench would also be installed along the perimeter of the pond to better treat dissolved phosphorus from the contributing drainage area.

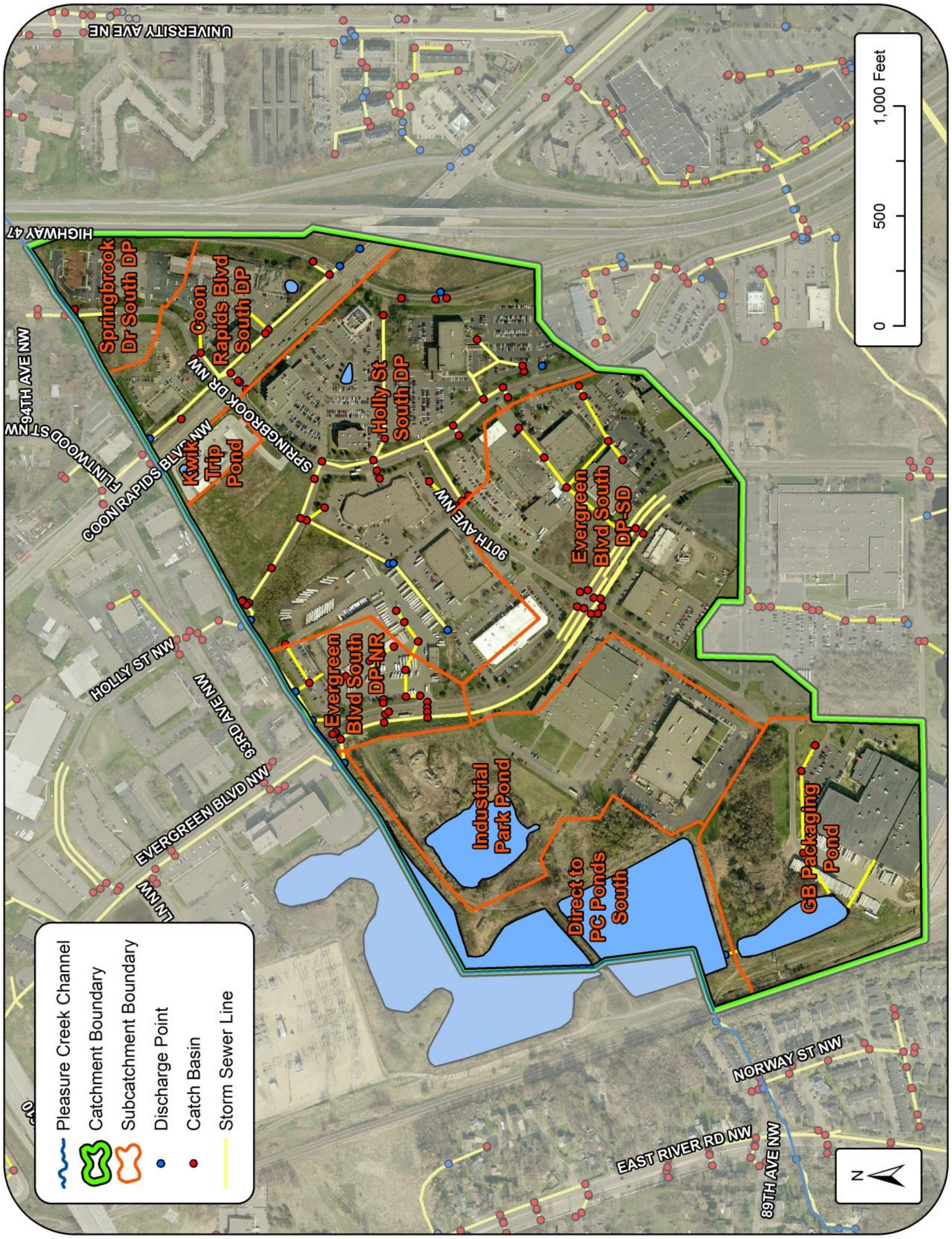
PROPOSED RETROFITS CONSIDERED BUT REJECTED

Multiple hydrodynamic devices were studied along discharge points into the creek at Springbrook Dr., Coon Rapids Blvd., Holly St., and Evergreen Blvd. Similar to previous catchments, water quality modeling results found none of the devices removed more than 15 lbs-TSS/year or 0.2 lbs-TP/year above what the Pleasure Creek Ponds were already treating. Considering the cost for each device, such little pollutant retention made these devices cost-prohibitive.

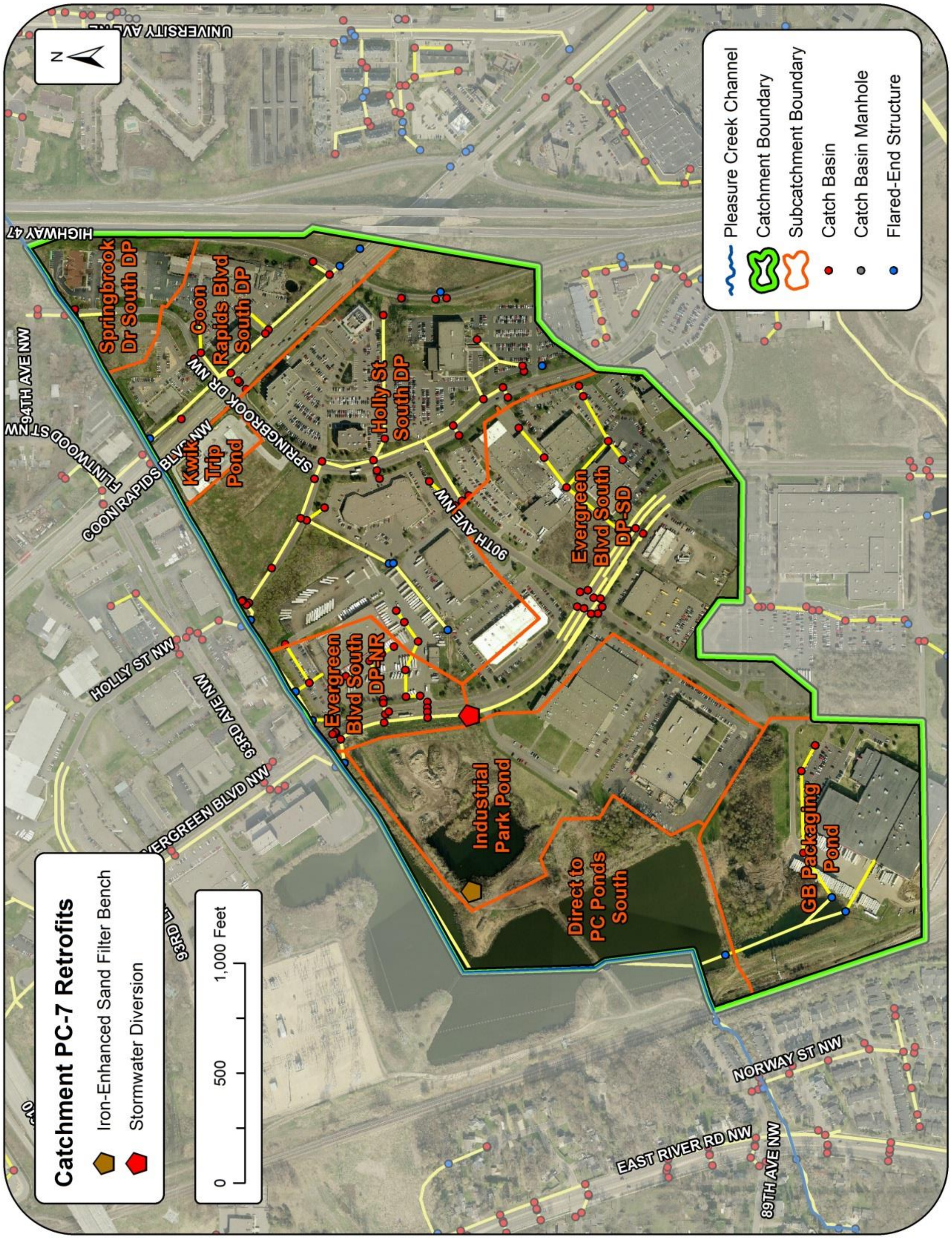
A new pond was explored for the vacant (as of publication) lot along Holly St. NW south of Pleasure Creek. This location is optimal, with a large expanse of open space and a sizable upstream drainage area. When modeled in WinSLAMM, though, the pond was unable to remove a significantly larger amount of sediment and other pollutants than was already being removed by the Pleasure Creek Ponds. This project was found to be cost-prohibitive.

Lastly, infiltration practices were not pursued within this catchment due to the prevalence of hydric soils.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS

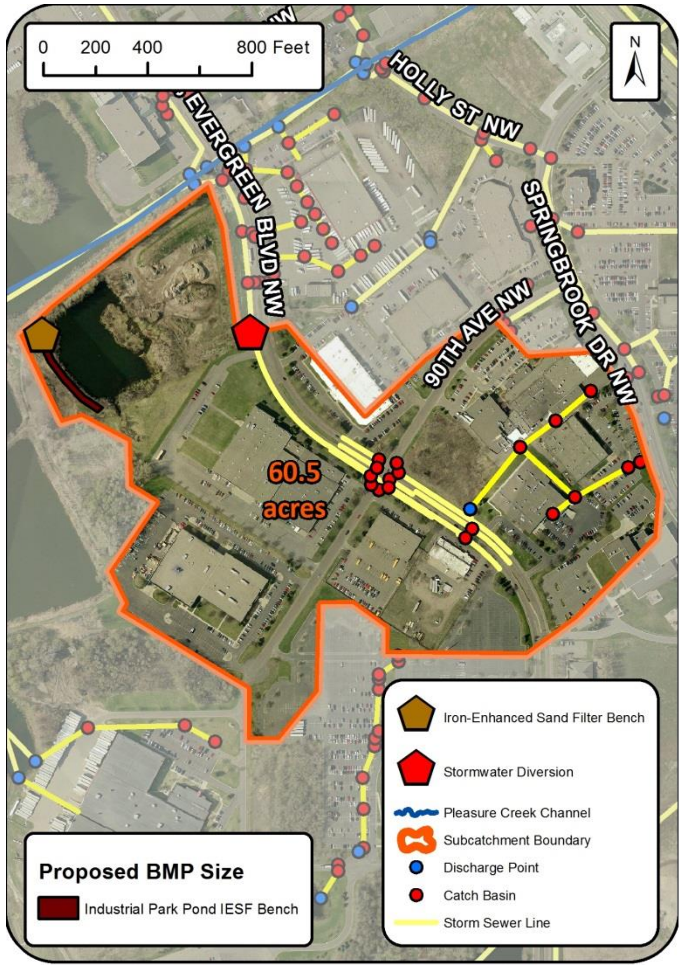


POTENTIAL RETROFITS



Project ID: 7-A

IESF Bench (with a Stormwater Diversion)
Industrial Park Pond Subcatchment



Drainage Area – 60.5 acres (25.8 acres without stormwater diversion)
Location – Western shore of the Industrial Park Pond
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – To treat dissolved phosphorus, an IESF bench is proposed along the western shore of the Industrial Park Pond. Outflow from the IESF can be directed to the Pleasure Creek Ponds to the north or west. An engineering plan is paramount for this site to determine if hydraulic head between the Industrial Park Pond and the Pleasure Creek Ponds is great enough to ensure the IESF bench can dry out between rain events.

A stormwater diversion is also proposed as part of this project, which would divert storm flow from the 42” storm sewer line running along Evergreen Blvd. NW into Industrial Park Pond. This would increase the amount of water flowing through the IESF bench and make this project more cost effective. The table below lists proposed volume and pollutant reductions for the project, both with and without the stormwater diversion.

	IESF Bench				
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	BMP Description	w/ SW Diversion		w/out SW Diversion	
	Total Size of BMPs	10,000	sq-ft	10,000	sq-ft
	TP (lb/yr)	8.1	1.8%	4.2	1.0%
	TSS (lb/yr)	0	0.0%	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$5,110		$3,650	
	Design & Construction Costs**	$346,400		$289,400	
	Total Estimated Project Cost (2015)	**$351,510**		**$293,050**	
	Annual O&M***	$2,296		$2,296	
Efficiency	30-yr Average Cost/lb-TP	**$1,730**		**$2,872**	
	30-yr Average Cost/1,000lb-TSS	**N/A**		**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**	

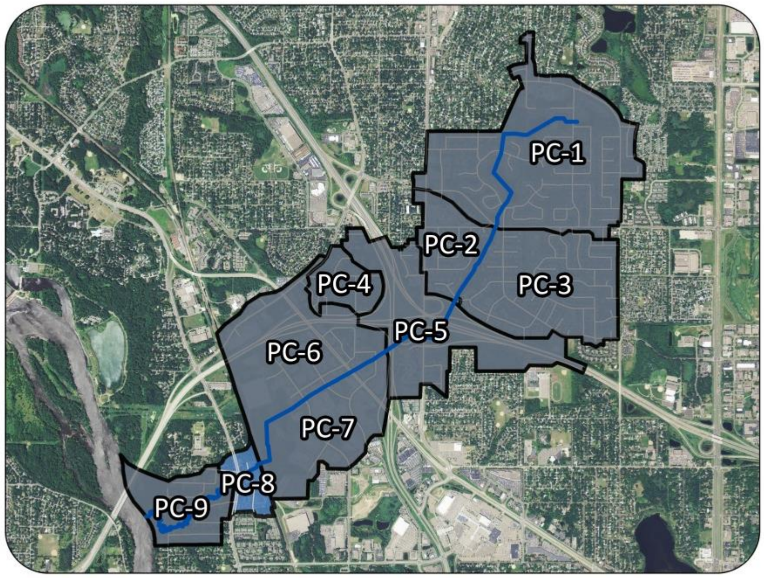
*Indirect Cost: 50 hours at $73/hour for IESF + 20 hours at $73/hour for SW diversion

**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF, no additional costs included for SW diversion

Catchment PC-8

Existing Catchment Summary	
Acres	41.7
Dominant Land Cover	Residential
Parcels	238



CATCHMENT DESCRIPTION

PC-8 consists of both single family and multi-family residential lots. Much of the catchment area is attached multi-family townhomes along Norway St. NW. Pleasure Creek splits the catchment, running from the Burlington Northern Railroad tracks in the east to East River Rd. NW. There are three stormwater discharge points to Pleasure Creek, two at East River Road and the third on Norway Street.

EXISTING STORMWATER TREATMENT

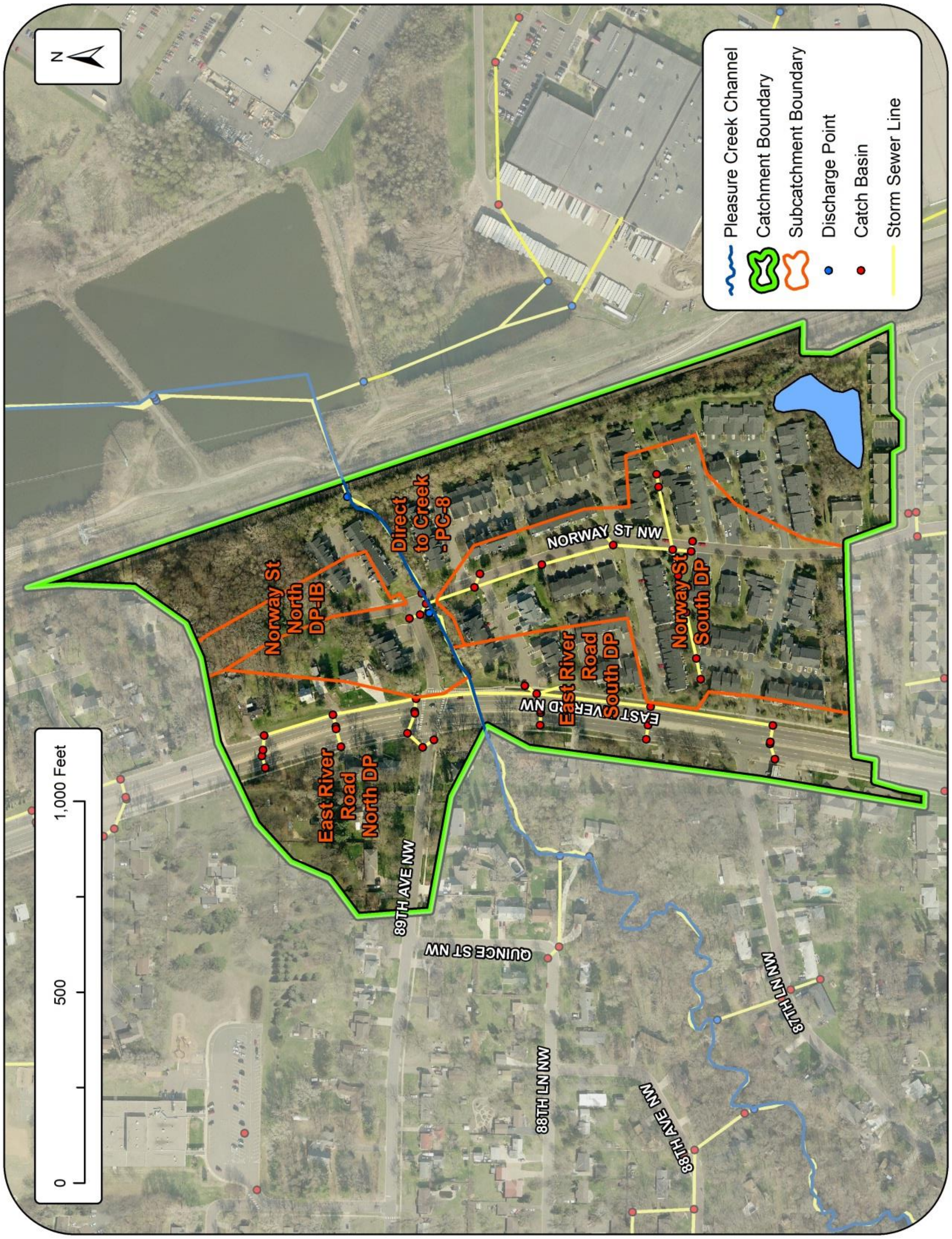
No existing stormwater ponds or other structural BMPs lie within the catchment. Street cleaning is performed catchment-wide at least three times annually by the City of Coon Rapids.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	29.3	2.1	7%	**27.2**
	TSS (lb/yr)	9,312	930	10%	**8,382**
	Volume (acre-feet/yr)	27.1	0.0	0%	**27.1**

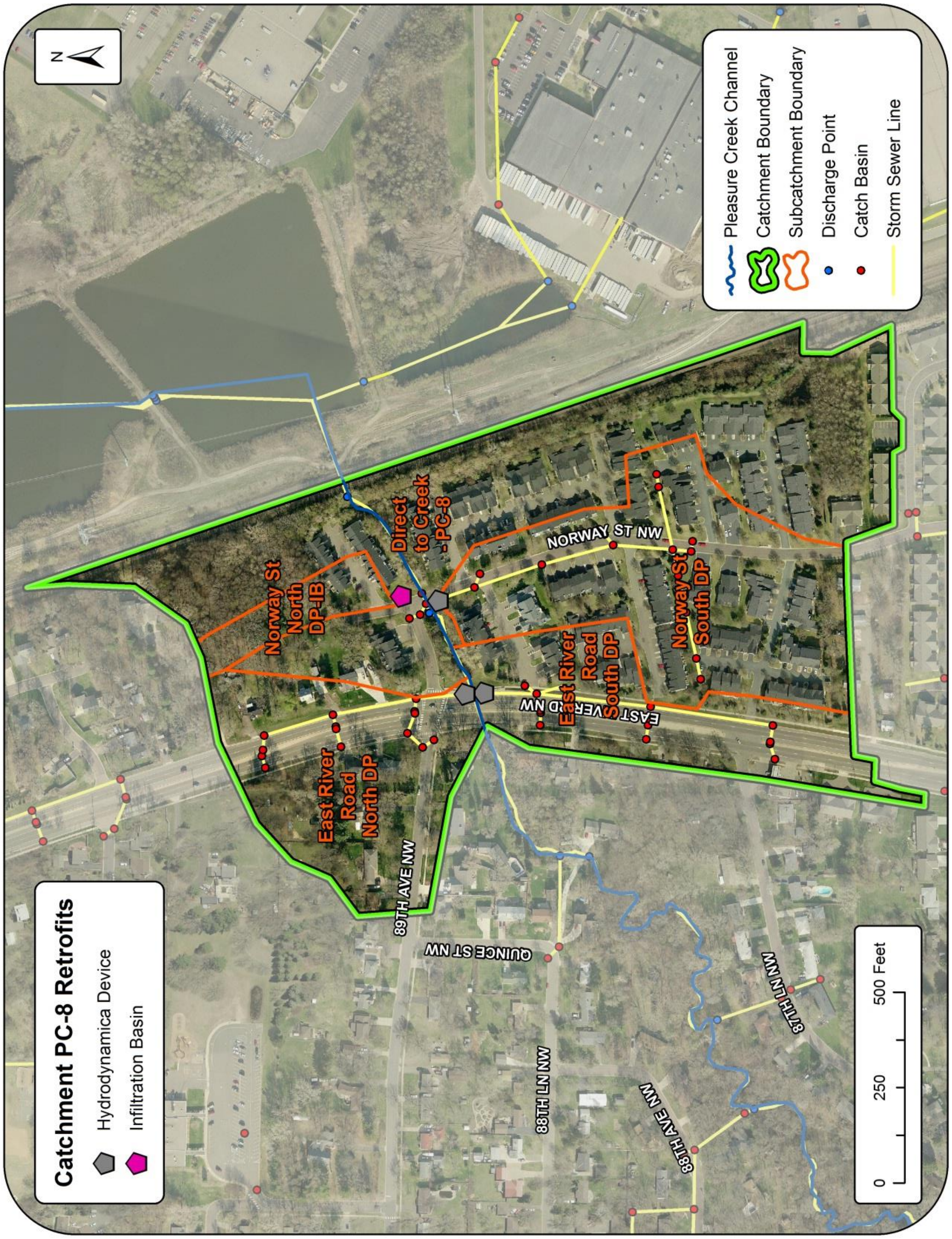
PROPOSED RETROFITS OVERVIEW

Suspended solids are a greater target in this catchment, as there are no in-line ponds remaining to treat runoff generated within the catchment. Three hydrodynamic devices were proposed to treat runoff at each discharge point to the creek. An infiltration basin was proposed northeast of the creek's intersection with Norway St. NW. Lastly, an increase to the City of Coon Rapids' street cleaning frequency was proposed.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 8-A

Infiltration Basin
Norway St. North DP-IB
Subcatchment

Drainage Area – 1.4 acres
Location – East of Norway St. NW and 89th Ave. NW intersection
Property Ownership – Private
Site Specific Information – An infiltration basin is proposed to treat 1.4 acres of multi-family residential properties. Native soils are non-hydric, B-type with average to poor drainage rates. Infiltration tests should be performed prior to installation to determine infiltration rates and ponding depth of the practice (assuming no water should pond longer than 48 hours). Two modeled scenarios are shown in the table below, one with a ponding depth of 6" and another with a ponding depth of 12". Underdrains were not included in these model scenarios.

Infiltration Basin

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Ponding Depth of BMP	6 inches		12 inches	
	Total Size of BMP	350	sq-ft	350	sq-ft
	TP (lb/yr)	0.2	0.7%	0.4	1.5%
	TSS (lb/yr)	69	0.8%	111	1.3%
	Volume (acre-feet/yr)	0.2	0.7%	0.3	1.1%
Cost	Administration & Promotion Costs*	$2,920		$2,920	
	Design & Construction Costs**	$7,876		$9,976	
	Total Estimated Project Cost (2015)	**$10,796**		**$12,896**	
	Annual O&M***	$225		$225	
Efficiency	30-yr Average Cost/lb-TP	**$2,924**		**$1,637**	
	30-yr Average Cost/1,000lb-TSS	**$8,476**		**$5,900**	
	30-yr Average Cost/ac-ft Vol.	**$2,924**		**$2,183**	

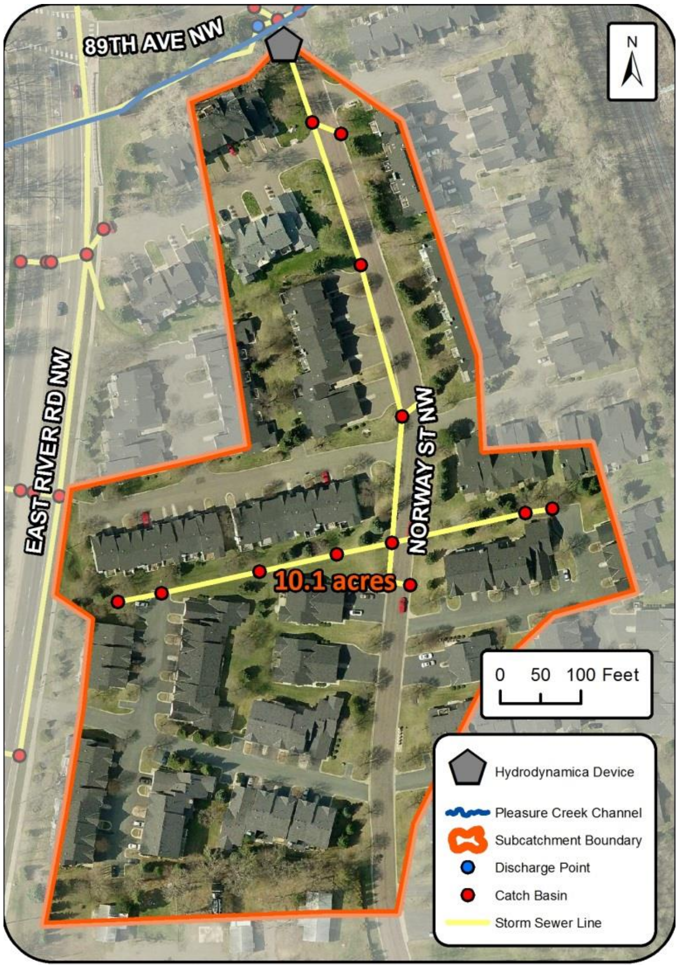
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 12" depth
($20/sq-ft for materials and labor) + (12 hours at $73/hour for design) for 6" depth

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

Project ID: 8-B

Hydrodynamic Device
Norway St. South DP
Subcatchment



Drainage Area – 10.1 acres
Location – Along the Norway St. NW storm sewer line south of Pleasure Creek
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining Norway St. NW and surrounding multi-family residential properties.

	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	2.6%
	TSS (lb/yr)	300	3.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$6,426**	
	30-yr Average Cost/1,000lb-TSS	**$14,995**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

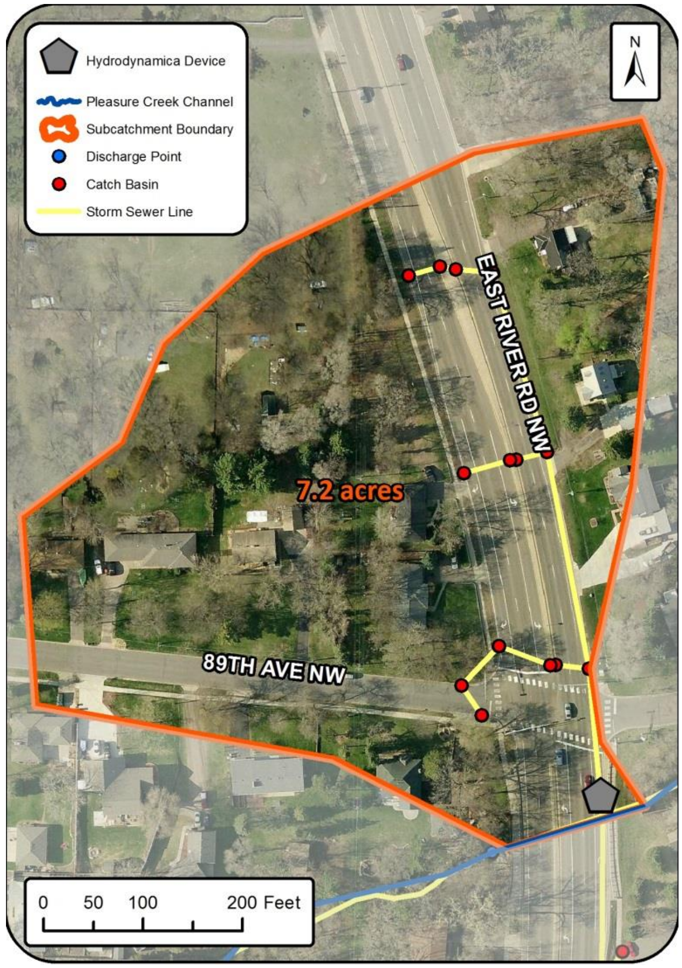
*Indirect Cost: (24 hours at $73/hour)

**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: 8-C

Hydrodynamic Device
East River Road North DP
Subcatchment



Drainage Area – 7.2 acres
Location – Along East River Rd. NW north of storm sewer line intersection with Pleasure Creek
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining East River Rd. NW and surrounding properties. Model results in the table below assume the device is installed far enough downstream on the East River Rd. NW storm sewer line to accept runoff from all catch basins north of Pleasure Creek.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.5	1.8%
	TSS (lb/yr)	197	2.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$8,997**	
	30-yr Average Cost/1,000lb-TSS	**$22,835**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

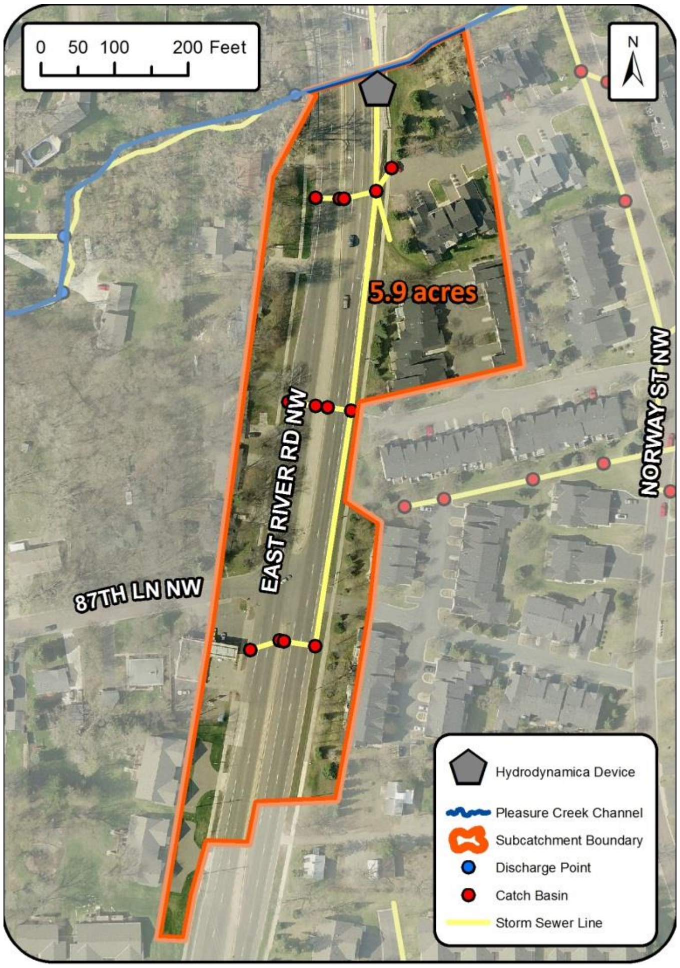
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: 8-D

Hydrodynamic Device
East River Road South DP
Subcatchment

Drainage Area – 5.9 acres
Location – Along East River Rd. NW south of storm sewer line intersection with Pleasure Creek
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device could be installed to accept runoff from stormwater catch basins draining East River Rd. NW and surrounding properties. Model results in the table below assume the device is installed far enough downstream on the East River Rd. NW storm sewer line to accept runoff from all catch basins south of Pleasure Creek.



	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	1.5%
	TSS (lb/yr)	186	2.2%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$1,752
	Design & Construction Costs**		$54,000
	Total Estimated Project Cost (2015)		**$55,752**
	Annual O&M***		$840
Efficiency	**30-yr Average Cost/lb-TP**	**$6,746**	
	30-yr Average Cost/1,000lb-TSS	**$14,508**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

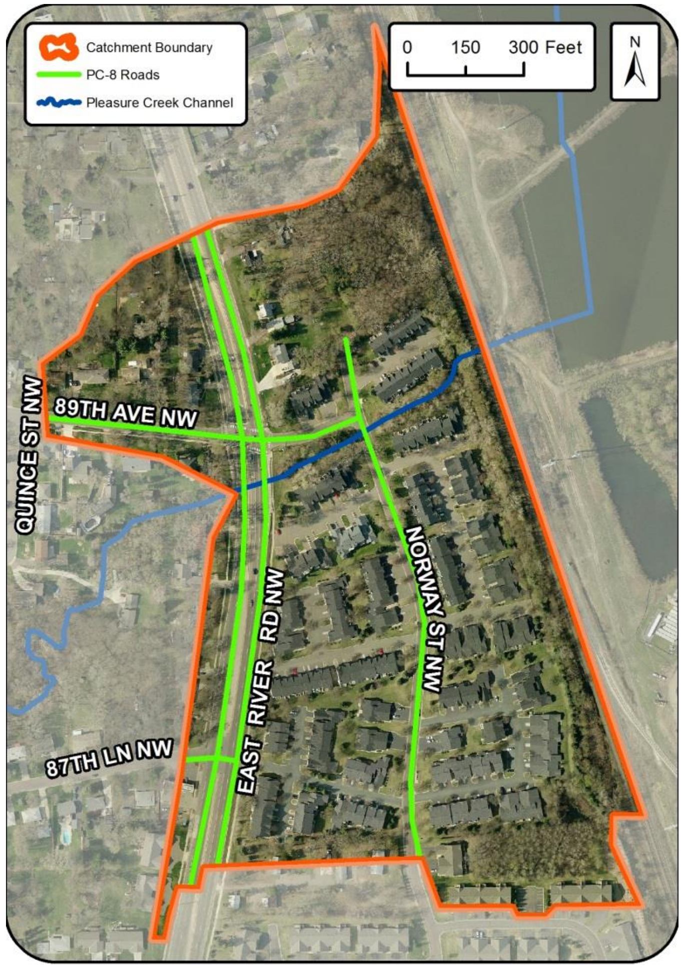
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

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

Project ID: 8-E

Enhanced Street Cleaning
PC-8 Catchment



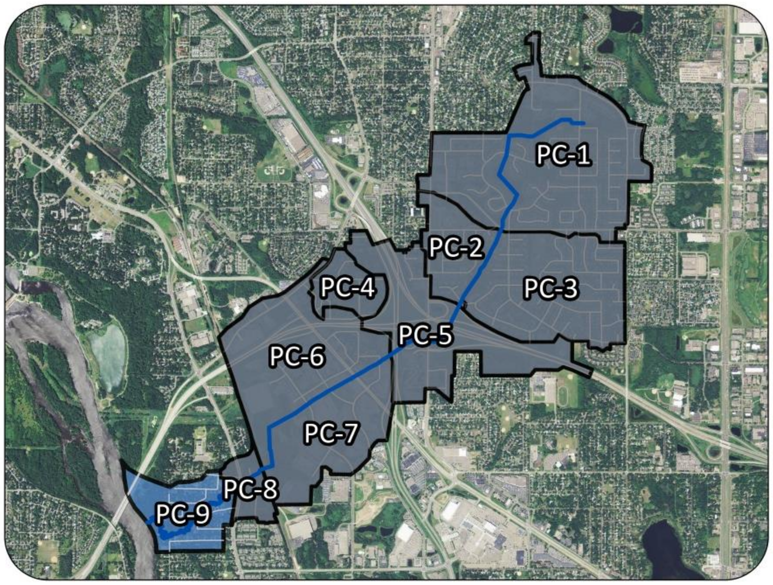
Drainage Area – 41.7 acres
Location – Throughout catchment PC-8
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – Street Cleaning is currently performed by the City of Coon Rapids three times per year. This frequency could be increased to treat additional sediment and TSS-bound phosphorus across all roadways within the catchment. Results in the table below assume an increase in frequency using only mechanical sweepers.

	Enhanced Street Cleaning						
	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Street Cleaning Frequency	Once every 4 weeks		Once every 2 weeks		Once every week	
	Curb Miles	2.7	miles	2.7	miles	2.7	miles
	TP (lb/yr)	0.9	3.3%	1.4	5.1%	1.7	6.3%
	TSS (lb/yr)	376	4.5%	603	7.2%	728	8.7%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,460		$1,460		$1,460	
	Operations Costs**	$1,404		$3,024		$6,035	
	Total Estimated Project Cost (2015)	**$2,864**		**$4,484**		**$7,495**	
	Annual O&M***	N/A		N/A		N/A	
Efficiency	30-yr Average Cost/lb-TP	**$3,182**		**$3,203**		**$4,409**	
	30-yr Average Cost/1,000lb-TSS	**$7,617**		**$7,436**		**$10,295**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

*Indirect Cost: (20 hours at $73/hour base cost)
**Direct Cost: See 'Enhanced Street Cleaning' BMP Description for more information
***Included with 'Operations Costs'

Catchment PC-9

Existing Catchment Summary	
Acres	112.1
Dominant Land Cover	Residential
Parcels	190



CATCHMENT DESCRIPTION

This catchment is the furthest downstream in the Pleasure Creek subwatershed. The creek bisects the catchment, running a very sinuous route from East River Rd. NW to its confluence with the Mississippi River. Single family residential lots dominate the landscape, with parkland closer to the Mississippi River. This catchment has a pronounced slope from east to west, with a 64 ft. elevation change between the pavement surface of East River Rd. NW and the Mississippi River.

There are four storm sewer discharge points in the catchment to Pleasure Creek, located (from east to west) at 88th Ln. NW, 87th Ln. NW, 88th Ave. NW, and 86th Ave. NW. A portion of the catchment does not drain to Pleasure Creek, but flows overland into the Mississippi River. This is mainly county-owned parkland and the Highway 610 overpass above the river.

EXISTING STORMWATER TREATMENT

A stormwater pond and wetland are located in the county- and state-owned parkland east of Highway 610 but provide no benefit to Pleasure Creek as these waterbodies are not hydrologically connected. These waterbodies were not included as stormwater BMPs in the WinSLAMM model. Street cleaning by the City of Coon Rapids is the primary treatment in the catchment.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	49.3	3.9	8%	**45.4**
	TSS (lb/yr)	14,661	1,707	12%	**12,954**
	Volume (acre-feet/yr)	33.8	0.0	0%	**33.8**

PROPOSED RETROFITS OVERVIEW

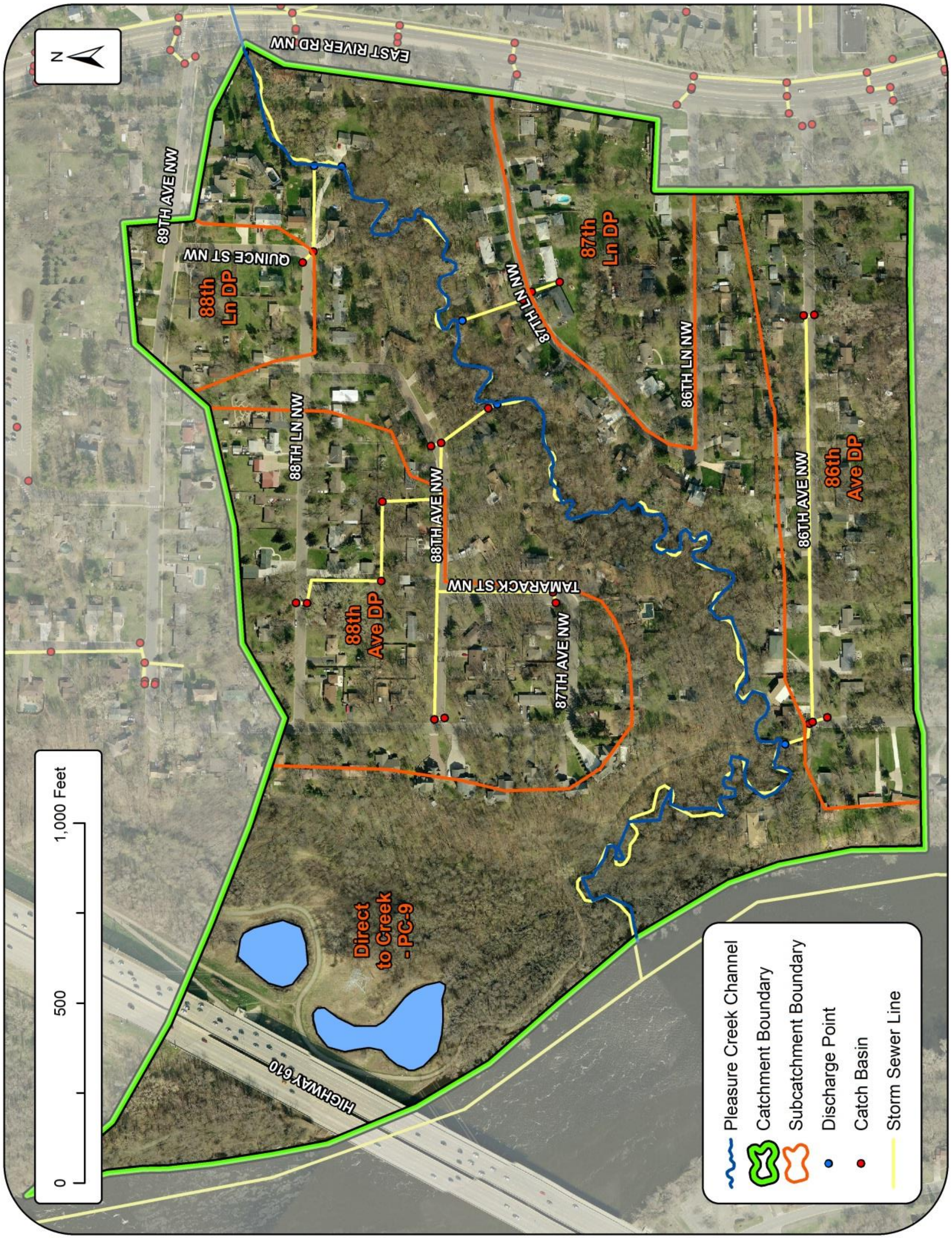
Both the suspended and dissolved stormwater pollutant loads were targeted in this catchment. Curb-cut rain gardens were proposed on single family lots where soils were favorable for infiltration and sufficient upstream runoff could be treated. Hydrodynamic devices were also proposed at each of the discharge points into Pleasure Creek to better capture the suspended load within the catchment and to augment larger events that may bypass the rain gardens (if both practices were pursued).

Mitigating streambank erosion is also a viable option in this area. Erosion along the streambank, particularly along the streambank toe, can be a significant source of suspended sediment within any stream. The most recent ditch report generated by the CCWD identified nine stretches of the creek with visible erosion that needed to be addressed. Six of these nine still remain. Each were analyzed and proposed as a project in this section.

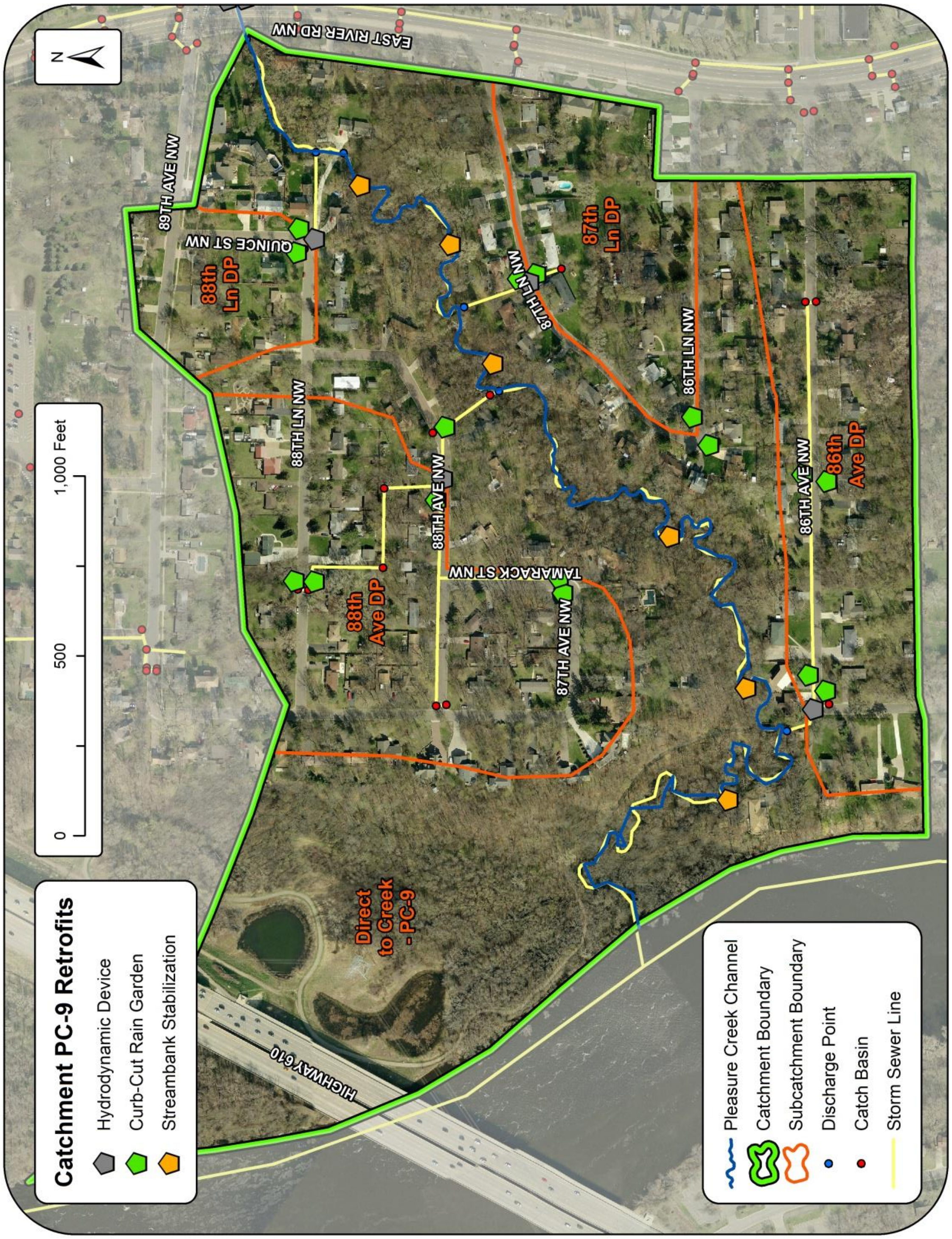
PROPOSED RETROFITS CONSIDERED BUT REJECTED

No structural BMPs were proposed in the parkland near the Mississippi River or along the Highway 610 corridor. The pond and wetland adjacent to Highway 610 already provide sufficient treatment for the highway. The parkland is generally pervious and does not necessitate additional treatment.

CURRENT STORMWATER INFRASTRUCTURE AND BMPS



POTENTIAL RETROFITS



Project ID: 9-A

Curb-Cut Rain Gardens
PC-9 Catchment

Drainage Area – 112.1 acres
Location – Throughout catchment PC-9
Property Ownership – Private
Site Specific Information – Stormwater runoff generated within the catchment flows untreated to storm sewer catch basins which discharge directly to Pleasure Creek. Rain gardens are proposed throughout the residential neighborhoods west of East River Rd. NW to better treat both TSS and TP. Up to 15 optimal sites were located during desktop analysis. Considering typical landowner participation rates, scenarios with 2, 6, 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	2		6		12	
	Total Size of BMPs	500	sq-ft	1,500	sq-ft	3,000	sq-ft
	TP (lb/yr)	1.3	2.9%	3.7	8.1%	7.6	16.7%
	TSS (lb/yr)	418	3.2%	1,179	9.1%	2,394	18.5%
	Volume (acre-feet/yr)	1.1	3.3%	3.0	8.9%	7.6	22.5%
Cost	Administration & Promotion Costs*	$9,344		$12,848		$18,104	
	Design & Construction Costs**	$14,752		$44,256		$88,512	
	Total Estimated Project Cost (2015)	**$24,096**		**$57,104**		**$106,616**	
	Annual O&M***	$450		$1,350		$2,700	
Efficiency	**30-yr Average Cost/lb-TP**	**$964**		**$879**		**$823**	
	30-yr Average Cost/1,000lb-TSS	**$2,998**		**$2,760**		**$2,612**	
	30-yr Average Cost/ac-ft Vol.	**$1,139**		**$1,084**		**$823**	

*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: 9-B

Hydrodynamic Device
88th Lane DP Subcatchment

Drainage Area – 4.7 acres
Location – Intersection of 88th Ln. NW and Quince St. NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device is proposed to treat TSS and TSS-bound phosphorus from residential properties along Quince St. NW, 89th Ave. NW and 88th Lane NW. The table below lists pollutant reduction potential for a device collecting runoff from both catch basins at the intersection of Quince St. NW and 88th Ln. NW. If site constraints only allow for collection from one catch basin, then pollutant retention estimates will be less than estimated below.

Hydrodynamic Device

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.3	0.7%
	TSS (lb/yr)	131	1.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2015)	**$55,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$8,995**	
	30-yr Average Cost/1,000lb-TSS	**$20,598**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

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

Project ID: 9-C

Hydrodynamic Device
87th Lane DP Subcatchment

Drainage Area – 8.5 acres
Location – Throughout catchment PC-9
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device is proposed to treat TSS and TSS-bound phosphorus from residential properties along 87th Ln. NW and 86th Ln. NW. The BMP should be installed to accept runoff from the southern catch basin along 87th Ln. NW. A device treating runoff from both catch basins may overload the practice and lead to additional resuspension.

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	1.3%
	TSS (lb/yr)	237	1.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$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**	

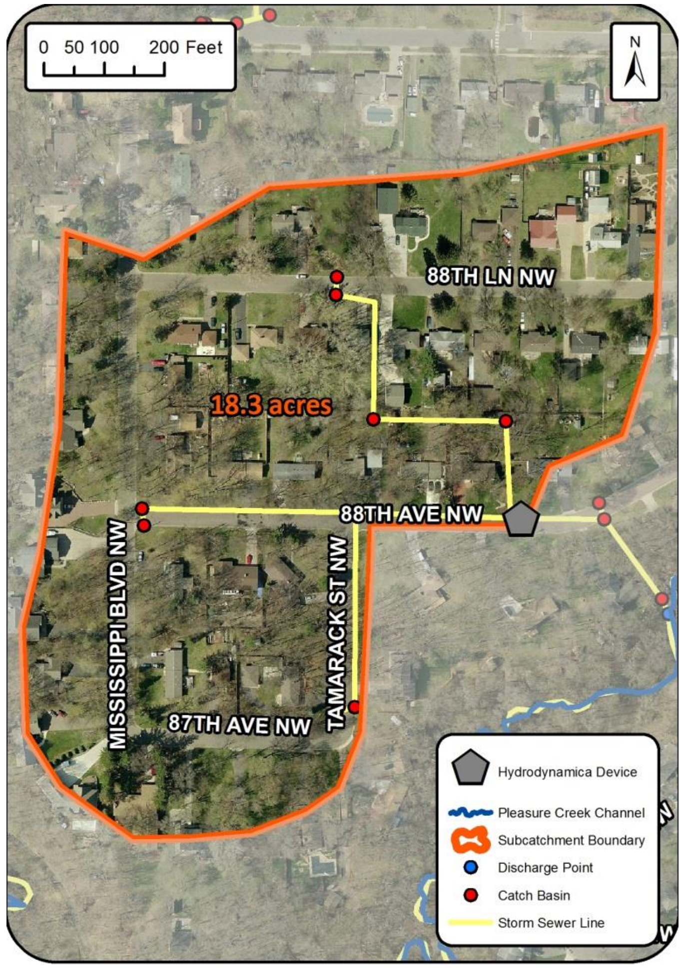
*Indirect Cost: (24 hours at $73/hour)

**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: 9-D

Hydrodynamic Device
88th Ave DP Subcatchment



Drainage Area – 18.3 acres
Location – Along 88th Ave. NW east of Tamarack St. NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device is proposed to treat TSS and TSS-bound phosphorus from residential properties between 88th Ln. NW and 87th Ave. NW.

	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	2.0%
	TSS (lb/yr)	354	2.7%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$12,707**	
	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: 9-E

Hydrodynamic Device
86th Ave DP Subcatchment

Drainage Area – 15.1 acres
Location – At intersection of 86th Ave NW and Mississippi Blvd. NW
Property Ownership – Public (City of Coon Rapids)
Site Specific Information – A hydrodynamic device is proposed to treat TSS and TSS-bound phosphorus from residential properties along 86th Ave. NW and Mississippi Blvd. NW. The device should be installed such that it accepts runoff from both catch basins at the intersections of 86th Ave. NW and Mississippi Blvd. NW.

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	2.0%
	TSS (lb/yr)	334	2.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2015)	**$109,752**	
	Annual O&M***	$840	
Efficiency	30-yr Average Cost/lb-TP	**$4,998**	
	30-yr Average Cost/1,000lb-TSS	**$13,468**	
	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: 9-F

Enhanced Street Cleaning
PC-9 Catchment

Drainage Area – 112.1 acres
Location – Throughout catchment PC-9
Property Ownership – Public (City of Coon Rapids)
Information – Street cleaning is currently performed by the City of Coon Rapids three times per year along residential streets. This frequency could be increased to treat additional sediment and TSS-bound phosphorus collected across municipal roadways in the catchment. Results in the table below assume an increase in frequency using only mechanical sweepers.

	Enhanced Street Cleaning						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Street Cleaning Frequency**	Once every 4 weeks		Once every 2 weeks		Once every week	
	Curb Miles	5.4	miles	5.4	miles	5.4	miles
	TP (lb/yr)	1.7	3.7%	2.7	5.9%	3.3	7.3%
	TSS (lb/yr)	718	5.5%	1,168	9.0%	1,422	11.0%
	Volume (acre-feet/yr)	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,460		$1,460		$1,460	
	Operations Costs**	$2,808		$6,048		$12,069	
	Total Estimated Project Cost (2015)	**$4,268**		**$7,508**		**$13,529**	
	Annual O&M***	N/A		N/A		N/A	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,511**		**$2,781**		**$4,100**	
	30-yr Average Cost/1,000lb-TSS	**$5,944**		**$6,428**		**$9,514**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

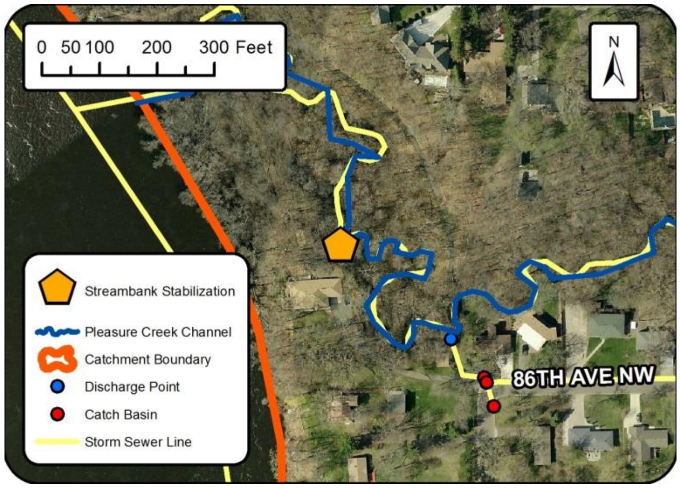
*Indirect Cost: (20 hours at $73/hour base cost)

**Direct Cost: See 'Enhanced Street Cleaning' BMP Description for more information

***Included with 'Operations Costs'

Project ID: 9-G

Streambank Stabilization
Ditch Inspection Station
10+41



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 10+41, along left bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the left bank at station 10+41 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 12.5 ft on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

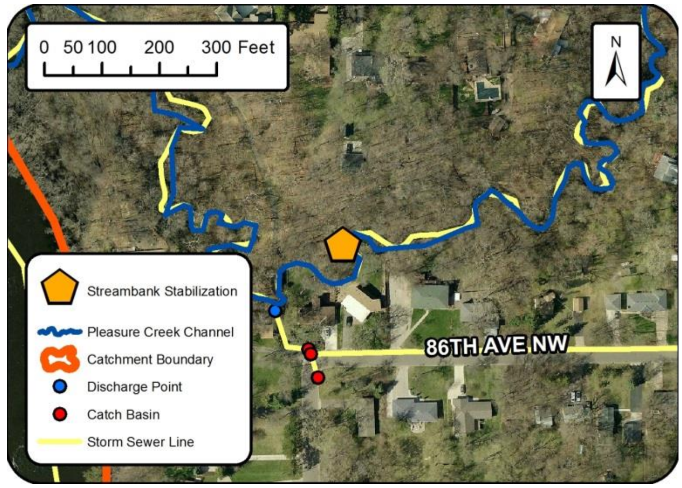
Streambank Stabilization

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Estimated Length of Stabilization	35	ft
	TP (lb/yr)	5.3	1.0%
	TSS (lb/yr)	6,563	5.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$2,920
	Design & Construction Costs**		$27,500
	Total Estimated Project Cost (2015)		**$30,420**
	Annual O&M***		$350
Efficiency	**30-yr Average Cost/lb-TP**	**$257**	
	30-yr Average Cost/1,000lb-TSS	**$208**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)
***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 9-H

Streambank Stabilization
Ditch Inspection Station
14+52



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 14+52, along right bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the right bank at station 14+52 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 7.5 ft on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

Streambank Stabilization

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Estimated Length of Stabilization	35	ft
	TP (lb/yr)	3.2	0.6%
	TSS (lb/yr)	3,938	3.3%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***		$2,920
	Design & Construction Costs**		$27,500
	Total Estimated Project Cost (2015)		**$30,420**
	Annual O&M***		$350
Efficiency	**30-yr Average Cost/lb-TP**	**$426**	
	30-yr Average Cost/1,000lb-TSS	**$346**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

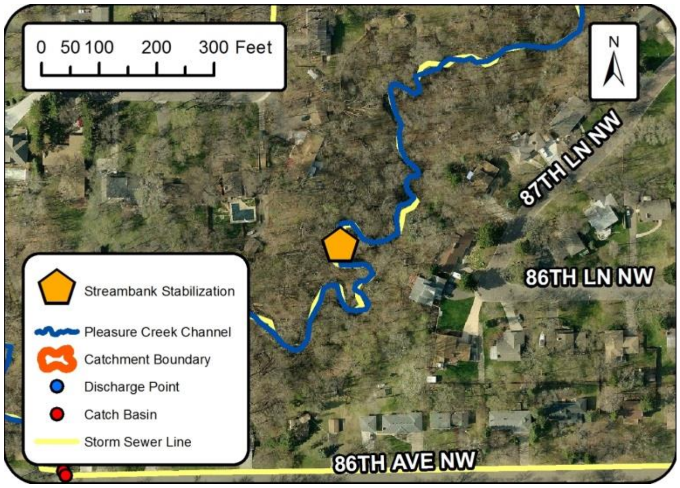
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)

***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 9-I

Streambank Stabilization
Ditch Inspection Station
23+40



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 23+40, along right bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the right bank at station 23+40 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 20 ft on average across the project reach. The recession rate was estimated to be 0.15 ft/yr.

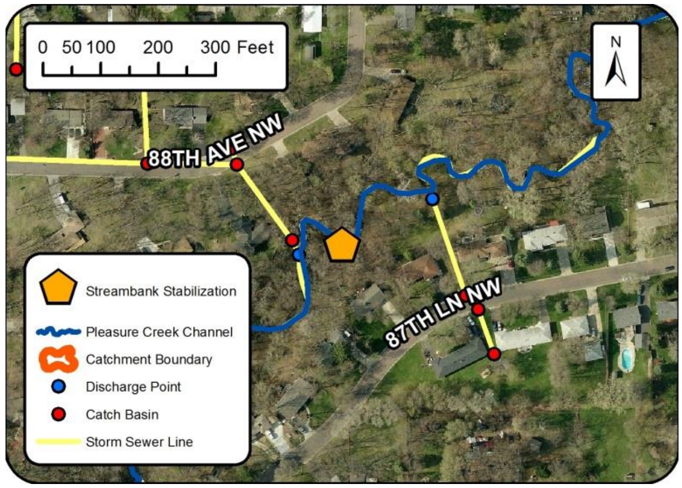
Streambank Stabilization

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Estimated Length of Stabilization	75	ft
	TP (lb/yr)	18.0	3.5%
	TSS (lb/yr)	22,500	18.9%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$47,500	
	Total Estimated Project Cost (2015)	**$50,420**	
	Annual O&M***	$750	
Efficiency	30-yr Average Cost/lb-TP	**$135**	
	30-yr Average Cost/1,000lb-TSS	**$108**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)
***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 9-J

Streambank Stabilization
Ditch Inspection Station
34+20



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 34+20, along left bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the left bank at station 34+20 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 7.5 ft on average across the project reach. The recession rate was estimated to be 0.4 ft/yr.

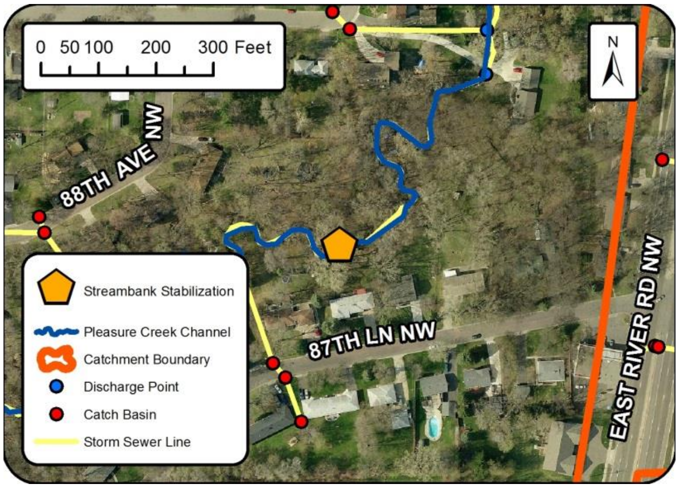
Streambank Stabilization

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
Treatment	Estimated Length of Stabilization	75	ft
Treatment	TP (lb/yr)	18.0	3.5%
Treatment	TSS (lb/yr)	22,500	18.9%
Treatment	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$2,920	
Cost	Design & Construction Costs**	$47,500	
Cost	Total Estimated Project Cost (2015)	**$50,420**	
Cost	Annual O&M***	$750	
Efficiency	30-yr Average Cost/lb-TP	**$135**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**$108**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)
***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 9-K

Streambank Stabilization
Ditch Inspection Station
39+45



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 39+45, along right bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the right bank at station 39+45 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 7.5 ft on average across the project reach. The recession rate was estimated to be 0.25 ft/yr.

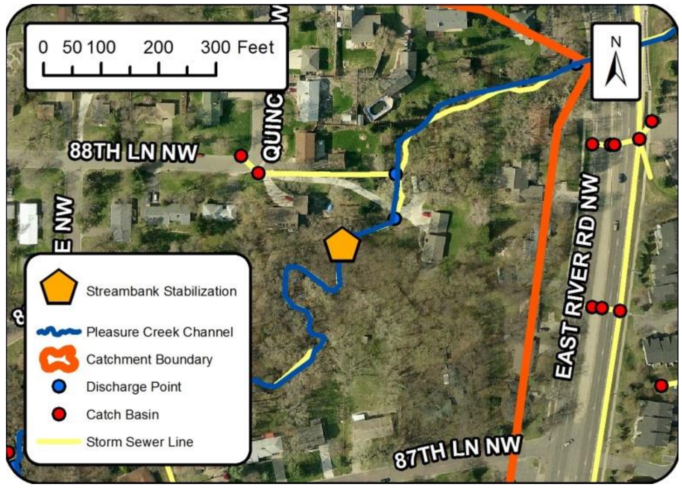
Streambank Stabilization

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
Treatment	Estimated Length of Stabilization	75	ft
Treatment	TP (lb/yr)	11.3	2.2%
Treatment	TSS (lb/yr)	14,063	11.8%
Treatment	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$2,920	
Cost	Design & Construction Costs**	$47,500	
Cost	Total Estimated Project Cost (2015)	**$50,420**	
Cost	Annual O&M***	$750	
Efficiency	30-yr Average Cost/lb-TP	**$215**	
Efficiency	30-yr Average Cost/1,000lb-TSS	**$173**	
Efficiency	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour
**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)
***$10/linear-ft - Annual inspection and regular maintenance

Project ID: 9-L

Streambank Stabilization
Ditch Inspection Station
45+70



Drainage Area – 1,693.9 acres
Location – Ditch inspection station 45+70, along right bank
Property Ownership – Private
Information – During the 2012 CCWD ditch inspection, significant erosion was found along the right bank at station 45+70 (see photo to right). A project is proposed to stabilize the bank and toe of the slope with rip rap. Pollutant reduction estimates are listed in the table below. Percent reductions are based on subwatershed-wide pollutant inputs to the creek. Eroding face height was estimated to be 7.5 ft on average across the project reach. The recession rate was estimated to be 0.25 ft/yr.

Streambank Stabilization

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Estimated Length of Stabilization	35	ft
	TP (lb/yr)	5.3	1.0%
	TSS (lb/yr)	6,563	5.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$27,500	
	Total Estimated Project Cost (2015)	**$30,420**	
	Annual O&M***	$350	
Efficiency	**30-yr Average Cost/lb-TP**	**$257**	
	30-yr Average Cost/1,000lb-TSS	**$208**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($500/linear-ft for materials and labor) + ($10,000 for design)

***$10/linear-ft - Annual inspection and regular maintenance

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Appendix A – Modeling Methods and Input

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 18.

Table 18: 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 Blaine or the City of Coon Rapids. The practices listed below were included in the existing conditions model. BMPs listed in Appendix A are listed by BMP type, and ordered first by catchment and second by their order within the catchment from most upstream to most downstream.

Infiltration Basins

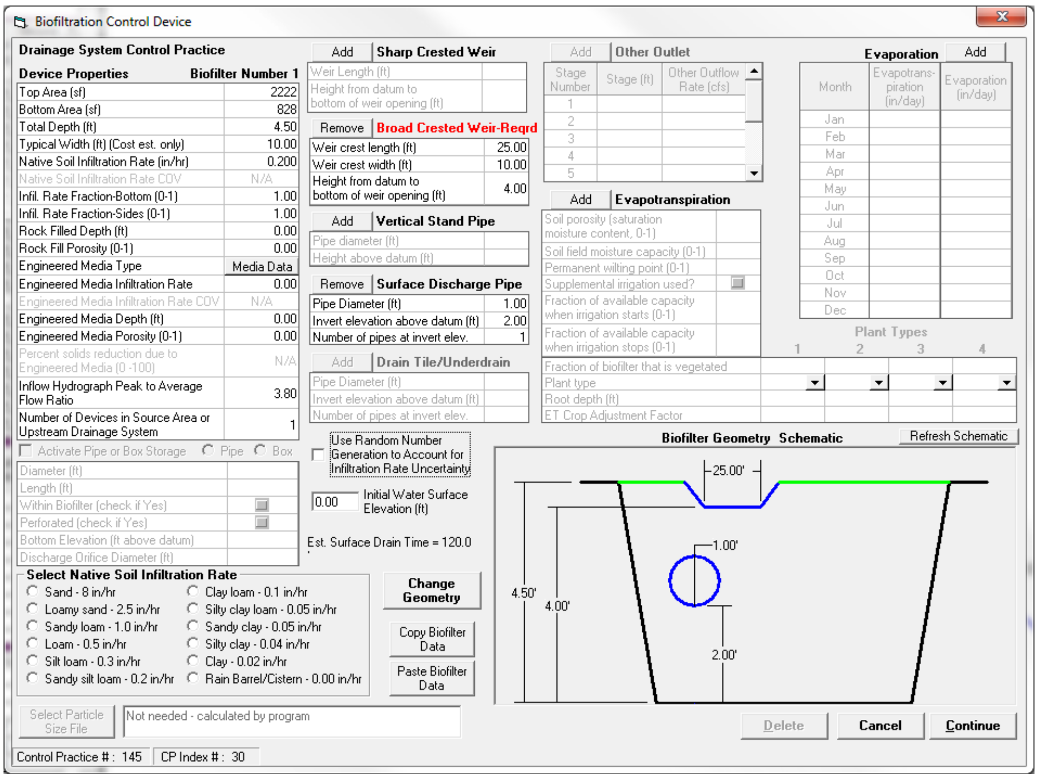

Figure 10: Infiltration basin IB1 in catchment PC-1 WinSLAMM model inputs

Grass Swales

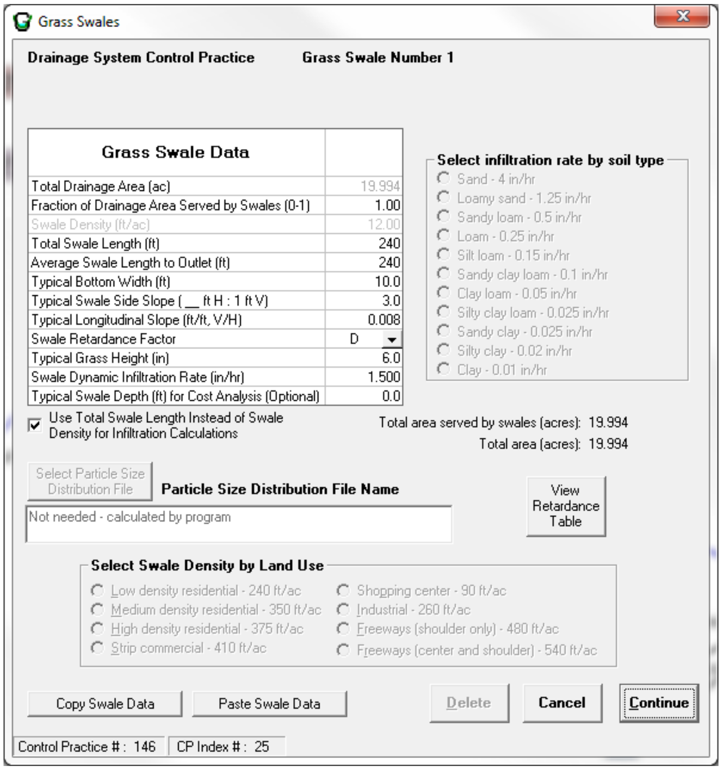

Figure 11: President Park grass swale in catchment PC-1 WinSLAMM model inputs

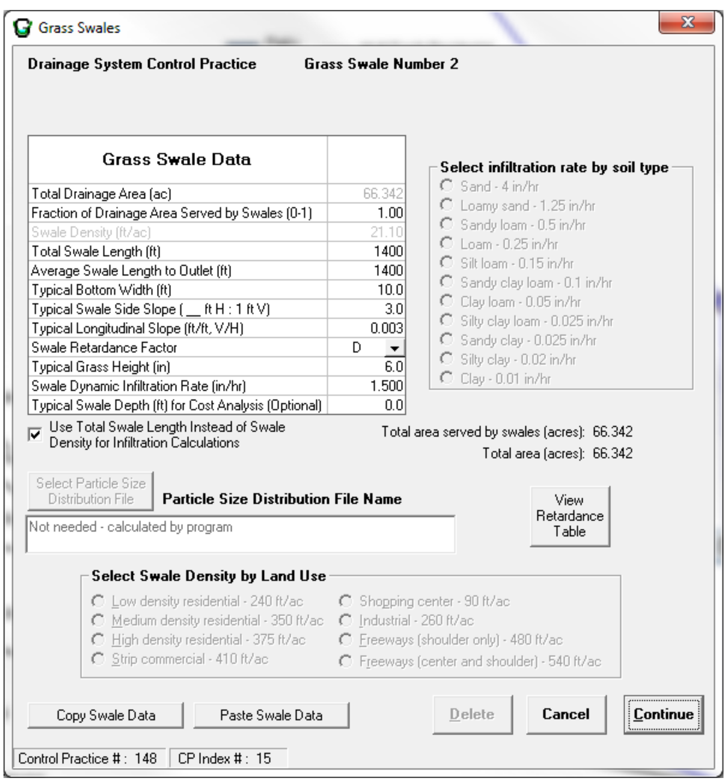

Figure 12: Cloverleaf Park grass swale in catchment PC-3 WinSLAMM model inputs

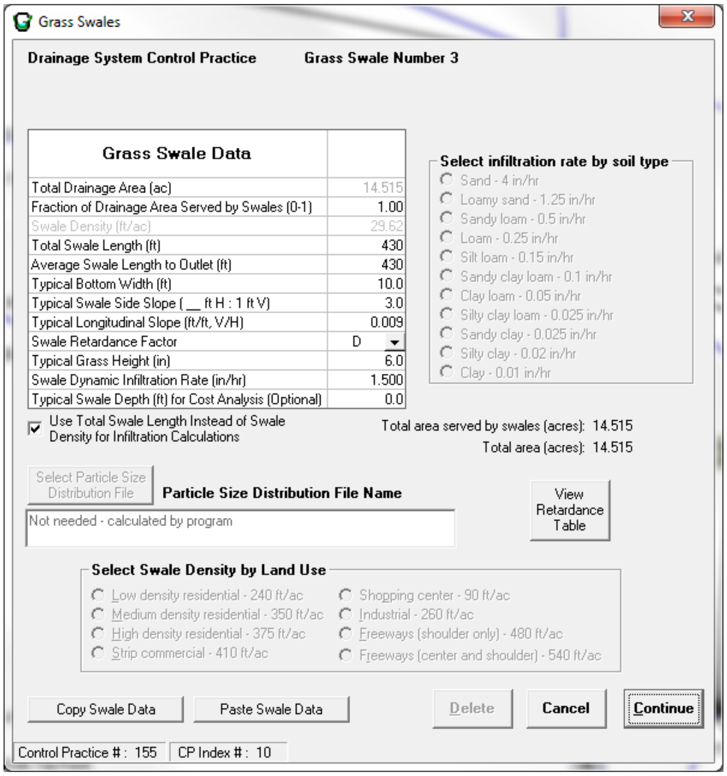

Figure 13: DOT grass swale in catchment PC-5 WinSLAMM model inputs

Stormwater Ponds and Wetlands

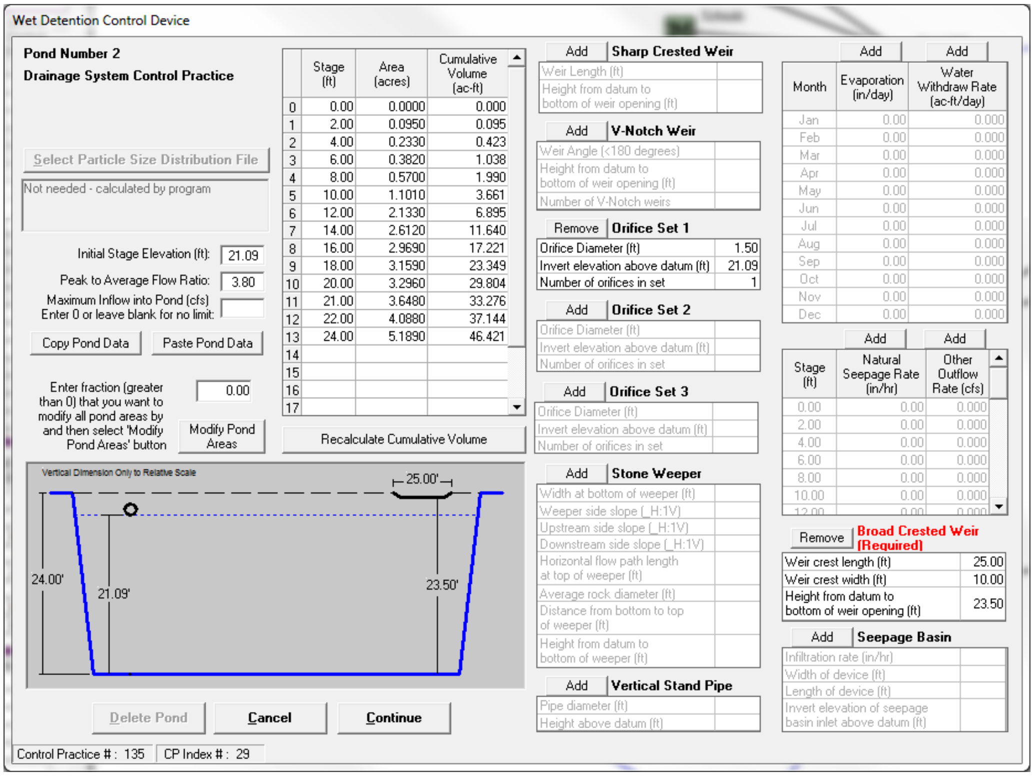

Figure 14: Stormwater pond 302 in catchment PC-1 WinSLAMM model inputs

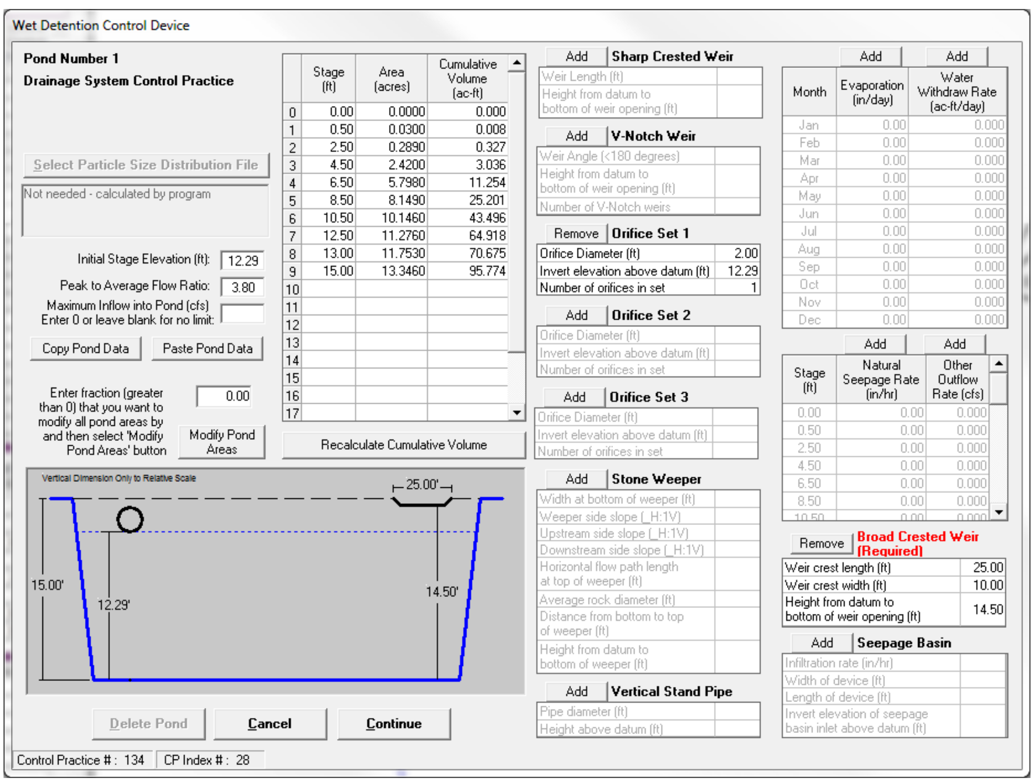

Figure 15: Stormwater pond 301 in catchment PC-1 WinSLAMM model inputs

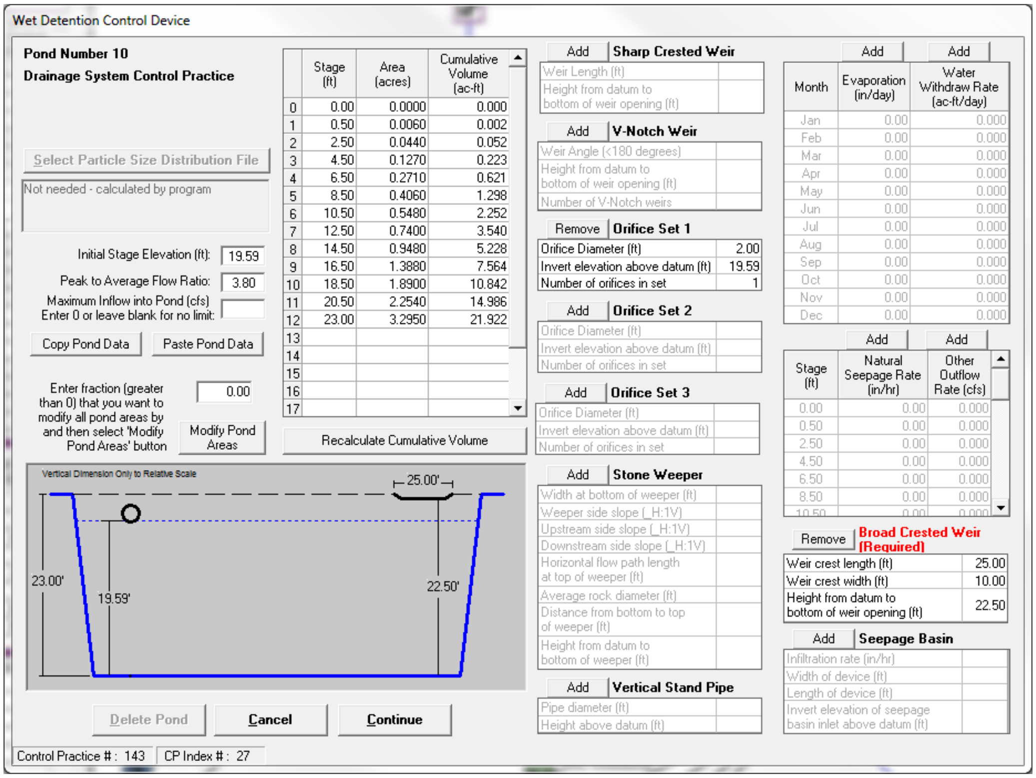

Figure 16: Stormwater pond 318 in catchment PC-1 WinSLAMM model inputs

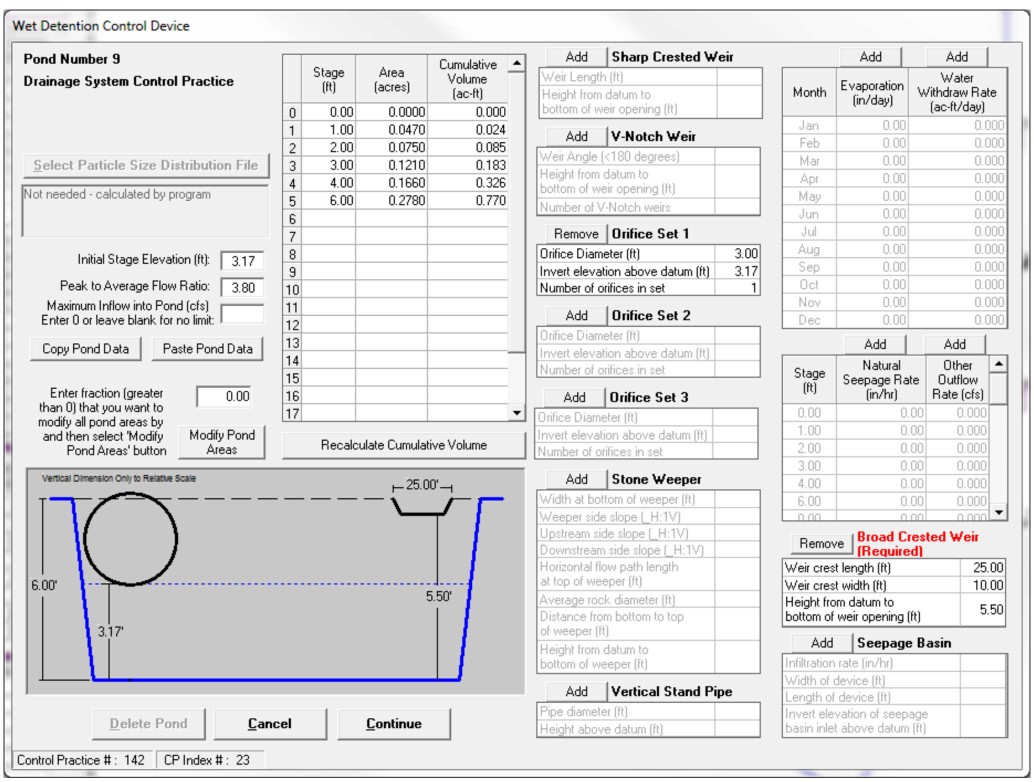

Figure 17: Stormwater pond 316 in catchment PC-1 WinSLAMM model inputs.

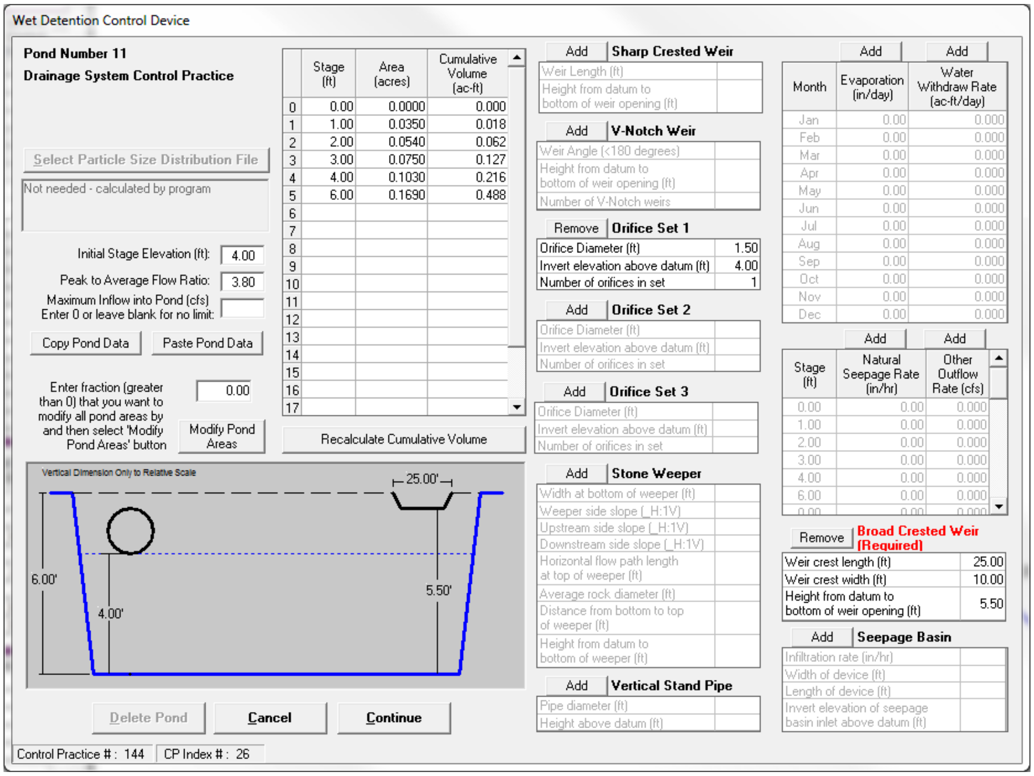

Figure 18: Stormwater pond PC1 catchment PC-1 WinSLAMM model inputs.

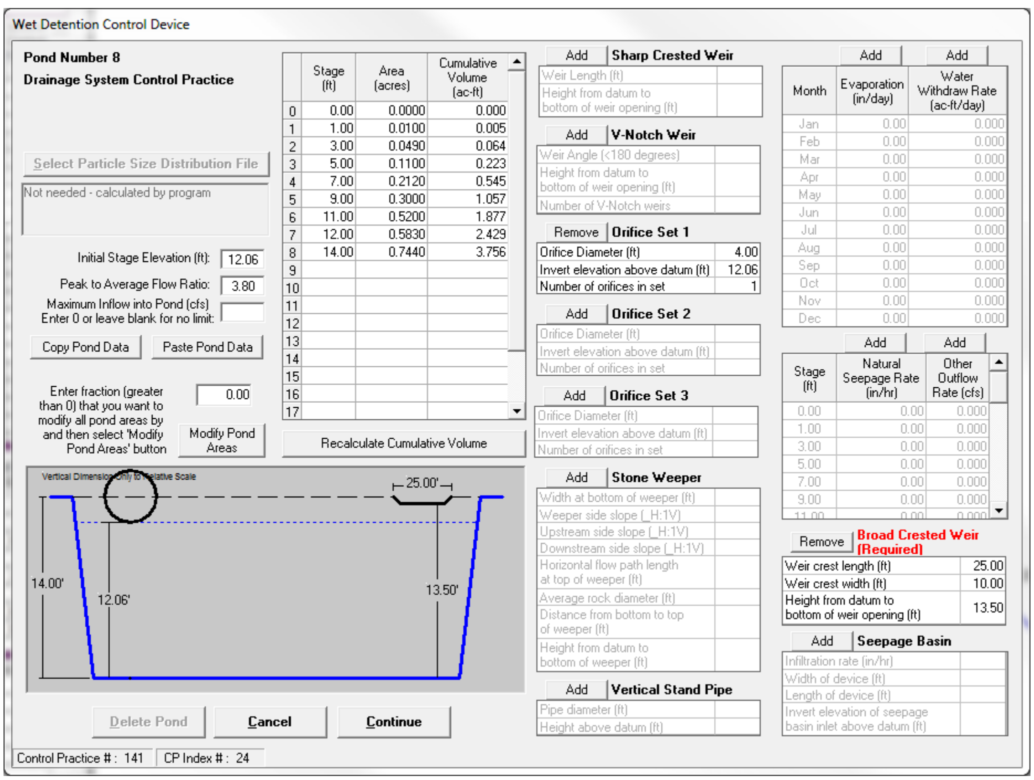

Figure 19: Stormwater pond 314 in catchment PC-1 WinSLAMM model inputs.

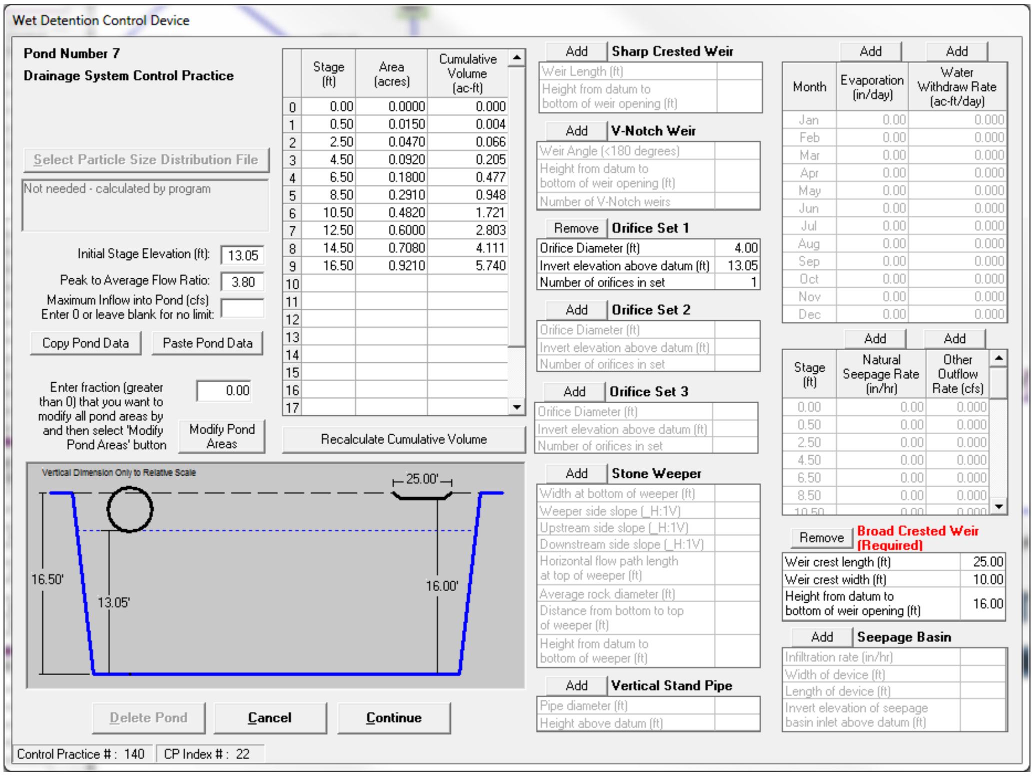

Figure 20: Stormwater pond 313 in catchment PC-1 WinSLAMM model inputs.

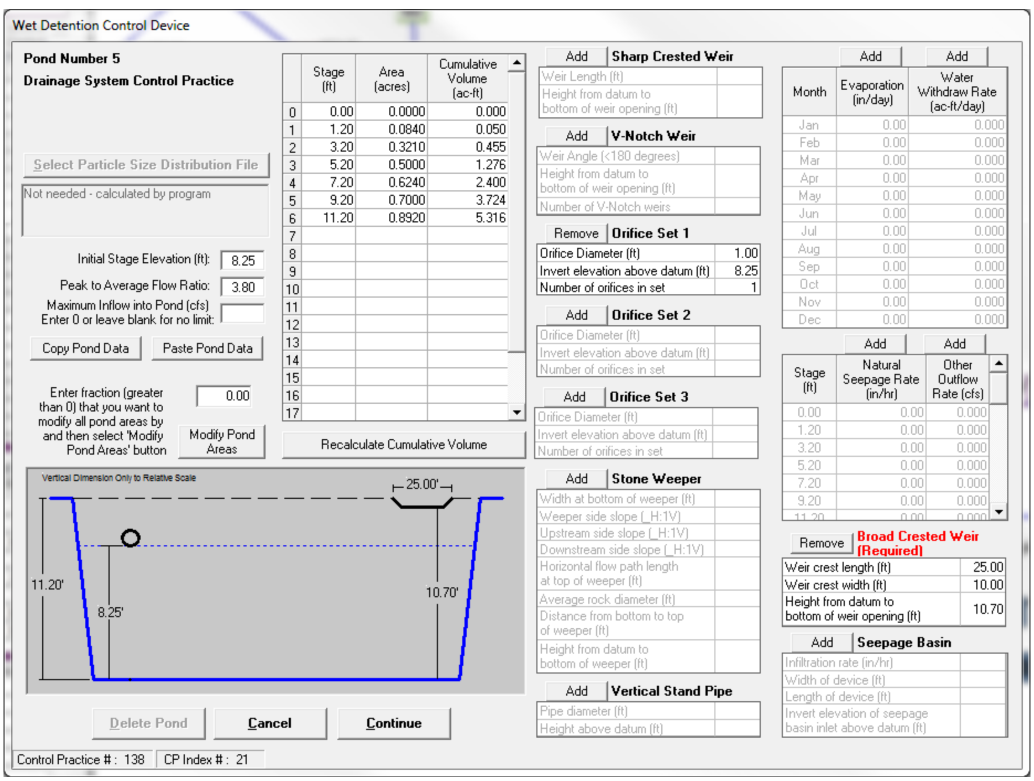

Figure 21: Stormwater pond 311 in catchment PC-1 WinSLAMM model inputs.

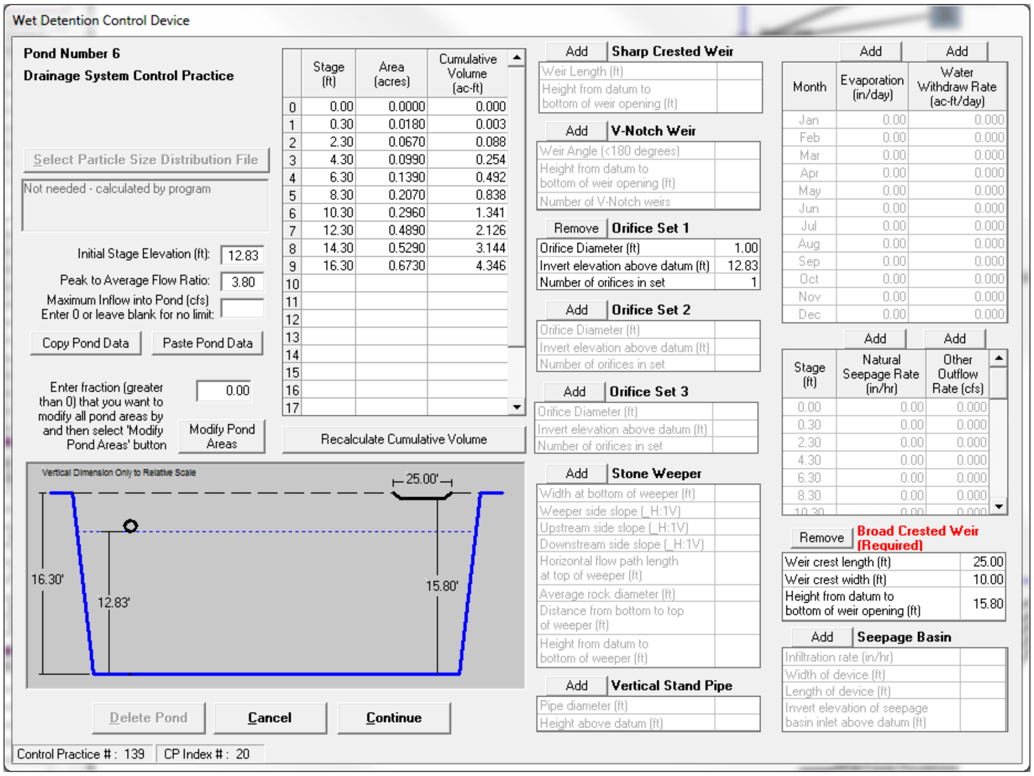

Figure 22: Stormwater pond 312 in catchment PC-1 WinSLAMM model inputs.

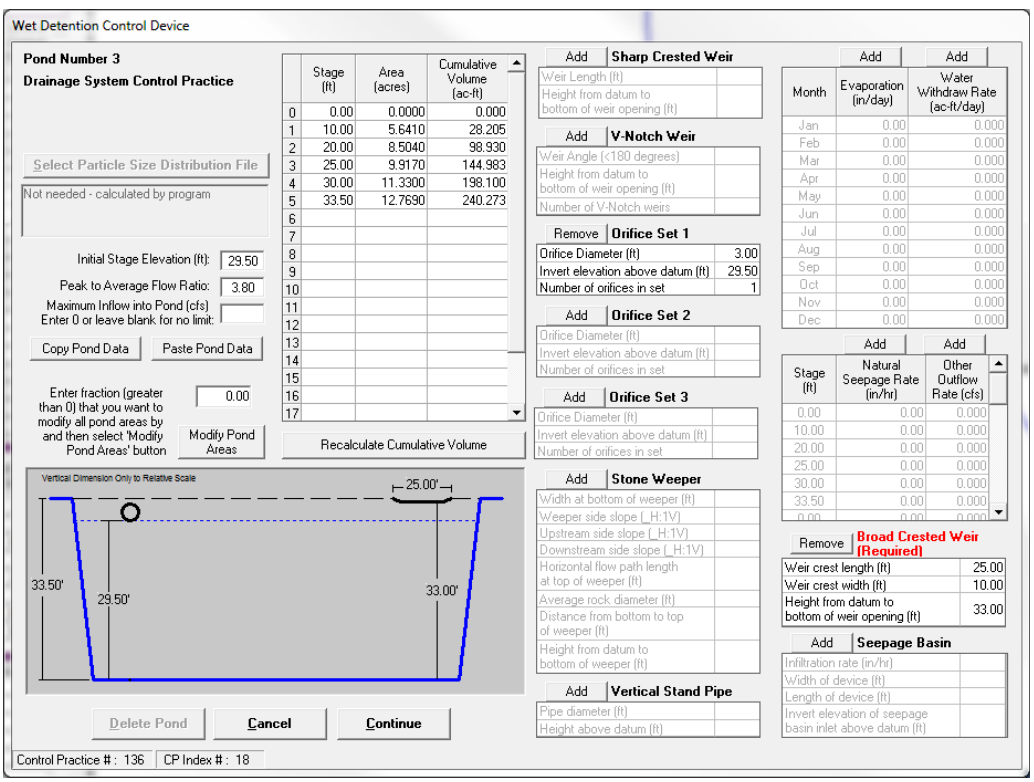

Figure 23: Stormwater pond 303 in catchment PC-1 WinSLAMM model inputs.

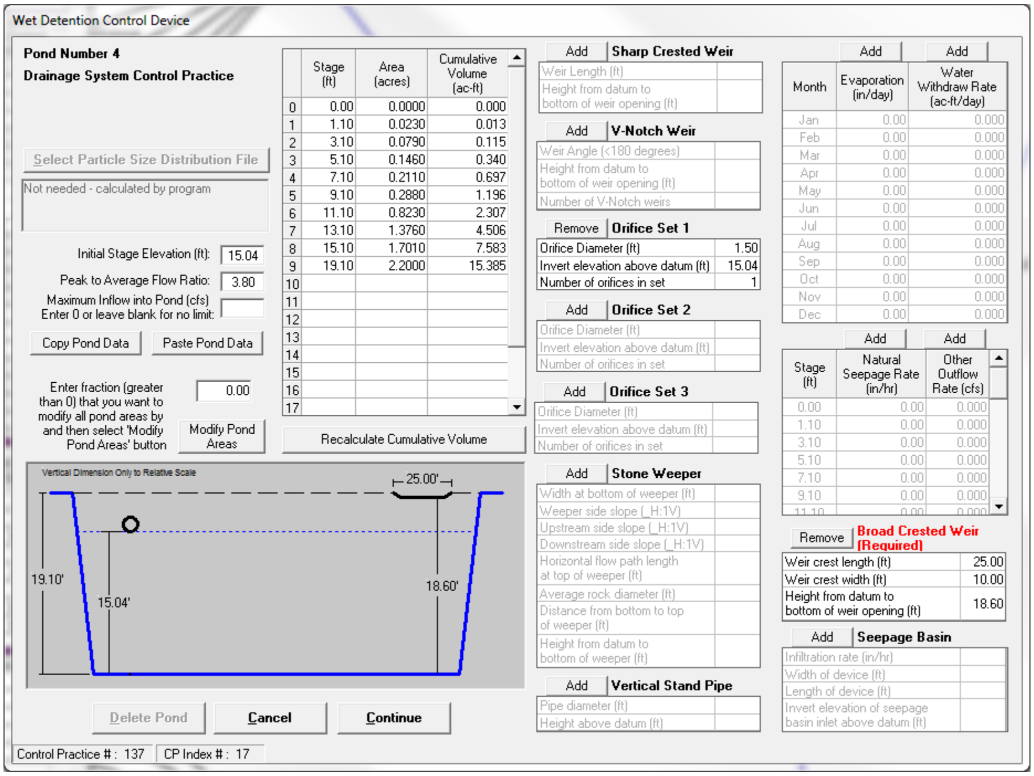

Figure 24: Stormwater pond 310 in catchment PC-1 WinSLAMM model inputs.

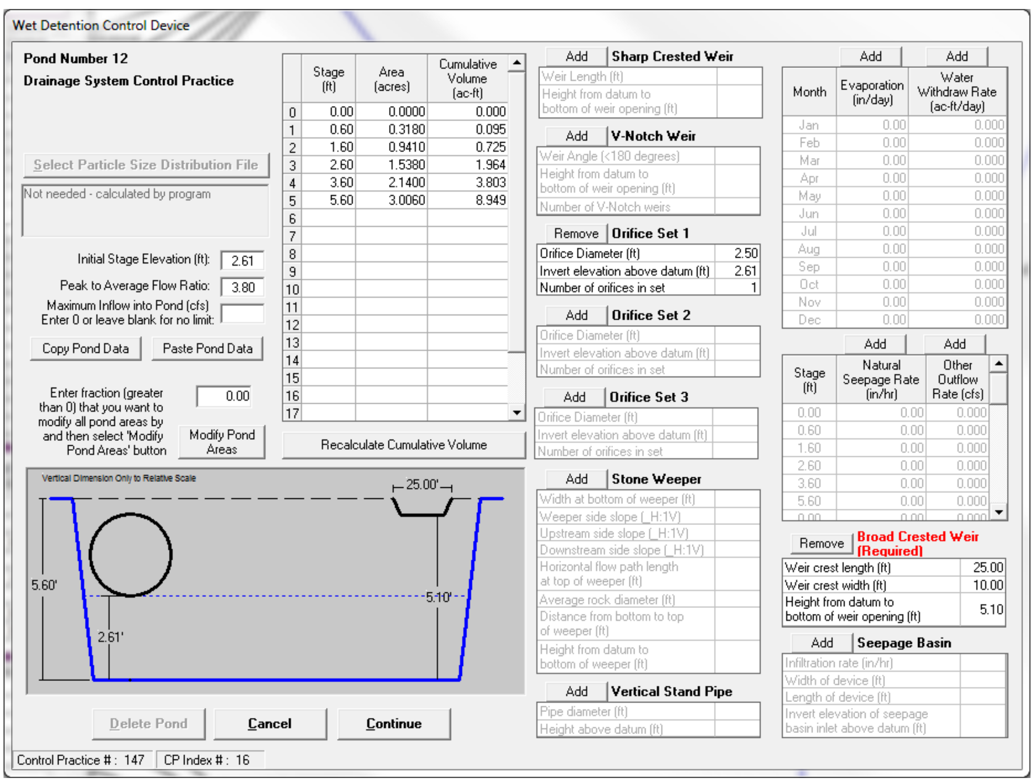

Figure 25: Stormwater pond 304 in catchment PC-3 WinSLAMM model inputs.

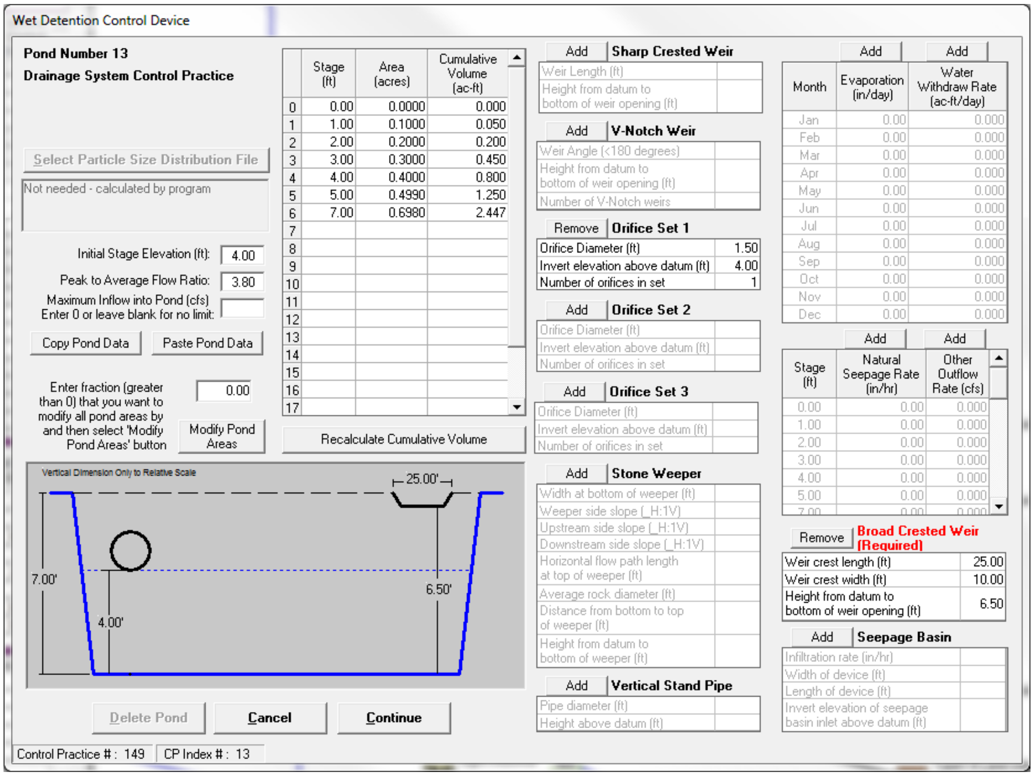

Figure 26: Westwood stormwater pond in catchment PC-5 WinSLAMM model inputs.

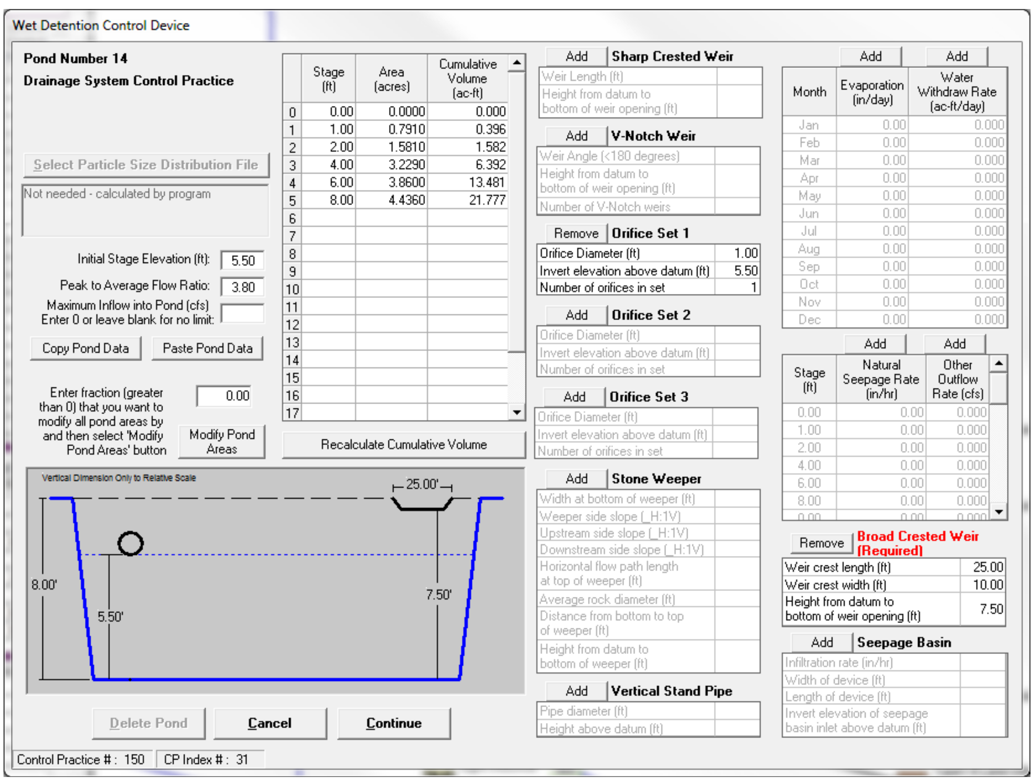

Figure 27: Westwood wetland in catchment PC-5 WinSLAMM model inputs.

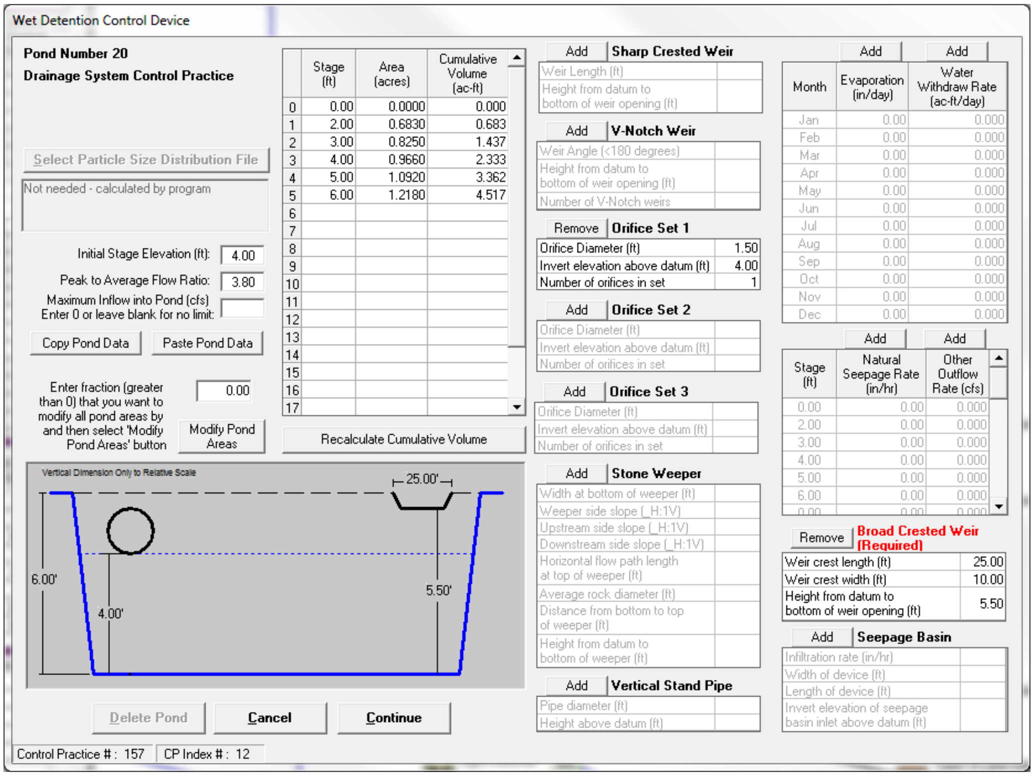

Figure 28: Stormwater pond DOT 5 in catchment PC-5 WinSLAMM model inputs.

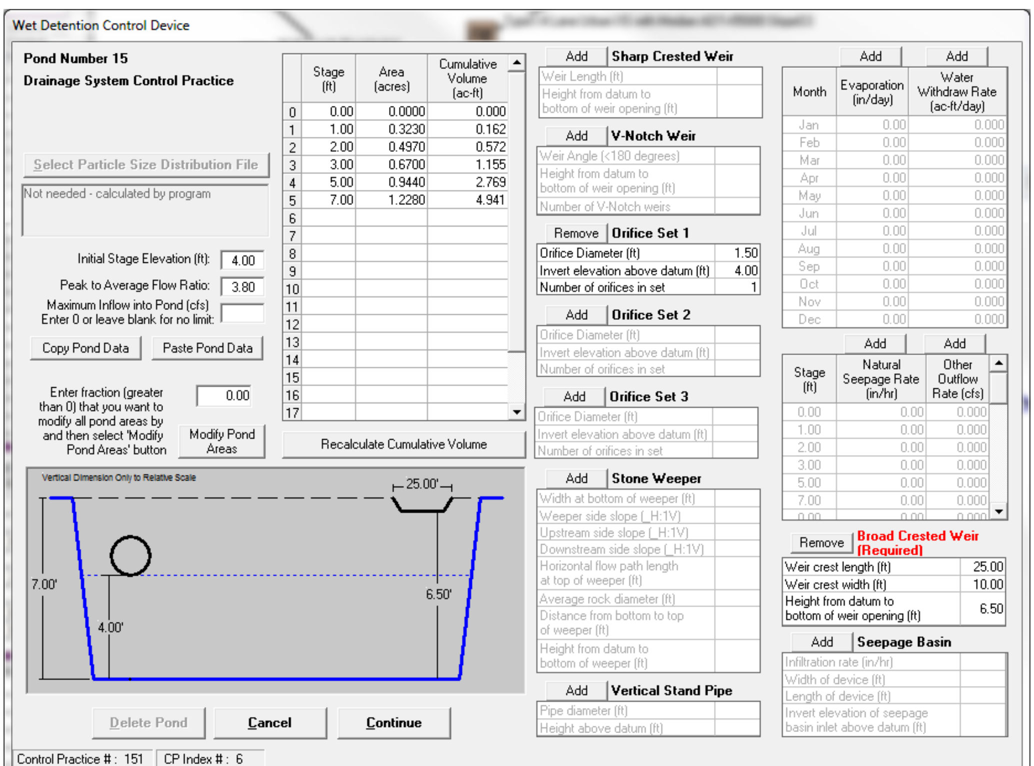

Figure 29: 92nd Lane stormwater pond in catchment PC-5 WinSLAMM model inputs.

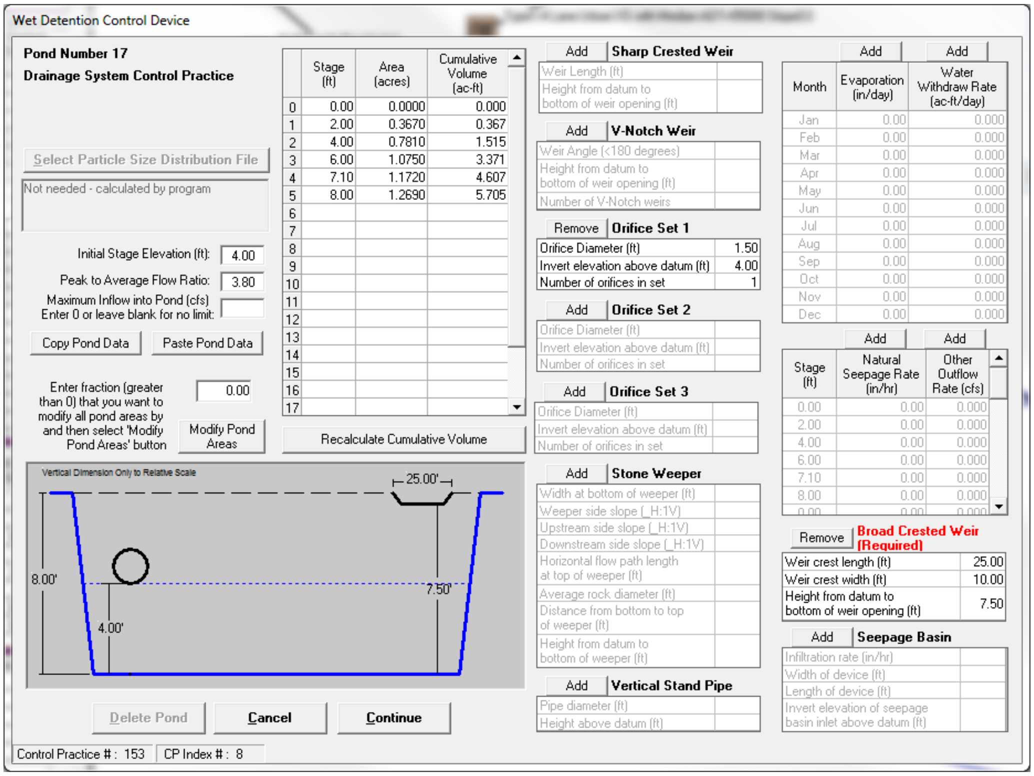

Figure 30: Stormwater pond DOT 2 in catchment PC-5 WinSLAMM model inputs.

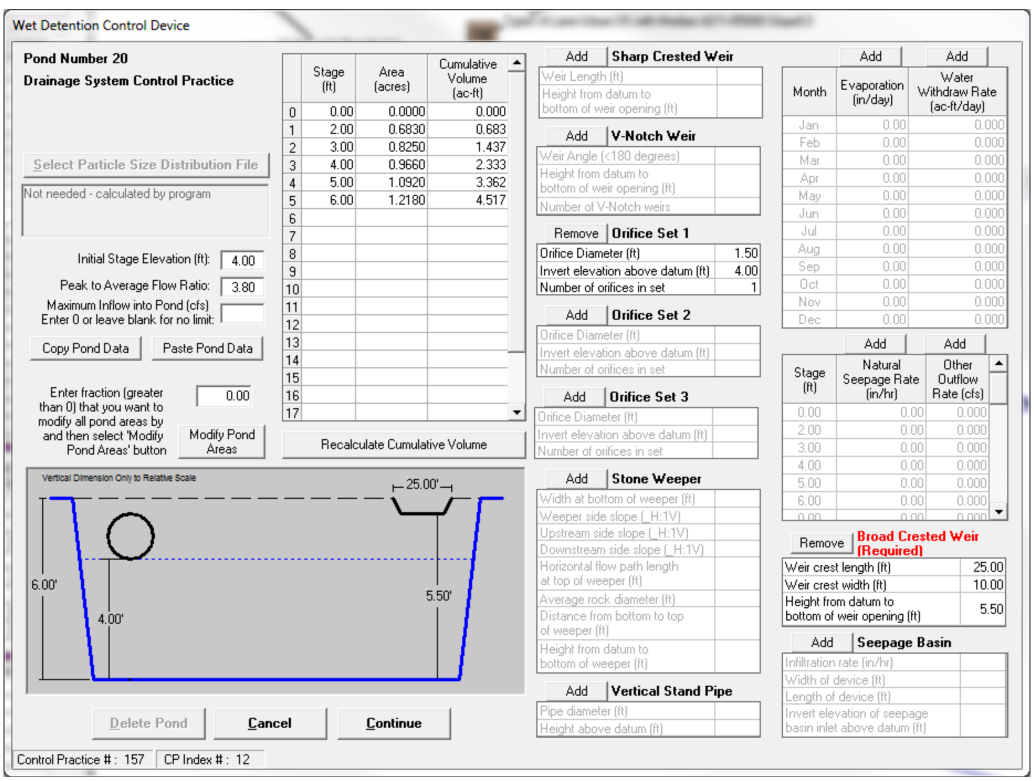

Figure 31: Stormwater pond DOT 5 in catchment PC-5 WinSLAMM model inputs.

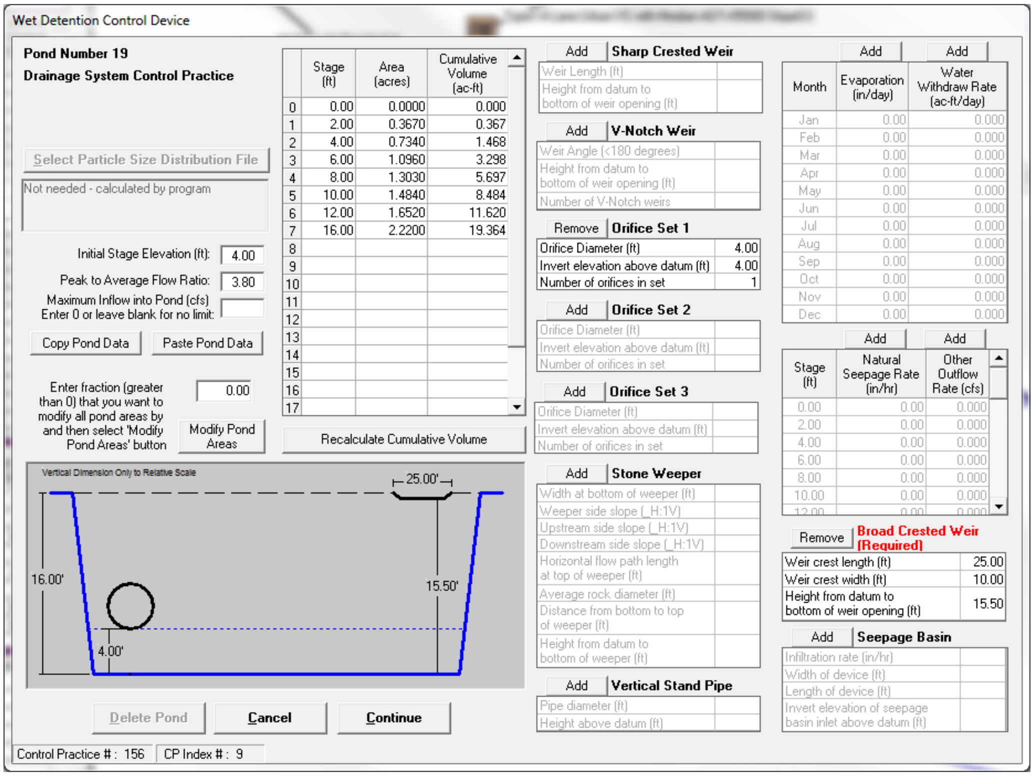

Figure 32: Stormwater pond DOT 4 in catchment PC-5 WinSLAMM model inputs.

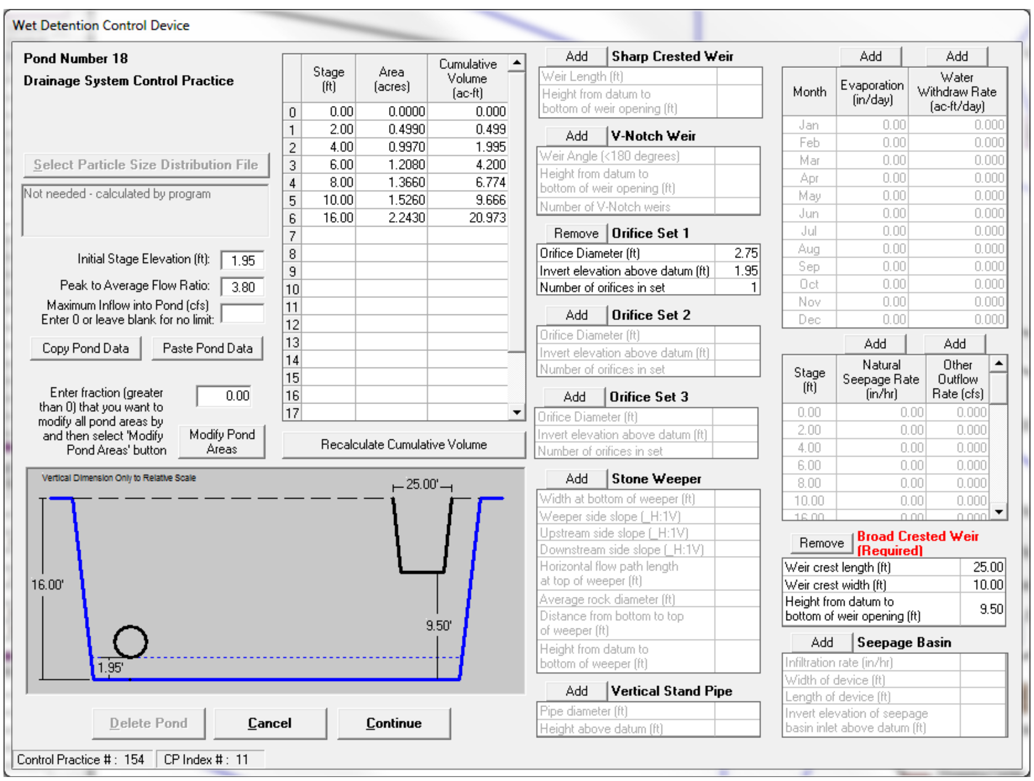

Figure 33: Stormwater pond DOT 3 in catchment PC-5 WinSLAMM model inputs.

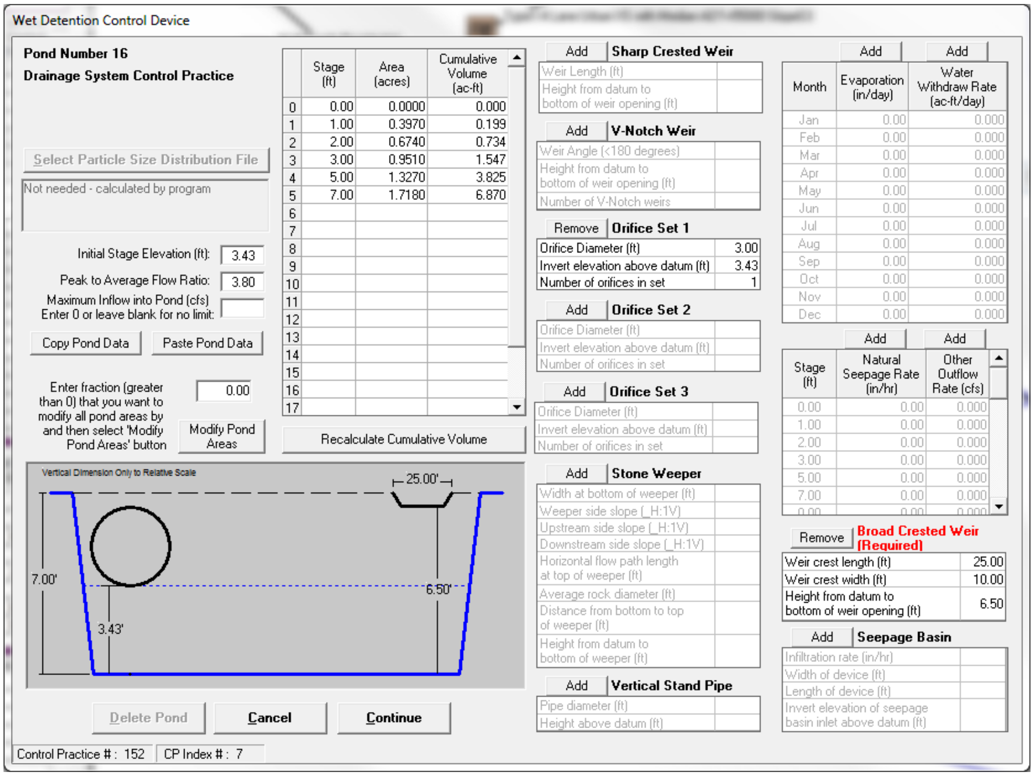

Figure 34: Stormwater pond DOT 1 in catchment PC-5 WinSLAMM model inputs.

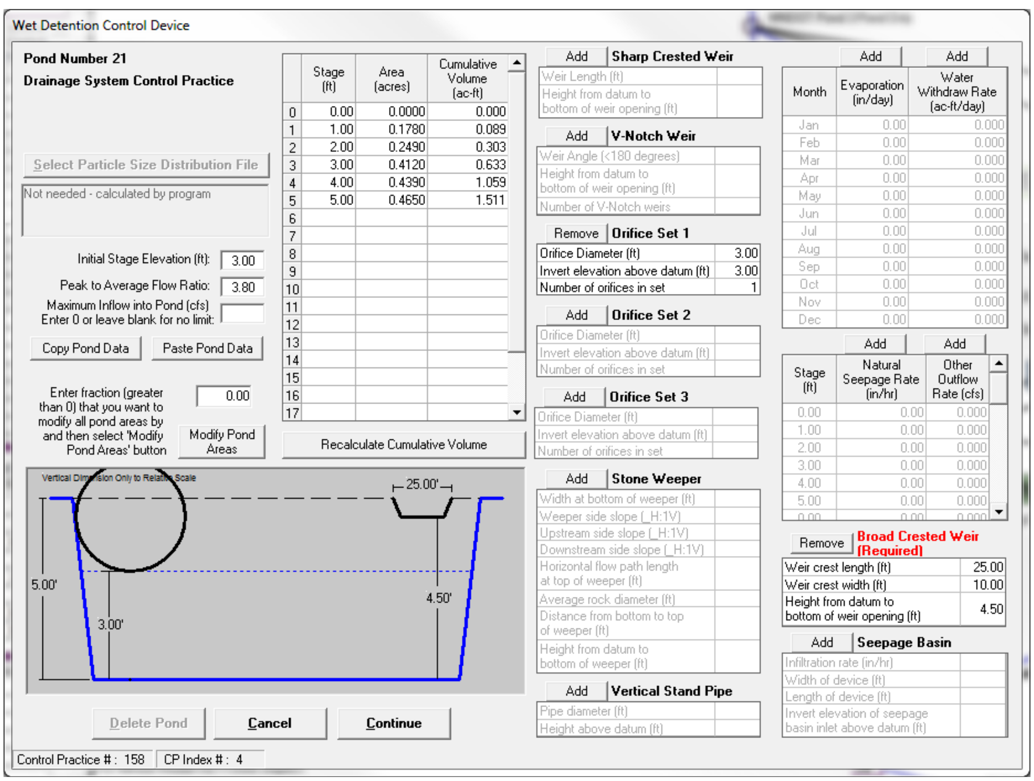

Figure 35: In Town Suites stormwater pond in catchment PC-6 WinSLAMM model inputs.

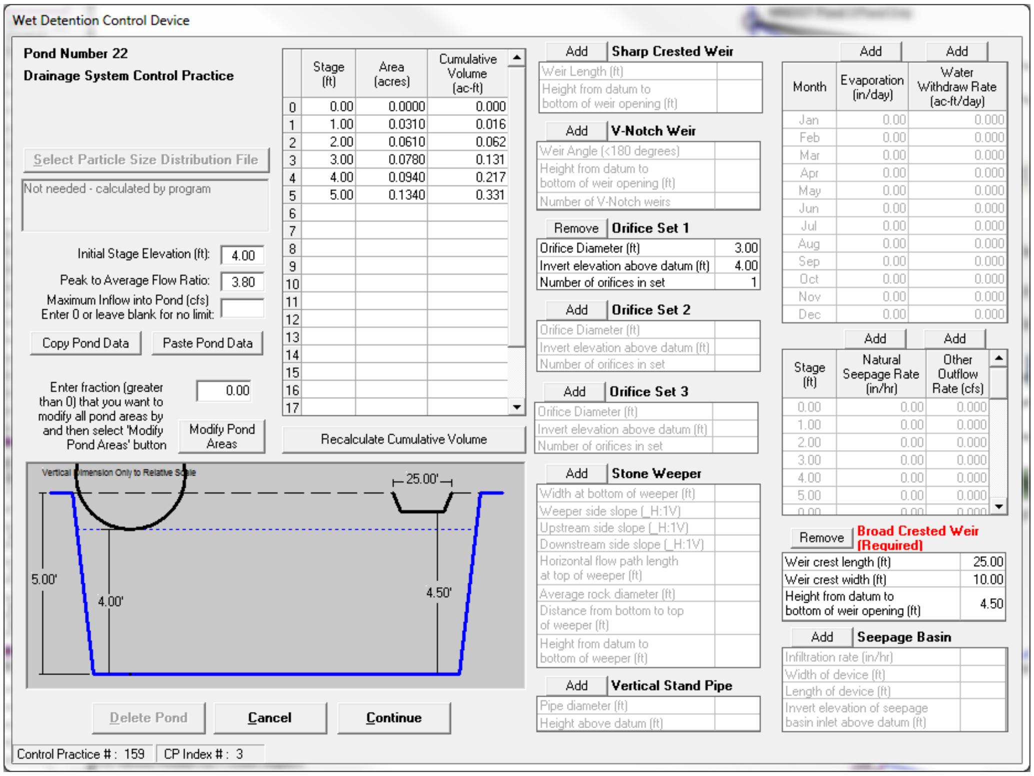

Figure 36: Kwik Trip stormwater pond in catchment PC-7 WinSLAMM model inputs.

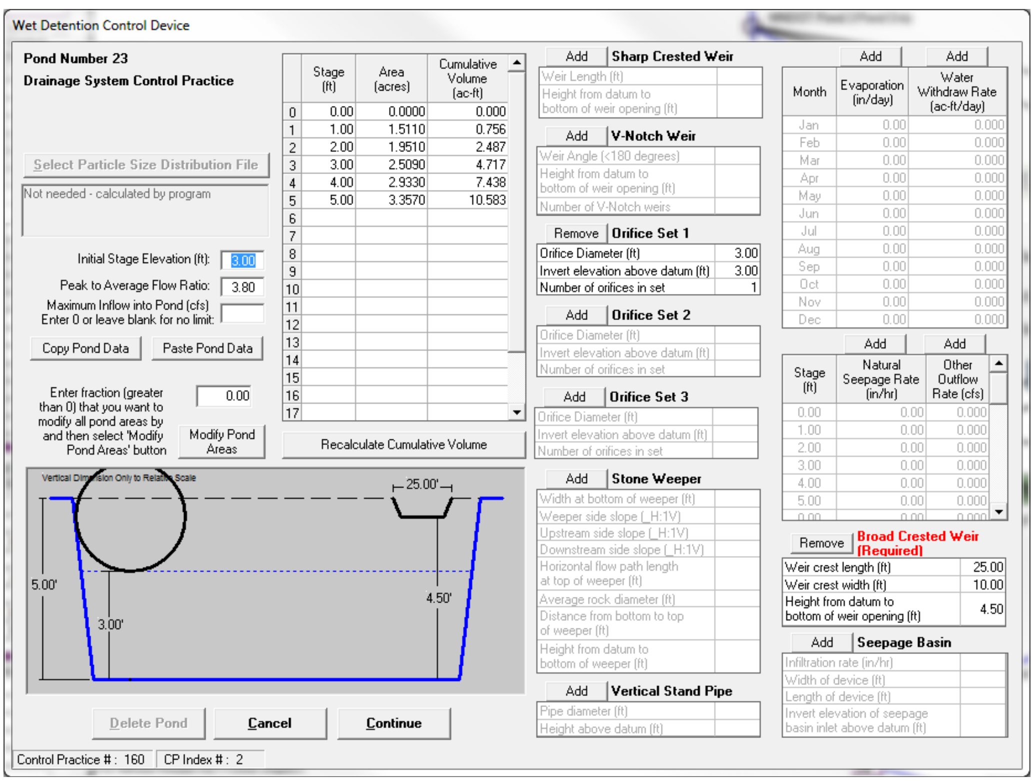

Figure 37: Industrial Park stormwater pond in catchment PC-7 WinSLAMM model inputs.

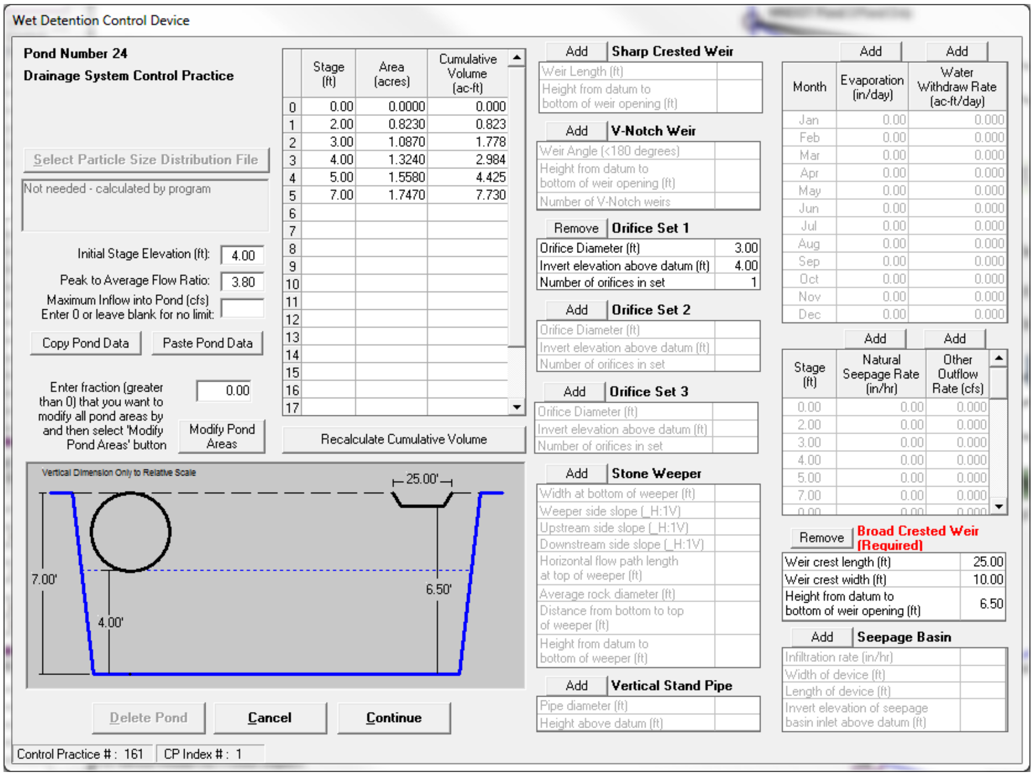

Figure 38: GB Packaging stormwater pond in catchment PC-7 WinSLAMM model inputs.

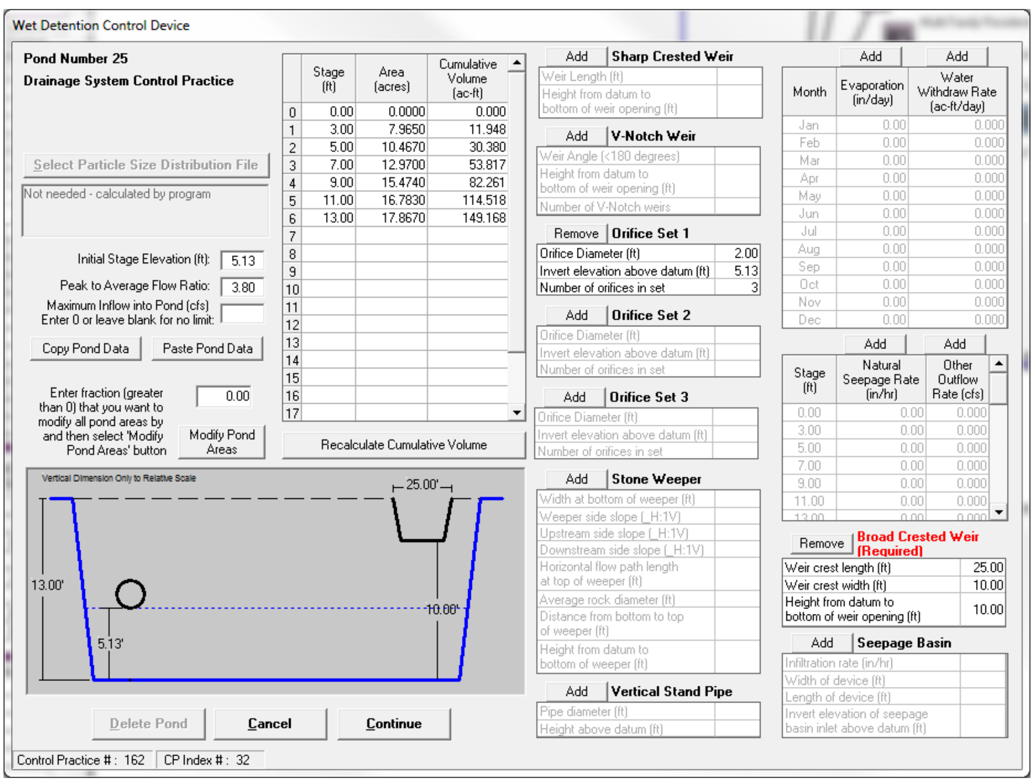

Figure 39: Pleasure Creek north stormwater pond in catchment PC-7 WinSLAMM model inputs.

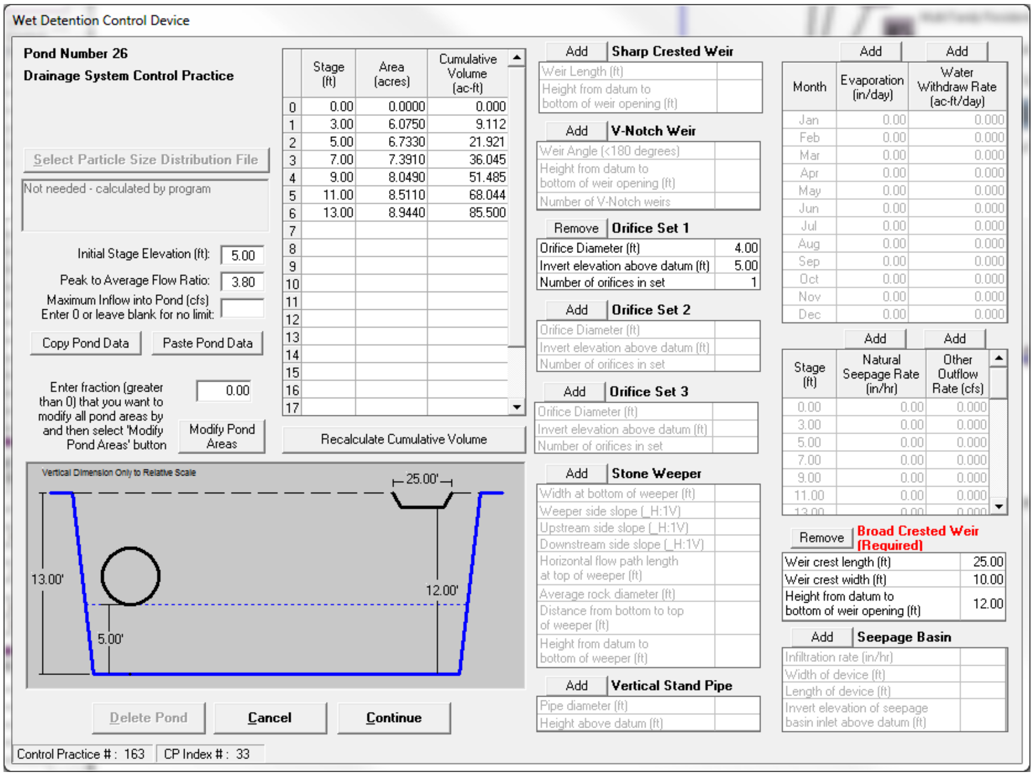

Figure 40: Pleasure Creek south stormwater pond in catchment PC-7 WinSLAMM model inputs.

Street Cleaning

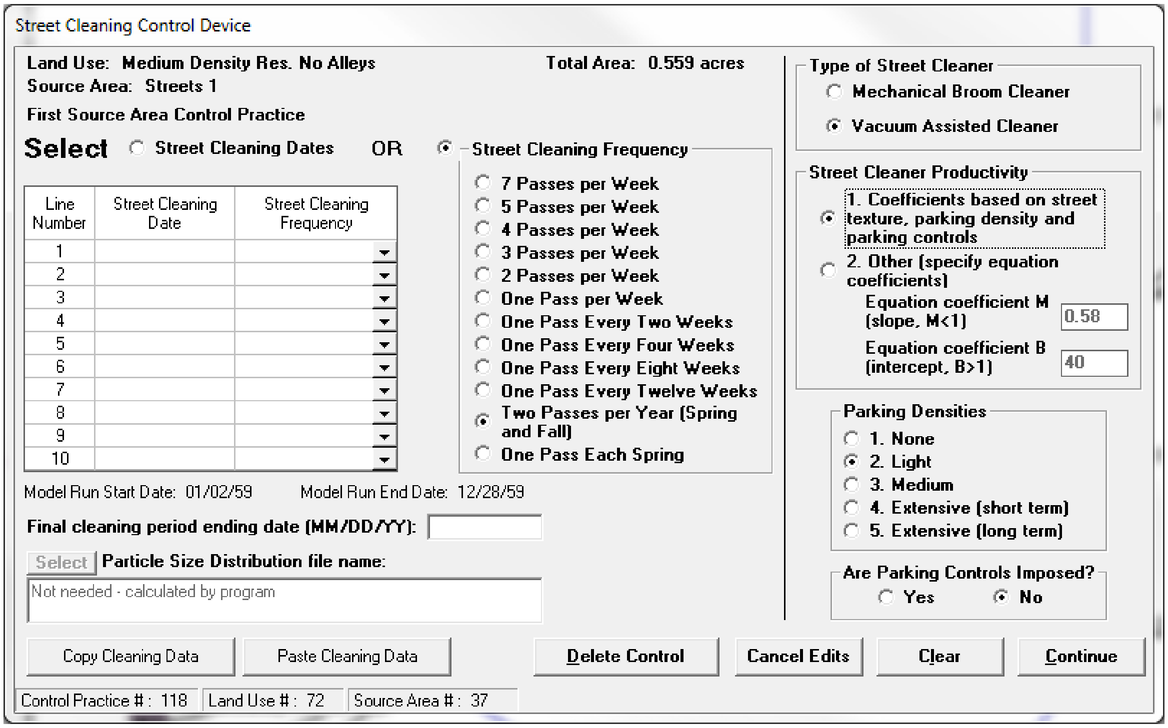

Figure 41: Street Cleaning (City of Blaine) WinSLAMM model inputs

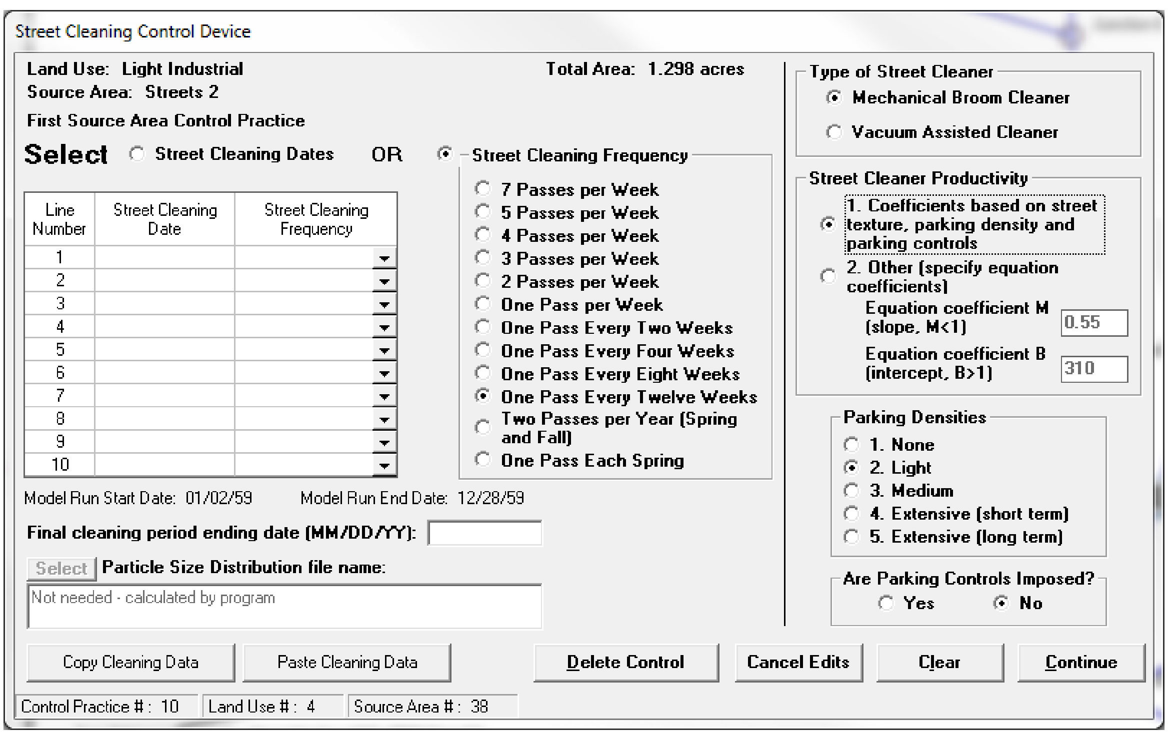

Figure 42: Street Cleaning (City of Coon Rapids) WinSLAMM model inputs

Proposed Conditions

Curb-Cut Rain Garden

Curb-cut rain gardens were modeled as drainage area control practices within WinSLAMM. Table 19 describes specific input parameters for rain gardens in the WinSLAMM model. Figure 43 shows the WinSLAMM biofiltration parameter input screen.

Table 19: 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
Engineered 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

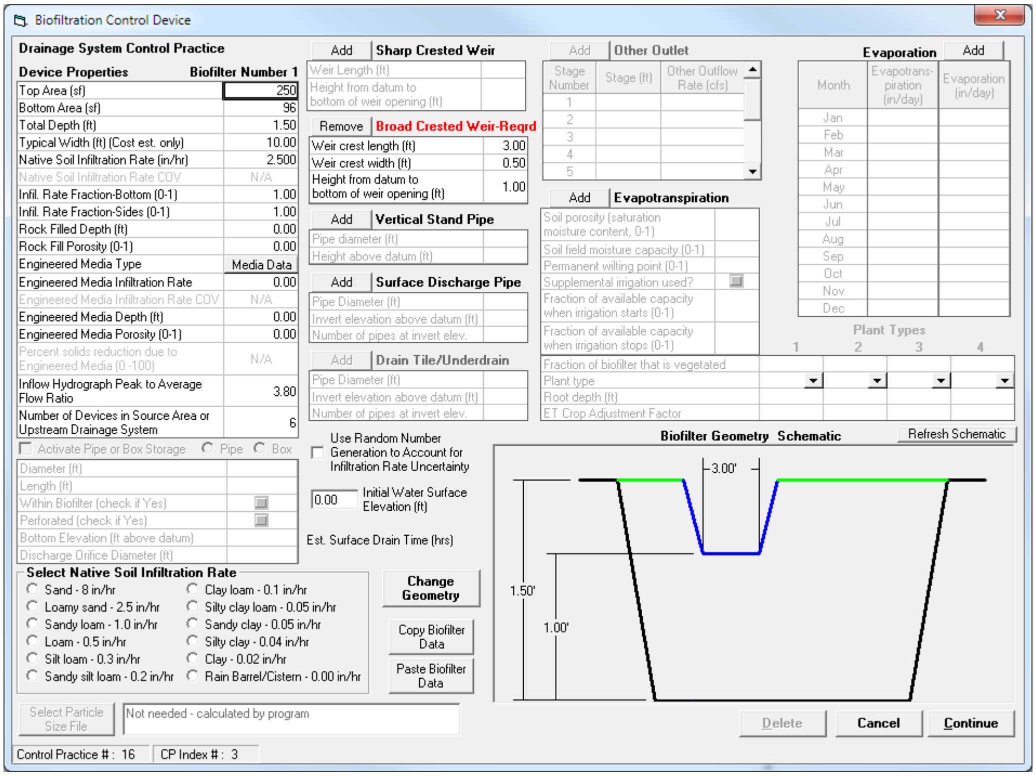

Figure 43: Bioinfiltration Control Practice Input Screen: Curb-cut Rain Garden (WinSLAMM)

Infiltration Basin

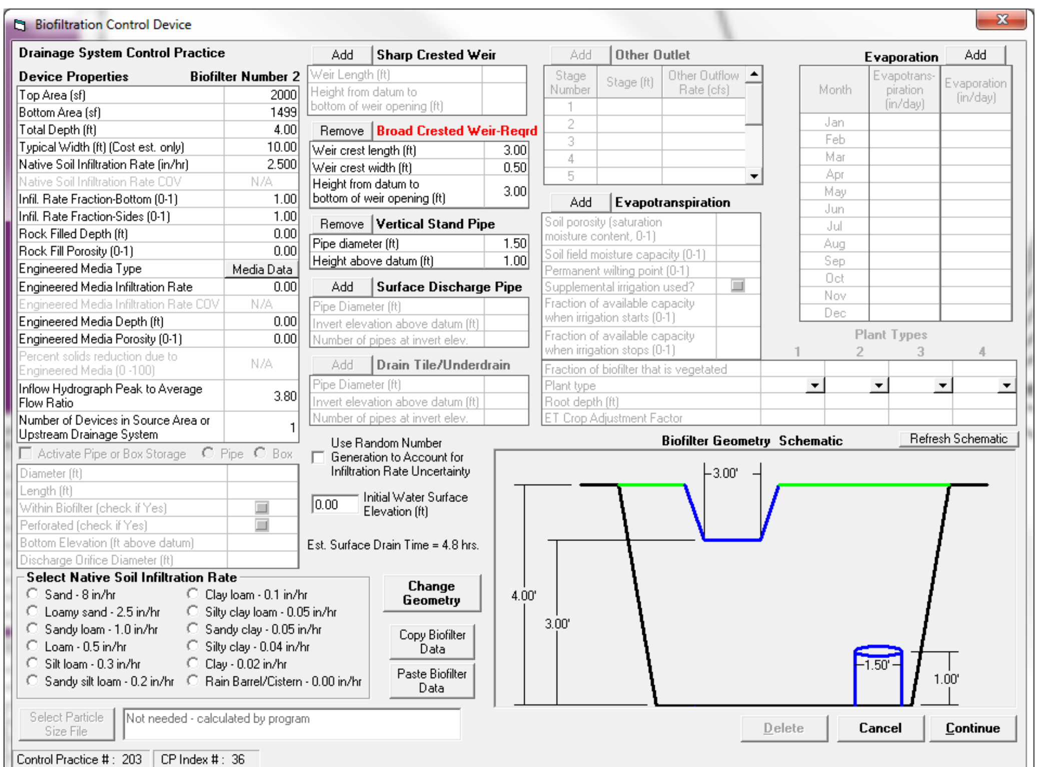

Figure 44: WinSLAMM model inputs for an infiltration basin installed in Swan Park along 98th Lane (Catchment PC-2)

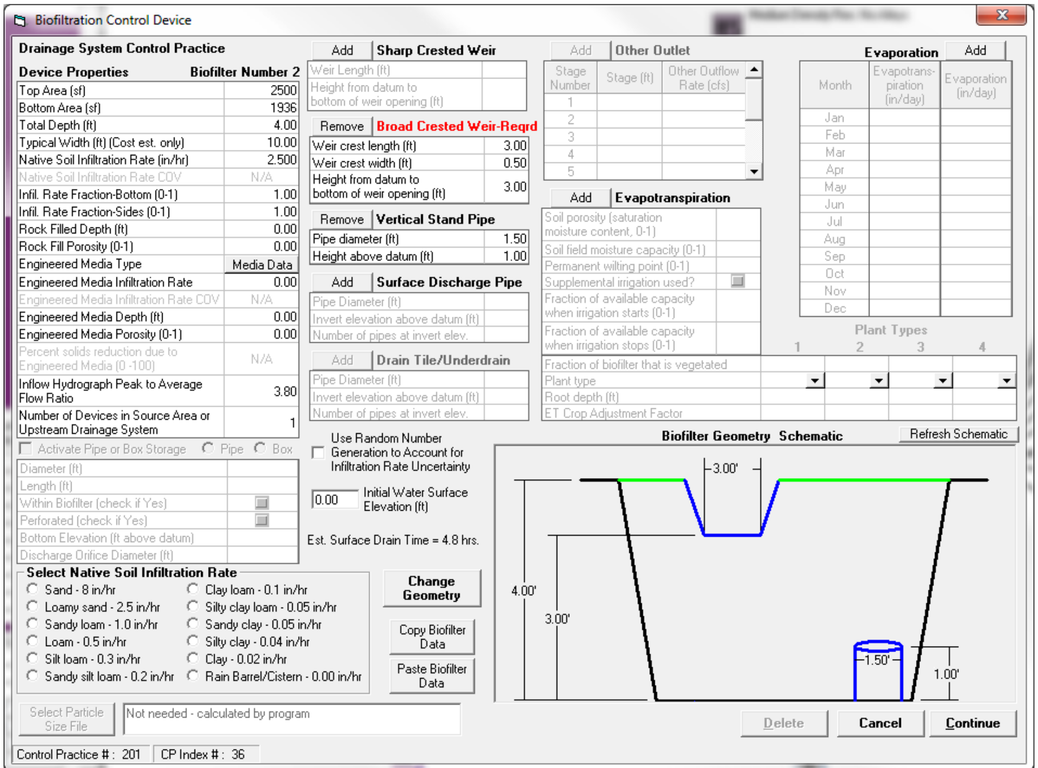

Figure 45: WinSLAMM model inputs for an infiltration basin installed in Swan Park on 97th Ln. (Catchment PC-2)

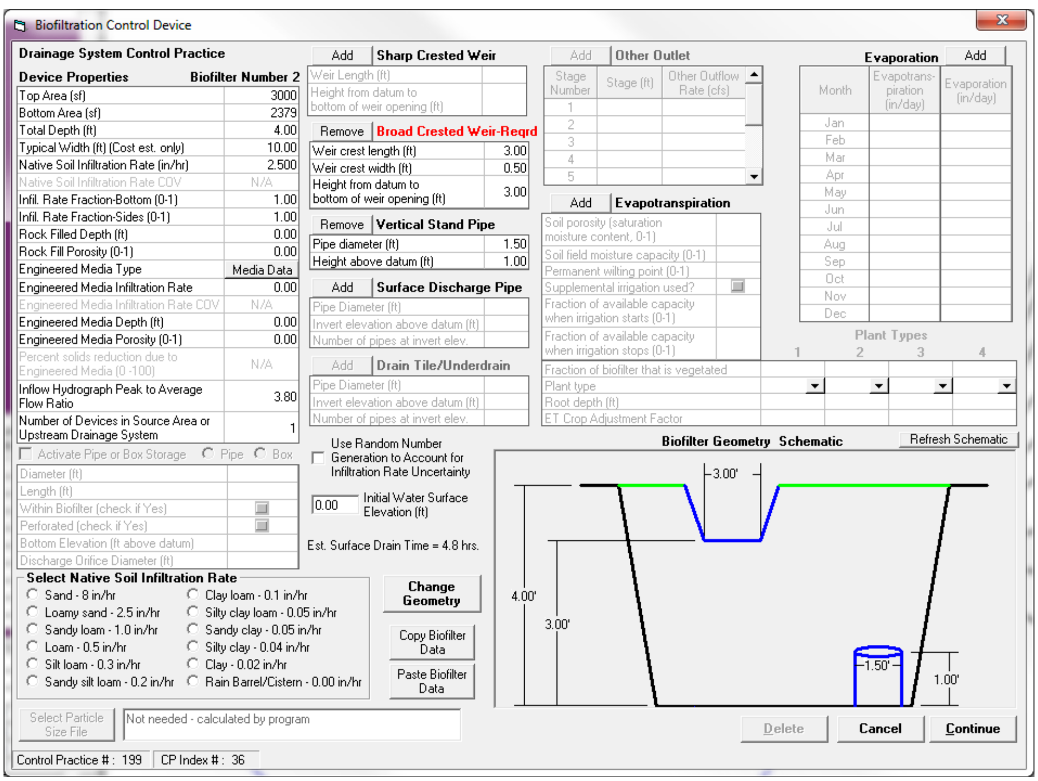

Figure 46: WinSLAMM model inputs for an infiltration basin installed along 96th Ln. (Catchment PC-2)

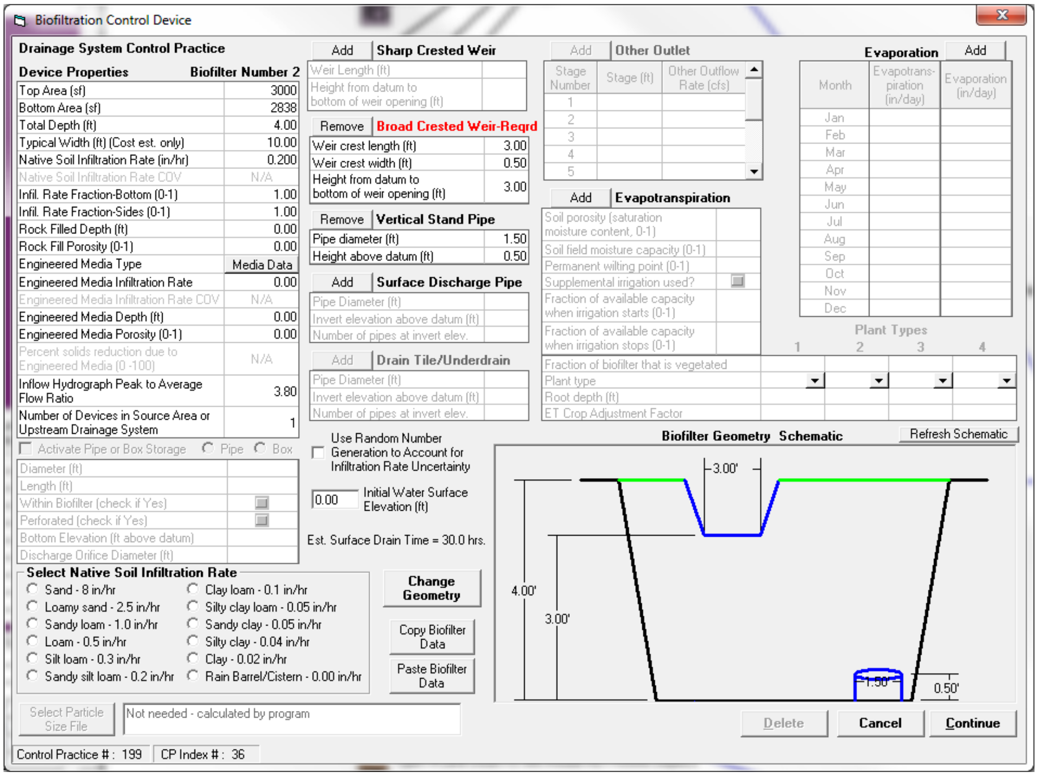

Figure 47: WinSLAMM model inputs for an infiltration basin installed in the southern portion of Van Buren Park (Catchment PC-3)

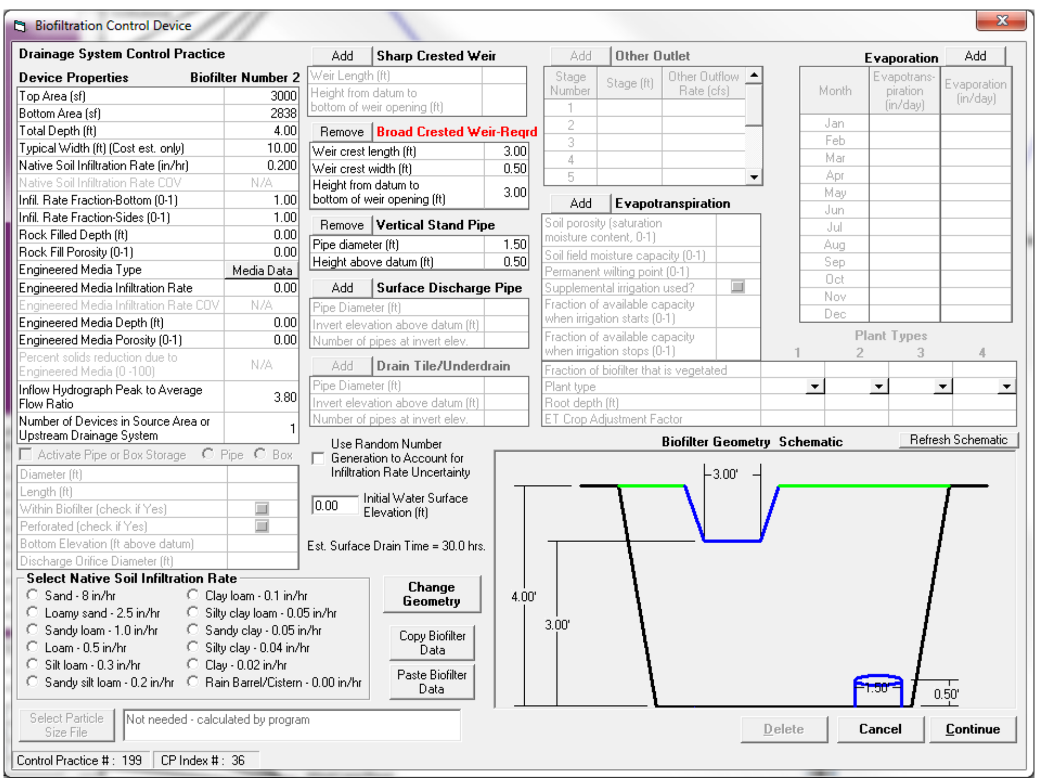

Figure 48: WinSLAMM model inputs for an infiltration basin installed in the northern portion of Van Buren Park (Catchment PC-3)

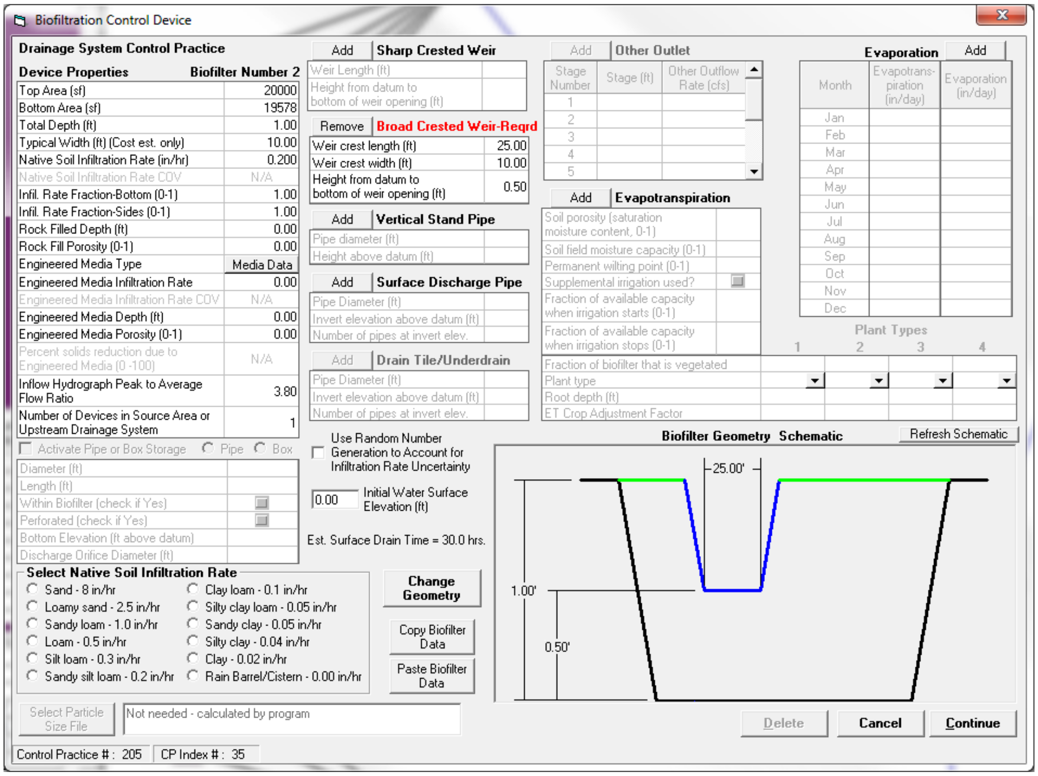

Figure 49: WinSLAMM model inputs for an infiltration basin installed in Cloverleaf Park (Catchment PC-3)

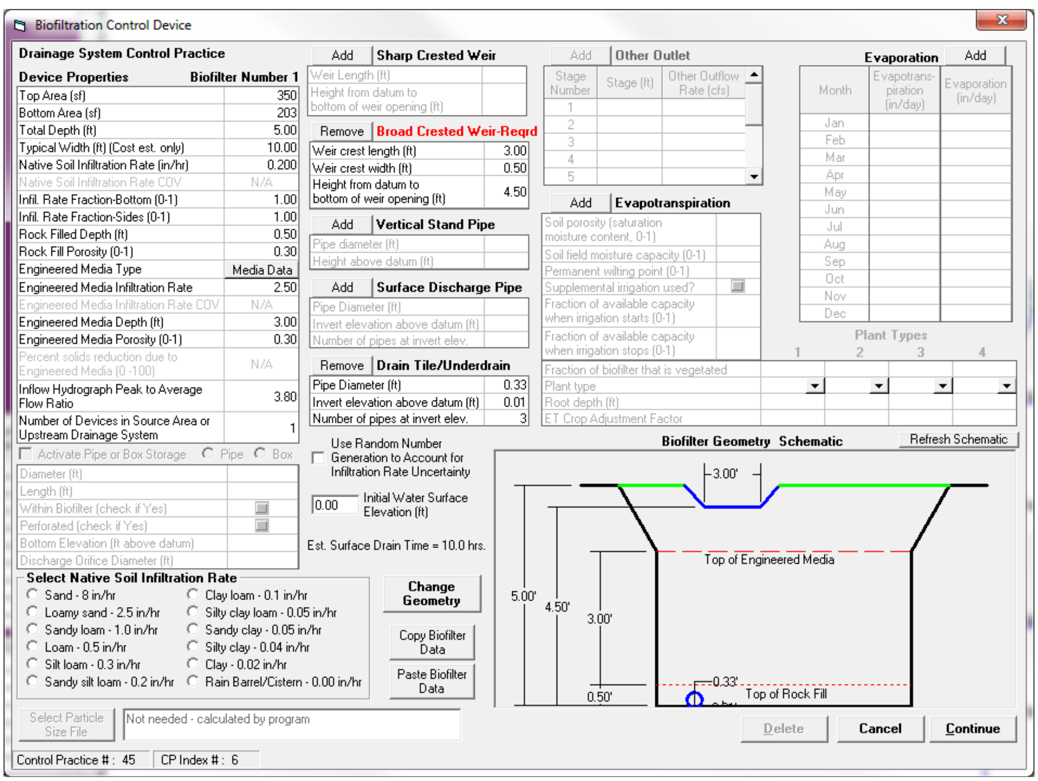

Figure 50: WinSLAMM model inputs for an infiltration basin installed in Catchment PC-8

Hydrodynamic Device

Table 20: Hydrodynamic Device Sizing Criteria. No devices smaller than an 8' diameter were proposed in the Pleasure Creek subwatershed

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

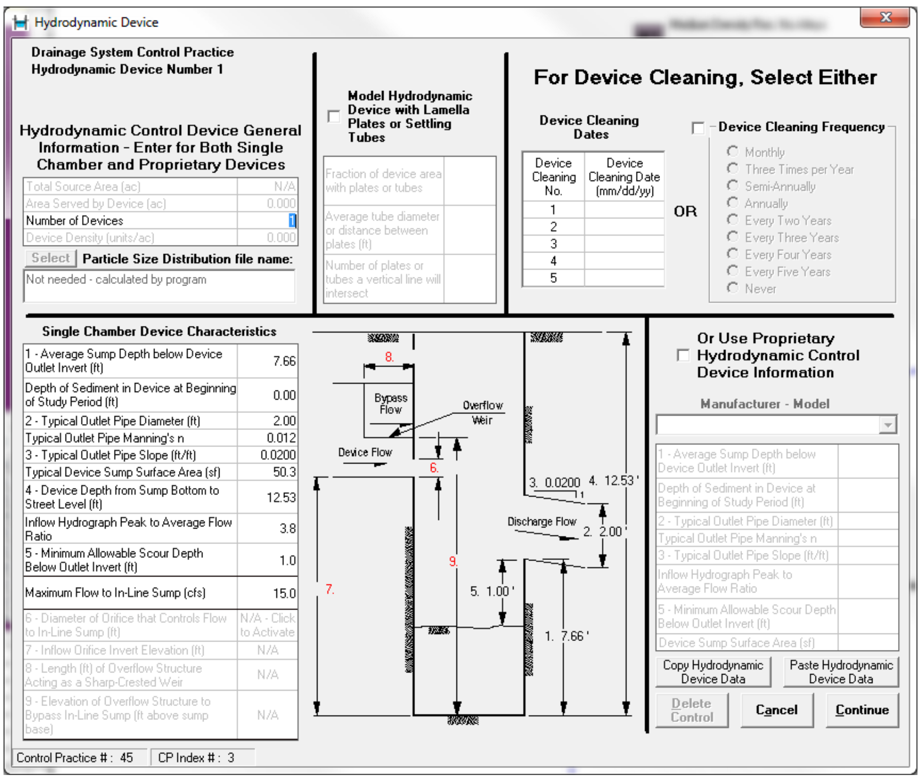

Figure 51: Hydrodynamic Device (8' diam.) WinSLAMM model inputs

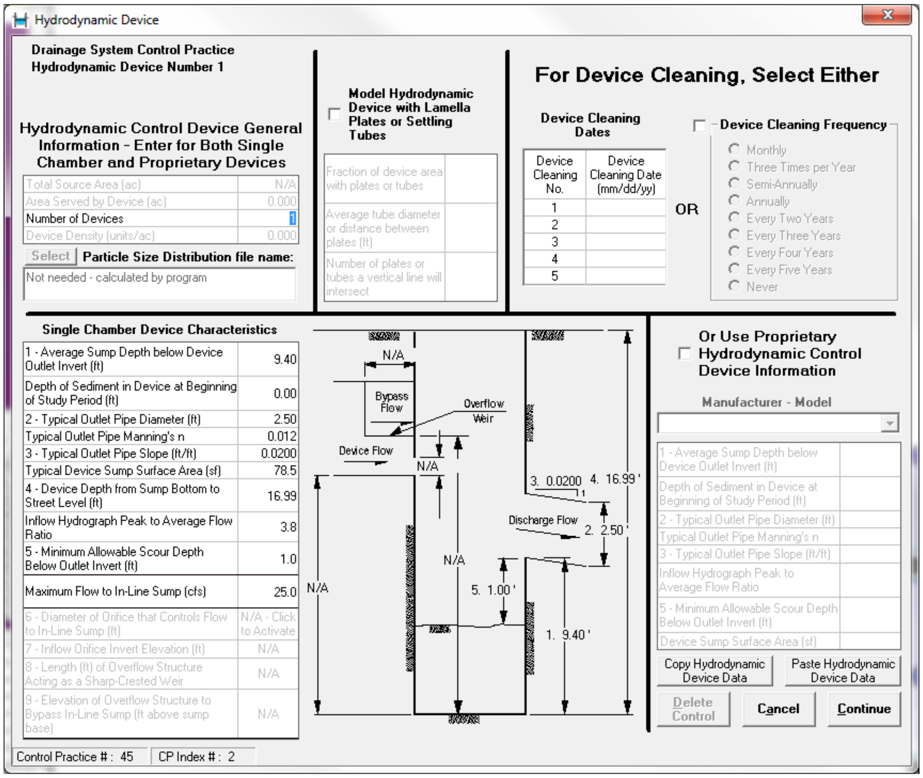

Figure 52: Hydrodynamic Device (10' diam.) WinSLAMM model inputs

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.

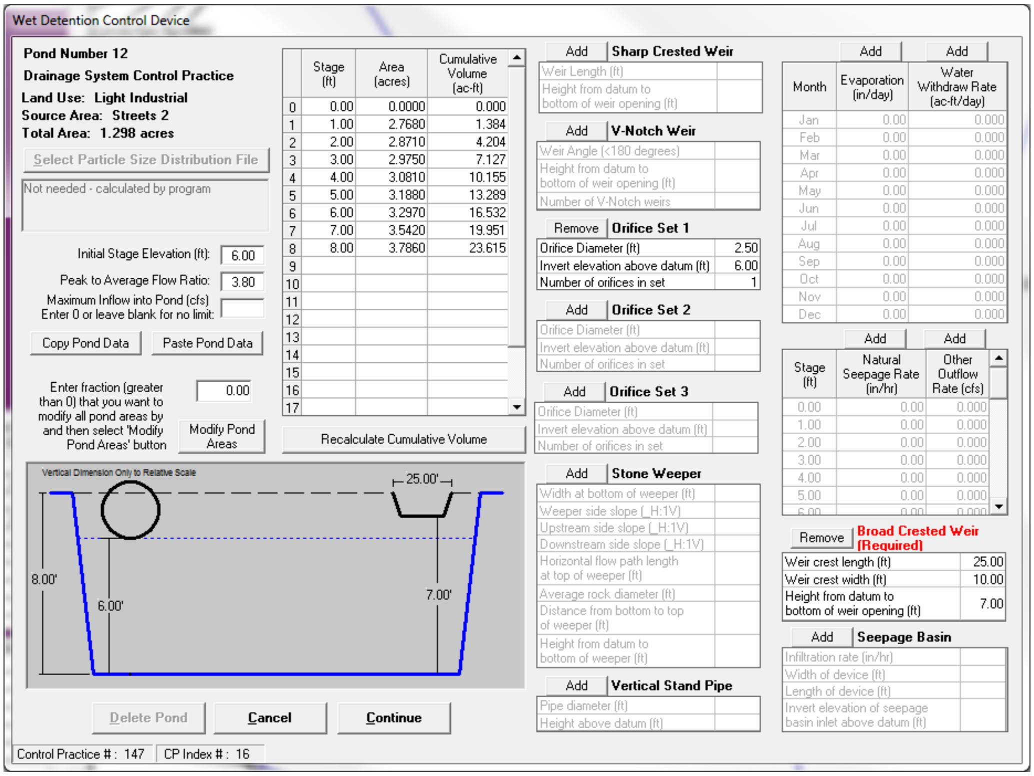

Figure 53: Stormwater pond 304 modification WinSLAMM model inputs (Catchment PC-3)

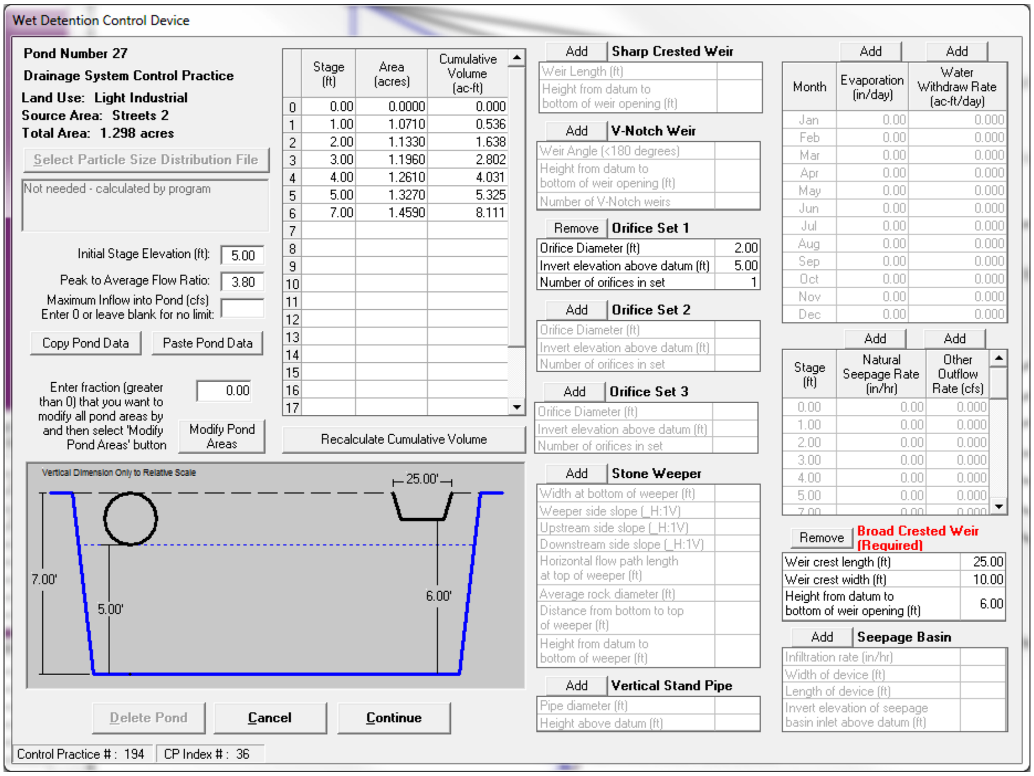

Figure 54: New Evergreen Blvd. stormwater pond WinSLAMM model inputs (Catchment PC-6)

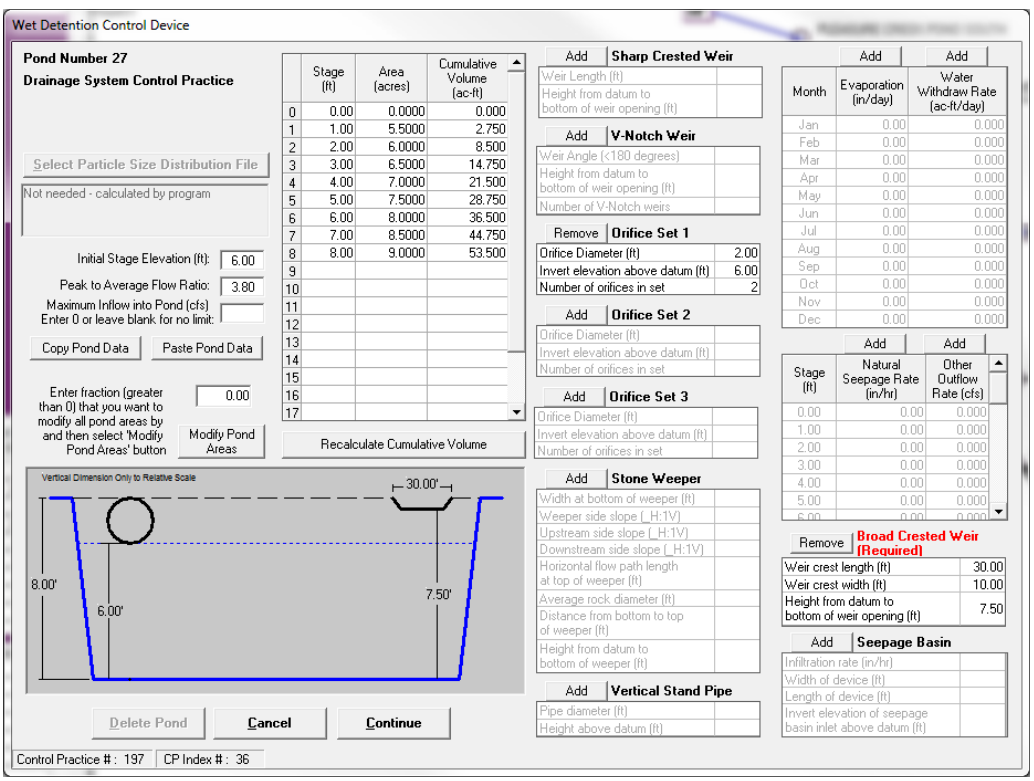

Figure 55: New Mississippi River stormwater pond WinSLAMM model inputs (Catchment PC-9)

Iron-Enhanced Sand Filter Benches

Iron-Enhanced Sand Filter (IESF) benches were proposed along existing ponds requiring additional phosphorus removal. IESFs were sized based on space available and proximity to the existing storm sewer outlet.

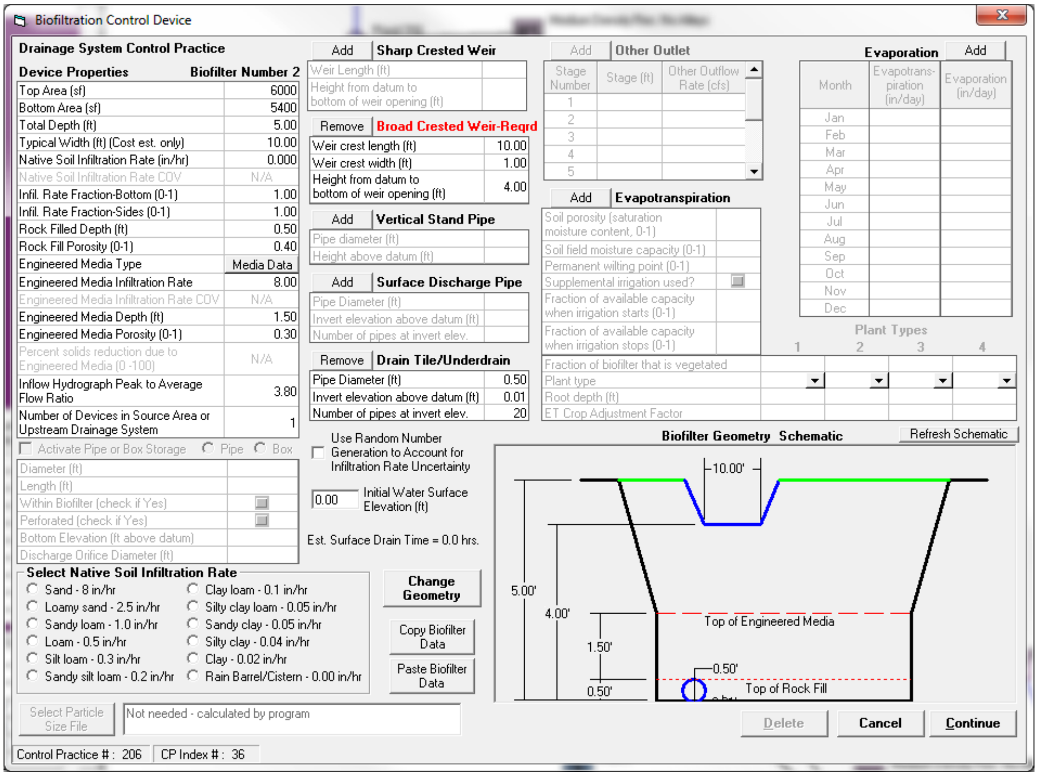

Figure 56: Pond 303 IESF bench (Catchment PC-1) WinSLAMM model inputs

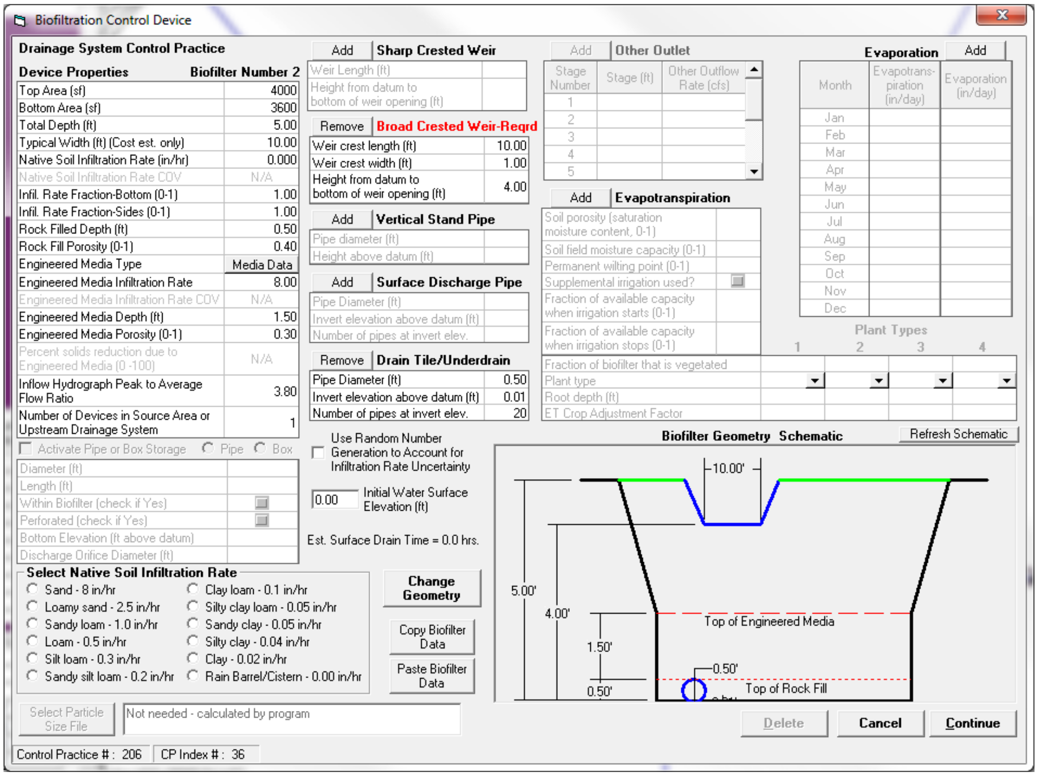

Figure 57: Pond 310 IESF bench (Catchment PC-1) WinSLAMM model inputs

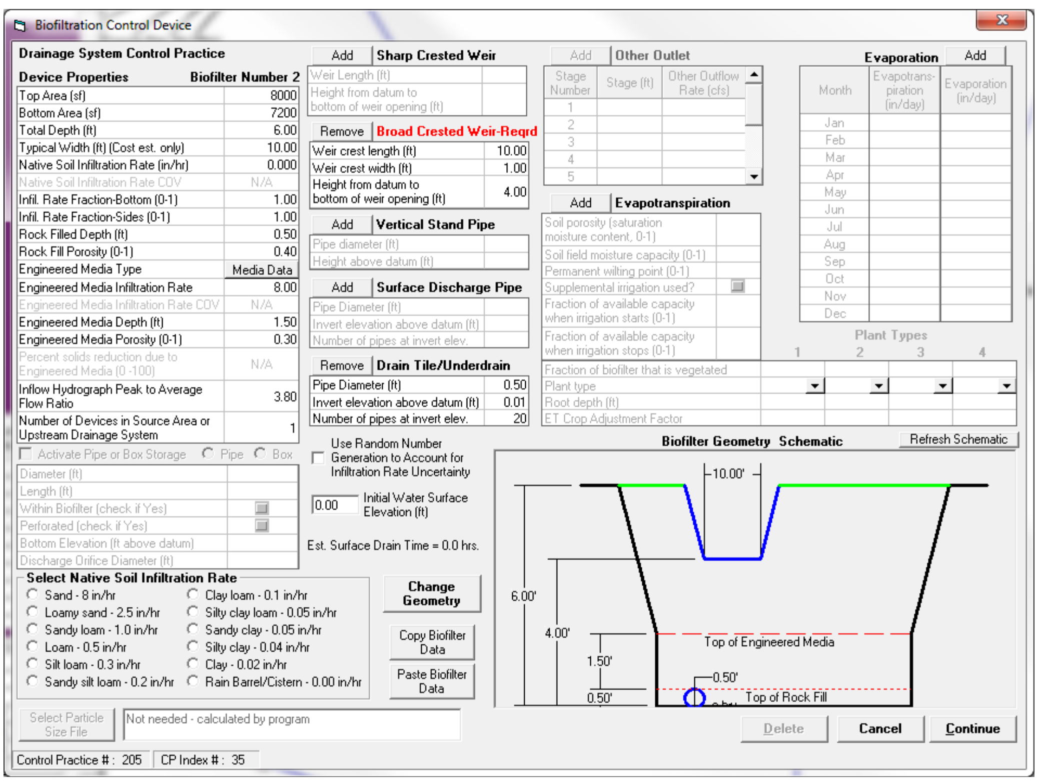

Figure 58: Pond 304 IESF bench (Catchment PC-3) WinSLAMM model inputs

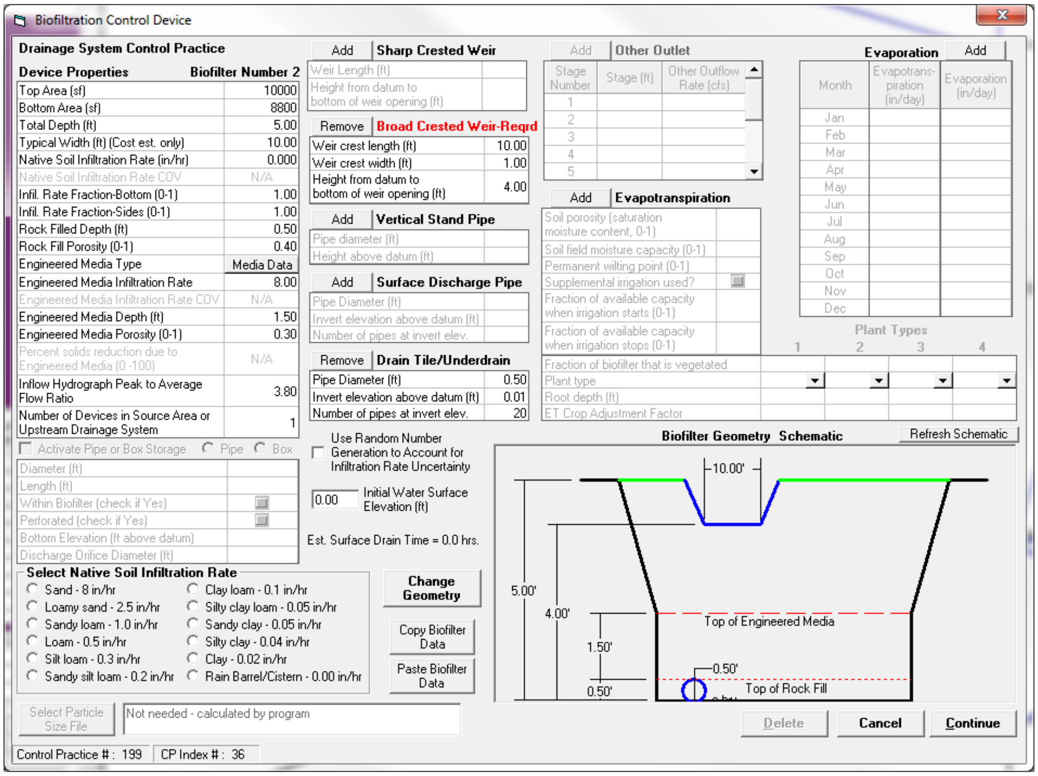

Figure 59: Industrial Park pond IESF bench (Catchment PC-7) WinSLAMM model inputs

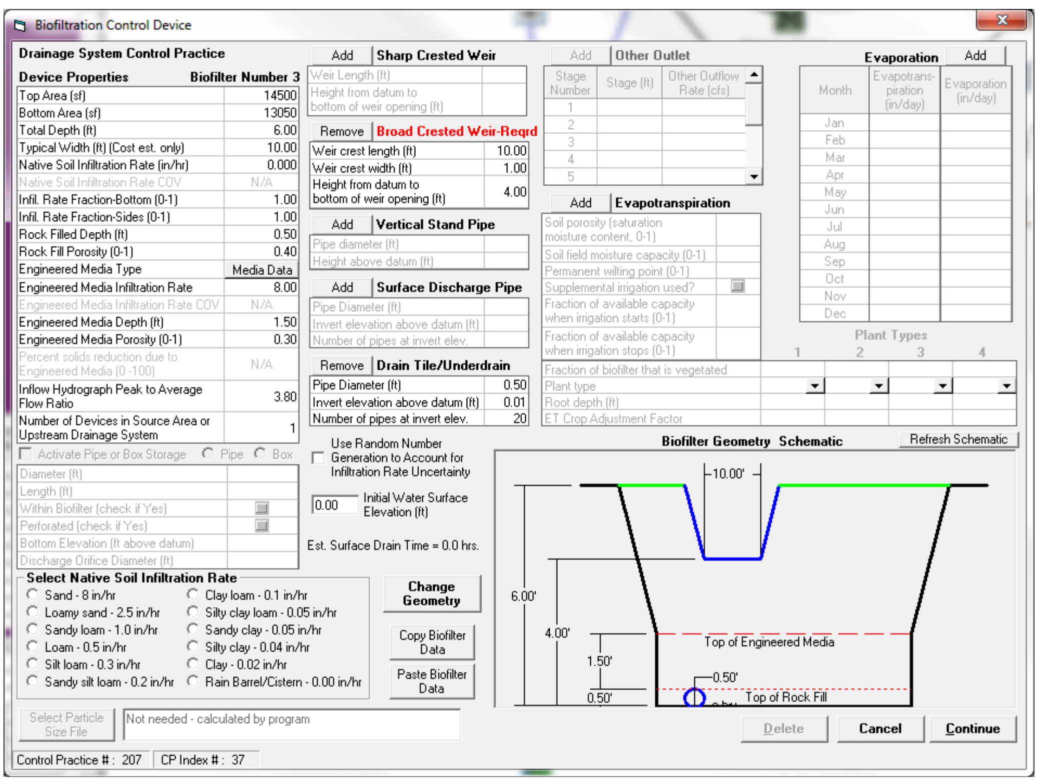

Figure 60: Pleasure Creek Ponds north IESF bench (Catchments PC-6 and PC-7) WinSLAMM model inputs

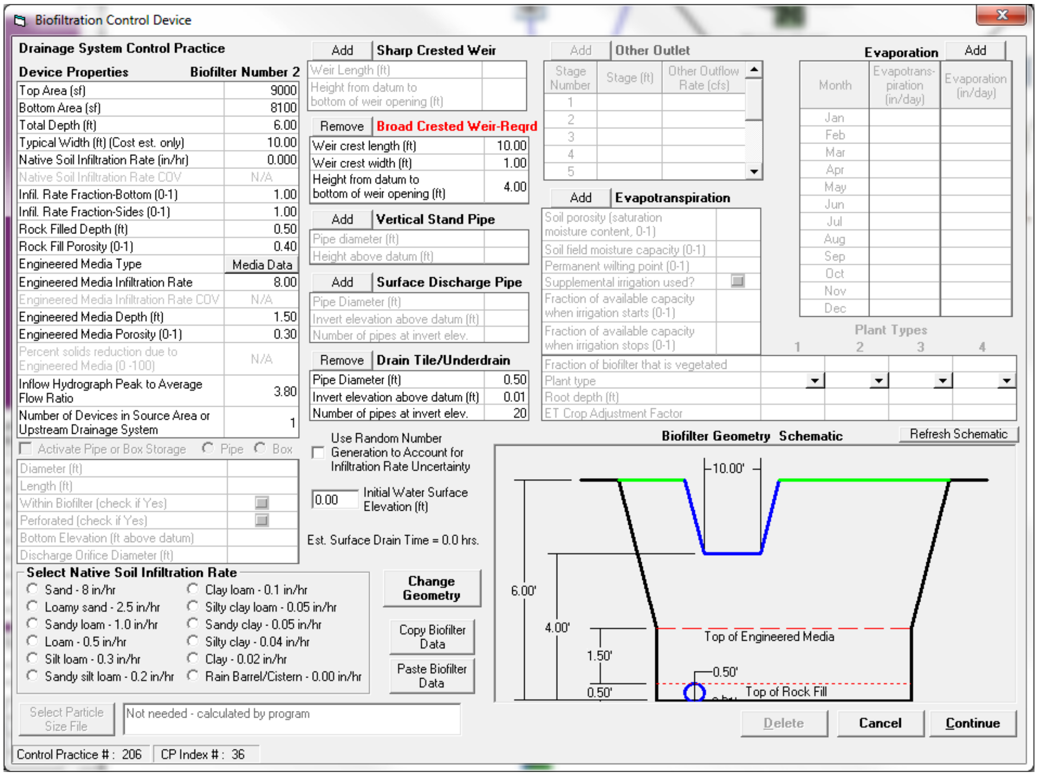

Figure 61: Pleasure Creek Ponds south IESF bench (Catchments PC-6 and PC-7) WinSLAMM model inputs

Enhanced Street Cleaning

Street cleaning schedules with higher frequencies were proposed to increase sediment and sediment-bound phosphorus reductions in catchments south of the Pleasure Creek Ponds, PC-8 and PC-9. Three frequencies were modeled with a cleaning run once every 4 weeks, once every 2 weeks, and once every week.

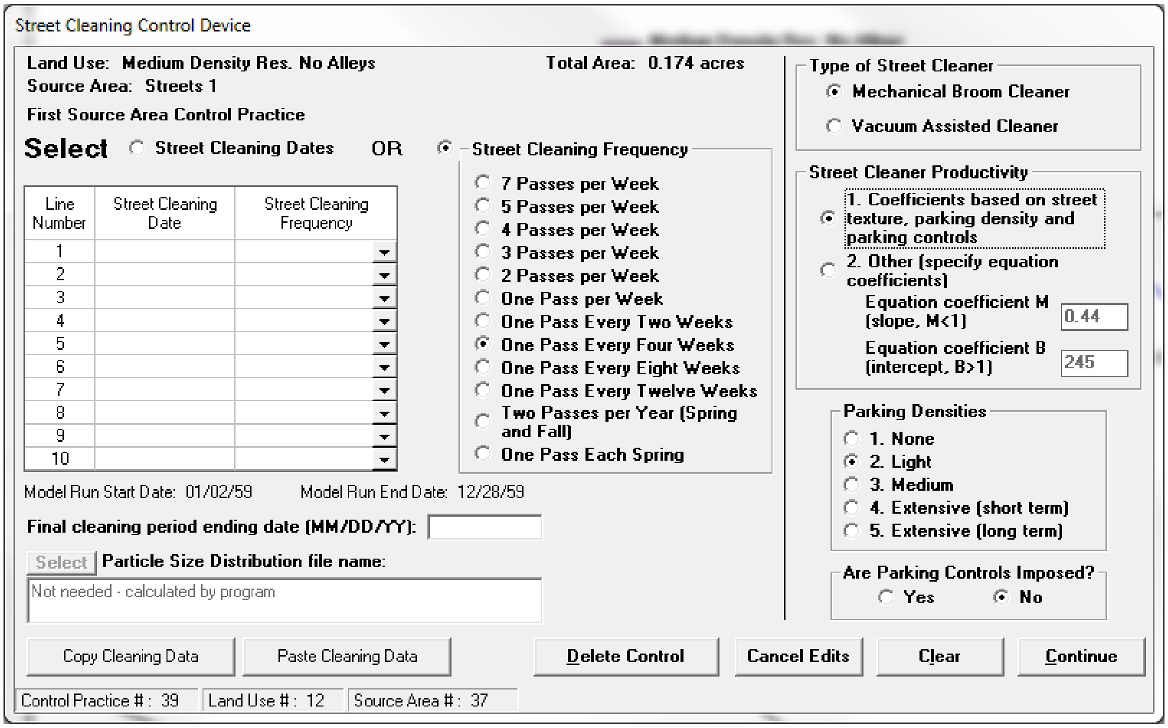

Figure 62: One pass every four weeks WinSLAMM model inputs

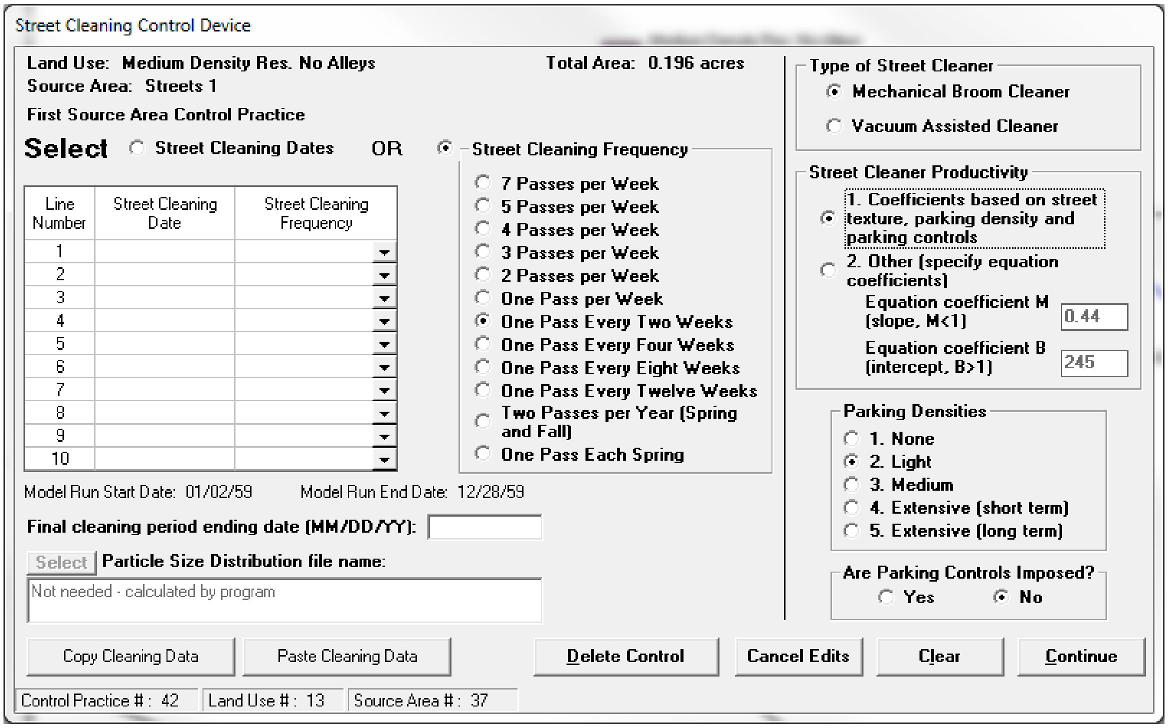

Figure 63: One pass every two weeks WinSLAMM model inputs

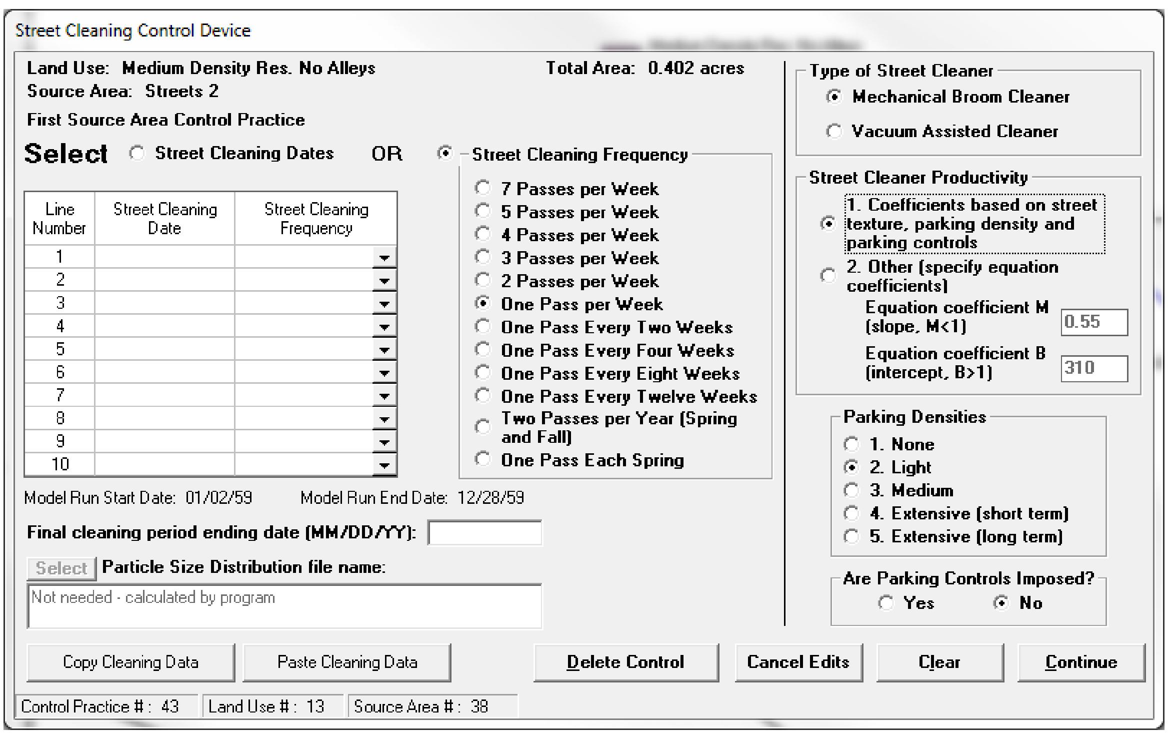

Figure 64: One pass every week WinSLAMM model inputs

Streambank Stabilization

A ditch survey completed in May 2012 by CCWD identified nine locations along the stream requiring streambank stabilization efforts. To date three have already been completed. The remaining six were analyzed using the criteria below to determine their pollutant inputs to the creek.

Instances of erosion along the creek were classified according to severity along each distinct bank. Erosion severity determinations and voided soil volumes were estimated utilizing RAP-M Rapids Assessment Point Method: Inventory and Evaluation of Erosion and Sedimentation for Illinois by R. D. Windhorn, Dec. 2000. Recession rate descriptions are shown in the table below.

Table 21: Streambank Recession Rate Classifications

Severity	Lateral Recession Rate (ft/yr)	Description
Slight	0.01-0.059	Some bare bank but active erosion not readily apparent. No vegetative overhang or exposed tree roots.
Moderate	0.06-0.29	Bank is predominantly bare, with some vegetative overhang and exposed tree roots. Little to no sloughing present.
Severe	0.3-0.49	Bank is bare, with vegetative overhang, exposed tree roots, and some fallen trees. Sloughing is present.
Very Severe	0.5+	Bank is bare, with vegetative overhang and many exposed tree roots and fallen trees. Sloughing is quite evident.

Total sediment and phosphorus reduction estimates were based upon the Board of Water and Soil Resources Pollution Reduction Estimator, which estimates loading based upon a correlation between voided sediment volume and type with soil density averages and phosphorus concentrations. For the purpose of this analysis the following assumptions were made;

- Soils were assumed to be silt, the most prevalent type in the stream corridor
- Soils had a bulk density of 85 lbs/cu-ft.
- Soils had a TP concentration of 1 lbs/1,250 lbs sediment (per page A5 of BWSR manual, BWSR calculator has incorrect correction factor)
- Sediment delivery rates were 100% due to the proximity to the creek

Appendix B – Project Cost Estimates

Introduction

The *Cost Estimating* section on page 19 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. *Appendix B* is a compilation of tables that show 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 new ponds, pond modifications, and IESF benches.

Pond Modification and New Ponds

Table 22: Catchment PC-3 – Pond modification

Activity	Units	Unit Price	Quantity	Unit Price
Feasibility Study and Project Design	Each	$ 15,000.00	1	$ 15,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition	acres	$ 30,000.00	4	$ 120,000.00
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Brush Removal	Each	$ 15,000.00	1	$ 15,000.00
Sediment Testing	Each	$ 10,000.00	1	$ 10,000.00
Site Restoration	Each	$ 5,000.00	1	$ 5,000.00
	Project Total Before Excavation =			$ 180,000.00

Activity	Management Levels		
	1	2	3
Soil To Excavate (cu-yds)	23,500	23,500	23,500
Cost To Excavate ($/cu-yd)	$20	$35	$50
Cost To Excavate (Total $)	$470,000	$822,500	$1,175,000
Other Construction Costs ($)	$180,000	$180,000	$180,000
Total Project Cost ($)	$650,000	$1,002,500	$1,355,000

Table 23: Catchment PC-6 – New pond along Foley Blvd.

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 (already owned by Anoka Co. Regional Railroad Authority)	acres	$ -	0	$ -
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 20.00	8,600	$ 172,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
	Total for project =			$ 262,000.00

Table 24: Catchment PC-9 – New pond along the Mississippi River

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 100,000.00	1	$ 100,000.00
Mobilization	Each	$ 50,000.00	1	$ 50,000.00
Land Acquisition (already owned by Anoka Co. Parks and Recreation)	acres	$ -	0	$ -
Wetland Mitigation (2:1 replacement; 9 acres impacted, replace 18 acres)	sq-ft	$ 1.75	784,080	$ 1,372,140.00
Site Prep	Each	$ 25,000.00	1	$ 25,000.00
Excavation and Disposal	cu-yards	$ 40.00	77,440	$ 3,097,600.00
Outlet Control Structure	Each	$ 30,000.00	1	$ 30,000.00
Channel Rerouting	Each	$ 250,000.00	1	$ 250,000.00
Site Restoration/Revegetation	Each	$ 50,000.00	1	$ 50,000.00
	Total for project =			$ 4,974,740.00

Iron-Enhanced Sand Filter Benches

Table 25: Catchment PC-1 – Pond 303 IESF

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 20,000.00	1	$ 20,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition (already owned by City of Blaine)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	889	$ 13,335.00
IESF Materials and Installation	sq-ft	$ 15.00	6,000	$ 90,000.00
Outlet/Inlet Control Structures	Each	$ 12,000.00	1	$ 12,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 160,335.00

Table 26: Catchment PC-1 – Pond 310 IESF

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 20,000.00	1	$ 20,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition (already owned by City of Blaine)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	595	$ 8,925.00
IESF Materials and Installation	sq-ft	$ 15.00	4,000	$ 60,000.00
Outlet/Inlet Control Structures	Each	$ 12,000.00	1	$ 12,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 125,925.00

Table 27: Catchment PC-3 – Pond 304 IESF

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 20,000.00	1	$ 20,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition (already owned by MNDOT)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	1,185	$ 17,775.00
IESF Materials and Installation	sq-ft	$ 15.00	8,000	$ 120,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
		Total for project =		$ 202,775.00

Table 28: Catchment PC-6 – North Pleasure Creek Pond IESF

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 35,000.00	1	$ 35,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (already owned by MNDOT)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	2,150	$ 32,250.00
IESF Materials and Installation	sq-ft	$ 15.00	14,500	$ 217,500.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 20,000.00	1	$ 20,000.00
		Total for project =		$ 359,750.00

Table 29: Catchment PC-6 – South Pleasure Creek Pond IESF

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 35,000.00	1	$ 35,000.00
Mobilization	Each	$ 15,000.00	1	$ 15,000.00
Land Acquisition (already owned by MNDOT)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	1,333	$ 19,995.00
IESF Materials and Installation	sq-ft	$ 15.00	9,000	$ 135,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 20,000.00	1	$ 20,000.00
		Total for project =		$ 264,995.00

Table 30: Catchment PC-6 – North and South Pleasure Creek Pond IESFs. Costs assume all aspects of the project are combined.

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 50,000.00	1	$ 50,000.00
Mobilization	Each	$ 25,000.00	1	$ 25,000.00
Land Acquisition (already owned by MNDOT)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 20,000.00	1	$ 20,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	3,485	$ 52,275.00
IESF Materials and Installation	sq-ft	$ 15.00	23,500	$ 352,500.00
Outlet/Inlet Control Structures	Each	$ 60,000.00	1	$ 60,000.00
Site Restoration	Each	$ 30,000.00	1	$ 30,000.00
		Total for project =		$ 589,775.00

Table 31: Catchment PC-7 – Industrial Park Pond IESF including costs for the stormwater diversion

Activity	Units	Unit Price	Quantity	Unit Price
Design	Each	$ 20,000.00	1	$ 20,000.00
Mobilization	Each	$ 5,000.00	1	$ 5,000.00
Land Acquisition (already owned by Coon Rapids)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 10,000.00	1	$ 10,000.00
Common Excavation & Disposal	cu-yards	$ 15.00	1,485	$ 22,275.00
IESF Materials and Installation	sq-ft	$ 15.00	10,000	$ 150,000.00
Outlet/Inlet Control Structures	Each	$ 20,000.00	1	$ 20,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
Stormwater Infrastructure Rerouting	Each	$ 40,000.00	1	$ 40,000.00
		Total for project =		$ 277,275.00

Appendix C – Wellhead Protection Areas

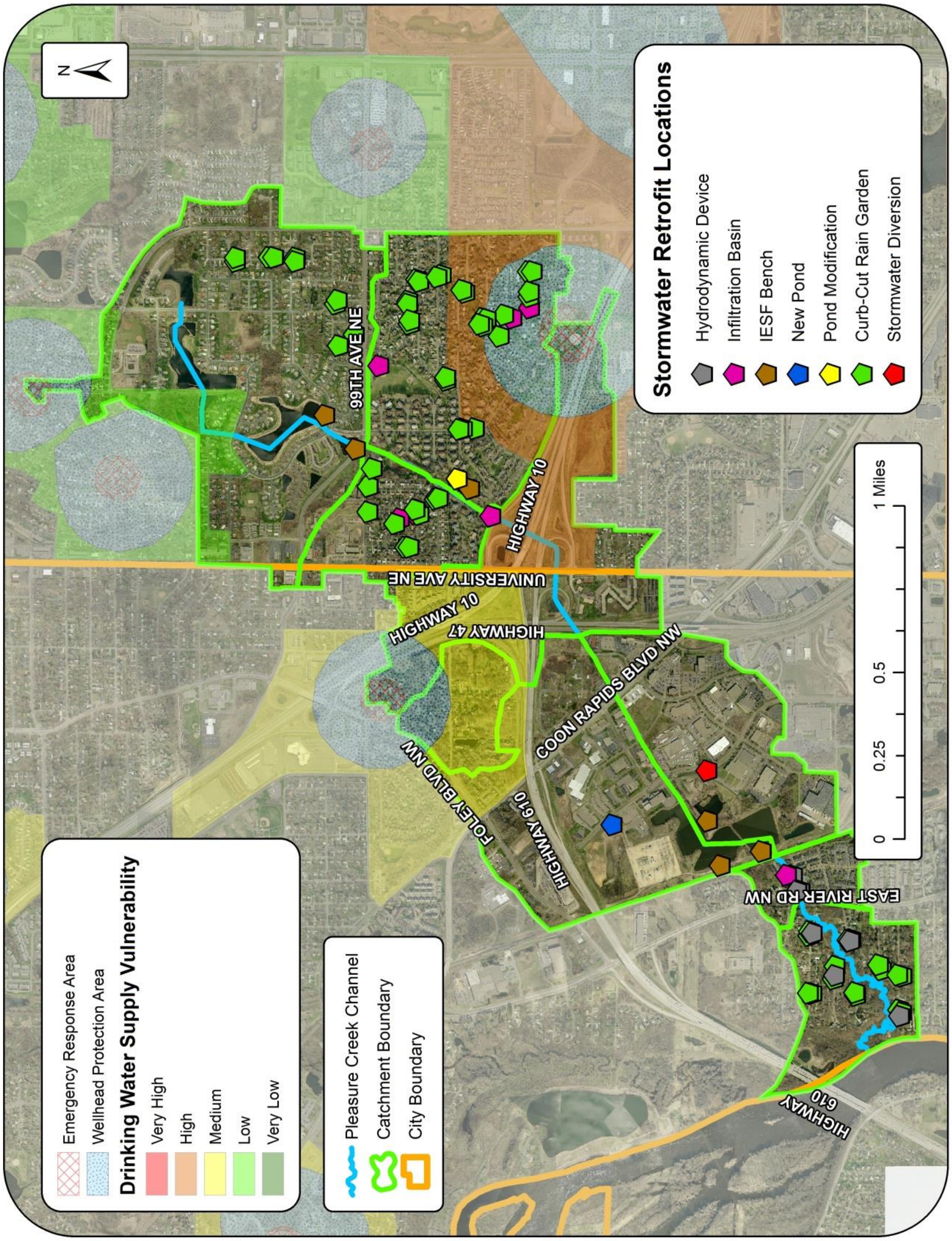

Figure 65: Subwatershed-wide map showing all proposed retrofits included in this report and potential overlap with wellhead protection areas.