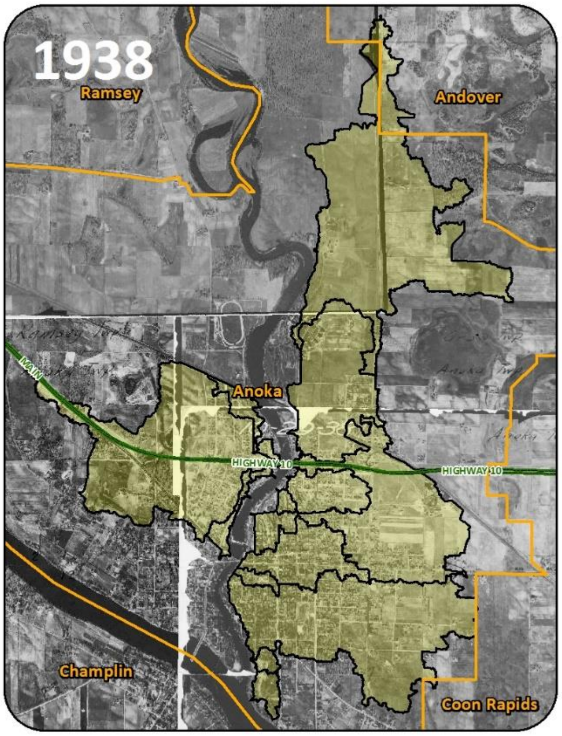

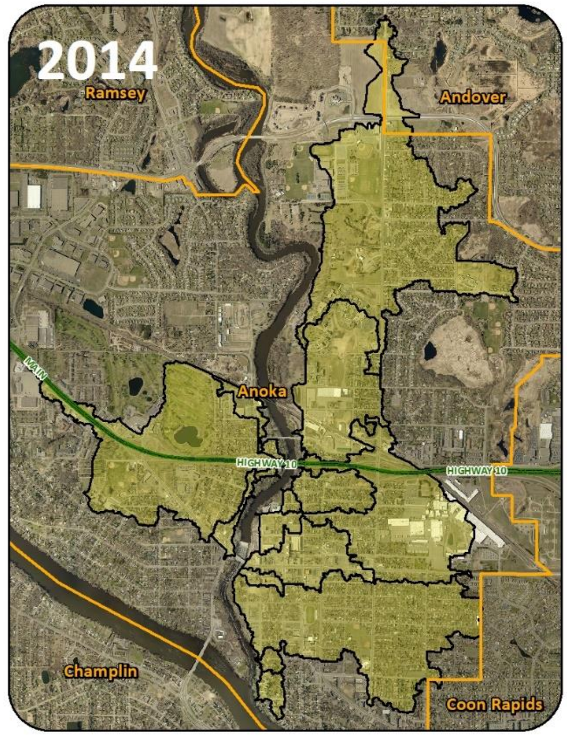

City of Anoka
Stormwater Retrofit Analysis

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

CITY OF ANOKA AND

LOWER RUM RIVER WATERSHED MANAGEMENT ORGANZIZATION

August 2016

Cover photo: Aerial images from 1938 and 2014 showing the change in land use within the subwatersheds analyzed in this report.

Disclaimer: At the time of printing, this report identifies and ranks potential BMPs for selected subwatersheds in the City of Anoka that drain to the Rum River. 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 City of Anoka.

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Executive Summary

The City of Anoka and the Lower Rum River Watershed Management Organization (LRRWMO) contracted the Anoka Conservation District (ACD) to complete this stormwater retrofit analysis (SRA) for the purpose of identifying and ranking water quality improvement projects in selected subwatersheds that drain to the Rum River. The subwatersheds are located on the western and eastern side of the Rum River within the City of Anoka and consist of commercial, industrial, and residential land uses. Volume, total phosphorus (TP), and total suspended solids (TSS) were the target parameters analyzed.

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

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

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. 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 – Modeling Methods.

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

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

- Bioretention,
- Hydrodynamic devices,
- Permeable Pavement,
- Iron enhanced sand filter pond benches,
- Existing stormwater pond modifications,
- New stormwater ponds, and

- Water reuse.

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

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

The 1,474-acre target study area was consolidated into four drainage networks and 17 catchments. Based on WinSLAMM model results, the total study area contributes an estimated 941 acre-feet of runoff, 299,153 pounds of TSS, and 807 pounds of TP annually.

The tables in the Project Ranking and Selection section (pages 13-18) summarize potential projects ranked by cost effectiveness with respect to either TP or TSS. Potential projects are organized from most cost effective to least based on pollutants removed.

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

Document Organization

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

Background

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

Analytical Process and Elements

The analytical process and elements section overviews the procedures that were followed when analyzing the subwatershed. It explains the processes of retrofit scoping, desktop analysis, field investigation, modeling, cost/treatment analysis, project ranking, and project selection. Refer to Appendix A – Modeling Methods for a detailed description of the modeling methods.

Project Ranking and Selection

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

This section also ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by the amount of pollutant removed by each project over 30 years. The final cost per pound 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 list provided in this report is merely a starting point.

BMP Descriptions

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

Catchment Profiles

The drainage areas targeted for this analysis were consolidated into 17 catchments distributed between four drainage networks and assigned unique identification numbers. For each catchment, the following information is detailed:

Drainage Network

Catchments were grouped into drainage networks based on their geographic distribution throughout the study area and drainage to a common waterbody (i.e. the Rum River). The drainage networks were used to further subdivide the report to aid with organization and clarity.

Catchment Description
Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads under existing conditions. Existing conditions included notable stormwater treatment practices for which information was available from the City of Anoka. 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.

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

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

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

Background

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

The drainage areas studied for this analysis are located in the City of Anoka and discharge to the Rum River. The total area of the 17 catchments is 1,474 acres. Six of the catchments lie on the western side of the Rum River and are roughly bound by Greenhaven Road to the north and Park Street to the south. The remaining eleven catchments are on the eastern side of the Rum River. These catchments are bound roughly by Bunker Lake Boulevard to the north and East River Road to the south.

These catchments were selected for analysis because they drain to a high priority waterbody, and existing treatment in many of the catchments could be supplemented. Stormwater retrofits may provide cost-effective options for additional treatment of runoff, thereby improving water quality in the Rum River.

The catchments analyzed are urbanized. Development throughout the City of Anoka has resulted in the installation of subsurface drainage systems (i.e. stormwater infrastructure) to convey stormwater runoff, which increased due to the coverage of impervious surfaces throughout the catchments. The runoff generated within the areas targeted for this analysis is still conveyed to the Rum River, as it was historically. However, the runoff is now captured by catch basins and directed underground before being discharged to the Rum River via stormwater pipes.

Stormwater runoff from impervious surfaces can carry a variety of pollutants. While stormwater treatment to remove these pollutants is adequate in some areas, other areas were built prior to modern-day stormwater treatment technologies and requirements. The City of Anoka and LRRWMO contracted the ACD to complete this SRA for the purpose of identifying and analyzing projects to improve the quality of stormwater runoff to the Rum River. Overall subwatershed loading of TP, TSS, and stormwater volume were estimated for selected drainage areas. Proposed 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.

Analytical Process and Elements

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

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

In this analysis, the focus areas were the contributing drainage areas to storm sewer outfalls that discharge directly into the Rum River. More specifically, outfalls with limited existing treatment were selected. Included are areas of residential, commercial, industrial, and institutional land uses. Existing stormwater infrastructure maps and topography data were used to determine drainage boundaries for the 17 catchments included in this analysis. Street reconstruction plan sets were also digitized by ACD where updated stormwater infrastructure GIS data was lacking.

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

Table 1: Target Pollutants

Target Pollutant	Description
Total Phosphorus (TP)	Phosphorus is a nutrient essential to plant growth and is commonly the factor that limits the growth of plants in surface water bodies. TP is a combination of particulate phosphorus (PP), which is bound to sediment and organic debris, and dissolved phosphorus (DP), which is in solution and readily available for plant growth (active).
Total Suspended Solids (TSS)	Very small mineral and organic particles that can be dispersed into the water column due to turbulent mixing. TSS loading can create turbid and cloudy water conditions and carry with it PP. As such, reductions in TSS will also result in TP reductions.
Volume	Higher runoff volumes and velocities can carry greater amounts of TSS to receiving water bodies. It can also exacerbate in-stream erosion, thereby increasing TSS loading. As such, reductions in volume may reduce TSS loading and, by extension, TP loading. However, in-stream erosion is not an issue in these catchments because stormwater is piped directly to the Rum River.

Desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that do not need to be analyzed because of existing stormwater treatment 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 were verified. Site constraints were assessed to determine the most feasible retrofit options as well as eliminate sites from consideration. The field investigation may have 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. WinSLAMM (version 10.2.0), which allows routing of multiple catchments and stormwater treatment practices, was used for this analysis. This is important for estimating treatment train effects associated with multiple BMPs in series. Furthermore, it allows for estimation of volume and pollutant loading at the outfall point to the waterbody, which is the primary point of interest in this type of study.

WinSLAMM estimates volume and pollutant loading based on acreage, land use, and soils information. Therefore, the volume and pollutant estimates in this report are not waste load allocations, nor does this report serve as a TMDL for the study area. The WinSLAMM model was not calibrated and was only used as an estimation tool to provide relative ranking across potential retrofit projects. Soils throughout the study area were predominantly sandy based on the information available in the Anoka County soil survey. 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 – Modeling Methods.

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 the watershed delineation tool in ArcSWAT. The drainage areas were then consolidated into catchments using geographic information systems (specifically, ArcGIS). Land use data (based on 2010 Metropolitan Council land use file) were used to calculate acreages of each land use type within each catchment. Each land use polygon classification was compared with 2014 aerial photography, the most recent available at the time of this analysis, and corrected if land use had changed since 2010. This process addressed recent development throughout the study area by reclassifying land use types accordingly. Soil types throughout the subwatershed were modeled as sand and silt in this analysis based on the information available in the Anoka County soil survey. Entering the acreages, land use, and soil data into WinSLAMM ultimately 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 were available from the City of Anoka (Figure 1 and Figure 2). For example, street cleaning with mechanical or vacuum street sweepers, stormwater treatment ponds, hydrodynamic devices, and others were included in the “existing conditions” model if information was available.

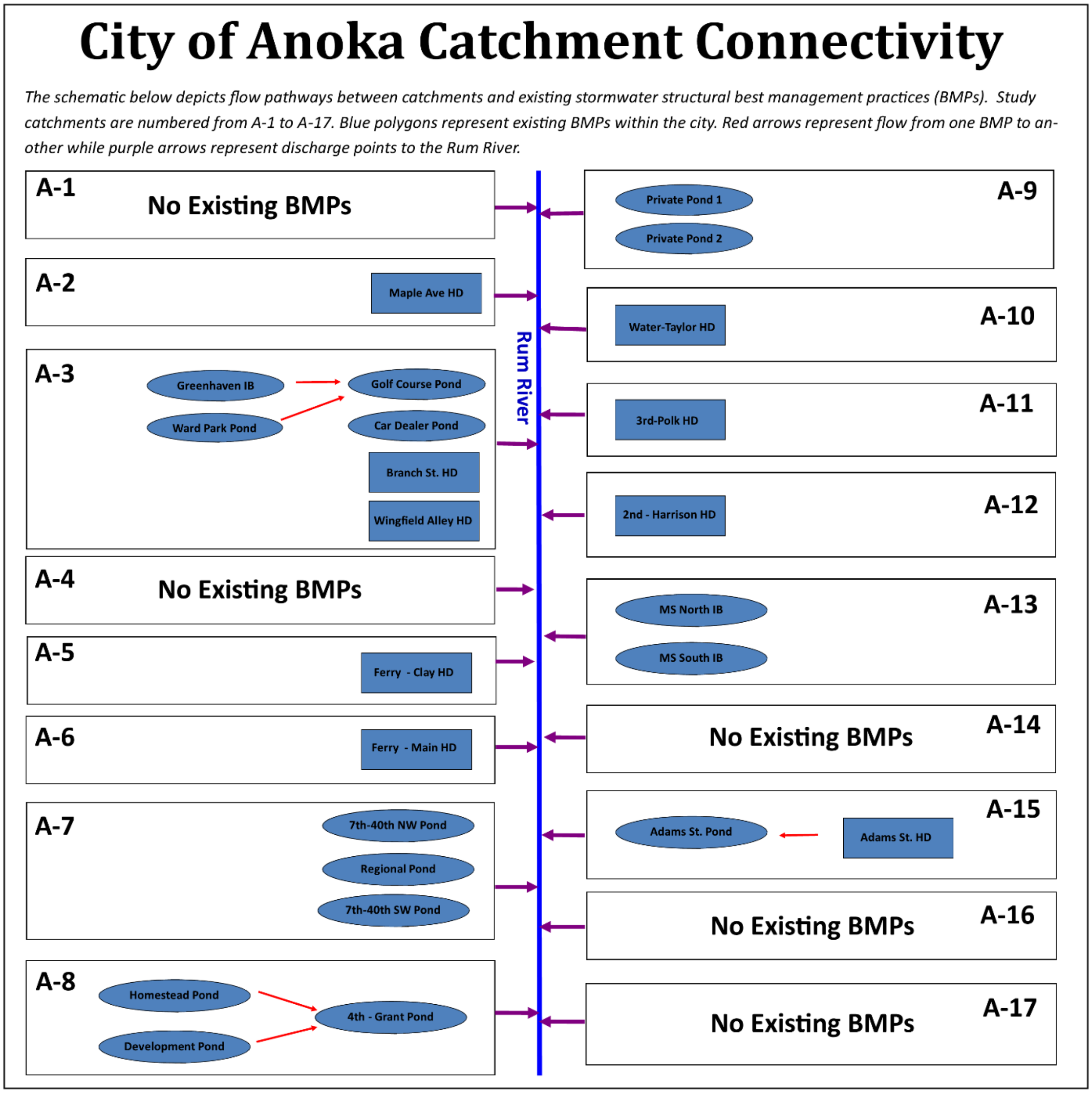


Figure 1: Schematic showing the existing BMPs in each catchment and their connectivity.

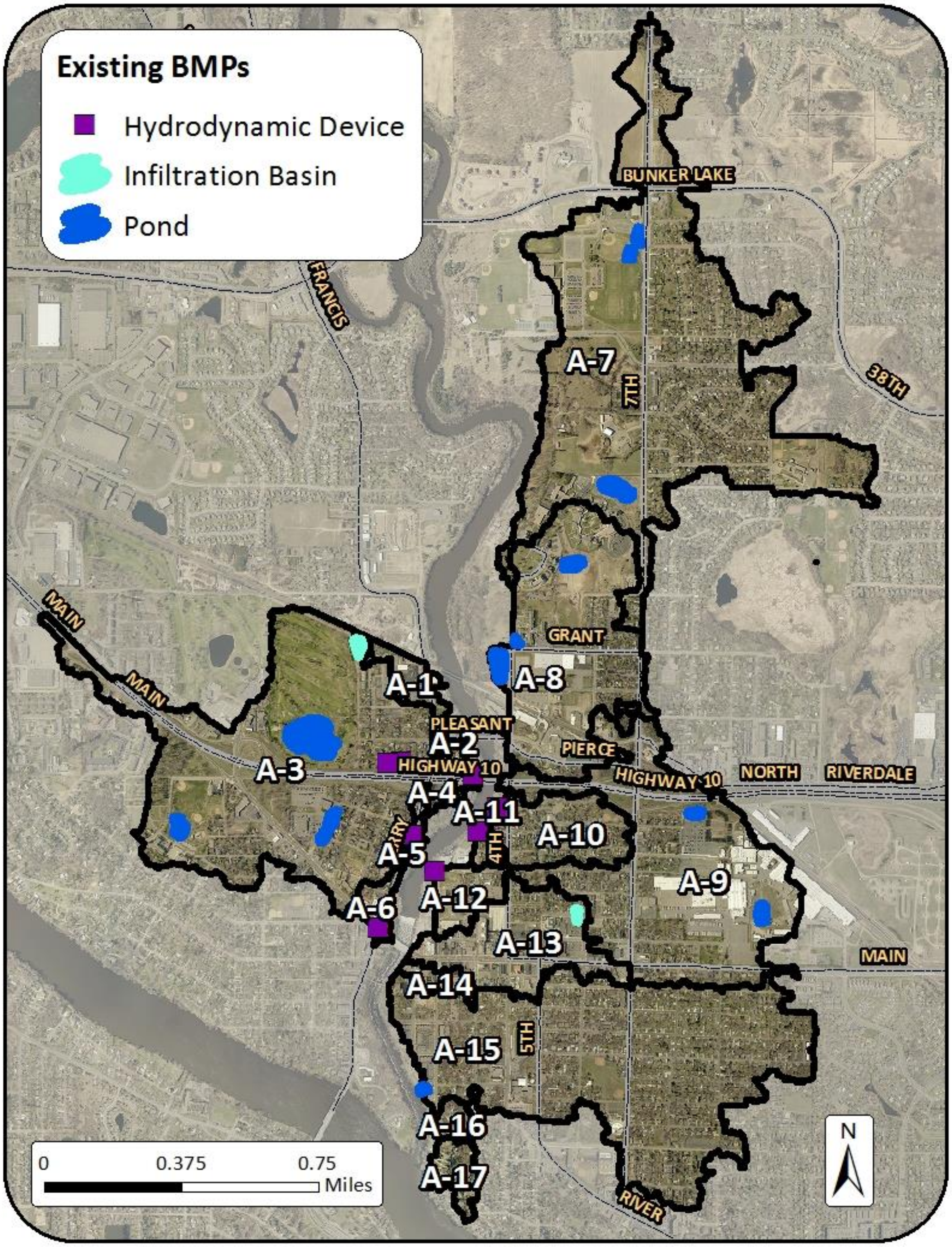


Figure 2: Study area map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included throughout the study area.

Finally, each proposed 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 – Modeling Methods.

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 2016 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 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. Detailed feasibility analyses may be necessary for some projects.

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

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

Project Ranking and Selection

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

Project Ranking

If all identified practices were installed (Figure 3), significant pollution reduction could be accomplished. However, funding limitations and landowner interest will likely be limiting factors for implementation. The tables on the following pages rank all modeled projects by cost-effectiveness.
Projects were ranked in two ways:

1) Cost per pound of total phosphorus removed (Table 2, Table 3, and Table 4) and
2) Cost per 1,000 pounds of total suspended solids removed (Table 5, Table 6, and Table 7).

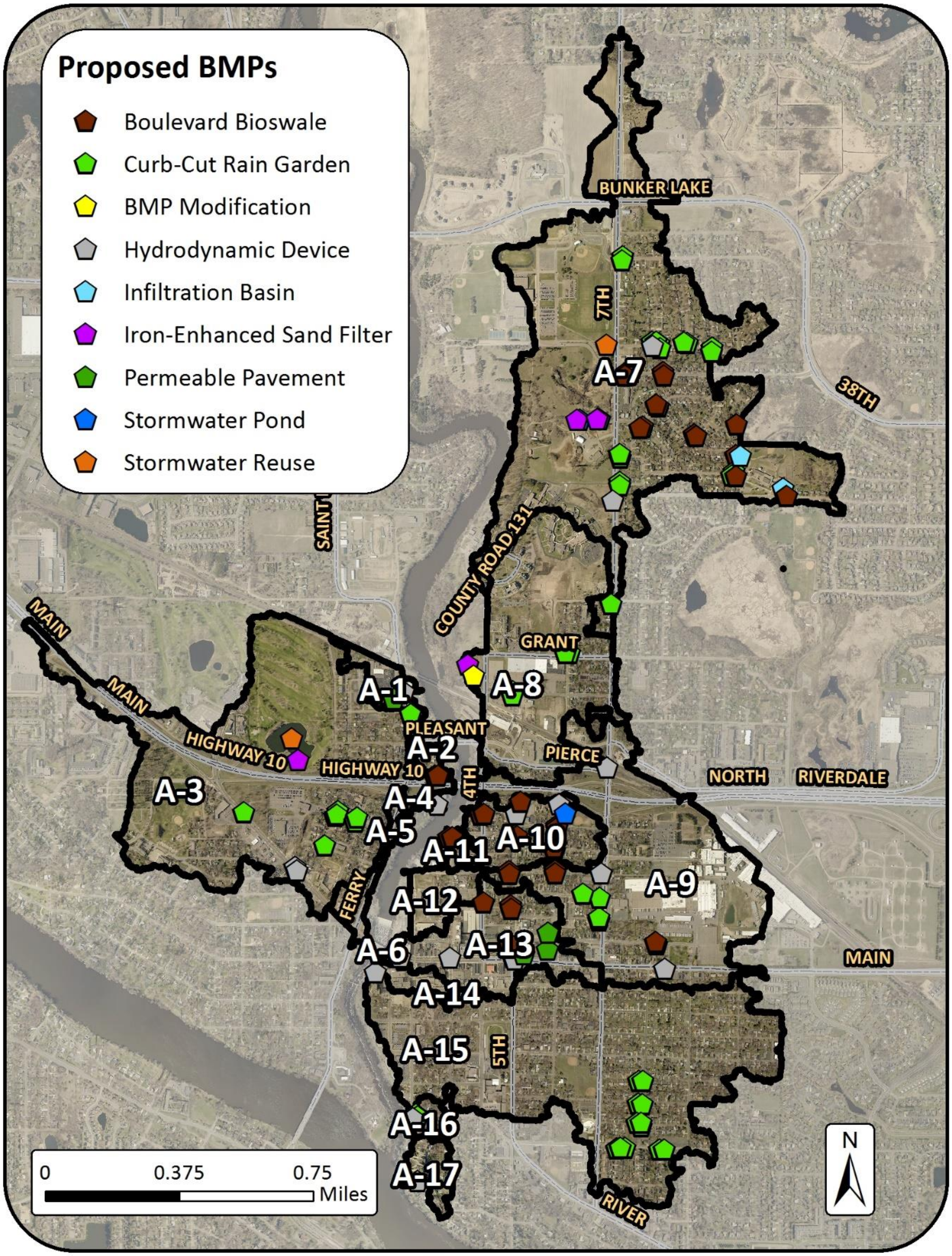


Figure 3: Study area map showing the proposed retrofits included in this report.

Table 2: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 1 – 16 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
1	7-H1	73	New Pond	7th Ave.	A-7	111.6	54,558	0.9	$802,138.00	$5,500.00	$289.00
2	7-D	69	Infiltration Basin	Colfax Ave. and Blackoaks Ln.	A-7	9.6	3,256	8.1	$118,796.00	$225.00	$436.00
3	7-H2	74	New Pond	7th Ave.	A-7	31.5	13,452	0.4	$360,484.00	$1,800.00	$439.00
4	7-E	70	Infiltration Basin	Sunny Ln.	A-7	1.7	676	1.8	$22,796.00	$225.00	$579.00
5	10-C	97	Infiltration Basin	5th Ave. and Polk St.	A-10	2.6	808	2.1	$43,796.00	$225.00	$648.00
6	7-I1	75	IESF Bench	7th Ave.	A-7	26.6	0	0	$580,991.00	$4,591.00	$902.00
7	16-A	128	Curb-Cut Rain Garden	Washington St.	A-16	0.5-1.0	157-315	0.4-0.8	$8,982-$17,234	$225-$450	$1,024-$1,049
8	1-A	38	Curb-Cut Rain Garden	Ferry St. and Front Ave.	A-1	0.5	187	0.5	$8,982.00	$225.00	$1,049.00
9	3-A	48	Curb-Cut Rain Garden	Various locations in catchment	A-3	0.5-3.5	157-1,089	0.4-2.7	$15,844-$65,356	$225-$1,575	$1,072-$1,506
10	7-A	66	Curb-Cut Rain Garden	Various locations in catchment	A-7	0.5-8.1	153-2,539	0.4-6.2	$15,844-$147,876	$225-$3,825	$1,081-$1,506
11	9-A	87	Curb-Cut Rain Garden	Various locations in catchment	A-9	0.5-2.0	155-623	0.4-1.5	$15,844-$40,600	$225-$900	$1,127-$1,506
12	8-B	81	Pond Modification	4th Ave. and Grant St.	A-8	10.5	6,443	0	$330,840-$690,840	$1,300.00	$1,174-$2,317
13	15-A	125	Curb-Cut Rain Garden	Various locations in catchment	A-15	0.4-4.4	135-1,343	0.4-3.7	$15,844-$90,112	$225-$2,250	$1,194-$1,883
14	3-D	51	IESF Bench	Green Haven Golf Course Pond	A-3	10.4	0	0	$282,955.00	$3,214.00	$1,216.00
15	3-E	52	Stomwater Reuse	Green Haven Golf Course Pond	A-3	18.2	3,409	46.4	$608,760.00	$3,000.00	$1,280.00
16	8-A	80	Curb-Cut Rain Garden	Various locations in catchment	A-8	0.7-0.8	190-301	0.7-1.1	$17,234.00	$450.00	$1,281-$1,464

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

Table 3: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 17 – 31 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
17	8-C	82	IESF Bench	4th Ave. and Grant St.	A-8	7.2	0	0	$282,955.00	$1,607.00	$1,534.00
18	7-I2	76	IESF Bench	7th Ave.	A-7	7.2	0	0	$305,875.00	$1,837.00	$1,669.00
19	7-G	72	Stomwater Reuse	38th Ave. and 7th Ave.	A-7	17.5	5,987	18.7	$958,760.00	$3,000.00	$1,998.00
20	10-E	99	New Pond	Rudy Johnson Park	A-10	4	1,712	0.1	$239,925.00	$300.00	$2,074.00
21	9-E	91	Boulevard Bioswale	Various locations in catchment	A-9	0.2	112	0.2	$8,526.00	$225.00	$2,131.00
22	13-D	112	Hydrodynamic Device	5th Ave. and Main St.	A-13	1.4	644	0	$109,752.00	$630.00	$3,063.00
23	2-A	44	Boulevard Bioswale	Maple Ave.	A-2	0.2	55	0.1	$8,526.00	$225.00	$3,140.00
24	7-F	71	Boulevard Bioswale	Various locations in catchment	A-7	0.2	61	0.1	$8,526.00	$225.00	$3,264.00
25	10-D	98	Boulevard Bioswale	Various locations in catchment	A-10	0.1	52	0.1	$8,526.00	$225.00	$3,427.00
26	11-A	102	Boulevard Bioswale	3rd Ave.	A-11	0.1	49	0.1	$8,526.00	$225.00	$3,523.00
27	7-B	67	Hydrodynamic Device	38th Ln. and 8th Ave.	A-7	1.2	491	0	$109,752.00	$630.00	$3,574.00
27	9-B	88	Hydrodynamic Device	7th Ave. and Pierce St.	A-9	1.2	686	0	$109,752.00	$630.00	$3,574.00
29	9-D	90	Hydrodynamic Device	Main St. and 8 1/2 Ave.	A-9	1.1	777	0	$109,752.00	$630.00	$3,899.00
30	3-C	50	Hydrodynamic Device	Main St. and State Ave.	A-3	0.6	302	0	$55,752.00	$630.00	$4,147.00
31	1-B	39	Hydrodynamic Device	Ferry St.	A-1	1	584	0	$109,752.00	$630.00	$4,288.00
31	9-C	89	Hydrodynamic Device	7th Ave. and Harrison St.	A-9	1	407	0	$109,752.00	$630.00	$4,288.00

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

Table 4: Cost-effectiveness of retrofits with respect to TP reduction. Projects ranked 33 – 48 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ lb-TP/year (30-year)[1]
33	13-C	111	Hydrodynamic Device	Main St. and 5th Ave.	A-13	0.9	427	0	$109,752.00	$630.00	$4,765.00
34	13-A	109	Hydrodynamic Device	Main St. and 1st Ave.	A-13	0.5	272	0	$55,752.00	$630.00	$4,977.00
34	13-B	110	Hydrodynamic Device	Main St. and 3rd Ave.	A-13	0.5	285	0	$55,752.00	$630.00	$4,977.00
34	3-B	49	Hydrodynamic Device	Main St. and State Ave.	A-3	0.5	280	0	$55,752.00	$630.00	$4,977.00
37	13-H	116	Boulevard Bioswale	Various locations in catchment	A-13	0.1	22	0.1	$8,526.00	$225.00	$5,092.00
38	4-A	55	Hydrodynamic Device	Maple Ln.	A-4	0.3	113	0	$28,752.00	$630.00	$5,295.00
39	14-A	121	Hydrodynamic Device	Parking lot off 1st Ave.	A-14	0.8	385	0	$109,752.00	$630.00	$5,361.00
39	7-C	68	Hydrodynamic Device	7th Ave.	A-7	0.8	383	0	$109,752.00	$630.00	$5,361.00
41	17-A	133	Hydrodynamic Device	Oakwood Dr.	A-17	0.6	244	0	$109,752.00	$630.00	$7,147.00
42	10-A	95	Hydrodynamic Device	6th Ave. and Taylor St.	A-10	0.5	211	0	$109,752.00	$630.00	$8,577.00
43	10-B	96	Hydrodynamic Device	5th Ave. and Taylor St.	A-10	0.5	195	0	$109,752.00	$630.00	$8,577.00
44	16-B	129	Hydrodynamic Device	Oakwood Dr. and Washington St.	A-16	0.4	163	0	$109,752.00	$630.00	$10,721.00
45	13-F	114	Permeable Pavement	St. Stephen's Catholic School	A-13	1.6	562	1.6	$282,796.00	$20,925.00	$18,970.00
46	13-E	113	Permeable Pavement	St. Stephen's Catholic Church	A-13	0.9	320	0.9	$162,796.00	$11,925.00	$19,279.00
47	13-G	115	Permeable Pavement	St. Stephen's Catholic School	A-13	1.9	672	1.9	$343,796.00	$25,500.00	$19,453.00
48	1-C	40	Permeable Pavement	Anoka-Hennepin Education Center	A-1	2.9	1,325	3.5	$552,656.00	$41,165.00	$20,547.00

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

Table 5: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 1 – 16 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
1	7-H1	73	New Pond	7th Ave.	A-7	111.6	54,558	0.9	$802,138.00	$5,500.00	$591.00
2	7-H2	74	New Pond	7th Ave.	A-7	31.5	13,452	0.4	$360,484.00	$1,800.00	$1,027.00
3	7-D	69	Infiltration Basin	Colfax Ave. and Blackoaks Ln.	A-7	9.6	3,256	8.1	$118,796.00	$225.00	$1,285.00
4	7-E	70	Infiltration Basin	Sunny Ln.	A-7	1.7	676	1.8	$22,796.00	$225.00	$1,457.00
5	8-B	81	Pond Modification	4th Ave. and Grant St.	A-8	10.5	6,443	0	$330,840-$690,840	$1,300.00	$1,913-$3,776
6	10-C	97	Infiltration Basin	5th Ave. and Polk St.	A-10	2.6	808	2.1	$43,796.00	$225.00	$2,085.00
7	1-A	38	Curb-Cut Rain Garden	Ferry St. and Front Ave.	A-1	0.5	187	0.5	$8,982.00	$225.00	$2,804.00
8	16-A	128	Curb-Cut Rain Garden	Washington St.	A-16	0.5-1.0	157-315	0.4-0.8	$8,982-$17,234	$225-$450	$3,252-$3,340
9	8-A	80	Curb-Cut Rain Garden	Various locations in catchment	A-8	0.7-0.8	190-301	0.7-1.1	$17,234.00	$450.00	$3,404-$5,392
10	3-A	48	Curb-Cut Rain Garden	Various locations in catchment	A-3	0.5-3.5	157-1,089	0.4-2.7	$15,844-$65,356	$225-$1,575	$3,447-$4,797
11	7-A	66	Curb-Cut Rain Garden	Various locations in catchment	A-7	0.5-8.1	153-2,539	0.4-6.2	$15,844-$147,876	$225-$3,825	$3,448-$4,922
12	9-A	87	Curb-Cut Rain Garden	Various locations in catchment	A-9	0.5-2.0	155-623	0.4-1.5	$15,844-$40,600	$225-$900	$3,617-$4,859
13	15-A	125	Curb-Cut Rain Garden	Various locations in catchment	A-15	0.4-4.4	135-1,343	0.4-3.7	$15,844-$90,112	$225-$2,250	$3,912-$5,579
14	9-E	91	Boulevard Bioswale	Various locations in catchment	A-9	0.2	112	0.2	$8,526.00	$225.00	$4,561.00
15	10-E	99	New Pond	Rudy Johnson Park	A-10	4	1,712	0.1	$239,925.00	$300.00	$4,847.00
16	9-D	90	Hydrodynamic Device	Main St. and 8 1/2 Ave.	A-9	1.1	777	0	$109,752.00	$630.00	$5,519.00

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

Table 6: Cost-effectiveness of retrofits with respect to TSS reduction. Projects ranked 17 – 32 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
17	7-G	72	Stomwater Reuse	38th Ave. and 7th Ave.	A-7	17.5	5,987	18.7	$958,760.00	$3,000.00	$5,839.00
18	9-B	88	Hydrodynamic Device	7th Ave. and Pierce St.	A-9	1.2	686	0	$109,752.00	$630.00	$6,251.00
19	13-D	112	Hydrodynamic Device	5th Ave. and Main St.	A-13	1.4	644	0	$109,752.00	$630.00	$6,659.00
20	3-E	52	Stomwater Reuse	Green Haven Golf Course Pond	A-3	18.2	3,409	46.4	$608,760.00	$3,000.00	$6,833.00
21	1-B	39	Hydrodynamic Device	Ferry St.	A-1	1	584	0	$109,752.00	$630.00	$7,343.00
22	3-C	50	Hydrodynamic Device	Main St. and State Ave.	A-3	0.6	302	0	$55,752.00	$630.00	$8,240.00
23	7-F	71	Boulevard Bioswale	Various locations in catchment	A-7	0.2	61	0.1	$8,526.00	$225.00	$8,352.00
24	13-B	110	Hydrodynamic Device	Main St. and 3rd Ave.	A-13	0.5	285	0	$55,752.00	$630.00	$8,731.00
25	7-B	67	Hydrodynamic Device	38th Ln. and 8th Ave.	A-7	1.2	491	0	$109,752.00	$630.00	$8,734.00
26	3-B	49	Hydrodynamic Device	Main St. and State Ave.	A-3	0.5	280	0	$55,752.00	$630.00	$8,887.00
27	13-A	109	Hydrodynamic Device	Main St. and 1st Ave.	A-13	0.5	272	0	$55,752.00	$630.00	$9,149.00
28	2-A	44	Boulevard Bioswale	Maple Ave.	A-2	0.2	55	0.1	$8,526.00	$225.00	$9,202.00
29	10-D	98	Boulevard Bioswale	Various locations in catchment	A-10	0.1	52	0.1	$8,526.00	$225.00	$9,853.00
30	13-C	111	Hydrodynamic Device	Main St. and 5th Ave.	A-13	0.9	427	0	$109,752.00	$630.00	$10,043.00
31	11-A	102	Boulevard Bioswale	3rd Ave.	A-11	0.1	49	0.1	$8,526.00	$225.00	$10,342.00
32	9-C	89	Hydrodynamic Device	7th Ave. and Harrison St.	A-9	1	407	0	$109,752.00	$630.00	$10,537.00

[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 ranked 33 – 48 are shown on this table. 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	Estimated Annual Operations & Maintenance	Estimated cost/ 1,000lb-TSS/year (30-year)[1]
33	14-A	121	Hydrodynamic Device	Parking lot off 1st Ave.	A-14	0.8	385	0	$109,752.00	$630.00	$11,139.00
34	7-C	68	Hydrodynamic Device	7th Ave.	A-7	0.8	383	0	$109,752.00	$630.00	$11,197.00
35	4-A	55	Hydrodynamic Device	Maple Ln.	A-4	0.3	113	0	$28,752.00	$630.00	$14,057.00
36	17-A	133	Hydrodynamic Device	Oakwood Dr.	A-17	0.6	244	0	$109,752.00	$630.00	$17,575.00
37	10-A	95	Hydrodynamic Device	6th Ave. and Taylor St.	A-10	0.5	211	0	$109,752.00	$630.00	$20,324.00
38	10-B	96	Hydrodynamic Device	5th Ave. and Taylor St.	A-10	0.5	195	0	$109,752.00	$630.00	$21,992.00
39	13-H	116	Boulevard Bioswale	Various locations in catchment	A-13	0.1	22	0.1	$8,526.00	$225.00	$23,072.00
40	16-B	129	Hydrodynamic Device	Oakwood Dr. and Washington St.	A-16	0.4	163	0	$109,752.00	$630.00	$26,309.00
41	1-C	40	Permeable Pavement	Anoka-Hennepin Education Center	A-1	2.9	1,325	3.5	$552,656.00	$41,165.00	$44,971.00
42	13-F	114	Permeable Pavement	St. Stephen's Catholic School	A-13	1.6	562	1.6	$282,796.00	$20,925.00	$54,006.00
43	13-E	113	Permeable Pavement	St. Stephen's Catholic Church	A-13	0.9	320	0.9	$162,796.00	$11,925.00	$54,224.00
44	13-G	115	Permeable Pavement	St. Stephen's Catholic School	A-13	1.9	672	1.9	$343,796.00	$25,500.00	$55,000.00
48	3-D	51	IESF Bench	Green Haven Golf Course Pond	A-3	10.4	0	0	$282,955.00	$3,214.00	N/A
48	7-I1	75	IESF Bench	7th Ave.	A-7	26.6	0	0	$580,991.00	$4,591.00	N/A
48	7-I2	76	IESF Bench	7th Ave.	A-7	7.2	0	0	$305,875.00	$1,837.00	N/A
48	8-C	82	IESF Bench	4th Ave. and Grant St.	A-8	7.2	0	0	$282,955.00	$1,607.00	N/A

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

Project Selection

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

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

BMP Descriptions

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

BMPs were proposed for a specific site within the research area. Each of these projects, including site location, size, and estimated cost and pollutant reduction potential are noted in detail in the Catchment Profiles section. Project types included in the following sections are:

- Bioretention
    - Curb-cut Rain Garden
    - Boulevard Bioswale
    - Infiltration Basin
- Hydrodynamic Device
- Permeable Pavement
- Iron-Enhanced Sand Filter Pond Bench
- Modification to an Existing Pond
- New Stormwater Pond
- Stormwater Reuse

Bioretention

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

Bioretention can function as either filtration (biofiltration) or infiltration (bioinfiltration). Biofiltration BMPs are designed with a buried perforated drain tile that allows water in the basin to discharge to the stormwater drainage system after having been filtered through the soil. Bioinfiltration BMPs have no underdrain, ensuring that all water that enters the basins will either infiltrate into the soil or be evapotranspired into the air. Bioinfiltration provides 100% retention and treatment of captured stormwater, whereas biofiltration basins provide excellent removal of particulate contaminants but limited removal of dissolved contaminants, such as DP (Table 8).

Table 8: Matrix describing curb-cut rain garden efficacy for pollutant removal based on type.

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

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

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

Please note infiltration examples included in this section would require site specific investigations to verify soils are appropriate for infiltration.

Curb-cut Rain Gardens

Curb-cut rain gardens capture stormwater that is in roadside gutters and redirects 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).

Figure 4: Rain garden before/after 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 gardens 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.

Boulevard Bioswale

One option for retrofitting a stormwater BMP within an existing boulevard is a bioswale. This practice is similar to the curb-cut rain garden in its orientation and size. Bioswales typically range from 5-30' in length, house a rich native plant community, and are installed between the existing sidewalk and roadway curb (Figure 5). Unlike rain gardens, these practices are typically much shallower (1-3" in depth) and have a curb-cut inlet and outlet (Figure 5). Although many rain gardens have outlets in the form of underdrains or risers, the bioswale outlet allows for a nearly continuous flow of

Figure 5: Right-of-way bioswale installed in New York City (NYC Environmental Protection, 2013)

stormwater through the practice. Although some infiltration does occur, the primary form of treatment is the settling of pollutants as stormwater flows through the dense plant community.

This practice was modeled to estimate the pollutant reduction capacity for TSS, TP, and stormwater volume in medium density residential drainage areas ranging from 0.25 to 4 acres (Table 9). A 20' long (parallel to roadway), 4' wide (perpendicular to roadway), and 3" deep bioswale was modeled with an infiltration rate of 2.5"/hour. No underdrain was modeled with this practice as they are designed to be flow-through systems with limited ponding (≤ 3"). Additional model inputs are noted in Appendix A – Modeling Methods.

Table 9: WinSLAMM model results for the boulevard bioswale with a 2.5"/hour infiltration rate.

Drainage Area (acres)	*Standard Boulevard Bioswale*					
	TP Removal		TSS Removal		Volume Removal	
	lbs-TP	%	lbs-TSS	%	ac-ft	%
0.25	0.07	33.3%	43	38.0%	0.058	21.9%
0.5	0.09	23.7%	61	28.3%	0.067	12.6%
1	0.08	13.0%	53	15.6%	0.074	7.0%
2	0.07	8.0%	45	9.8%	0.082	3.8%
3	0.08	6.8%	47	8.6%	0.087	2.7%
4	0.08	6.2%	48	8.0%	0.09	2.1%

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. > 500 sq.-ft.) infiltration basin. This allows 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 2016 dollars. A reduced construction cost (i.e. \$15 to \$20 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.

Hydrodynamic Devices

In heavily urbanized settings 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 6). 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.

In order to calculate the 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.

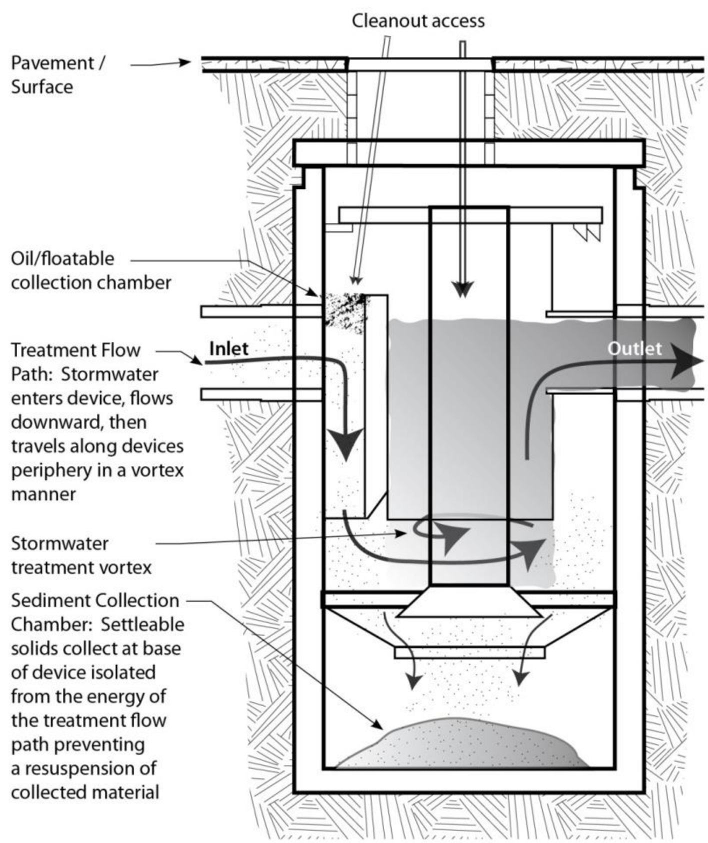


Figure 6: Schematic of a typical hydrodynamic device

Permeable Pavement

Relatively flat, low traffic areas provide a suitable location for diverting stormwater runoff from impervious surfaces to porous pavement. Void space between concrete pavers or within permeable asphalt and concrete allow water to percolate through the surface to an underlying layer(s) of coarse aggregate rock (Figure 7). This aggregate can act as a reservoir providing water quality and quantity benefits by filtering the stormwater and creating storage. From here water can either be stored temporarily or can infiltrate into the ground to recharge local groundwater aquifers. Many designs include permeable geotextile fabric to separate the un-compacted soil subgrade from the coarse aggregate and to facilitate infiltration. If soils don't allow for infiltration, a liner can be installed with an underdrain attached to nearby storm sewers or additional stormwater BMPs. This still allows for filtration through the pavement and aggregate, and reduces peak discharge from the site.

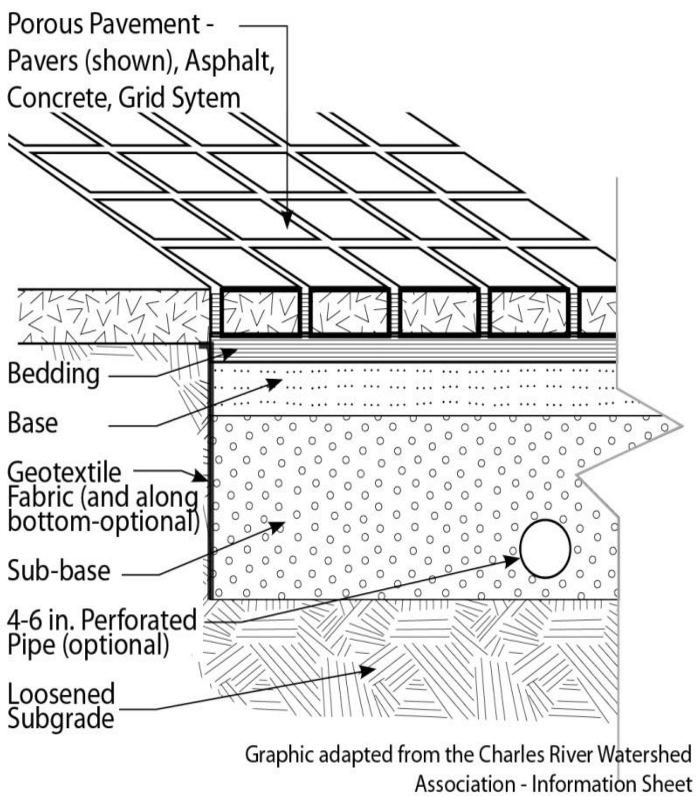


Figure 7: Schematic of typical permeable pavement surface and subgrade.

This practice is ideally suited for small drainage areas flowing to low traffic pavement surfaces (Figure 8). For a residential property, roof runoff can be diverted via rain leaders to a permeable driveway. On a commercial property, parking spaces within a large parking lot could be converted to permeable pavement to capture runoff from the parking lot, sidewalks, and any buildings on the property. On a residential roadway, parking spaces on either side of the street could be converted to permeable pavement. In this case the practice could treat not just the roadway but multiple properties along the street. Permeable pavement can be used for many

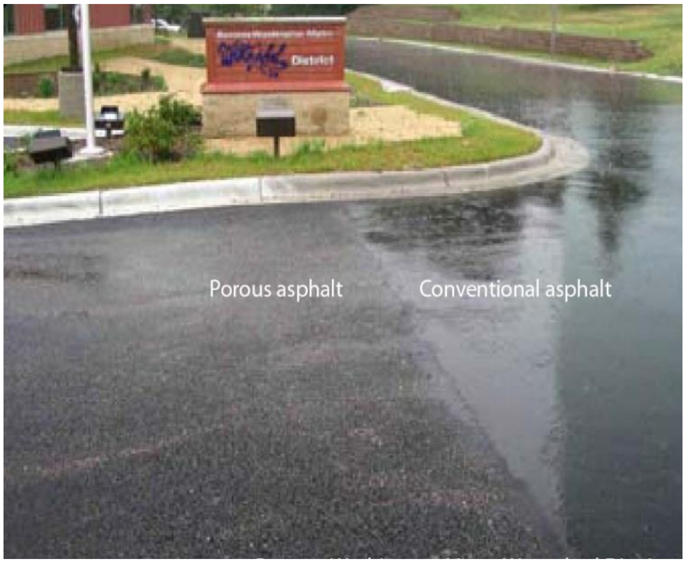


Figure 8: Photo comparing conventional and permeable asphalt

other scenarios in areas where soil type, seasonal water table, and frost line allow for groundwater recharge.

The capacity for this practice is completely dependent on the reservoir size within the aggregate and whether or not infiltration can occur on the site. In most cases the permeable pavement treats stormwater received from just the surface itself and adjacent impervious surfaces. A general design guideline used in this analysis is a ratio between the permeable pavement surface area and the area of the impervious surface draining to the practice of 1:2. Other than reservoir capacity, this ratio also depends on the infiltration rate (in the case that the BMP allows for infiltration) or drainage time (if an underdrain is installed) and how well the practice is maintained as clogging can greatly decrease the ability of the practice to capture runoff.

The pollutant removal potential of permeable pavement was estimated using WinSLAMM. A detailed account of the methodologies used is included in Appendix A – Modeling Methods. 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, which easily adsorbs to sediment when in particulate form. Median values for pollutant removal percentage by wet retention ponds are 84% for TSS and 50% for TP (MN Stormwater Manual). 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 address this deficiency, researchers at the University of Minnesota developed a method to augment phosphorus retention within a sand filter. They've named this technology the "Iron Enhanced Sand Filter" (IESF; Figure 9). Locally, this practice has also been identified as the "Minnesota Filter." IESFs rely on the properties of iron to bind dissolved phosphorus as it passes through an iron rich medium. Depending on topographic characteristics of the installation sites, IESFs can rely on gravitational flow and natural water level fluctuation, or water pumping to hydrate the IESF. IESFs 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, a ferric-chloride injection system could be installed to bind dissolved phosphorus into a flocculent, which would settle in the bottom of the new pond.

Figure 9 shows an IESF 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. 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's capacity would exit the pond via the existing outlet.

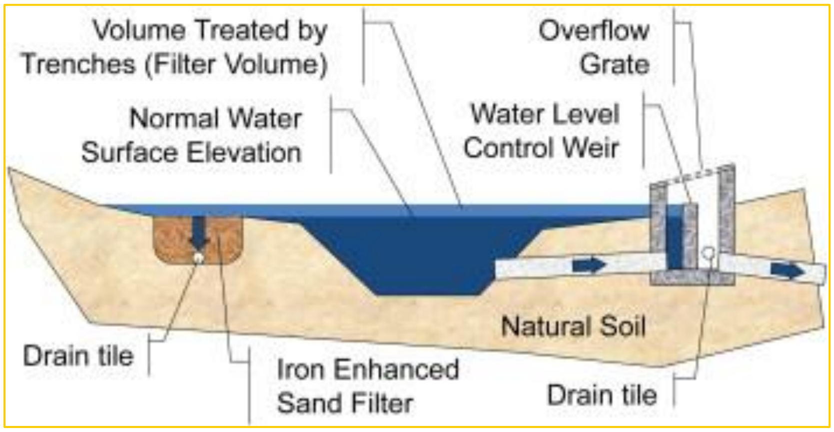


Figure 9: Iron Enhanced Sand Filter Concept (Erickson & Gulliver, 2010)

Benefits for stormwater ponds were modeled utilizing WinSLAMM. After selecting an optimal pond configuration in terms of cost-benefit, or by using the existing pond configuration if no updates are needed, modeling for an IESF was also completed in WinSLAMM. WinSLAMM is able to calculate flow through constructed features such as rain gardens with underdrains, soil amendments, and controlled overflow elevations. An IESF works much the same way. Storm event based discharge volumes and phosphorus concentrations estimated by WinSLAMM at the pond outlet were entered into WinSLAMM as inputs into the IESF. Various iterations of IESFs were modeled to identify an optimal treatment level compared to construction costs and space available. A detailed account of the methodologies used is included in Appendix A – Modeling Methods.

To account for the DP treated by the IESF, an additional 80% DP removal was assumed for each IESF 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 DP 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 projects were assumed to involve some excavation and disposal of soil, land acquisition (if necessary), erosion control, and vegetation management. 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. Annual maintenance costs were estimated to be $10,000 per acre of IESF based on information received from local, private consulting firms. Additional costs associated with specific projects are listed in Appendix B – Project Cost Estimates.

Modification to an Existing Pond

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

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

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

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

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

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

New Stormwater Pond

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 10).

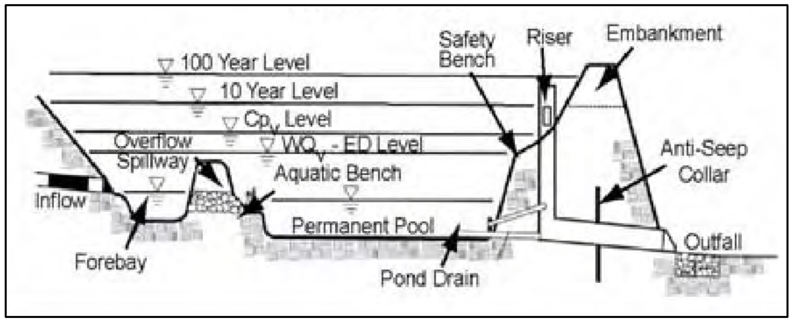


Figure 10: Schematic of a stormwater retention pond.

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 re-suspend 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. Additional costs associated with specific projects are listed in Appendix B – Project Cost Estimates.

Stormwater Reuse

Some of the major water resource issues today include improving stormwater treatment (quantity and quality), increasing groundwater recharge, and decreasing public water usage. Stormwater reuse is a powerful BMP strategy that can be applied to address each of these on a scale ranging from a single property to an entire neighborhood. Stormwater reuse allows for the utilization of stormwater to supplement potable sources, in applications that do not require water to be at a standard set for consumption. An example of this might be using captured stormwater to irrigate a golf course or recreational fields.

Benefits from this practice are twofold. First, stormwater runoff is given multiple opportunities for treatment. Treatment through settling, filtering, or hydrodynamic separation at the BMP site provides initial treatment of particulates, litter, and other debris. Application of the stormwater as irrigation allows for infiltration through the soil layer and treatment of the dissolved load of pollutants that may have remained. The second benefit is the reduced usage of potable water. As there is no need for highly treated water when irrigating a lawn, the stress placed on water treatment facilities and the water distribution network can be reduced.

The concept for this practice at its smallest scale is that of a rain barrel on a residential property. Runoff from the impervious roof is captured by gutters and diverted to the rain barrel until it is needed for watering the lawn or garden. At a larger scale, runoff from roofs, driveways, sidewalks, and roadways is diverted to roadway catch basins and to the storm sewer network. A cistern or similar containment unit holds water from storm sewers until it is needed for irrigation. These structures can vary in size from tens of gallons to hundreds of thousands of gallons. Stormwater detention and retention ponds are also popular choices as construction and maintenance costs are often much cheaper than underground cisterns.

These practices often require significant capital investment as updates to the local stormwater infrastructure may be needed. Large cisterns, whether made of concrete or plastic, can require high transportation and installation costs. Additional infrastructure may also be necessary, including a foundation to sustain the weight of the cistern (whether above or below ground), pump, and conveyance system. A detailed maintenance plan is also necessary even if other forms of pretreatment (e.g. hydrodynamic device, baffle, etc.) are installed. Lastly, during dry periods potable water may still be needed to supplement stormwater when the containment unit is empty.

The pollutant removal potential of stormwater reuse devices was estimated using the stormwater model 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, promotion, design, administration, and maintenance over the anticipated life of the practice were considered in addition to actual construction costs. Costs for projects are listed in detail in Appendix B – Project Cost Estimates. Load reduction estimates for these projects are noted in the Catchment Profiles section.

Catchment Profiles

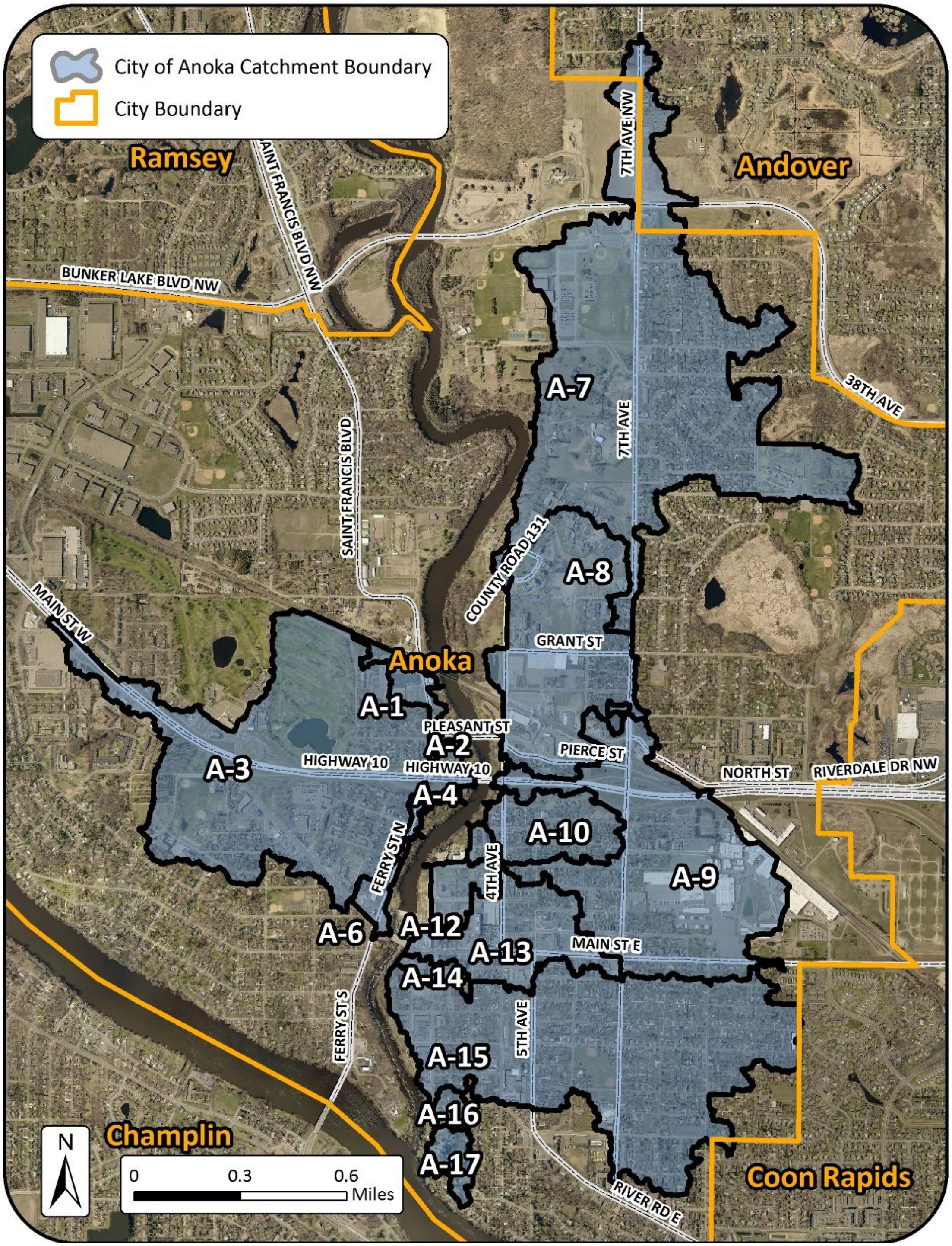
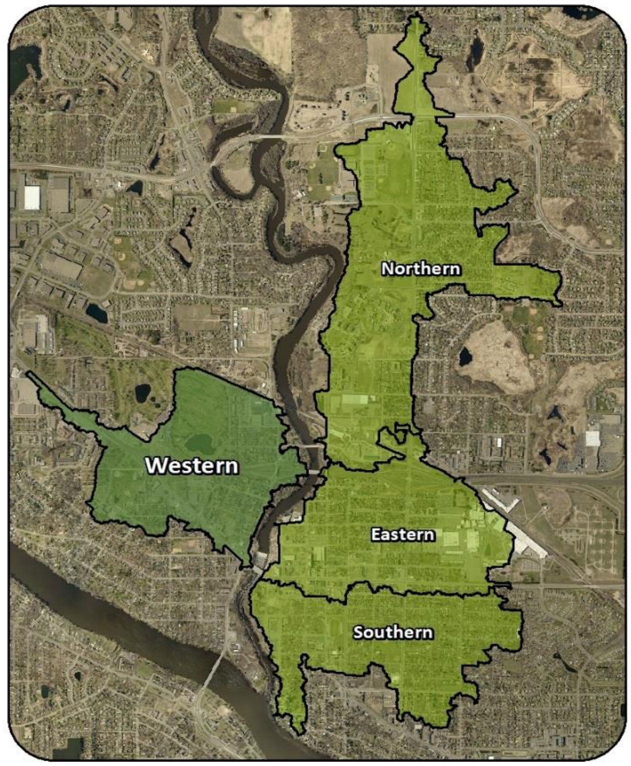


Figure 11: The 1,469-acre drainage area was divided into 17 catchments for this analysis. Catchment profiles on the following pages provide additional information.

Western Drainage Network

Catchment ID	Page
A-1	35
A-2	41
A-3	45
A-4	53
A-5	56
A-6	59

Existing Network Summary	
Acres	313.2
Dominant Land Cover	Residential
Volume (ac-ft/yr)	208.0
TP (lb/yr)	151.3
TSS (lb/yr)	50,263



DRAINAGE NETWORK SUMMARY

The western drainage network includes all areas of the City of Anoka draining to the western shores of the Rum River south of the Burlington Northern railroad tracks to approximately Main St. Six catchments lie within this drainage network, each with their own outfall to the Rum River. These outfalls are located at (from north to south) Ferry Street 200' south of the Burlington Northern railroad tracks (Catchment A-1), Maple Avenue (A-2), US-10 (A-3), Maple Lane (A-4), Clay Street (A-5), and Main St. (A-6).

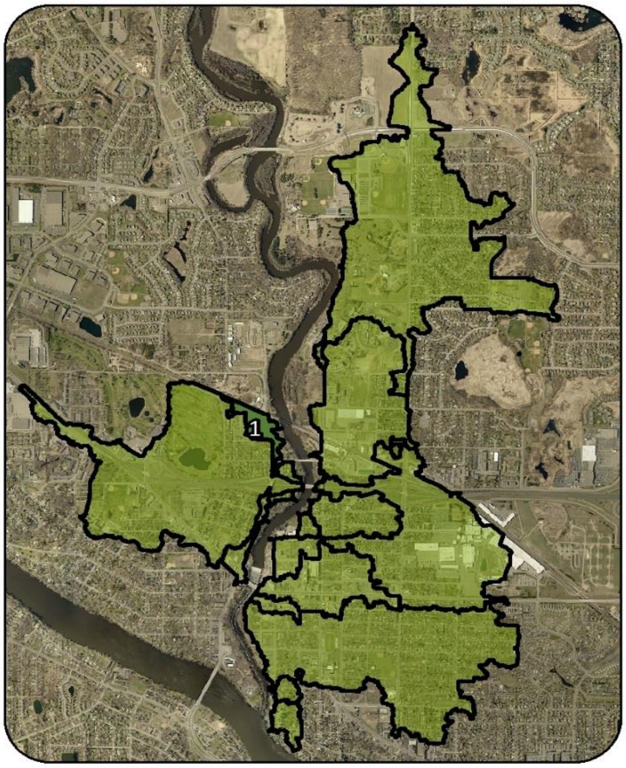
Catchment size varies greatly, from just over two acres to up to 280 acres. Notable areas of the drainage network include the US-10 and US-169 highway corridors, the public golf course, Ward Park, and commercial properties along Main St. and US-169.

EXISTING STORMWATER TREATMENT

Stormwater runoff generated across the network is, for the most part, quickly intercepted within either municipal, county, or MNDOT storm sewer and conveyed to one of six stormwater outfalls to the Rum River. Nine stormwater treatment devices exist throughout the network which treat stormwater prior to discharge into the Rum River. Most of these treat relatively small drainage areas (<15 acres). Exceptions to this include Ward Park pond, which treats 25 acres of residential streets and parkland, and the Green Haven Golf Course pond, which treats 177 acres of golf course, US-10, parkland, commercial, and residential land uses. Both of these ponds are in Catchment A-3. Additional detail on these ponds and other stormwater BMPs are provided in the Catchment Profiles.

Catchment A-1

Existing Catchment Summary	
Acres	14.8
Dominant Land Cover	Institutional
Parcels	25
Volume (ac-ft/yr)	12.4
TP (lb/yr)	10.4
TSS (lb/yr)	4,826



CATCHMENT DESCRIPTION

This catchment drains nearly 15 acres of public-institutional and industrial land uses along Ferry Street between the Burlington Northern railroad tracks and Highway 10. The catchment is highly impervious, predominantly due to the Anoka-Hennepin Education Service Center building and parking lot comprising about 50% of the geographical area of the catchment.

Stormwater generated in Catchment A-1 is directed to a storm sewer network beginning under the parking lot of the Anoka-Hennepin Education Service Center and flowing east to an outfall to the Rum River east of the A1 Recycling Center.

EXISTING STORMWATER TREATMENT

No existing treatment exists in this catchment beyond street cleaning provided by the City of Anoka two times per year. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	11.1	0.7	6%	**10.4**
	TSS (lb/yr)	5,278	452	9%	**4,826**
	Volume (acre-feet/yr)	12.4	0.0	0%	**12.4**

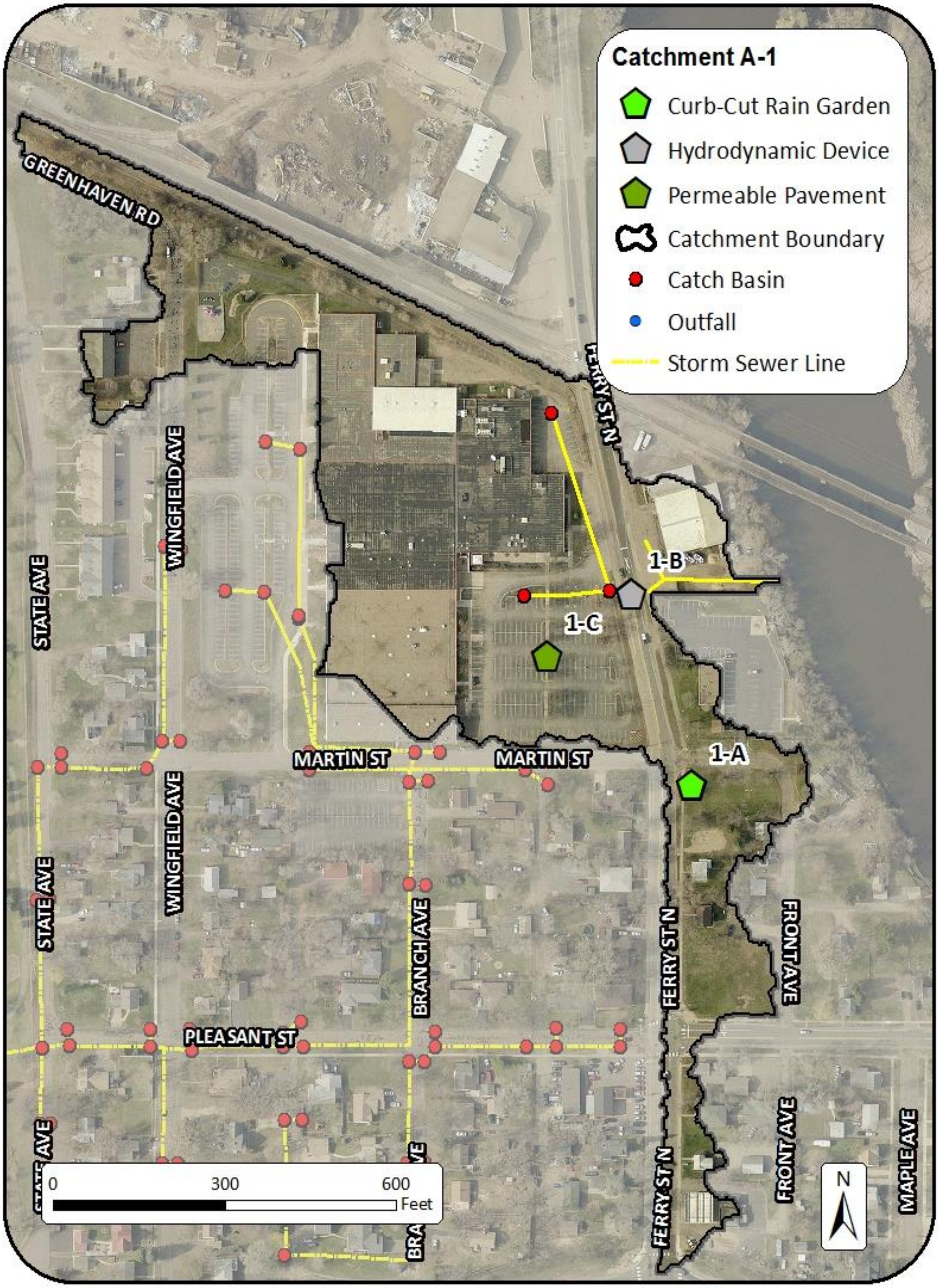
PROPOSED RETROFITS OVERVIEW

As no existing treatment exists in this catchment, in-line treatment along the main storm sewer line was proposed in a hydrodynamic device installed along Ferry St. within the road right-of-way. This unit could treat up to 14.8 acres of the predominantly impervious catchment.

To help reduce peak flows to the storm sewer network (and a potential hydrodynamic device installed along the network), permeable pavement was also proposed for the eastern parking lot of the Anoka-

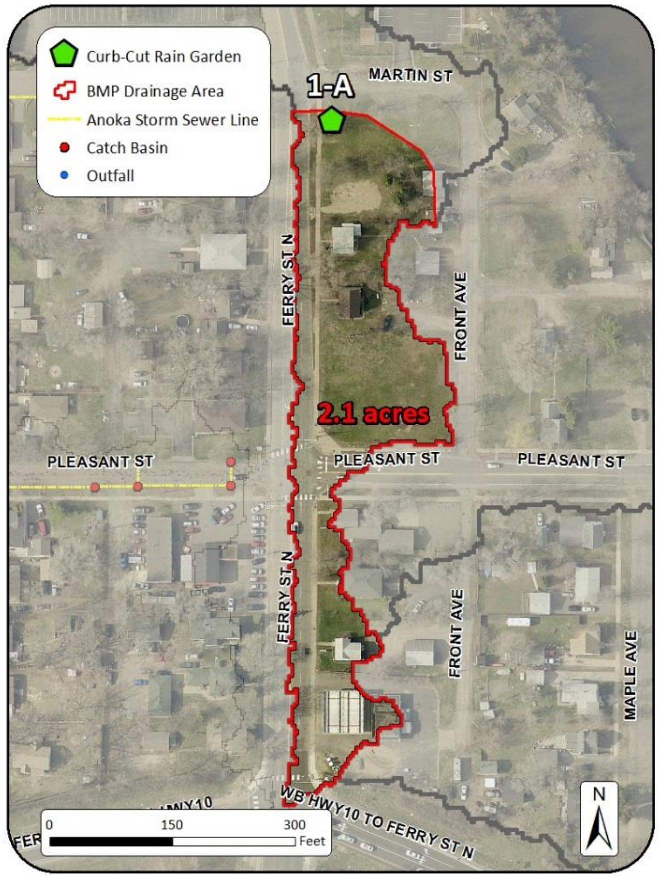
Hennepin Education Service Center. A rain garden was also proposed to be along Ferry Street to also reduce peak flows as well as to capture TSS and TP.

RETROFIT RECOMMENDATIONS



Project ID: 1-A

Ferry St. & Front Ave.
Curb-Cut Rain Garden



Drainage Area – 2.1 acres
Location – On Ferry Street at Front Avenue
Property Ownership – Public (City of Anoka)
Site Specific Information – One location was identified along Ferry Street on public property for a curb-cut rain garden. This retrofit could treat stormwater pollutants originating from Ferry Street and from surrounding residential properties.

	Curb-Cut Rain Garden		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	250	sq-ft
	TP (lb/yr)	0.5	4.8%
	TSS (lb/yr)	187	3.9%
	Volume (acre-feet/yr)	0.5	3.9%
Cost	**Administration & Promotion Costs***		$1,606
	Design & Construction Costs**		$7,376
	Total Estimated Project Cost (2016)		**$8,982**
	Annual O&M***		$225
Efficiency	**30-yr Average Cost/lb-TP**	**$1,049**	
	30-yr Average Cost/1,000lb-TSS	**$2,804**	
	30-yr Average Cost/ac-ft Vol.	**$1,090**	

*Indirect Cost: (10 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

Ferry Street
Hydrodynamic Device

Drainage Area – 14.8 acres
Location – Ferry Street
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on Ferry Street at the outlet of the catchment. A device at this location would be able to accept and treat runoff from the entire catchment.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.0	9.6%
	TSS (lb/yr)	584	12.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,288**	
	30-yr Average Cost/1,000lb-TSS	**$7,343**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

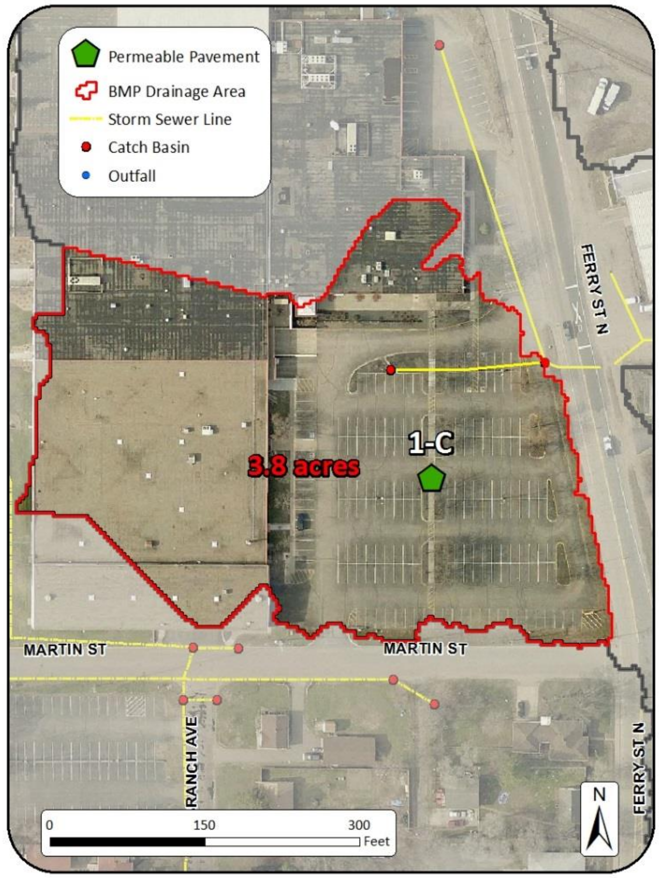
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: 1-C

Anoka-Hennepin Education Center
Permeable Pavement

Drainage Area – 3.8 acres
Location – Eastern parking lot of the Anoka-Hennepin Education Service Center
Property Ownership – Public
Site Specific Information – Permeable pavement is proposed for the eastern parking lot of the Anoka-Hennepin Education Services Center. This practice allows the treatment of a large surface area with minimal impact on the usable space. In order to treat the 3.8-acre drainage area, 54,886 sq.-ft. of permeable pavement is proposed.



	Permeable Pavement		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMP	54,886	sq-ft
	TP (lb/yr)	2.9	27.9%
	TSS (lb/yr)	1,325	27.5%
	Volume (acre-feet/yr)	3.5	28.2%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$549,736	
	Total Estimated Project Cost (2016)	**$552,656**	
	Annual O&M***	$41,165	
Efficiency	**30-yr Average Cost/lb-TP**	**$20,547**	
	30-yr Average Cost/1,000lb-TSS	**$44,971**	
	30-yr Average Cost/ac-ft Vol.	**$17,044**	

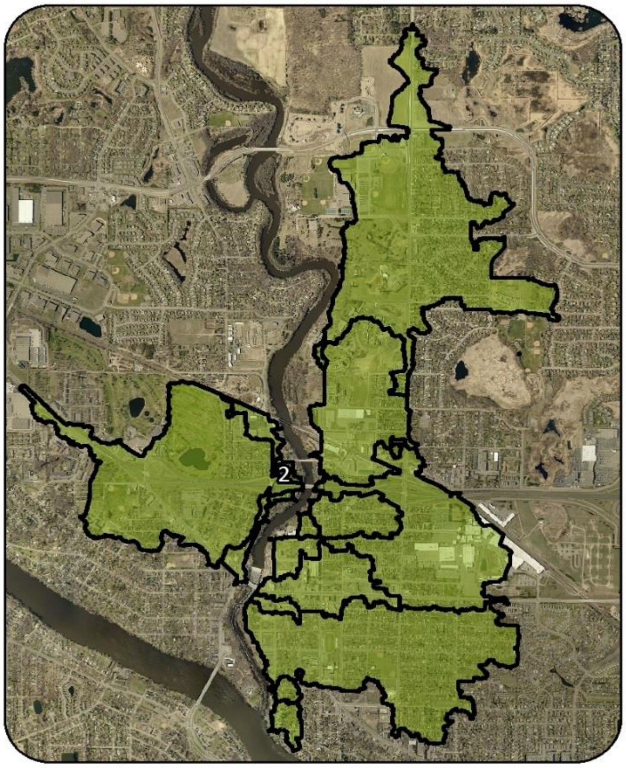
*Indirect Cost: 40 hours at $73/hour

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

***($0.75/sq-ft for routine maintenance)

Catchment A-2

Existing Catchment Summary	
Acres	3.7
Dominant Land Cover	Residential
Parcels	16
Volume (acre-feet/yr)	2.0
TP (lb/yr)	2.1
TSS (lb/yr)	678



CATCHMENT DESCRIPTION

Catchment 2 is bounded by residences on Polk Street NE, 39th Avenue NE, Johnson Street NE, and the railroad tracks. 37th Avenue NE bisects the catchment from east to west. The catchment is comprised primarily of single family residential properties. There are a few multi-family homes and one commercial property.

All stormwater runoff generated in this catchment flows overland to the south and is collected by catch basins. The stormwater is then conveyed east to the Rum River.

EXISTING STORMWATER TREATMENT

As part of a roadway reconstruction project in 2015, a subsurface treatment system was installed along the Maple Avenue storm sewer network just upstream of the outfall to the Rum River. This subsurface treatment system consists of a St. Anthony Falls Laboratory (SAFL) Baffle installed within a manhole. In addition to this structural stormwater treatment, the City of Anoka conducts street cleaning two times per year. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	2.5	0.4	16%	**2.1**
	TSS (lb/yr)	881	203	23%	**678**
	Volume (acre-feet/yr)	2.0	0.0	0%	**2.0**

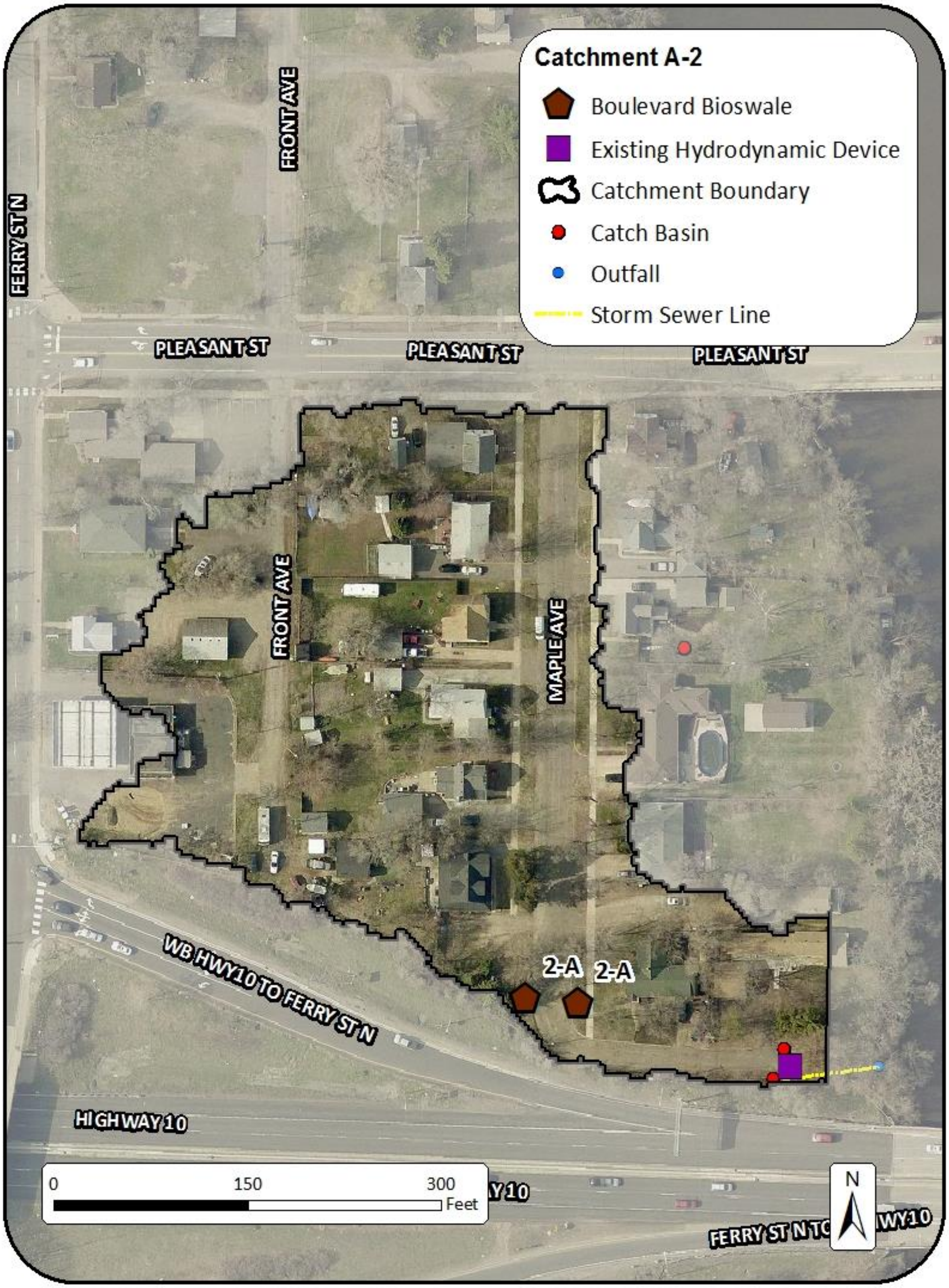
PROPOSED RETROFITS OVERVIEW

Two bioswales are proposed to supplement the treatment provided by the baffle. Infiltration rates should be sufficient enough to support infiltration practices considering the sandy Hubbard soils throughout the area.

RETROFITS CONSIDERED BUT REJECTED

Due to the small size of this catchment and its existing treatment no other retrofits were considered besides small bioretention practices.

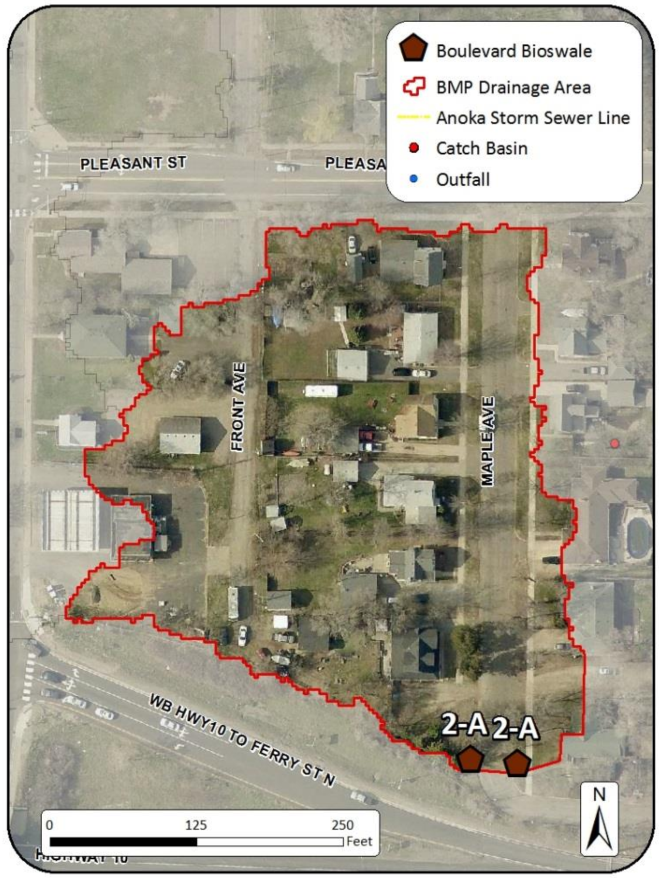
RETROFIT RECOMMENDATIONS



Project ID: 2-A

Maple Avenue
Boulevard Bioswale

Drainage Area – 0.5 acre
Location – At southern end of Maple Avenue
Property Ownership – Public
Site Specific Information – Bioswales are proposed for installation along Maple Avenue to reduce sediment and phosphorus loads. The existing sidewalks along Maple Ave. make boulevard bioswales a viable option. Locations for up to two bioswales are sited, where they will serve to treat runoff from the streets and the surrounding private properties. The table below shows the estimated cost and pollutant removal amounts based on treatment of the 0.5-acre drainage area.



Boulevard Bioswale

	Cost/Removal Analysis	2.5"/hr Infilt. Rate	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.2	7.7%
	TSS (lb/yr)	55	8.2%
	Volume (acre-feet/yr)	0.1	6.5%
Cost	Administration & Promotion Costs*	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$3,140**	
	30-yr Average Cost/1,000lb-TSS	**$9,202**	
	30-yr Average Cost/ac-ft Vol.	**$3,859**	

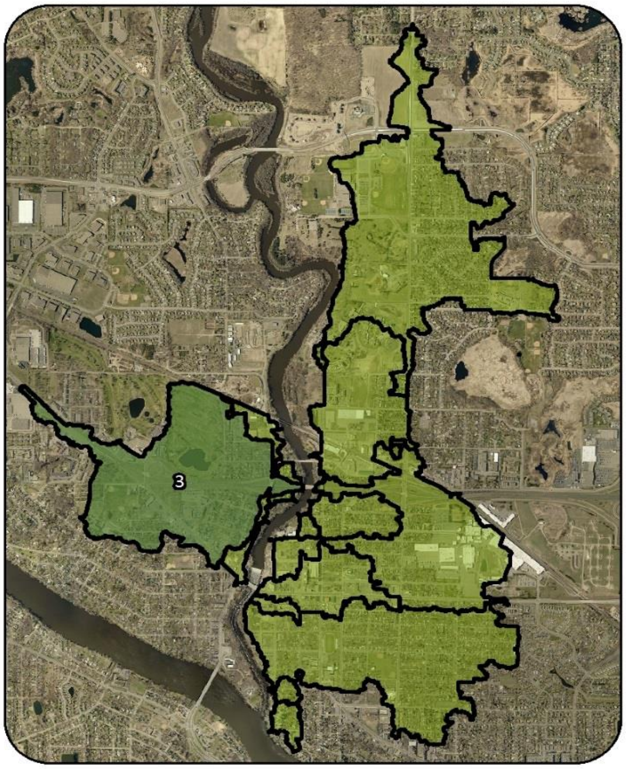
*Indirect Cost: (50 hours at $73/hour)

**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Catchment A-3

Existing Catchment Summary	
Acres	286.1
Dominant Land Cover	Residential
Parcels	322
Volume (acre-feet/yr)	179.9
TP (lb/yr)	127.4
TSS (lb/yr)	40,532



CATCHMENT DESCRIPTION

Catchment A-3 contains all of Highway 10 and most of Main Street in the City of Anoka research area west of the Rum River. Highway 10 bisects the catchment from east to west. Within the catchment north of Highway 10 is the public golf course, east of the clubhouse, the Anoka-Hennepin Education Center western parking lot, and approximately 25 acres of single-family residential housing. On the south side of this catchment is parkland, large commercial lots, Franklin Elementary School, and additional single-family residential housing.

Stormwater generated within this catchment flows through various municipal storm sewer networks to a state line running east below Highway 10. This network discharges into the Rum River through a 60" diameter pipe just south of Highway 10.

EXISTING STORMWATER TREATMENT

Five existing structural BMPs are installed on city-owned property throughout the catchment. On the south side of Ward Park is a depression acting as a pond. Stormwater along Western Street and Forest Avenue is directed towards this depression and overflow appears to only occur overland through the park. A second retention pond is located in the southeastern corner of the golf course. This pond treats 202 acres of the Green Haven Golf Course, Highway 10, Ward Park, and commercial properties along Main Street.

The three remaining city-owned structural BMPs were installed as part of a roadway reconstruction project in 2015. On the northern edge of the catchment, State Avenue was shortened by about 250' south of Greenhaven Road, creating a dead end. In place of the roadway, a swale was installed that treats runoff from State Avenue and Greenhaven Road. This swale discharges west into the Green Haven Golf Course, and likely only during very large storm events due to its ponding depth and small contributing drainage area.

Two SAFL Baffles were also installed in new manholes as part of the 2015 reconstruction projects. These are located along storm sewer lines under Branch Avenue and the alleyway between Wingfield Avenue and Branch Avenue.

A single privately-owned BMP was modeled as part of this analysis. This is a large pond located on the Main Motor Sales Company property adjacent to State Avenue. This pond currently only treats runoff from the Main Motors property and discharges to the municipal storm sewer line running north to Highway 10.

Lastly, street cleaning is provided by the City of Anoka two times per year. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	7			
	BMP Types	3 Ponds, 1 Infiltration Basin, 2 HDs, Street Cleaning			
	TP (lb/yr)	228.5	101.1	44%	**127.4**
	TSS (lb/yr)	88,416	47,884	54%	**40,532**
	Volume (acre-feet/yr)	181.0	0.0	0%	**179.9**

PROPOSED RETROFITS OVERVIEW

A variety of new stormwater treatment practices were proposed to supplement the existing treatment systems as well as to provide new opportunities to land uses that currently discharge untreated to the Rum River. Two BMPs were proposed at the golf course pond. The first project is an IESF bench along the golf course pond. If installed, this device could increase the retention of phosphorus from over 200 acres in the catchment. Secondly, stormwater reuse may also be an option for the golf course pond through using stormwater (in lieu of potable drinking water) to irrigate the grass on the course.

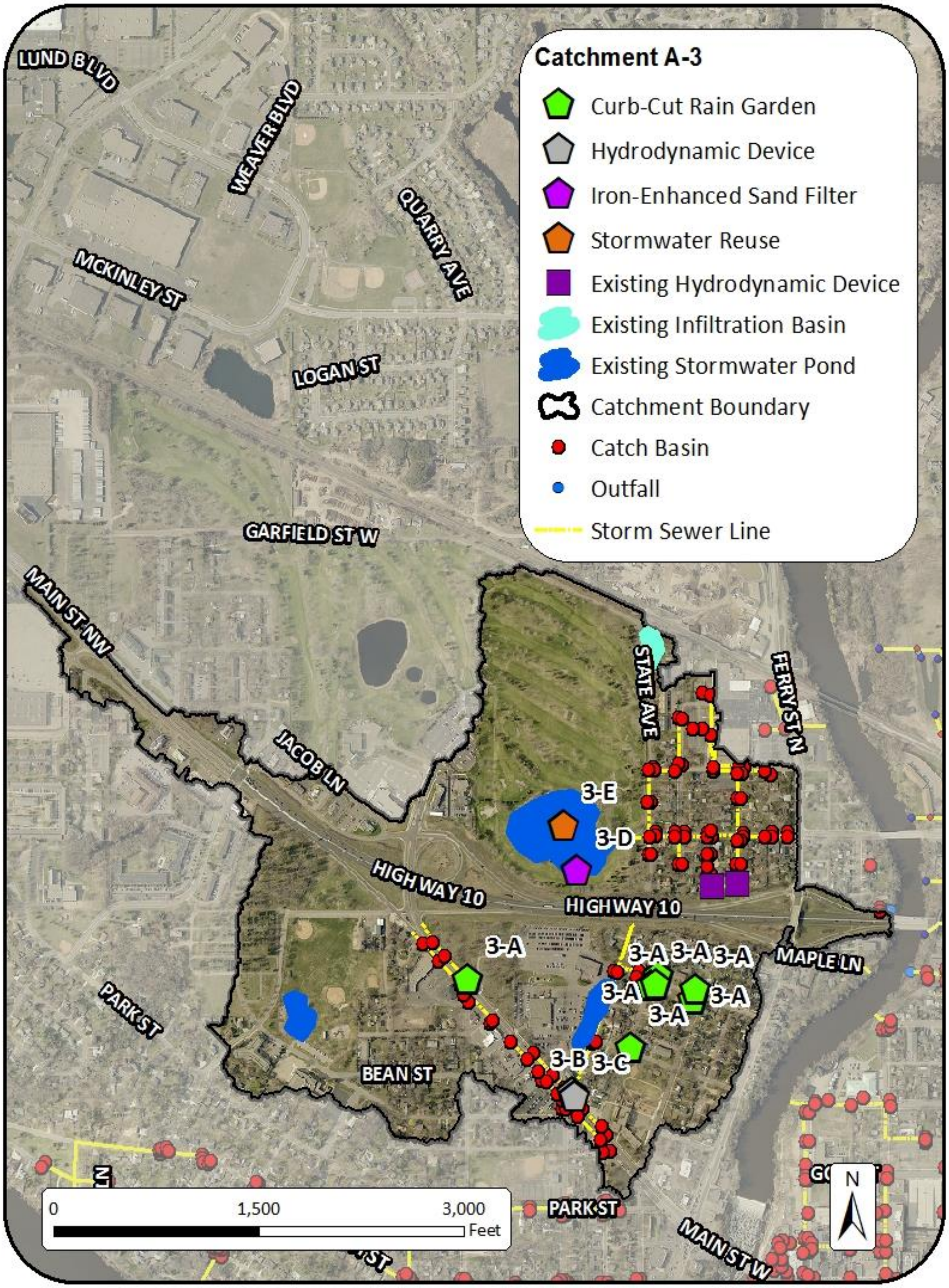
Two hydrodynamic devices are proposed to treat runoff generated along Main Street before it reaches the State Avenue line.

Bioretention practices were also explored throughout the catchment due to sandy soils found throughout the area. Up to seven curb-cut rain gardens were proposed for the residential and commercial areas south of Highway 10.

RETROFITS CONSIDERED BUT REJECTED

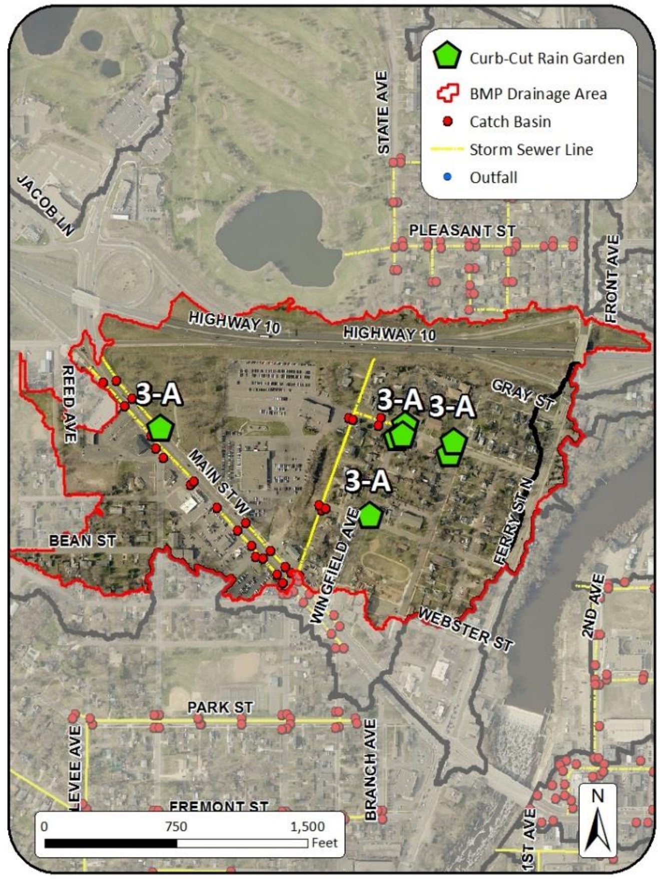
Curb-cut rain garden and boulevard bioswales were considered for the single-family residential housing area east of the golf course but were not proposed as drainage areas to the bioretention basins would be quite small due to the large number of catch basins throughout the area. Additionally, two hydrodynamic devices were proposed to be installed south of the Main St – Highway 10 interchange to treat storm sewer lines along Main Street. However, due to the number of retention ponds in the catchment, with modeling these hydrodynamic devices proved to be ineffective.

RETROFIT RECOMMENDATIONS



Project ID: 3-A

Curb-Cut Rain Gardens



Drainage Area – 1.5 - 10.5 acres
Location – Various locations throughout catchment
Property Ownership – Private
Site Specific Information – Single-family lots and a cemetery in the catchment provide various locations for curb-cut rain gardens to treat stormwater pollutants originating from private properties. Considering typical private landowner participation rates, scenarios with one, three, and seven rain gardens were analyzed to treat the contributing drainage areas.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		3		7	
	Total Size of BMPs	250	sq-ft	750	sq-ft	1,750	sq-ft
	TP (lb/yr)	0.5	0.4%	1.5	1.2%	3.5	2.7%
	TSS (lb/yr)	157	0.4%	468	1.2%	1,089	2.7%
	Volume (acre-feet/yr)	0.4	0.2%	1.1	0.6%	2.7	1.5%
Cost	Administration & Promotion Costs*	$8,468		$10,220		$13,724	
	Design & Construction Costs**	$7,376		$22,128		$51,632	
	Total Estimated Project Cost (2016)	**$15,844**		**$32,348**		**$65,356**	
	Annual O&M***	$225		$675		$1,575	
Efficiency	30-yr Average Cost/lb-TP	**$1,506**		**$1,169**		**$1,072**	
	30-yr Average Cost/1,000lb-TSS	**$4,797**		**$3,746**		**$3,447**	
	30-yr Average Cost/ac-ft Vol.	**$2,052**		**$1,558**		**$1,410**	

*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

Main St. & State Ave.
Hydrodynamic Device

Drainage Area – 5.0 acres
Location – Northwestern corner of the Main Street and State Avenue intersection
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on Main Street and would accept runoff from areas primarily west of Main St. and the surrounding land uses. It could provide treatment to stormwater prior to discharging into the State Avenue stormwater pipe.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.5	0.4%
	TSS (lb/yr)	280	0.7%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2016)	**$55,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,977**	
	30-yr Average Cost/1,000lb-TSS	**$8,887**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

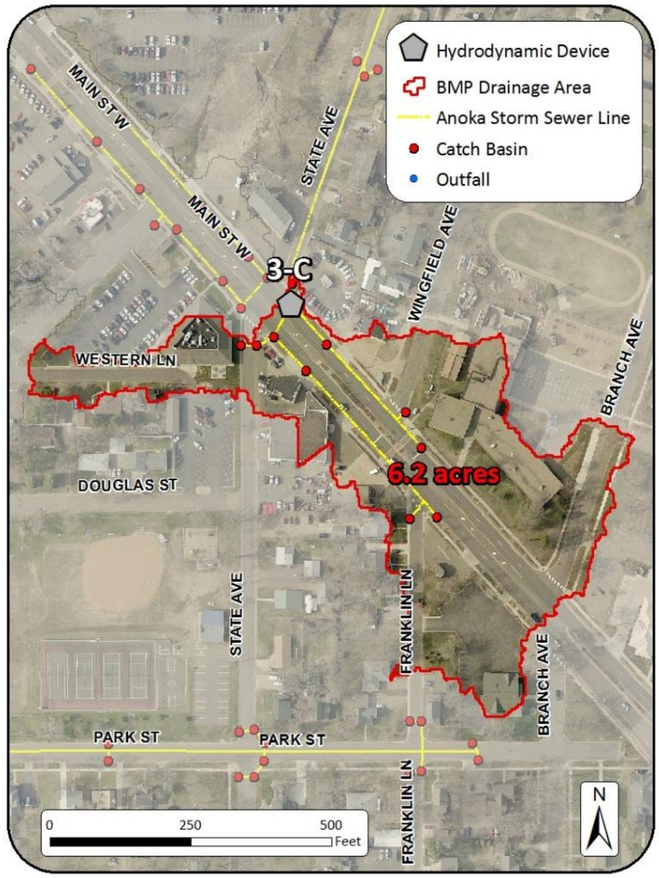
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 3-C

Main St. & State Ave.
Hydrodynamic Device



Drainage Area - 6.2 acres
Location – Northeastern corner of the Main Street and State Avenue intersection
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on Main Street and would accept runoff from the southern portion of Main Street and the surrounding land uses. It could provide stormwater treatment prior to discharging into the State Avenue stormwater pipe.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.6	0.5%
	TSS (lb/yr)	302	0.7%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2016)	**$55,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,147**	
	30-yr Average Cost/1,000lb-TSS	**$8,240**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

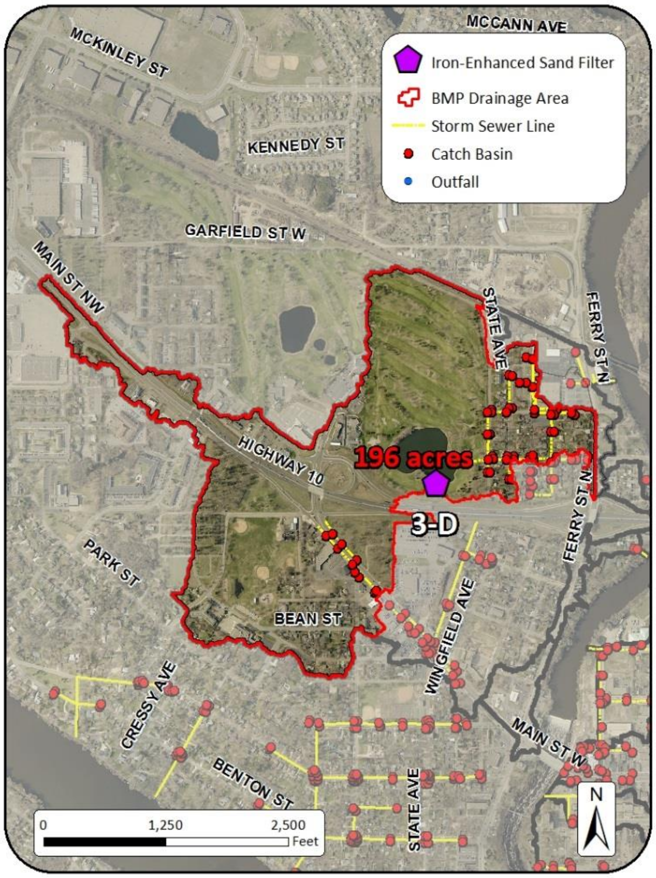
**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

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

Project ID: 3-D

Golf Course Pond
IESF Bench

Drainage Area – 196.0 acres
Location – South side of Green Haven Golf Course pond
Property Ownership – Public (City of Anoka)
Site Specific Information – An IESF bench is proposed as an improvement to the existing pond Green Haven Golf Course Pond. 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 south shore of the Green Haven Golf Course Pond. The IESF was sized to 14,000 sq.-ft. based on available space between the existing pond and the roadway.



	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	14,000	sq-ft
	TP (lb/yr)	10.4	8.2%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$277,480	
	Total Estimated Project Cost (2016)	**$282,955**	
	Annual O&M***	$3,214	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,216**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 75 hours at $73/hour

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

***$10,000/acre for IESF

Project ID: 3-E

Golf Course Pond Stormwater Reuse

Drainage Area – 196.0 acres
Location – Green Haven Golf Course
Property Ownership – Public (City of Anoka)
Site Specific Information – A stormwater reuse project was proposed for the Green Haven Golf Course Pond. The golf course could reuse the runoff captured in this pond to irrigate approximately 20-acres of the golf course. The pond currently provides storage for approximately 8.5 million gallons of water, and this system could use 500,000 gallons per week. This practice could provide water quality treatment as well as water conservation benefits.

	Stormwater Reuse		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	500,000	gallons
	TP (lb/yr)	18.2	14.3%
	TSS (lb/yr)	3,409	8.4%
	Volume (acre-feet/yr)	46.4	25.8%
Cost	**Administration & Promotion Costs***	$8,760	
	Design & Construction Costs**	$600,000	
	Total Estimated Project Cost (2016)	**$608,760**	
	Annual O&M***	$3,000	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,280**	
	30-yr Average Cost/1,000lb-TSS	**$6,833**	
	30-yr Average Cost/ac-ft Vol.	**$503**	

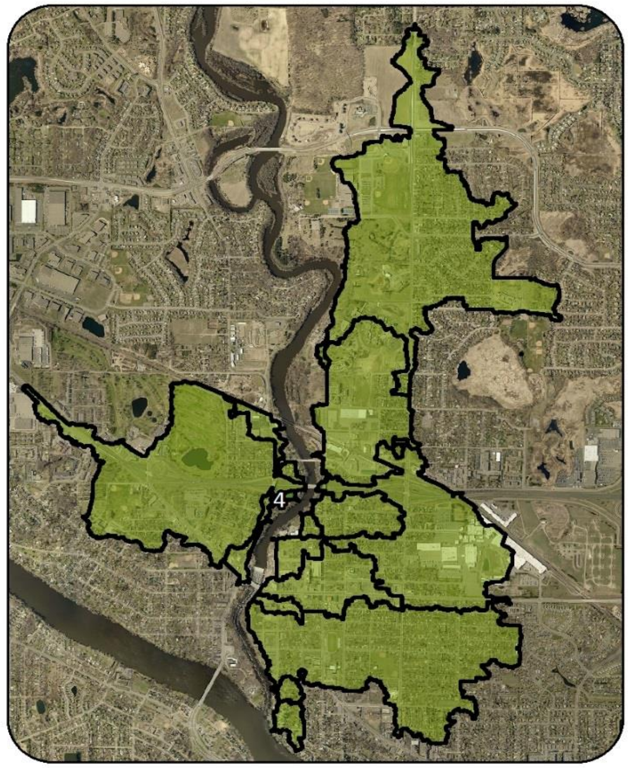
*120 hours at $73/hour

**See Appendix B for detailed cost information

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

Catchment A-4

Existing Catchment Summary	
Acres	2.2
Dominant Land Cover	Residential
Parcels	11
Volume (acre-feet/yr)	1.3
TP (lb/yr)	1.7
TSS (lb/yr)	573



CATCHMENT DESCRIPTION

This is the smallest catchment in this analysis, totaling just over two acres. The catchment consists only of drainage to two catch basins at the southeast corner of Maple Lane. The catch basins drain east and discharge directly to the Rum River.

EXISTING STORMWATER TREATMENT

No treatment currently exists in this catchment other than street cleaning, which is conducted two times per year. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	1.8	0.1	6%	**1.7**
	TSS (lb/yr)	618	45	7%	**573**
	Volume (acre-feet/yr)	1.3	0.0	0%	**1.3**

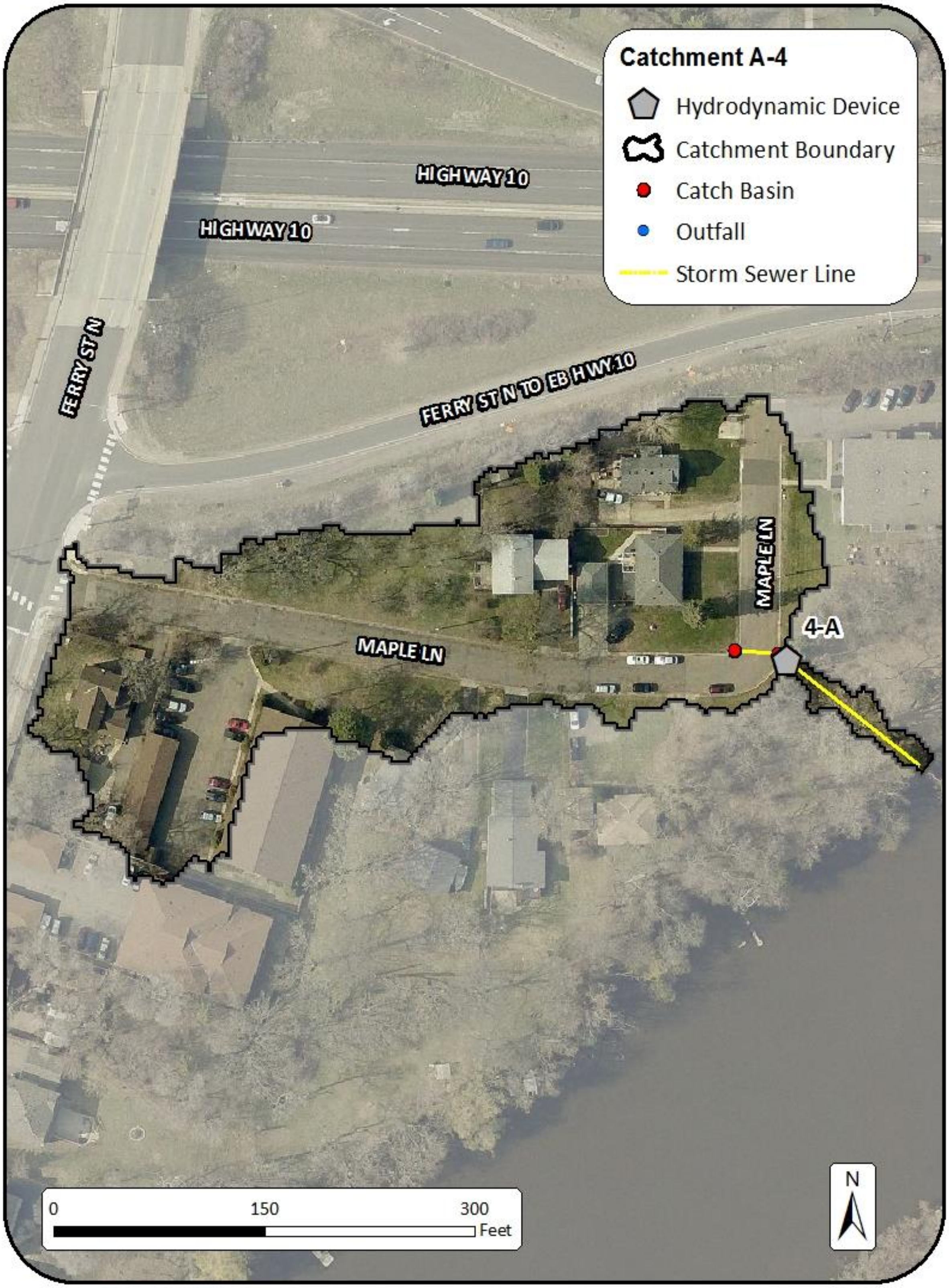
PROPOSED RETROFITS OVERVIEW

A single hydrodynamic device was proposed to treat drainage from the entire catchment.

RETROFITS CONSIDERED BUT REJECTED

Curb-cut rain gardens were considered in this catchment but were not proposed due to the steep slopes on the 2-3 properties with sufficient drainage areas to warrant a rain garden.

RETROFIT RECOMMENDATIONS



Project ID: 4-A

Maple Lane
Hydrodynamic Device

Drainage Area – 2.2 acres
Location – Maple Lane
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on Maple Lane to accept runoff from the entire catchment. This device could provide treatment before the water discharges into the Rum River.

Hydrodynamic Device

	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	6	ft diameter
	TP (lb/yr)	0.3	17.6%
	TSS (lb/yr)	113	19.7%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$27,000	
	Total Estimated Project Cost (2016)	**$28,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,295**	
	30-yr Average Cost/1,000lb-TSS	**$14,057**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

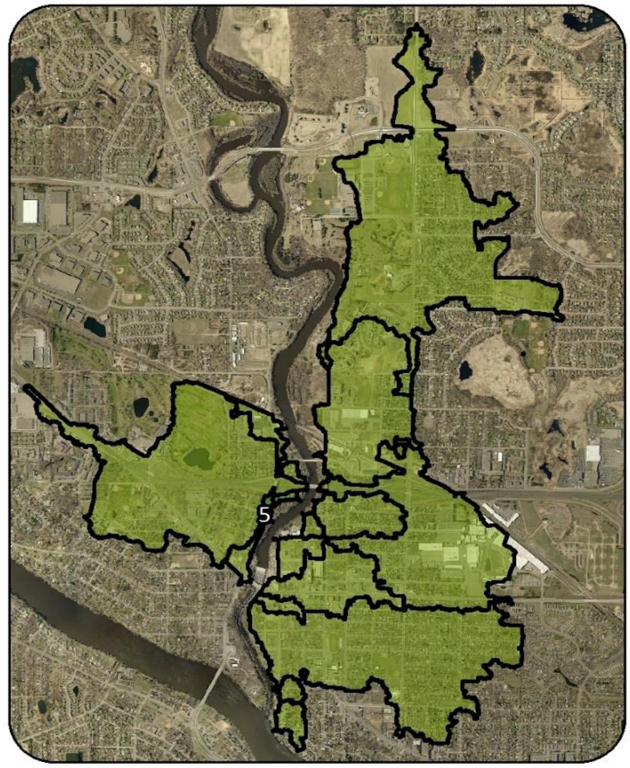
*Indirect Cost: (24 hours at $73/hour)

**Direct Cost: ($18,000 for materials) + ($9,000 for labor and installation costs)

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

Catchment A-5

Existing Catchment Summary	
Acres	3.7
Dominant Land Cover	Residential
Parcels	21
Volume (acre-feet/yr)	3.1
TP (lb/yr)	3.2
TSS (lb/yr)	1,051



CATCHMENT DESCRIPTION

This catchment consists primarily of paved surfaces, specifically the Ferry Street/Highway 169 corridor between Highway 10 and Calhoun Street. Overland runoff generated in the catchment is intercepted quickly in catch basins along Ferry Street and discharges into the Rum River from an outfall located just south of Clay Street.

EXISTING STORMWATER TREATMENT

A hydrodynamic device was installed along Ferry Street by the Minnesota Department of Transportation during a recent reconstruction of Ferry Street/Highway 169. As installed, this device treats the entire catchment.

Street cleaning was only included for the very small amount of municipal roadway located within this catchment. The largest roadway, Ferry Street/Highway 169, is a state-owned highway and was not modeled with municipal street cleaning.

Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	3.8	0.6	16%	**3.2**
	TSS (lb/yr)	1,293	242	19%	**1,051**
	Volume (acre-feet/yr)	3.1	0.0	0%	**3.1**

PROPOSED RETROFITS OVERVIEW

No stormwater retrofits were proposed in this catchment.

RETROFITS CONSIDERED BUT REJECTED

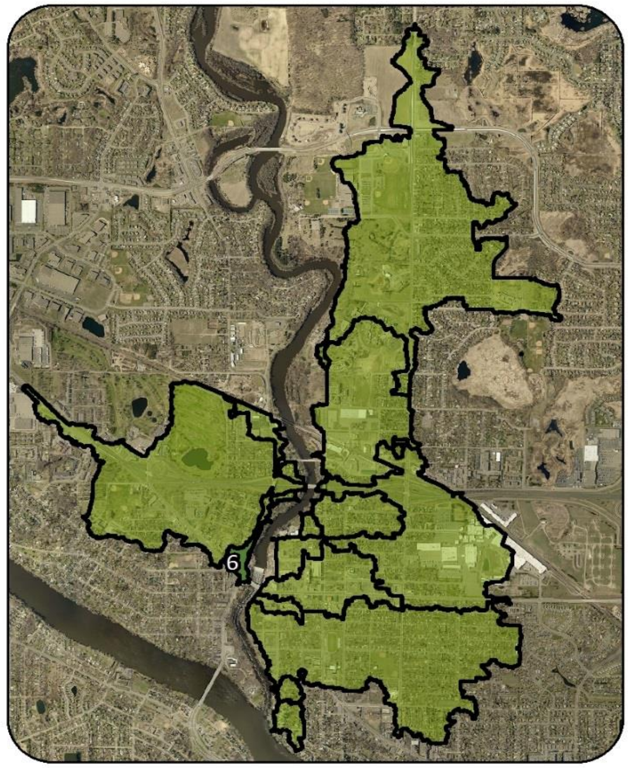
Curb-cut rain gardens and boulevard bioswales were considered along Ferry Street but were not proposed due to (1) the lack of boulevard to accommodate a bioswale and (2) the increased cost to divert water through a sidewalk and into a curb-cut rain garden makes the practice cost-prohibitive.

Therefore, the map below was included solely to provide additional detail of the catchment boundary, associated land uses, and streets.

RETROFIT RECOMMENDATIONS

Catchment A-6

Existing Catchment Summary	
Acres	8.7
Dominant Land Cover	Commercial
Parcels	28
Volume (acre-feet/yr)	9.3
TP (lb/yr)	6.5
TSS (lb/yr)	2,603



CATCHMENT DESCRIPTION

Catchment A-6 contains nearly 9 acres of heavily impervious area. The catchment is dominated by commercial properties and the Ferry Street/Highway 169 and Main Street roadways. Runoff generated in this area flows to a storm sewer below Ferry Street/Highway 169 and discharges into the Rum River just north of Main Street.

EXISTING STORMWATER TREATMENT

A hydrodynamic device was installed by the Minnesota Department of Transportation during a recent reconstruction of Ferry Street/Highway 169. The device is located along the Main Street storm sewer line just east of its intersection with Ferry Street/Highway 169 and treats the entire catchment.

Street cleaning was only included for the small amount of municipal roadways located within this catchment. The largest roadway, Ferry Street/Highway 169, is a state-owned highway and was not modeled with municipal street cleaning.

Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	7.7	1.2	16%	**6.5**
	TSS (lb/yr)	3,178	575	18%	**2,603**
	Volume (acre-feet/yr)	9.3	0.0	0%	**9.3**

PROPOSED RETROFITS OVERVIEW

No stormwater retrofits were proposed in this catchment.

RETROFITS CONSIDERED BUT REJECTED

Curb-cut rain gardens and boulevard bioswales were considered along Ferry Street but were not proposed due to (1) the lack of boulevard to accommodate a bioswale and (2) the increased cost to divert water through a sidewalk and into a curb-cut rain garden makes that practice cost-prohibitive. Permeable pavement was also considered for many of the private parking lots in the catchment but was not considered cost effective due to their small size.

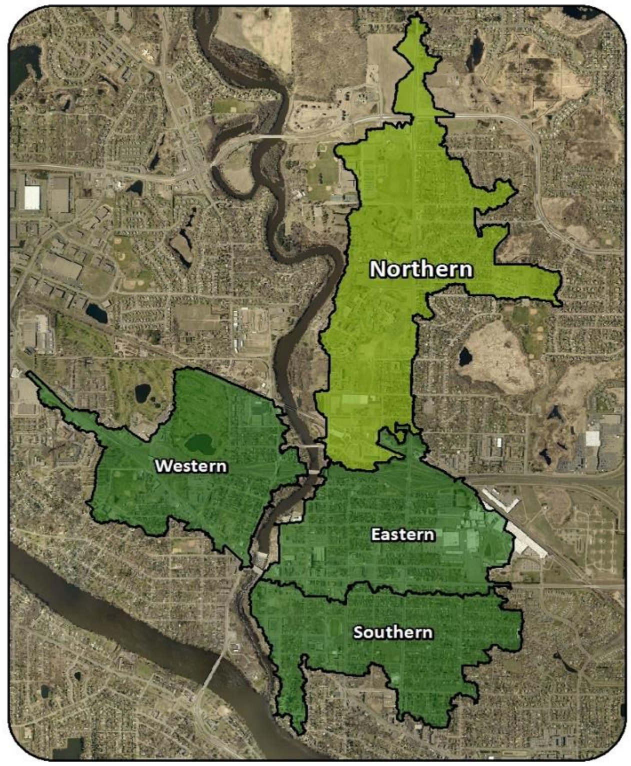
Therefore, the map below was included solely to provide additional detail of the catchment boundary, associated land uses, and streets.

RETROFIT RECOMMENDATIONS

Northern Drainage Network

Catchment ID	Page
A-7	63
A-8	77

Existing Network Summary	
Acres	525.5
Dominant Land Cover	Residential
Volume (ac-ft/yr)	319.6
TP (lb/yr)	266.2
TSS (lb/yr)	99,514



DRAINAGE NETWORK SUMMARY

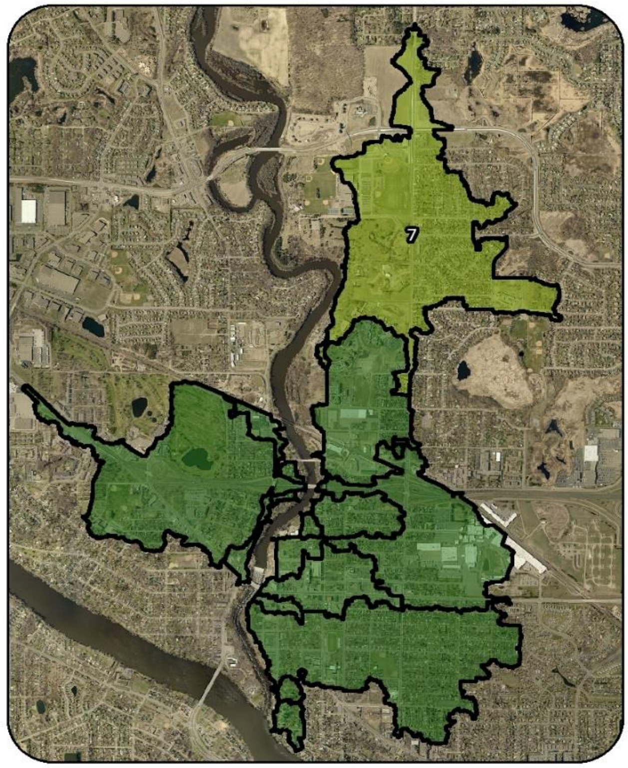
This network comprises most of the research area north of Highway 10 and east of the Rum River. The network is split into two catchments, each with a respective outfall to the Rum River. The northern outfall is located west of the 7th Avenue – Bryant Street intersection (Catchment A-7). The southern outfall is located west of the 4th Avenue – Grant Street intersection (A-8). This network includes many of the new developments in the city, as well as the Anoka High School and the Anoka Metro Regional Treatment Center. Land use in this network is primarily residential with small lots east of 7th Avenue and commercial or public properties with large campuses west of 7th Avenue.

EXISTING STORMWATER TREATMENT

Six stormwater retention ponds are located across the two catchments in this drainage network. Five of these only treat runoff from the properties they were built upon and some adjoining properties. The sixth, a large, city-owned regional pond west of the 4th Avenue and Grant Street intersection treats 147 acres of commercial and residential properties in its catchment. Street cleaning is also conducted by the City of Anoka two times annually.

Catchment A-7

Existing Catchment Summary	
Acres	378.3
Dominant Land Cover	Residential
Parcels	448
Volume (acre-feet/yr)	213.6
TP (lb/yr)	207.4
TSS (lb/yr)	76,598



CATCHMENT DESCRIPTION

Catchment A-7 is the northernmost and largest catchment in this analysis. It spans from 145th Lane in the north to Garfield Street in the south and includes 378 acres of residential, commercial, and public properties. All stormwater runoff generated within this catchment drains to a single outfall to the Rum River located west of the MNDOT Truck Station at the intersection of 7th Avenue and Bryant Avenue.

The area within this catchment is not the only area that drains to the Bryant Avenue stormwater outfall. The area draining to this pipe is actually much larger, an additional 1,600 acres, and includes properties from the Cities of Anoka, Andover, and Coon Rapids. This additional area includes drainage to wetlands along Bunker Lake Boulevard., Riverdale Drive (west of the Riverdale Crossing Shopping Center), and south of Sunny Acres Park. The additional acreage was not included within this analysis as (1) much of the area was outside of the City of Anoka, and (2) stakeholders determined project dollars were better used when dedicated to protecting the Rum River, as opposed to the upstream wetlands. All areas included within this catchment are "downstream" (or do not drain to) of these wetland complexes.

EXISTING STORMWATER TREATMENT

This catchment has three ponds that provide treatment. The ponds are located on the Anoka Ice Arena, Anoka High School baseball field, and the Anoka Metro Regional Treatment Center. These ponds treat only the properties they were installed upon. The other catchment-wide stormwater treatment is street cleaning provided by the City of Anoka two times per year. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	4			
	BMP Types	3 Ponds, Street Cleaning			
	TP (lb/yr)	233.6	26.2	11%	**207.4**
	TSS (lb/yr)	90,369	13,771	15%	**76,598**
	Volume (acre-feet/yr)	214.6	0.9	0%	**213.6**

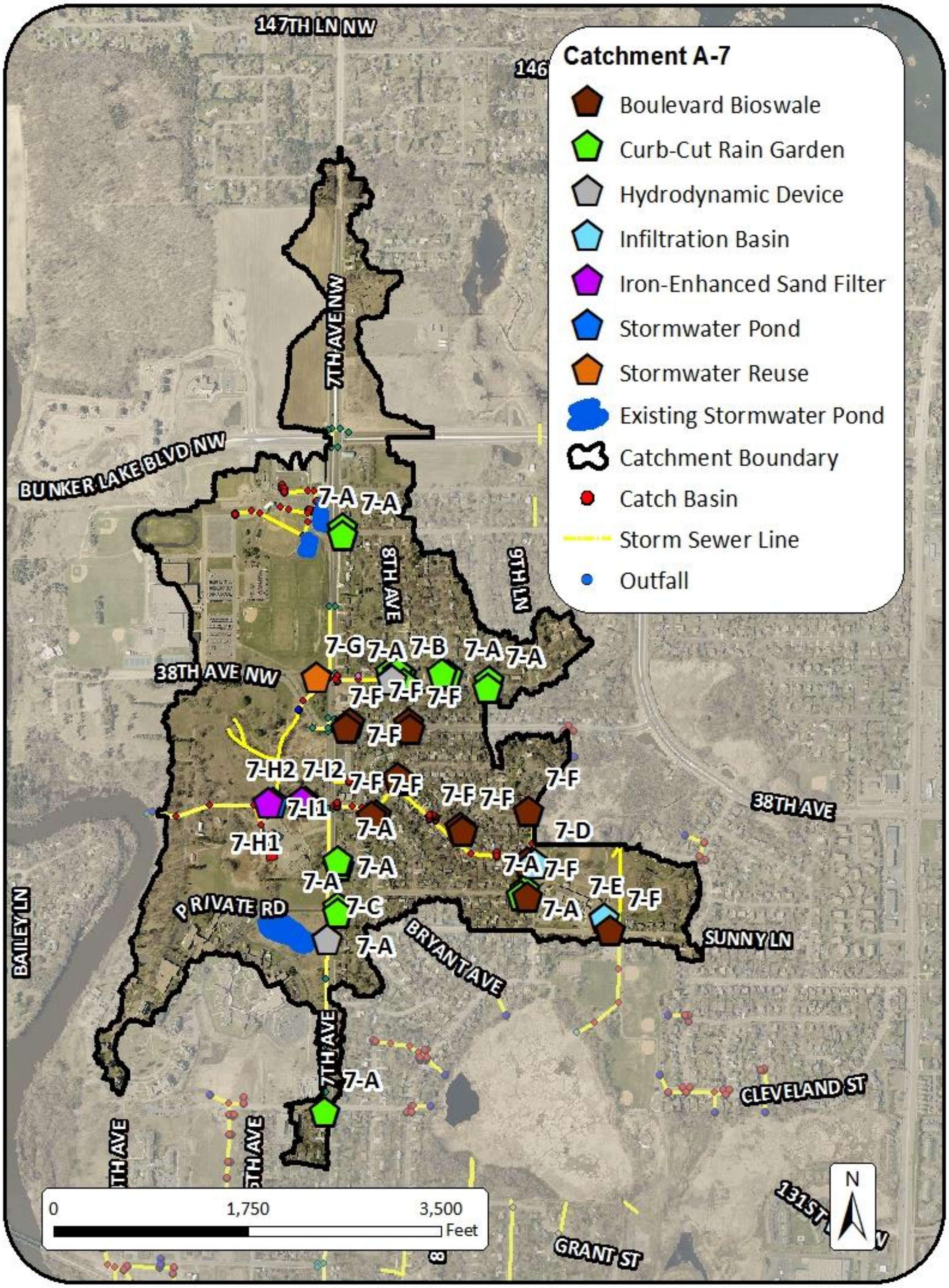
PROPOSED RETROFITS OVERVIEW

Due to the prevalence of sandy, Hubbard soils throughout the residential areas of the catchment, infiltration practices were pursued. Up to 15 curb-cut rain gardens and 14 boulevard bioswales were proposed across the catchment. Campus retrofit opportunities at Wilson Elementary School are proposed which would divert stormwater runoff from paved surfaces to two large infiltration basins. The Anoka High School property was flagged as a location for stormwater reuse. Stormwater from the large paved surfaces at the school, including building roofs, sidewalks, and parking areas, could be diverted to a holding structure to be later used to irrigate the soccer and baseball fields on the property.

Hydrodynamic devices were proposed in two locations. The first would be located along 38th Lane between 7th Avenue and 8th Avenue. The second would be located along 7th Avenue east of the Anoka Metro Treatment Center.

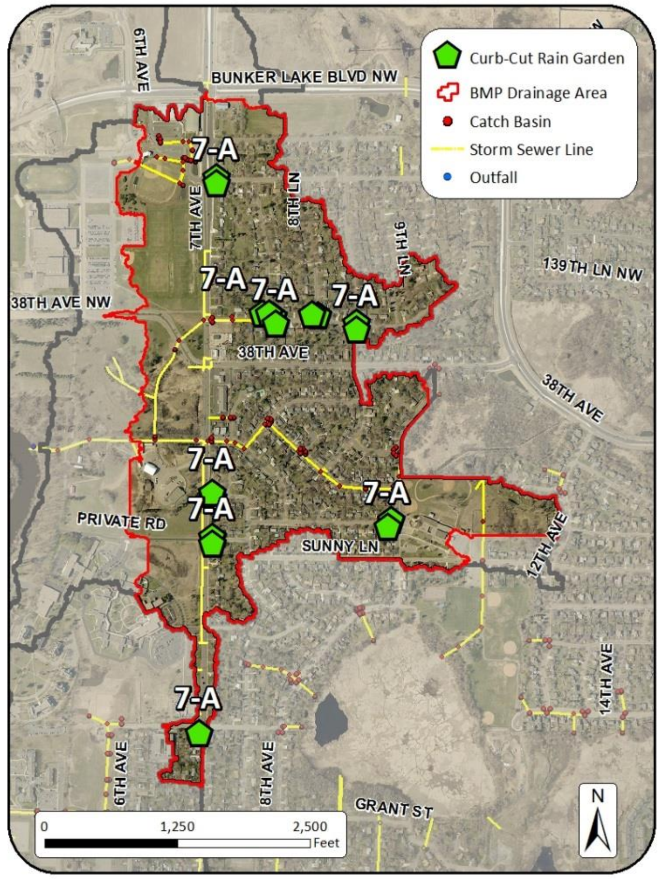
Catchment-wide treatment was proposed through the installation of a new pond west of 7th Avenue. This pond could be installed on currently undeveloped, state-owned land. This pond was modeled once with a smaller drainage, accepting water from just the eastern portion of the catchment and modeled with a larger drainage, runoff from almost the entire 378-acre drainage area. To help promote phosphorus retention, an IESF bench could also be included with this pond.

RETROFIT RECOMMENDATIONS



Project ID: 7-A

Curb-Cut Rain Gardens



Drainage Area – 1.5 – 25.5 acres
Location – Various locations throughout catchment
Property Ownership – Private
Site Specific Information – Single-family lots in the catchment provide various locations for curb-cut rain gardens to treat stormwater pollutants originating from private properties and streets. Considering typical landowner participation rates, scenarios with one, ten, and seventeen rain gardens were analyzed to treat the drainage area.

	Curb-Cut Rain Garden									
	Cost/Removal Analysis	New Treatment		% Reduction	New Treatment		% Reduction	New Treatment		% Reduction
Treatment	Number of BMPs	1			10			17		
	Total Size of BMPs	250	sq-ft		2,500	sq-ft		4,250	sq-ft	
	TP (lb/yr)	0.5		0.2%	4.6		2.2%	8.1		3.9%
	TSS (lb/yr)	153		0.2%	1,454		1.9%	2,539		3.3%
	Volume (acre-feet/yr)	0.4		0.2%	3.5		1.7%	6.2		2.9%
Cost	Administration & Promotion Costs*	$8,468			$16,352			$22,484		
	Design & Construction Costs**	$7,376			$73,760			$125,392		
	Total Estimated Project Cost (2016)	**$15,844**			**$90,112**			**$147,876**		
	Annual O&M***	$225			$2,250			$3,825		
Efficiency	30-yr Average Cost/lb-TP	**$1,506**			**$1,142**			**$1,081**		
	30-yr Average Cost/1,000lb-TSS	**$4,922**			**$3,613**			**$3,448**		
	30-yr Average Cost/ac-ft Vol.	**$1,931**			**$1,486**			**$1,407**		

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

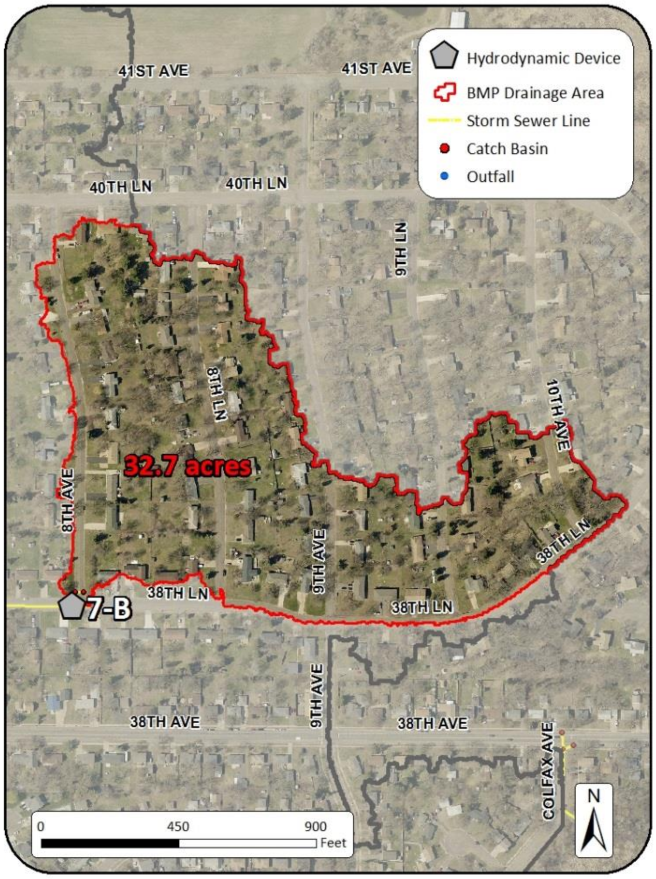
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 7-B

38th LN. & 8th Ave.
Hydrodynamic Device

Drainage Area – 32.7 acres
Location – 38th Lane at 8th Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on 38th Lane to accept runoff from residential properties and streets in the northeast portion of the catchment.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.2	0.6%
	TSS (lb/yr)	491	0.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,574**	
	30-yr Average Cost/1,000lb-TSS	**$8,734**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

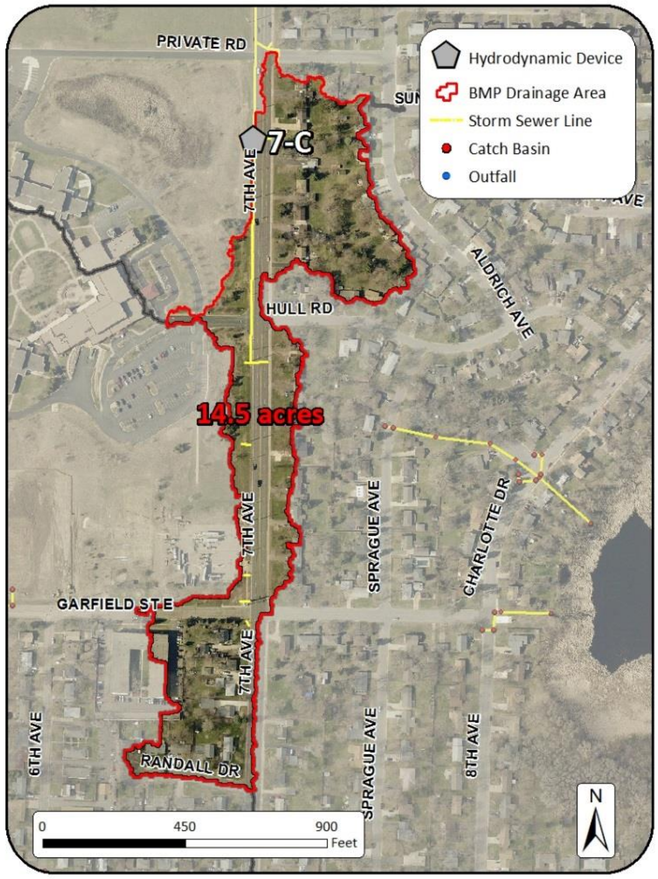
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: 7-C

7th Avenue

Hydrodynamic Device



Drainage Area – 14.5 acres
Location – 7th Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed on 7th Avenue between Hull Road and Sunny Lane. This device would accept runoff from residential properties and from 7th Avenue.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.8	0.4%
	TSS (lb/yr)	383	0.5%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,361**	
	30-yr Average Cost/1,000lb-TSS	**$11,197**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

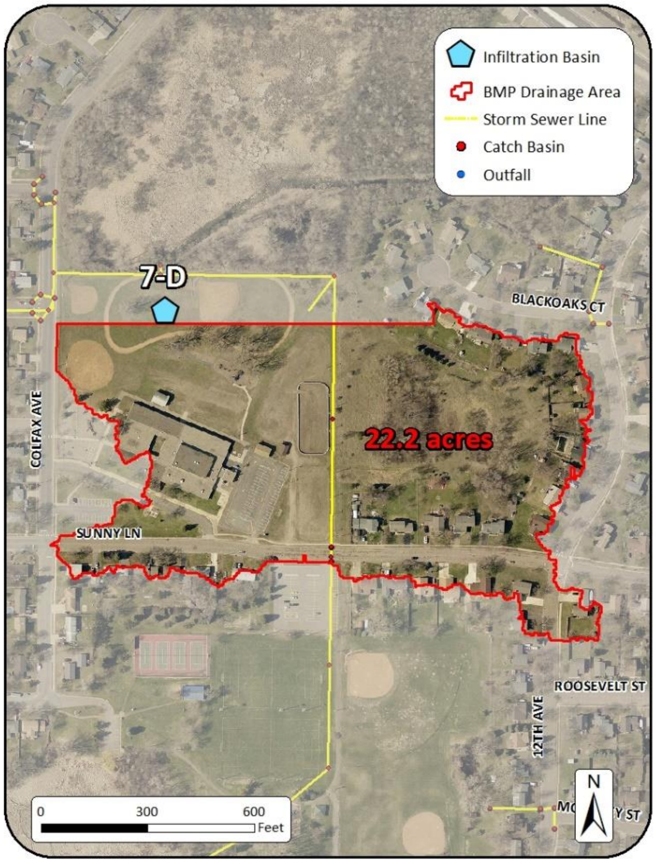
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 7-D

Colfax Ave. & Blackoaks Ln.
Infiltration Basin



Drainage Area – 22.2 acres
Location – NW side of Wilson Elementary School
Property Ownership – Public
Site Specific Information –An infiltration basin is proposed for the northwest corner of Wilson Elementary School where open space is available between baseball fields and a walking path. This project would involve "daylighting" the storm sewer line to the north (line runs east-west) and directing it to the proposed infiltration basin. The feasibility of this project is dependent on further soil testing to determine the infiltration capacity in this area (e.g. soil composition and separation from the water table) and further examination of the wetland complex to the south to determine the frequency with which that complex contributes flood water to the storm sewer line that would discharge to the proposed basin.

	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	1 foot	
	Total Size of BMP	5,000	sq-ft
	TP (lb/yr)	9.6	5%
	TSS (lb/yr)	3,256	4%
	Volume (acre-feet/yr)	8.1	4%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$115,876	
	Total Estimated Project Cost (2016)	**$118,796**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$436**	
	30-yr Average Cost/1,000lb-TSS	**$1,285**	
	30-yr Average Cost/ac-ft Vol.	**$515**	

*Indirect Cost: 40 hours at $73/hour

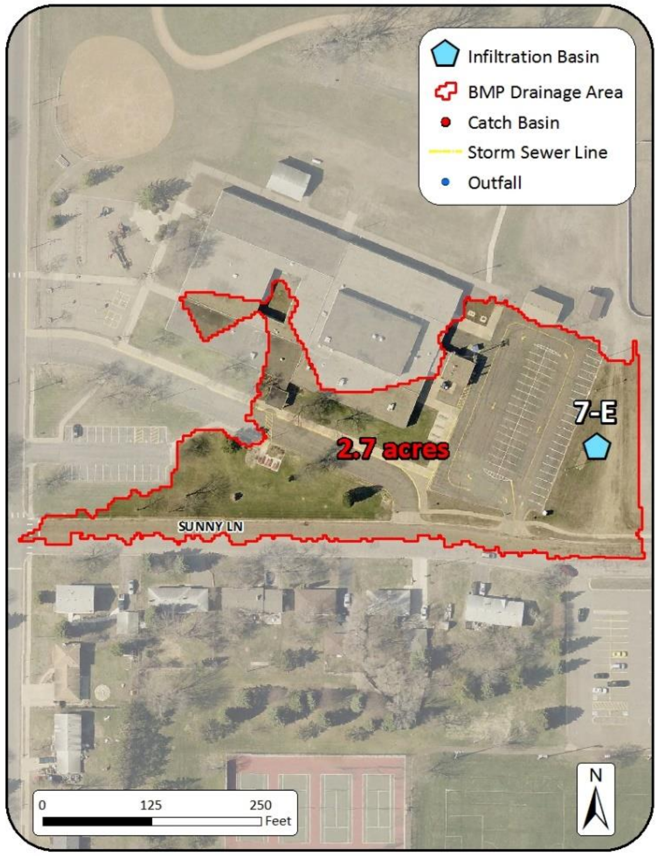
**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design) + $15,000 for construction costs relating to daylighting stormwater pipe

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

Project ID: 7-E

Sunny Lane
Infiltration Basin

Drainage Area – 2.7 acres
Location – SE side of Wilson Elementary School
Property Ownership – Public
Site Specific Information –An infiltration basin is proposed for the southeast corner of Wilson Elementary School adjacent to the main school parking lot. Open space is available between the parking lot and the road for the installation of this practice. This basin would accept stormwater from the elementary school property and Sunny Lane. A rain garden at this location would require an inlet that allows runoff to pass under the existing sidewalk.



	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	1 foot	
	Total Size of BMP	700	sq-ft
	TP (lb/yr)	1.7	1%
	TSS (lb/yr)	676	1%
	Volume (acre-feet/yr)	1.8	1%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$19,876	
	Total Estimated Project Cost (2016)	**$22,796**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$579**	
	30-yr Average Cost/1,000lb-TSS	**$1,457**	
	30-yr Average Cost/ac-ft Vol.	**$547**	

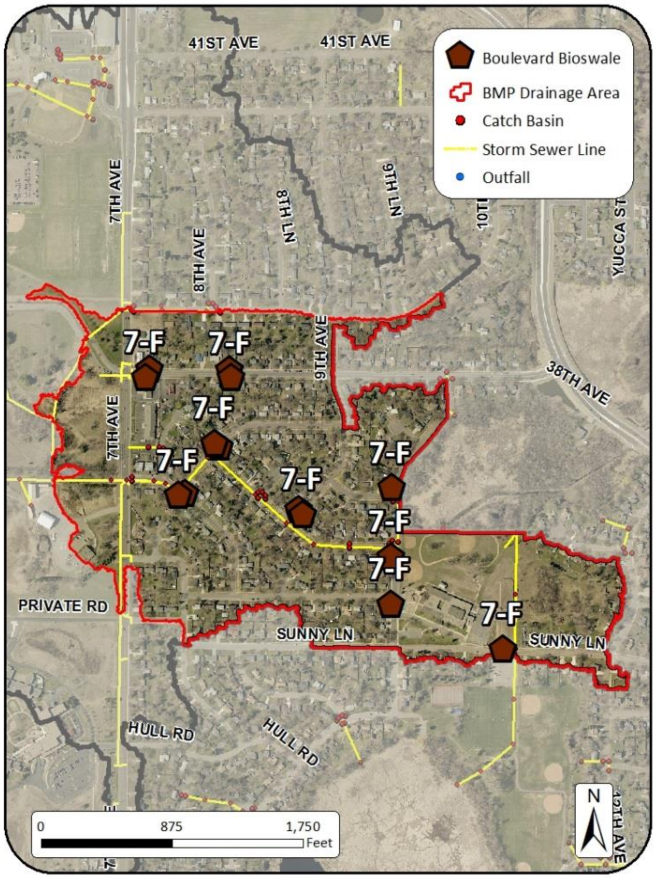
*Indirect Cost: 40 hours at $73/hour

**Direct Cost: ($20/sq-ft for materials and labor) + (12 hours at $73/hour for design)
+ $5,000 for rain garden inlet under existing sidewalk

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

Project ID: 7-F

Boulevard Bioswales



Drainage Area – 0.5 acre
Location –Various locations in SE portion of catchment
Property Ownership – Public
Site Specific Information – Bioswales are proposed for installation in various locations in the southeast portion of the catchment to accept runoff from residential and commercial properties. Locations for up to 14 bioswales are sited within the catchment. The table below shows the estimated cost and pollutant removal based on treatment of a 0.5-acre contributing drainage area.

	Boulevard Bioswale		
	Cost/Removal Analysis	**2.5"/hr Infilt. Rate**	
		New Treatment	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	61	0.1%
	Volume (acre-feet/yr)	0.1	0.1%
Cost	**Administration & Promotion Costs***	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,264**	
	30-yr Average Cost/1,000lb-TSS	**$8,352**	
	30-yr Average Cost/ac-ft Vol.	**$3,704**	

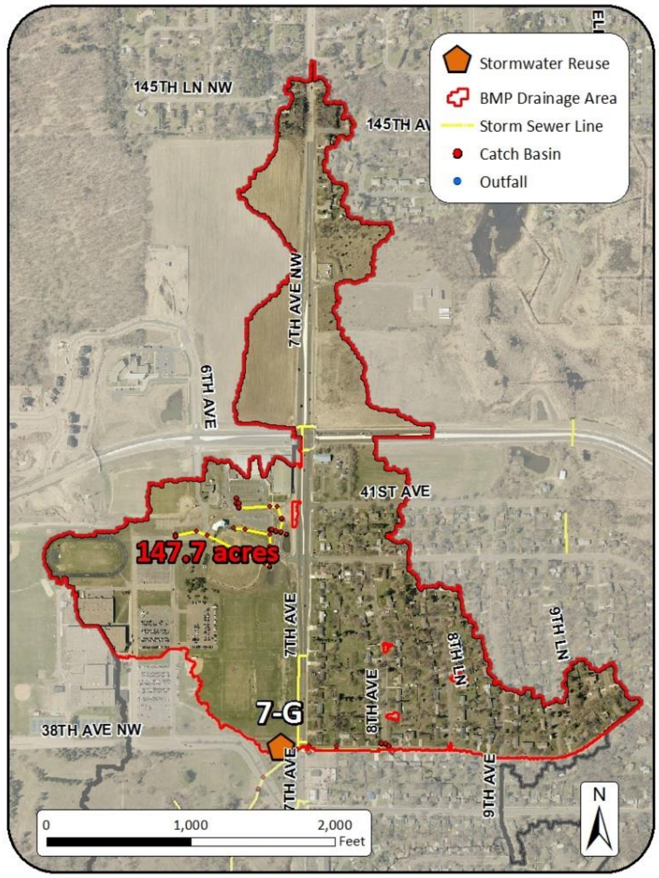
*Indirect Cost: (50 hours at $73/hour)

**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Project ID: 7-G

38th Ave. & 7th Ave.
Stormwater Reuse



Drainage Area – 147.7 acres
Location –Interchange of 38th Avenue NW and 7th Avenue
Property Ownership – Public
Site Specific Information – A water reuse system has been proposed for the southeastern corner of Anoka High School. An irrigation system could reuse the rainfall captured in this system which would provide water quality treatment as well as water conservation benefits. The proposed 500,000-gallon cistern would capture water from the northern portion of the catchment. The captured water could then be reused on approximately 20 acres of sports fields at Anoka High School.

	Stormwater Reuse		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	500,000	gallons
	TP (lb/yr)	17.5	8.4%
	TSS (lb/yr)	5,987	7.8%
	Volume (acre-feet/yr)	18.7	8.8%
Cost	**Administration & Promotion Costs***	$8,760	
	Design & Construction Costs**	$950,000	
	Total Estimated Project Cost (2016)	**$958,760**	
	Annual O&M***	$3,000	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,998**	
	30-yr Average Cost/1,000lb-TSS	**$5,839**	
	30-yr Average Cost/ac-ft Vol.	**$1,869**	

*120 hours at $73/hour

**See Appendix B for detailed cost information

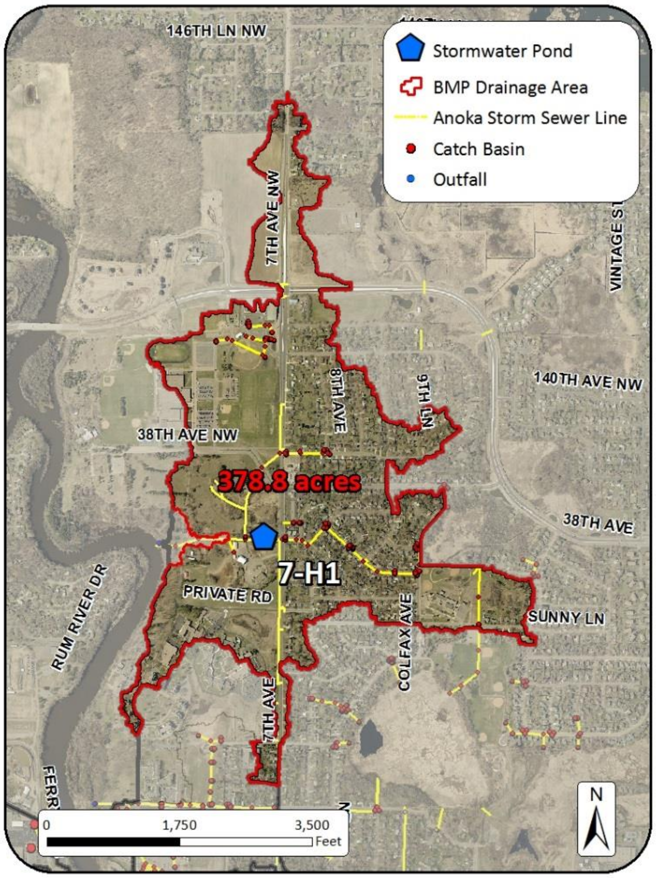
***Includes cleaning of unit and disposal of sediment/debris

Project ID: 7-H1

7th Avenue.

New Pond

Drainage Area – 378.8 acres
Location –West side of 7th Avenue
Property Ownership – Public (State of Minnesota)
Site Specific Information – A new pond is proposed for public property on the western side of 7th Avenue. One proposed scenario would be for the installation of a large pond that would accept water from almost the entire catchment. Currently, water from the catchment flows through a large storm sewer line and then into the Rum River. The proposed pond would receive water from the storm sewer line, providing additional treatment to the whole catchment.



New Pond

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	5.5	acres
	TP (lb/yr)	111.6	53.8%
	TSS (lb/yr)	54,558	71.2%
	Volume (acre-feet/yr)	0.9	0.4%
Cost	Administration & Promotion Costs*	$7,300	
	Design & Construction Costs**	$794,838	
	Total Estimated Project Cost (2015)	**$802,138**	
	Annual O&M***	$5,500	
Efficiency	30-yr Average Cost/lb-TP	**$289**	
	30-yr Average Cost/1,000lb-TSS	**$591**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

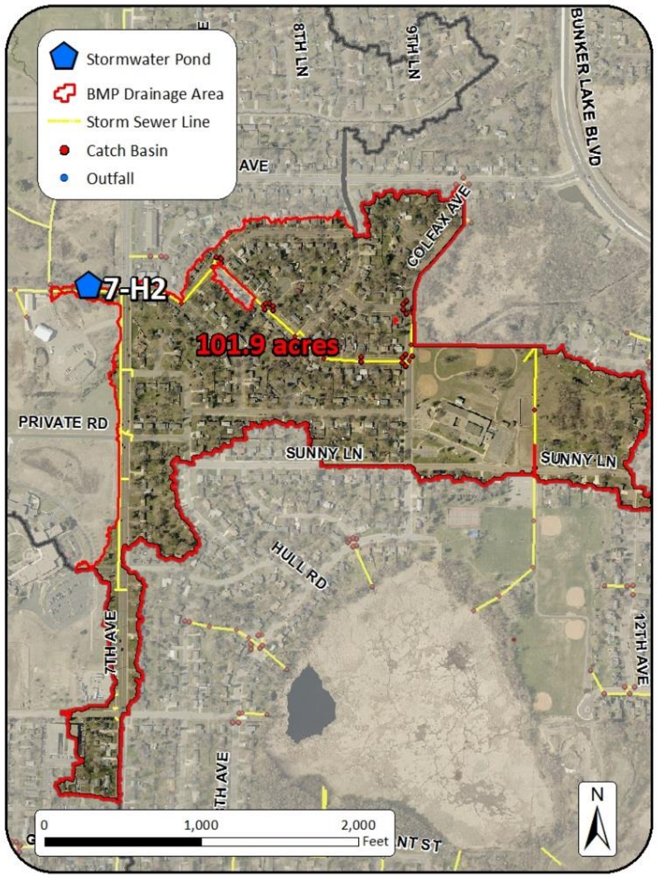
*Indirect Cost: 100 hours at $73/hour

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

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

Project ID: 7-H2

7th Avenue.
New Pond



Drainage Area – 101.9 acres
Location –West side of 7th Avenue
Property Ownership – Public (State of Minnesota)
Site Specific Information – A new pond is proposed for public property on the western side of 7th Avenue. This scenario includes a smaller pond that would accept water from the eastern portion of the catchment and provide additional treatment to water from approximately a quarter of the catchment.

New Pond

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	1.8	acres
	TP (lb/yr)	31.5	15.2%
	TSS (lb/yr)	13,452	17.6%
	Volume (acre-feet/yr)	0.4	0.2%
Cost	Administration & Promotion Costs*	$7,300	
	Design & Construction Costs**	$353,184	
	Total Estimated Project Cost (2015)	**$360,484**	
	Annual O&M***	$1,800	
Efficiency	30-yr Average Cost/lb-TP	**$439**	
	30-yr Average Cost/1,000lb-TSS	**$1,027**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

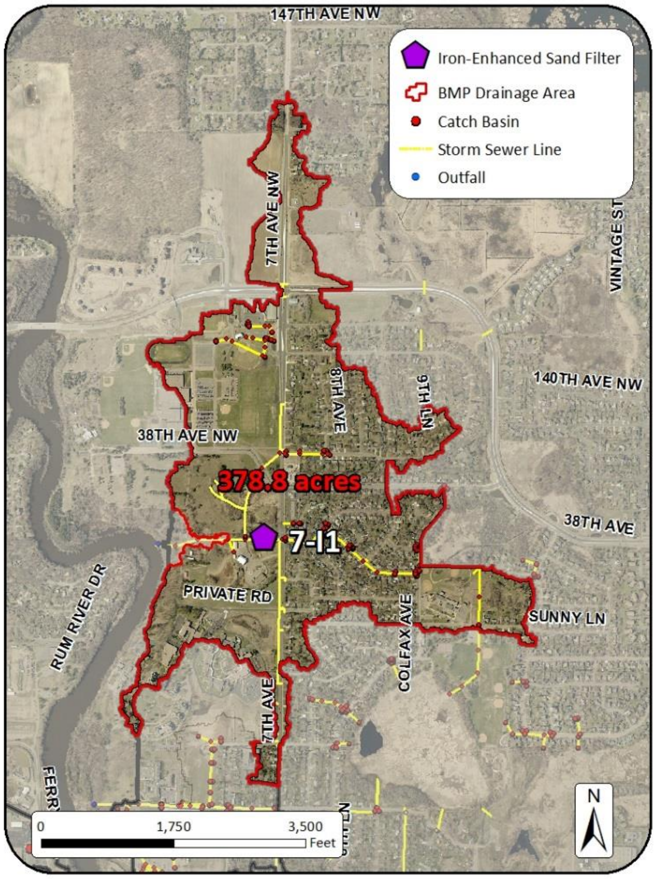
*Indirect Cost: 100 hours at $73/hour

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

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

Project ID: 7-I1

7th Avenue.
IESF Bench



Drainage Area – 378.8 acres
Location –West side of 7th Avenue
Property Ownership – Public (State of Minnesota)
Site Specific Information – An IESF bench is proposed as an improvement to the proposed pond with the larger drainage area (i.e. Project ID 7-H1). The pond would provide treatment through retention and settling. However, the addition of an IESF will increase removal of dissolved phosphorus. The IESF was sized to 20,000 sq.-ft. based on available space and the proposed size of the new pond.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	20,000	sq-ft
	TP (lb/yr)	26.6	12.8%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$575,516	
	Total Estimated Project Cost (2016)	**$580,991**	
	Annual O&M***	$4,591	
Efficiency	**30-yr Average Cost/lb-TP**	**$902**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

*Indirect Cost: 75 hours at $73/hour

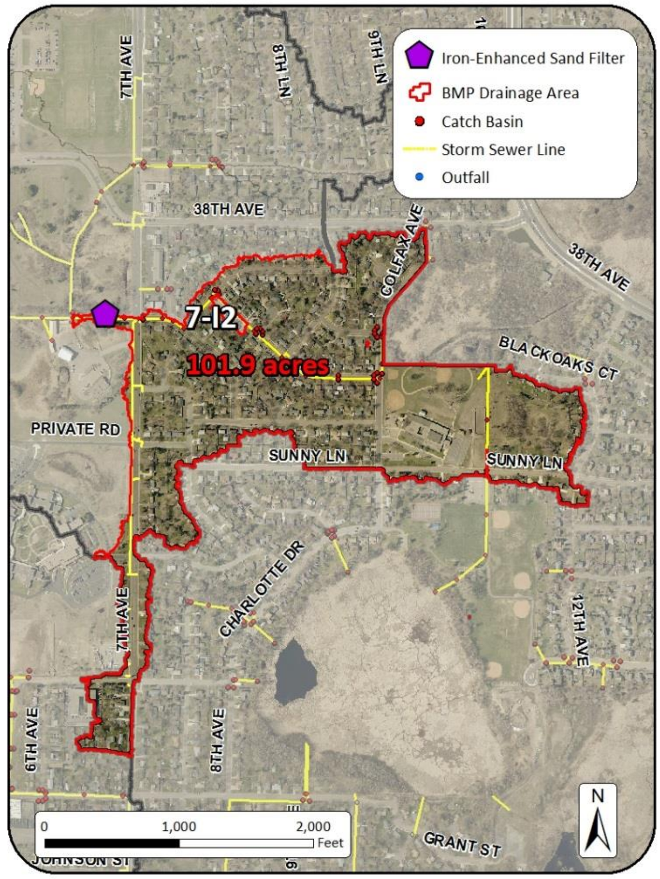
**Direct Cost: See Appendix B for detailed cost information

***$10,000/acre for IESF

Project ID: 7-I2

7th Avenue.

IESF Bench



Drainage Area – 101.9 acres
Location –West side of 7th Avenue
Property Ownership – Public (State of Minnesota)
Site Specific Information – An IESF bench is proposed as an improvement to the proposed pond with the smaller drainage area (i.e. Project ID 7-H2). The pond would provide treatment through retention and settling. However, the addition of an IESF will increase removal of dissolved phosphorus. The IESF was sized to 8,000 sq.-ft. based on available space and the proposed size of the new pond.

	IESF Bench		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8,000	sq-ft
	TP (lb/yr)	7.2	3.5%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$300,400	
	Total Estimated Project Cost (2016)	**$305,875**	
	Annual O&M***	$1,837	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,669**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

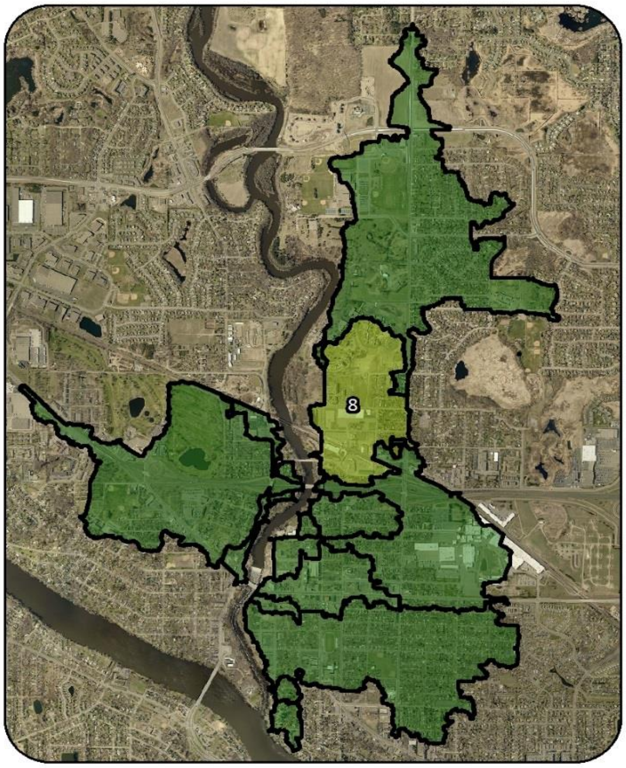
*Indirect Cost: 75 hours at $73/hour

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

***$10,000/acre for IESF

Catchment A-8

Existing Catchment Summary	
Acres	147.0
Dominant Land Cover	Residential
Parcels	163
Volume (acre-feet/yr)	106.0
TP (lb/yr)	58.8
TSS (lb/yr)	22,916



CATCHMENT DESCRIPTION

The southern of the two catchments in the northern drainage network is Catchment A-8. This catchment is bounded by the Anoka Metro Regional Treatment Center and county offices to the north, 7th Avenue to the east, and US-10 to the south. Runoff generated within the catchment flows through municipal storm sewer lines to a retention pond west of the 4th Avenue and Grant Street intersection. This pond treats the entire 147-acre catchment, and discharges directly into the Rum River 300 ft. west of the pond.

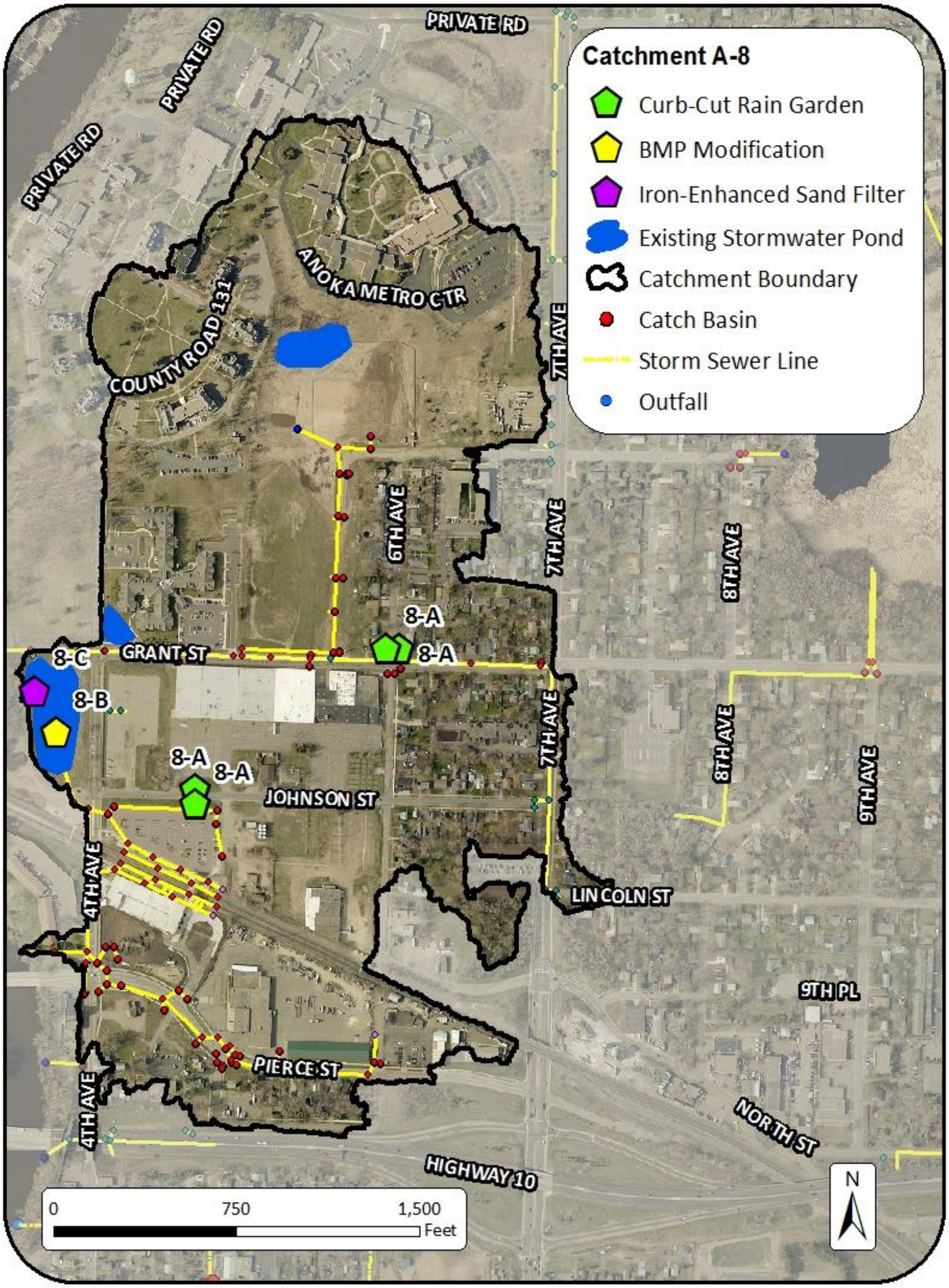
EXISTING STORMWATER TREATMENT

Most stormwater treatment in this catchment is supplied by the 4th Avenue and Grant Street. municipal retention pond. Upstream of this pond are two other retention ponds. The first is located on a City of Anoka development property on Garfield Street. The second pond is located on the Volunteers of America's Homestead of Anoka apartment complex. Each of these ponds treats only the property it was installed upon. Outside of the 4th Avenue and Grant Street retention pond, the only other catchment-wide treatment is provided by the City of Anoka in the form of street cleaning two times per year. Present-day stormwater pollutant loading and treatment are summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	4			
	BMP Types	3 Ponds, Street Cleaning			
	TP (lb/yr)	101.5	42.7	42%	**58.8**
	TSS (lb/yr)	48,067	25,151	52%	**22,916**
	Volume (acre-feet/yr)	107.0	1.1	1%	**106.0**

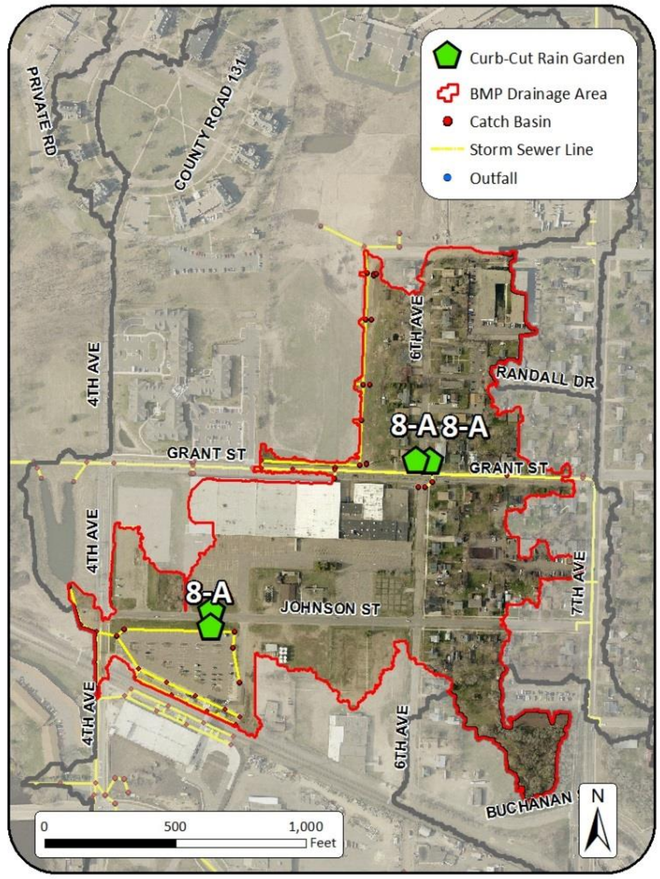
PROPOSED RETROFITS OVERVIEW

Proposed stormwater retrofit practices were focused on improving treatment within the catchments largest existing structure, the 4th Avenue and Grant Street municipal retention pond. The first proposed practice looks to modify the pond by increasing its storage capacity. This would be done to improve treatment of the existing landscape and to better prepare the pond for accommodating runoff from future development. The second practice would add an IESF bench along the western banks of the pond, increasing TP retention through the pond system. Upstream of the regional municipal pond, up to four curb-cut rain garden were proposed. These were proposed to supplement treatment provided by the pond in residential and commercial areas with soils that are conducive to infiltration practices.


Catchment A-8
Curb-Cut Rain Garden
BMP Modification
Iron-Enhanced Sand Filter
Existing Stormwater Pond
Catchment Boundary
Catch Basin
Storm Sewer Line
Outfall
PRIVATE RD
PRIVATE RD
PRIVATE RD
ANOKA METRO CTR
COUNTY ROAD 131
7TH AVE
6TH AVE
7TH AVE
8TH AVE
8-A
8-A
GRANT ST
8-C
8-B
8-A
8-A
JOHNSON ST
7TH AVE
8TH AVE
9TH AVE
4TH AVE
LINCOLN ST
9TH PL
PIERCE ST
NORTH ST
4TH AVE
HIGHWAY 10
0
750
1,500
Feet
N

Project ID: 8-A

Curb-Cut Rain Gardens



Drainage Area – 1.5 – 6.0 acres
Location – Various locations throughout catchment
Property Ownership – Private
Site Specific Information –Various locations for curb-cut rain gardens are proposed on residential and light industrial properties to treat stormwater pollutants. Considering private landowner participation rates, scenarios were run with two rain gardens placed on light industrial properties and two placed on residential properties.

	Curb Cut Rain Garden				
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	2		2	
	Land Use	LI		MDRNA	
	Total Size of BMPs	500	sq-ft	500	sq-ft
	TP (lb/yr)	0.8	1.4%	0.7	1.2%
	TSS (lb/yr)	301	1.3%	190	0.8%
	Volume (acre-feet/yr)	1.1	1.0%	0.7	0.7%
Cost	**Administration & Promotion Costs***	$2,482		$2,482	
	Design & Construction Costs**	$14,752		$14,752	
	Total Estimated Project Cost (2016)	**$17,234**		**$17,234**	
	Annual O&M***	$450		$450	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,281**		**$1,464**	
	30-yr Average Cost/1,000lb-TSS	**$3,404**		**$5,392**	
	30-yr Average Cost/ac-ft Vol.	**$931**		**$1,394**	

*Indirect Cost: (10 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: 8-B

4^{th} Ave. & Grant St. Pond Modification

Drainage Area – 147.1 acres
Location – 4^{th} Ave. and Grant St.
Property Ownership – Public
Site Specific Information –A modification is proposed for the pond at 4^{th} Avenue and Grant Street. This pond currently treats water from the entire catchment. Excavating 12,000 cubic yards of material would increase the size of the pond and improve the treatment efficiency. The price of the pond modification is shown below with three different management levels based on the contamination level of the excavated soil.

BMP Modification

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Pond Management Level	1		2		3	
	Amount of Soil Excavated	12,000	cu-yards	12,000	cu-yards	12,000	cu-yards
	TP (lb/yr)	10.5	17.9%	10.5	17.9%	10.5	17.9%
	TSS (lb/yr)	6,443	28.1%	6,443	28.1%	6,443	28.1%
	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**	$325,000		$505,000		$685,000	
	Total Estimated Project Cost (2016)	**$330,840**		**$510,840**		**$690,840**	
	Annual O&M***	$1,300		$1,300		$1,300	
Efficiency	30-yr Average Cost/lb-TP	**$1,174**		**$1,746**		**$2,317**	
	30-yr Average Cost/1,000lb-TSS	**$1,913**		**$2,845**		**$3,776**	
	30-yr Average Cost/ac-ft Vol.	**N/A**		**N/A**		**N/A**	

*Indirect Cost: 80 hours at $73/hour

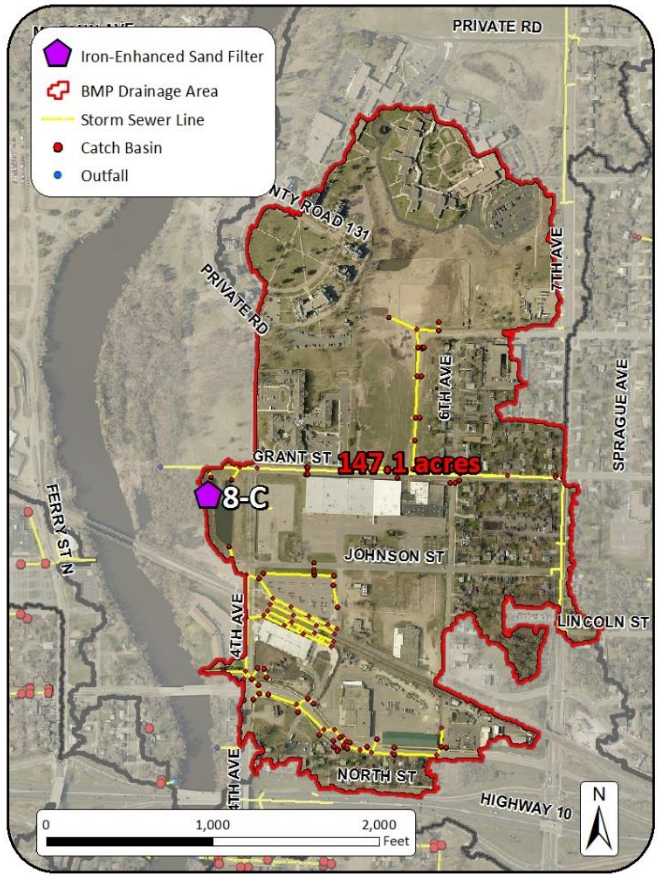
**Direct Cost: See Appendix B for detailed cost information

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

Project ID: 8-C

4th Ave. & Grant St.
IESF Bench

Drainage Area – 147.1 acres
Location – 4th Ave. and Grant St.
Property Ownership – Public
Site Specific Information – An IESF bench is proposed as an improvement to the existing pond at 4th Avenue and Grant Street. The pond provides treatment through retention and settling. However, the addition of an IESF Pond Bench will increase removal of dissolved phosphorus. The IESF was sized to 7,000 sq.-ft. based on available space and the size of the existing pond.



IESF Bench			
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	7,000	sq-ft
	TP (lb/yr)	7.2	12.2%
	TSS (lb/yr)	0	0.0%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$5,475	
	Design & Construction Costs**	$277,480	
	Total Estimated Project Cost (2016)	**$282,955**	
	Annual O&M***	$1,607	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,534**	
	30-yr Average Cost/1,000lb-TSS	**N/A**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

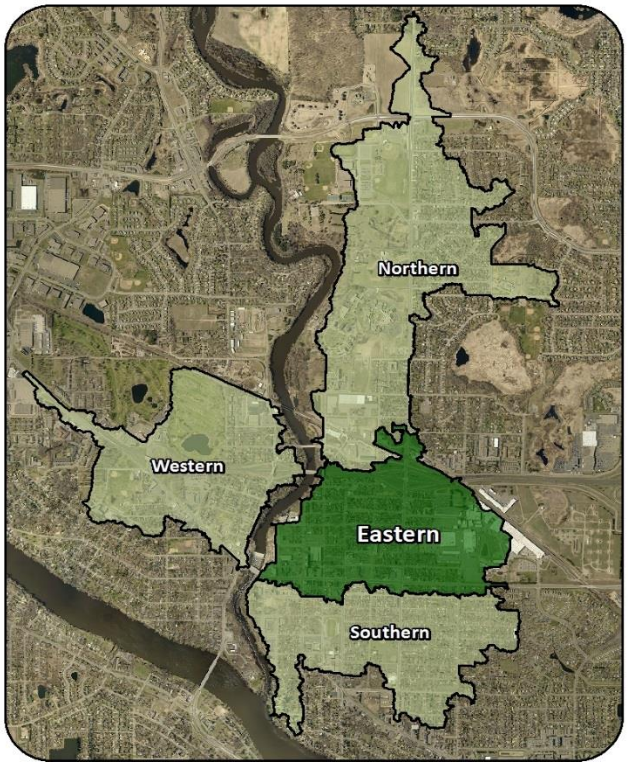
*Indirect Cost: 75 hours at $73/hour

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

***$10,000/acre for IESF

Eastern Drainage Network

Catchment ID	Page
A-9	84
A-10	92
A-11	100
A-12	103
A-13	106



Existing Network Summary	
Acres	327.1
Dominant Land Cover	Residential
Volume (ac-ft/yr)	265.5
TP (lb/yr)	247
TSS (lb/yr)	104,999

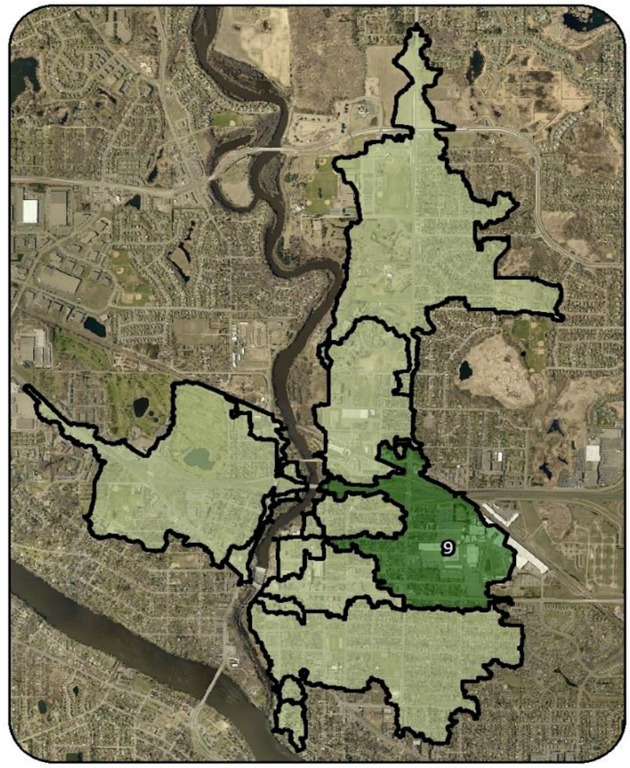
DRAINAGE NETWORK SUMMARY
The eastern drainage network includes all areas draining to the Rum River between US-10 and Main Street. The network has five major outfalls to the Rum River. Each of these outfalls has an upstream drainage area which was identified as a catchment and provided with a unique catchment name. These include (from north to south) US-10 (Catchment A-9), Taylor Street (A-10), Polk Street (A-11), Harrison Street (A-12), and Main Street (A-13).

EXISTING STORMWATER TREATMENT
Existing treatment in this network is comprised primarily of subsurface treatment systems at the three smaller outfalls to the Rum River on Taylor Street, Polk Street, and Harrison Street. Each of these were installed during recent roadway projects. On the larger industrial properties in Catchment A-9 are stormwater retention ponds which provide treatment to portions of the industrial buildings and parking lots.

Street cleaning is also conducted by the City of Anoka two times monthly in the downtown region (A-12 and A-13) and two times annually in the rest of the drainage area.

Catchment A-9

Existing Catchment Summary	
Acres	196.7
Dominant Land Cover	Industrial
Parcels	332
Volume (acre-feet/yr)	165.8
TP (lb/yr)	165.3
TSS (lb/yr)	72,929



CATCHMENT DESCRIPTION

Catchment A-9 is characterized by all of the geographic area flowing to storm sewer pipes along the US-10 highway corridor. This includes runoff from municipal and county storm sewer pipes from as far south as Main Street. The catchment includes the large industrial facilities for companies such as Pentair and the Federal Cartridge Corporation, commercial properties along Main Street and 7th Avenue, and residential properties on and adjacent to 7th Avenue between Main Street and Lincoln Street.

EXISTING STORMWATER TREATMENT

Only two structural BMPs were identified in this analysis for Catchment A-9, and both are located on industrial parcels in the eastern portion of the catchment. The first (the southern pond) treats nearly 20 acres of the Pentair property. The second (the northern pond) treats primarily parking lot runoff from the Federal Cartridge Corporation. The only form of catchment-wide treatment is provided by the City of Anoka in the form street cleaning two times annually. Present-day stormwater pollutant loading and treatment is summarized in the table below.

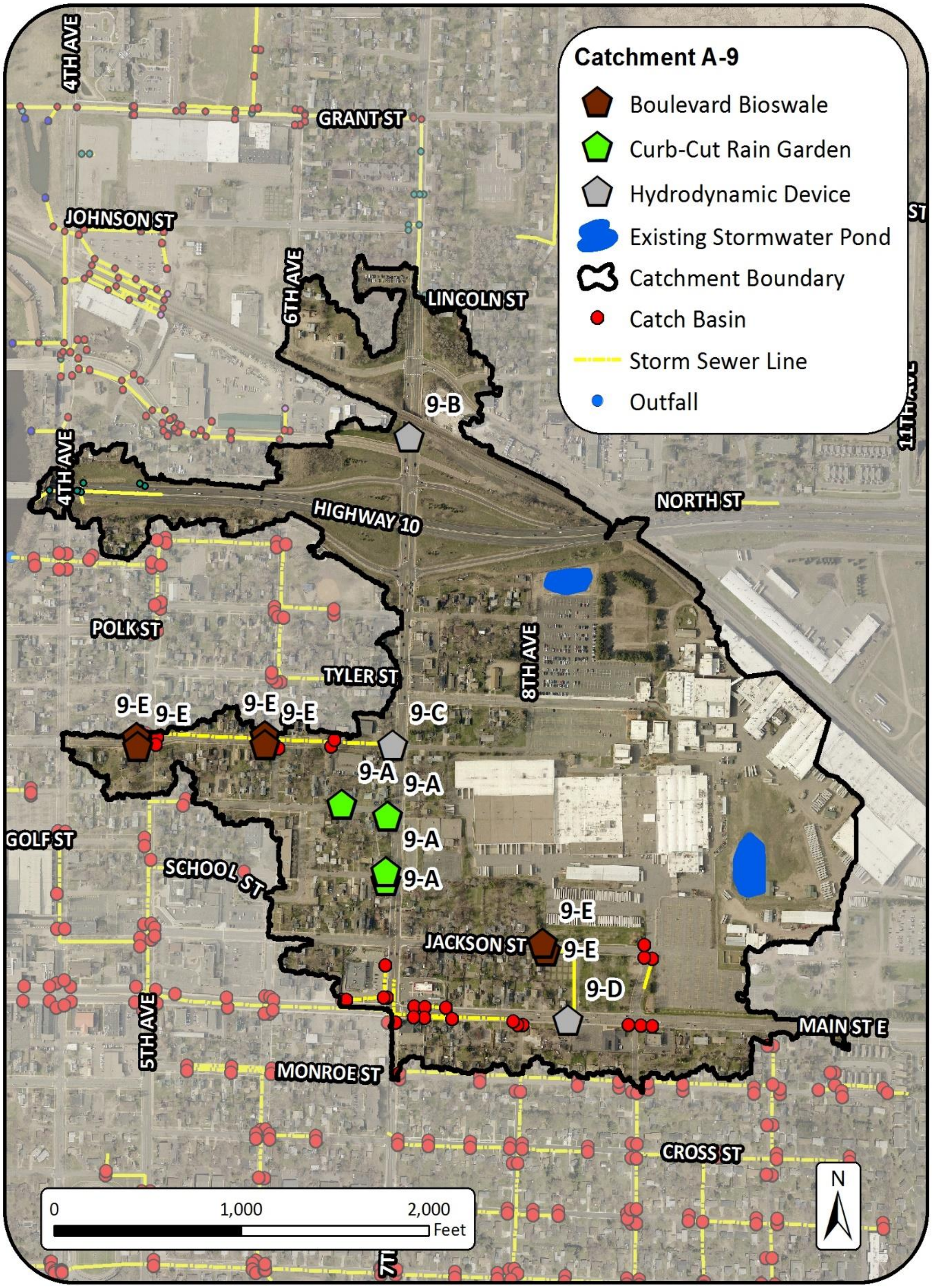
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	3			
	BMP Types	2 Ponds, Street Cleaning			
	TP (lb/yr)	181.9	16.6	9%	**165.3**
	TSS (lb/yr)	85,163	12,234	14%	**72,929**
	Volume (acre-feet/yr)	166.0	0.2	0%	**165.8**

PROPOSED RETROFITS OVERVIEW

Surface and subsurface BMPs were proposed to treat stormwater prior to reaching the Rum River. These practices could include three hydrodynamic devices, curb-cut rain gardens, boulevard bioswales, and an infiltration basin. The curb-cut rain gardens, boulevard bioswales, and the infiltration basin were all proposed in residential neighborhoods with sandy soils favoring infiltration practices. Hydrodynamic devices were proposed along or adjacent to major roadways (specifically 7th Avenue and Main Street) to treat commercial and highway runoff.

RETROFITS CONSIDERED BUT REJECTED

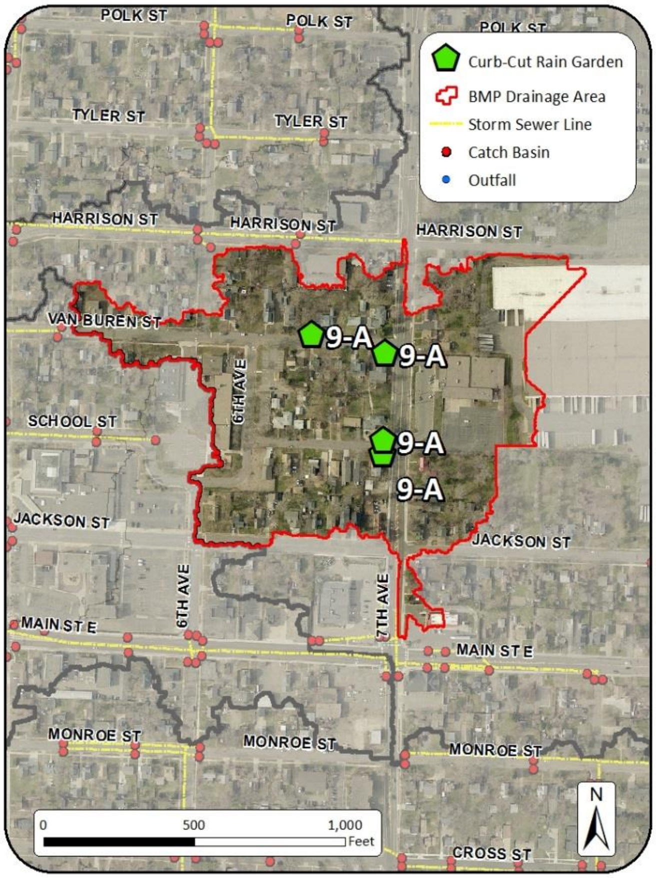
Large, regional treatment was explored in and along the US-10 corridor. This included diverting and/or "daylighting" stormwater into large open spaces along the interstate, specifically within the US-10 – 7th Avenue interchange and Rudy Johnson Park south of the interstate. Practices were deemed infeasible as there was not enough room within the open spaces of the corridor to daylight deep county and state storm sewer pipes.


Catchment A-9
Boulevard Bioswale
Curb-Cut Rain Garden
Hydrodynamic Device
Existing Stormwater Pond
Catchment Boundary
Catch Basin
Storm Sewer Line
Outfall
4TH AVE
GRANT ST
JOHNSON ST
6TH AVE
LINCOLN ST
9-B
HIGHWAY 10
NORTH ST
11TH AVE
POLK ST
TYLER ST
8TH AVE
9-E
9-C
9-A
GOLF ST
SCHOOL ST
JACKSON ST
9-D
MAIN ST E
5TH AVE
MONROE ST
CROSS ST
0
1,000
2,000
Feet
N

Project ID: 9-A

Curb-Cut Rain Gardens

Drainage Area – 1.5-6.0 acres
Location – Various locations in residential areas of catchment
Property Ownership – Public
Site Specific Information-Various locations for curb-cut rain gardens are proposed in residential areas to treat stormwater pollutants originating from streets and single-family residences. Considering typical landowner participation rates, scenarios with one, two, and four rain gardens were analyzed.



	Curb-Cut Rain Garden						
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1		2		4	
	Total Size of BMPs	250	sq-ft	500	sq-ft	1,000	sq-ft
	TP (lb/yr)	0.5	0.3%	1.0	0.6%	2.0	1.2%
	TSS (lb/yr)	155	0.2%	313	0.4%	623	0.9%
	Volume (acre-feet/yr)	0.4	0.2%	0.8	0.5%	1.5	0.9%
Cost	**Administration & Promotion Costs***		$8,468		$9,344		$11,096
	Design & Construction Costs**		$7,376		$14,752		$29,504
	Total Estimated Project Cost (2016)		**$15,844**		**$24,096**		**$40,600**
	Annual O&M***		$225		$450		$900
Efficiency	**30-yr Average Cost/lb-TP**	**$1,506**		**$1,253**		**$1,127**	
	30-yr Average Cost/1,000lb-TSS	**$4,859**		**$4,004**		**$3,617**	
	30-yr Average Cost/ac-ft Vol.	**$1,931**		**$1,605**		**$1,465**	

*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

7th Ave. & Pierce St.
Hydrodynamic Device

Drainage Area – 13.1 acres
Location – 7th Avenue and Pierce Street
Property Ownership – Public
Site Specific Information-A hydrodynamic device is proposed for the 7th Avenue and Highway 10 interchange. The device would accept runoff from the northern section of the catchment, which includes residential, industrial, freeway, and open land uses.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.2	0.7%
	TSS (lb/yr)	686	0.9%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,574**	
	30-yr Average Cost/1,000lb-TSS	**$6,251**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

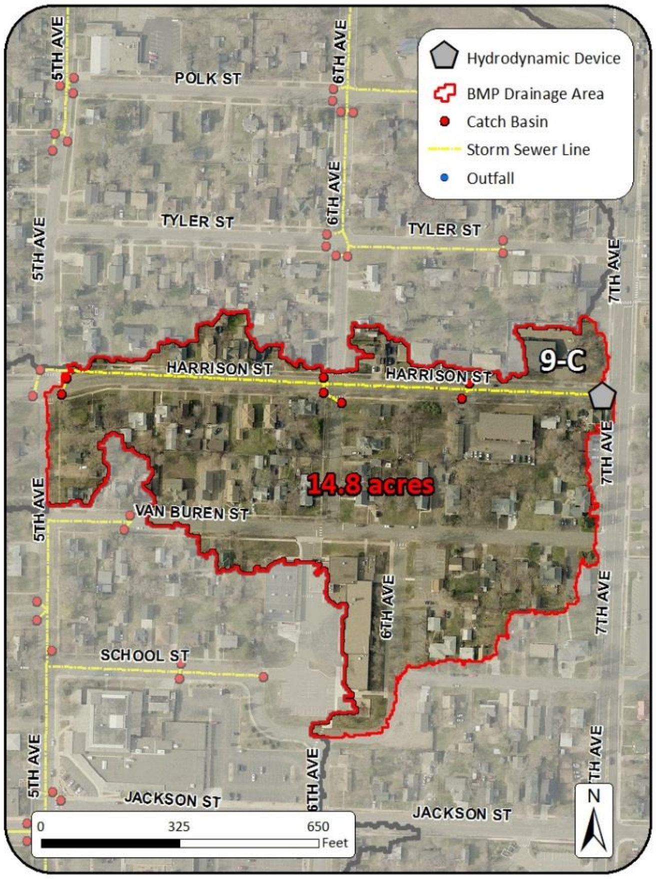
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 9-C

7th Ave. & Harrison St.
Hydrodynamic Device



Drainage Area – 14.8 acres
Location – 7th Avenue and Harrison Street
Property Ownership – Public
Site Specific Information-A hydrodynamic device is proposed for the intersection of 7th Avenue and Harrison Street. The device would accept runoff from the western section of the catchment, which is composed of 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)	1.0	0.6%
	TSS (lb/yr)	407	0.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,288**	
	30-yr Average Cost/1,000lb-TSS	**$10,537**	
	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: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 9-D

Main St. & 8 1/2 Ave.
Hydrodynamic Device

Drainage Area – 51.0 acres
Location – Main Street and 8 ½ Avenue
Property Ownership – Public
Site Specific Information-A hydrodynamic device is proposed for the intersection of Main Street and 8 ½ Avenue. The device would accept runoff from light industrial and residential areas in the eastern portion of the catchment.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.1	0.7%
	TSS (lb/yr)	777	1.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,899**	
	30-yr Average Cost/1,000lb-TSS	**$5,519**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

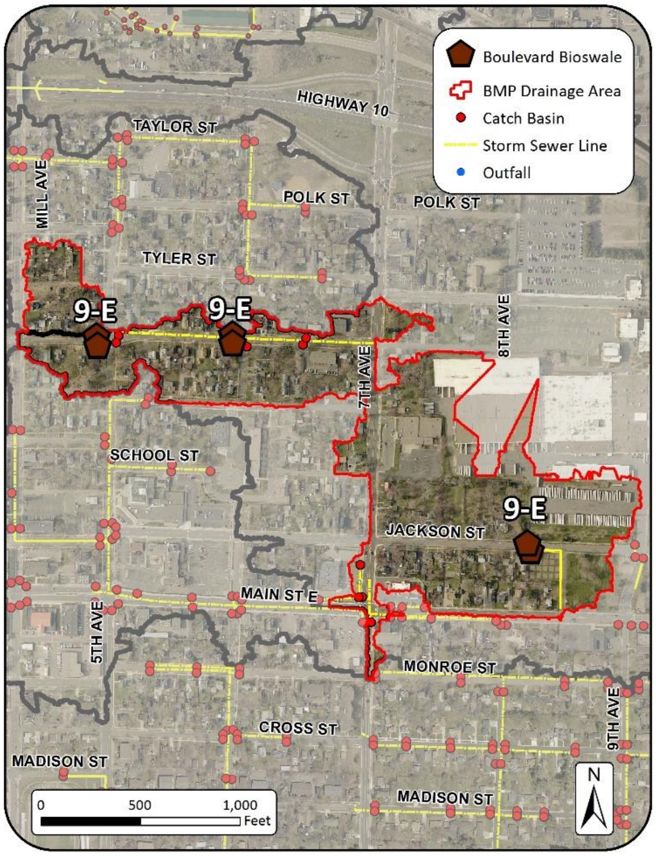
**Direct Cost: ($72,000 for materials) + ($36,000 for labor and installation costs)

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

Project ID: 9-E

Boulevard Bioswales

Drainage Area – 0.5 acre
Location – Throughout catchment
Property Ownership – Public
Site Specific Information – Bioswales are proposed for installation throughout the catchment. Locations for up to six bioswales are sited, where they will serve to treat runoff from residential properties. The table below shows the estimated cost and pollutant removal amounts based on treatment of a 0.5-acre drainage area.



	Boulevard Bioswale		
	Cost/Removal Analysis	2.5"/hr Infilt. Rate	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.2	0.1%
	TSS (lb/yr)	112	0.2%
	Volume (acre-feet/yr)	0.2	0.1%
Cost	Administration & Promotion Costs*	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$2,131**	
	30-yr Average Cost/1,000lb-TSS	**$4,561**	
	30-yr Average Cost/ac-ft Vol.	**$2,482**	

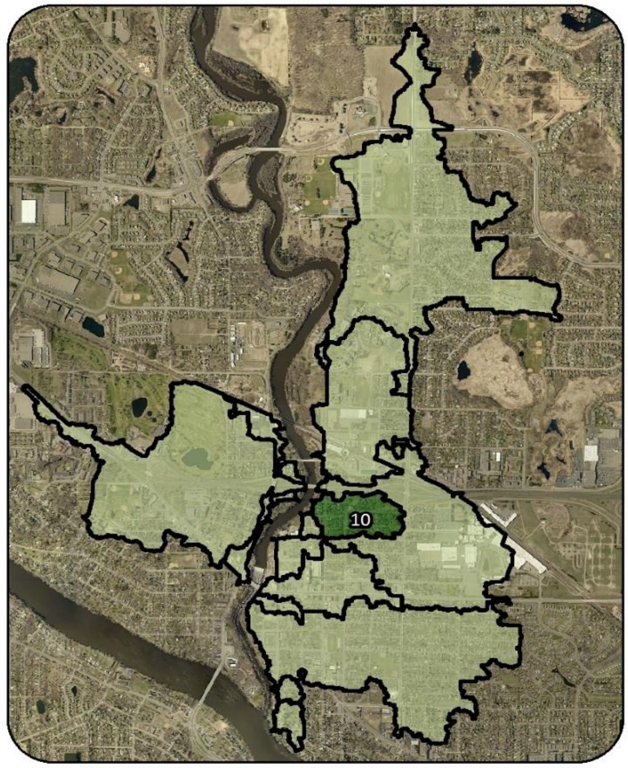
*Indirect Cost: (50 hours at $73/hour)

**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Catchment A-10

Existing Catchment Summary	
Acres	42.0
Dominant Land Cover	Residential
Parcels	150
Volume (acre-feet/yr)	20.4
TP (lb/yr)	21.9
TSS (lb/yr)	7,209



CATCHMENT DESCRIPTION

Catchment A-10 includes portions of the City of Anoka south of US-10, west of 7th Avenue, and north of Harrison Street. All area within the catchment drains to a single outfall located west of the Water Avenue and Taylor Street intersection. Land use in the catchment is predominantly single family residential, with parcels of parkland (Rudy Johnson Park), institutional, and multi-family residential housing.

EXISTING STORMWATER TREATMENT

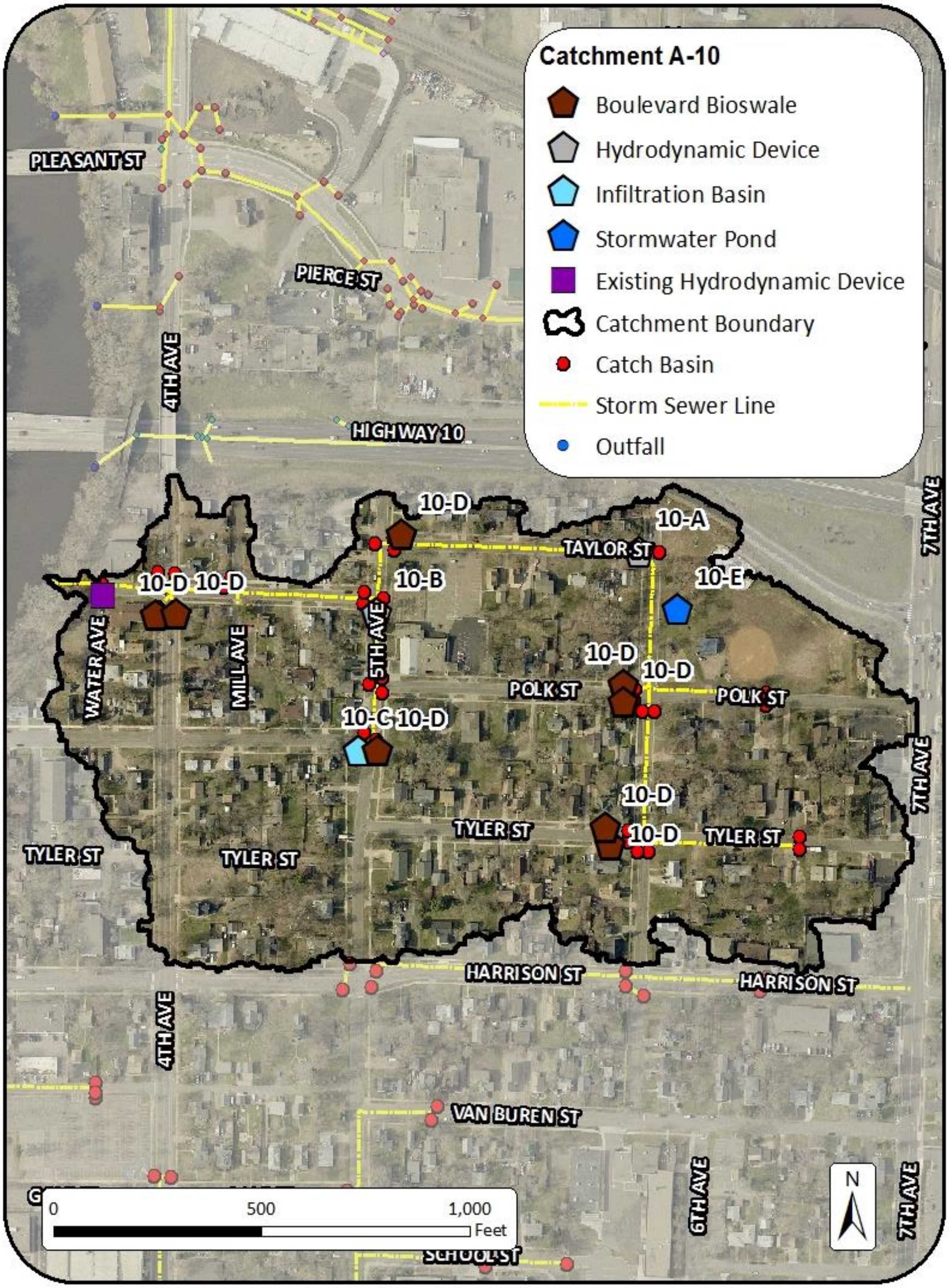
Runoff generated within the catchment is quickly intercepted in the city storm sewer network and routed to a single subsurface treatment device installed at the intersection of Water Avenue and Taylor Street. This device provides treatment to virtually the entire 42-acre catchment. Stormwater leaving this device is discharge into the Rum River directly west of the device location. In addition to this hydrodynamic device, street cleaning is performed two times per year by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	25.0	3.1	12%	**21.9**
	TSS (lb/yr)	8,604	1,395	16%	**7,209**
	Volume (acre-feet/yr)	20.4	0.0	0%	**20.4**

PROPOSED RETROFITS OVERVIEW

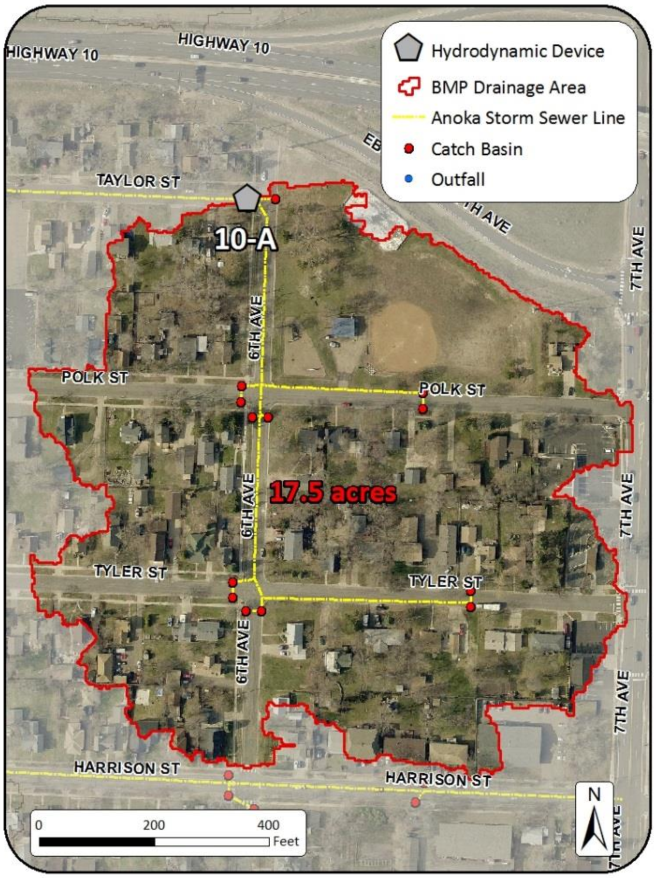
Retrofits proposed in Catchment A-10 would supplement treatment already provided by the hydrodynamic device located near the outfall to the Rum River. Most proposed practices look to infiltrate water at the surface, thereby reducing the peak discharge at the hydrodynamic device downstream and increasing pollutant retention. These practices include up to 8 boulevard bioswales, and an infiltration basin. There is also a new pond proposed in Rudy Johnson Park. Additional subsurface hydrodynamic devices were also proposed to reduce the pollutant load to the downstream device and increase catchment-wide pollutant retention.

RETROFIT RECOMMENDATIONS



Project ID: 10-A

6th Ave. & Taylor St.
Hydrodynamic Device



Drainage Area – 17.5 acres
Location – 6th Avenue and Taylor Street
Property Ownership – Public
Site Specific Information-A hydrodynamic device is proposed for the intersection of 6th Avenue and Taylor Street. The device would accept runoff from the eastern section of the catchment, which is composed of a park, residential properties and institutional land uses.

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	2.3%
	TSS (lb/yr)	211	2.9%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	30-yr Average Cost/lb-TP	**$8,577**	
	30-yr Average Cost/1,000lb-TSS	**$20,324**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

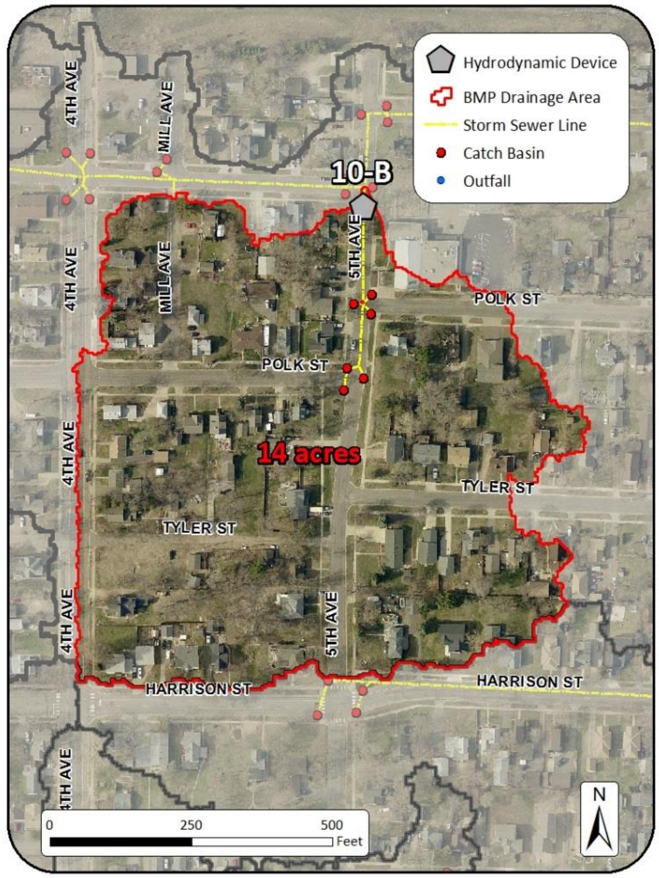
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 10-B

5th Ave. & Taylor St.
Hydrodynamic Device



Drainage Area – 14.0 acres
Location – 5th Avenue and Taylor Street
Property Ownership – Public
Site Specific Information-A hydrodynamic device is proposed for the intersection of 5th Avenue and Taylor Street. The device would accept runoff from predominately residential land uses.

	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	2.3%
	TSS (lb/yr)	195	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 (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$8,577**	
	30-yr Average Cost/1,000lb-TSS	**$21,992**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

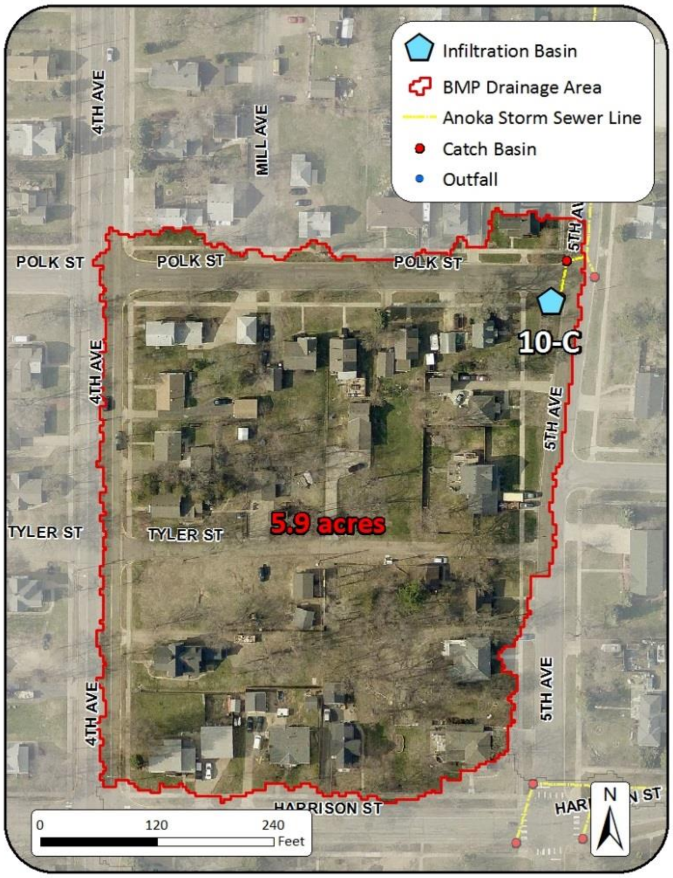
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 10-C

5th Ave. & Polk St.
Infiltration Basin



Drainage Area – 5.9 acres
Location – 5th Avenue and Polk Street
Property Ownership – Public
Site Specific Information – An infiltration basin is proposed for the southwest corner of the 5th Avenue and Polk Street intersection. Open space is available between the parking lot and the road for the installation of this practice. This basin would accept stormwater from residential properties.

	Infiltration Basin		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Ponding Depth of BMP**	1 foot	
	Total Size of BMP	2,000	sq-ft
	TP (lb/yr)	2.6	12%
	TSS (lb/yr)	808	11%
	Volume (acre-feet/yr)	2.1	10%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$40,876	
	Total Estimated Project Cost (2016)	**$43,796**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$648**	
	30-yr Average Cost/1,000lb-TSS	**$2,085**	
	30-yr Average Cost/ac-ft Vol.	**$803**	

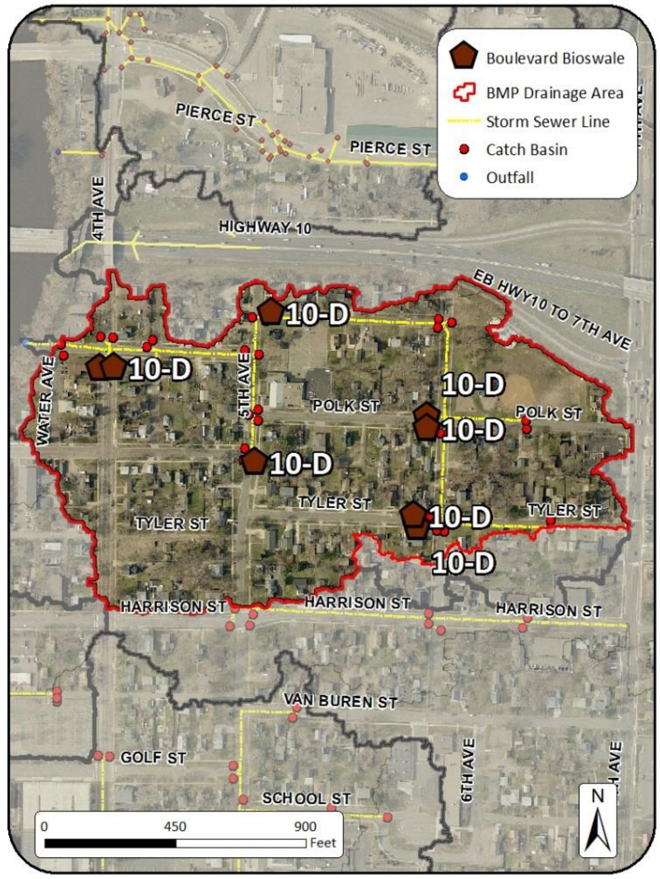
*Indirect Cost: 40 hours at $73/hour

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

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

Project ID: 10-D

Boulevard Bioswales



Drainage Area – 0.5 acre
Location – Throughout catchment
Property Ownership – Public
Site Specific Information – Bioswales are proposed for installation throughout the catchment. Locations for up to eight bioswales are sited, where they will serve to treat runoff from residential properties. The table below shows the estimated cost and pollutant removal amounts based on treatment of a 0.5-acre drainage area.

	Boulevard Bioswale		
	Cost/Removal Analysis	**2.5"/hr Infilt. Rate**	
		New Treatment	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.1	0.7%
	TSS (lb/yr)	52	0.7%
	Volume (acre-feet/yr)	0.1	0.6%
Cost	**Administration & Promotion Costs***	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,427**	
	30-yr Average Cost/1,000lb-TSS	**$9,853**	
	30-yr Average Cost/ac-ft Vol.	**$4,302**	

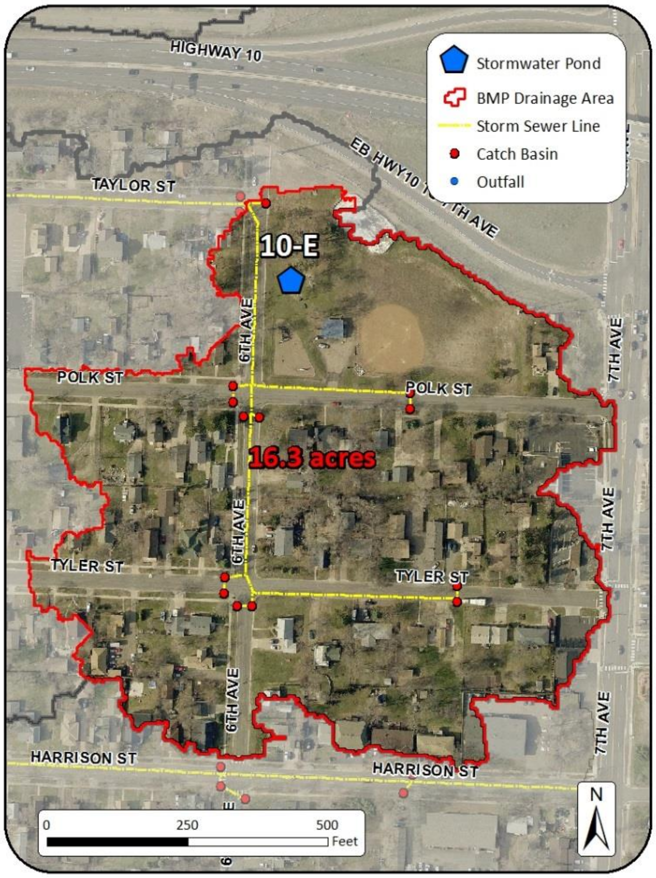
*Indirect Cost: (50 hours at $73/hour)

**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Project ID: 10-E

Rudy Johnson Park
New Pond



Drainage Area – 16.3 acre
Location – 6th Avenue and Taylor Street
Property Ownership – Public
Site Specific Information – A new pond is proposed for the northwest corner of Rudy Johnson Park. The pond would accept runoff from primarily residential properties. It will provide additional treatment to the catchment by allowing TSS and TP to settle out. The storm sewer line that runs north-south along 6th Ave. could be redirected into the proposed pond.

	New Pond		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	0.3	acres
	TP (lb/yr)	4.0	18.3%
	TSS (lb/yr)	1,712	23.7%
	Volume (acre-feet/yr)	0.1	0.3%
Cost	**Administration & Promotion Costs***	$7,300	
	Design & Construction Costs**	$232,625	
	Total Estimated Project Cost (2016)	**$239,925**	
	Annual O&M***	$300	
Efficiency	**30-yr Average Cost/lb-TP**	**$2,074**	
	30-yr Average Cost/1,000lb-TSS	**$4,847**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

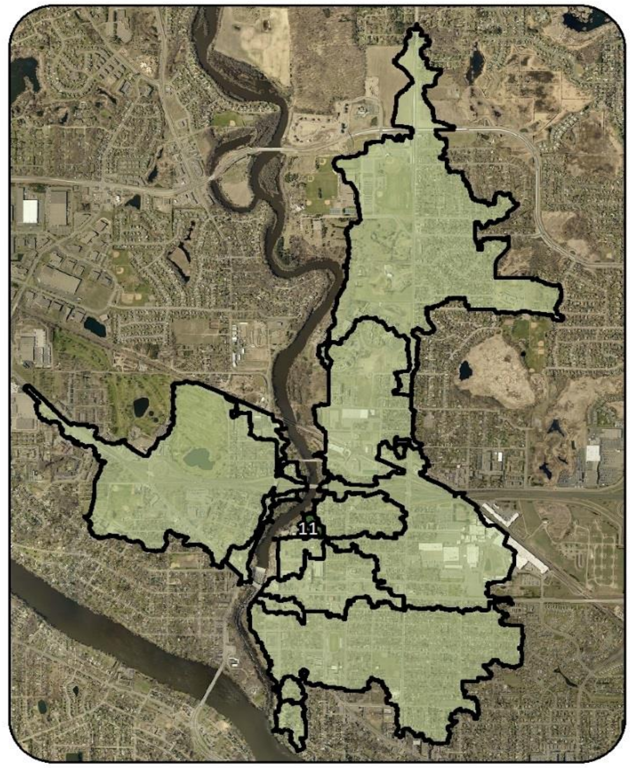
*Indirect Cost: 100 hours at $73/hour

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

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

Catchment A-11

Existing Catchment Summary	
Acres	4.9
Dominant Land Cover	Residential
Parcels	22
Volume (acre-feet/yr)	2.8
TP (lb/yr)	2.5
TSS (lb/yr)	806



CATCHMENT DESCRIPTION

Catchment A-11 is the smallest catchment east of the Rum River, and includes all of the geographic area draining to the Polk Street outfall. This outfall only receives water draining to the storm sewer network at this intersection. Land use in the catchment is only residential, but includes both single family homes and multifamily units.

EXISTING STORMWATER TREATMENT

A single hydrodynamic device treats most of this catchment, and is located at the intersection of Polk Street and 3rd Avenue. In addition to this hydrodynamic device, street cleaning is performed two times per year by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	3.1	0.6	19%	**2.5**
	TSS (lb/yr)	1,084	278	26%	**806**
	Volume (acre-feet/yr)	2.8	0.0	0%	**2.8**

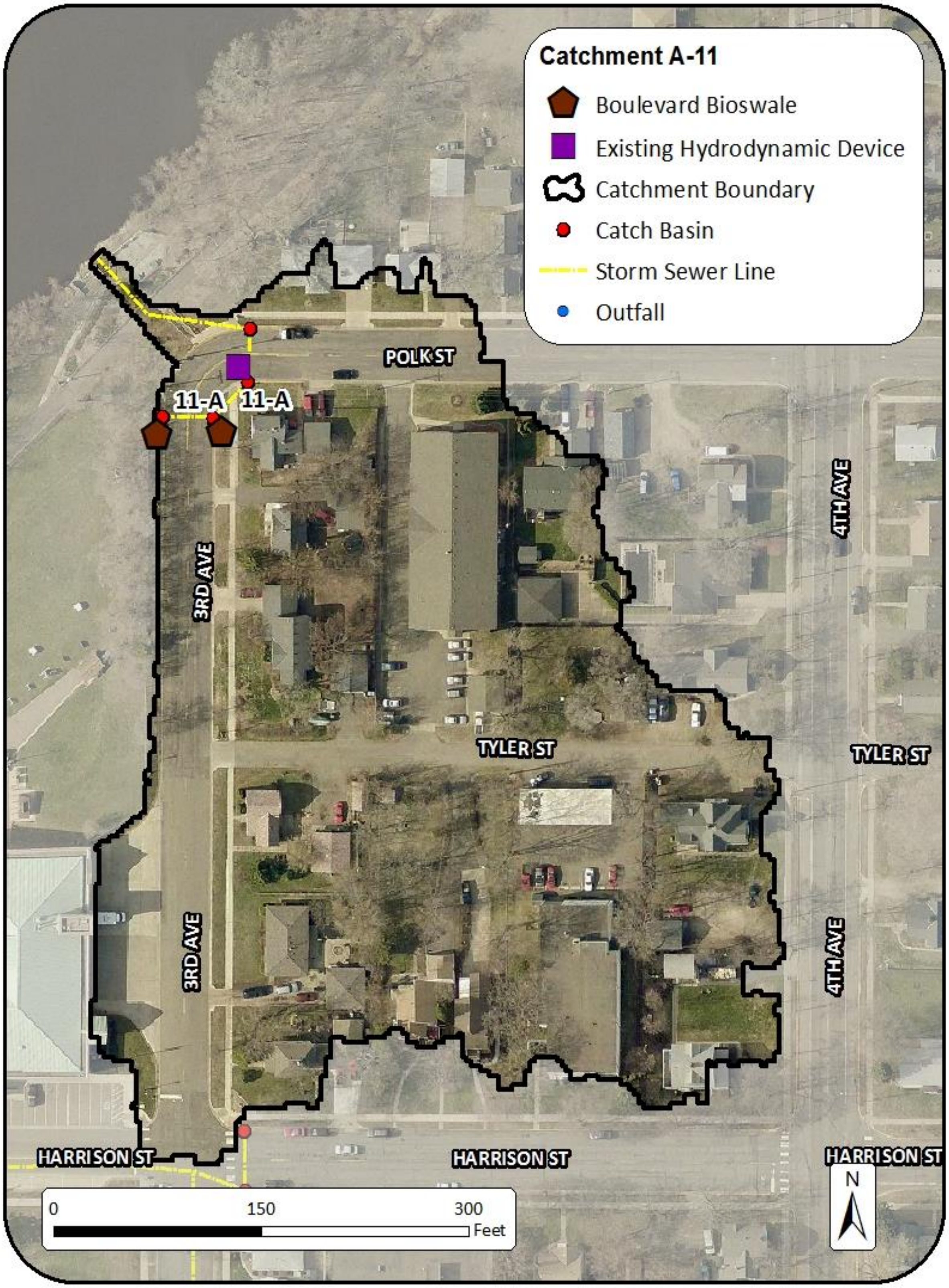
PROPOSED RETROFITS OVERVIEW

Two boulevard bioswales were proposed along 3rd Avenue to increase pollutant retention upstream of the hydrodynamic device.

RETROFITS CONSIDERED BUT REJECTED

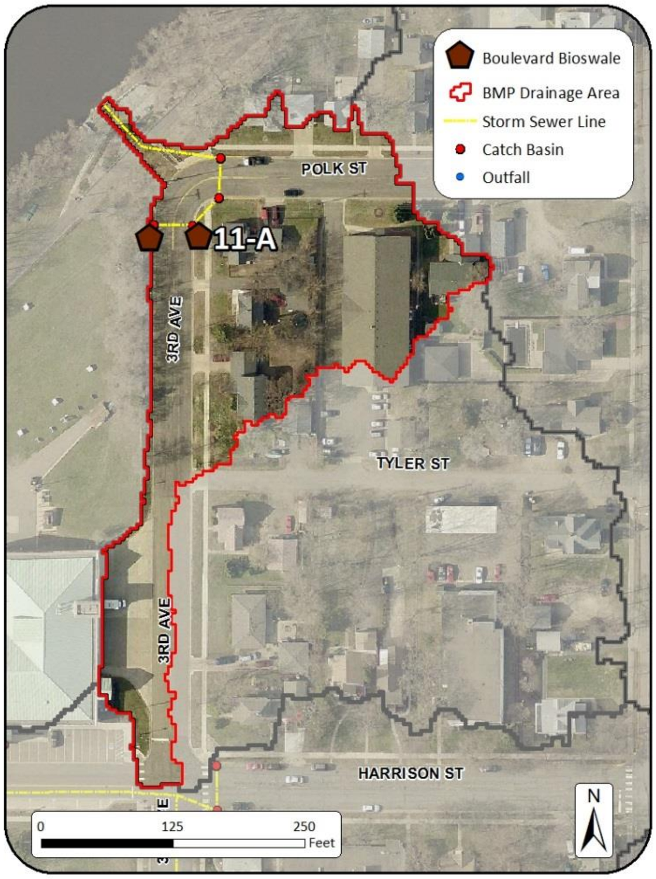
Additional bioretention opportunities were explored throughout the catchment but drainage areas to the practices were too small to warrant the installation costs.

RETROFIT RECOMMENDATIONS



Project ID: 11-A

3rd Avenue
Boulevard Bioswales



Drainage Area – 0.5 acres
Location – 3rd Avenue
Property Ownership – Public
Site Specific Information – Bioswales are proposed for installation, preferably at the northern end of 3rd Avenue. Locations for two bioswales are sited, where they will serve to treat runoff from residential properties. The table below shows the estimated cost and pollutant removal amounts based on treatment of a 0.5-acre drainage area.

	Boulevard Bioswale		
	Cost/Removal Analysis	**2.5"/hr Infilt. Rate**	
		New Treatment	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.1	5.8%
	TSS (lb/yr)	49	6.1%
	Volume (acre-feet/yr)	0.1	4.9%
Cost	**Administration & Promotion Costs***	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,523**	
	30-yr Average Cost/1,000lb-TSS	**$10,342**	
	30-yr Average Cost/ac-ft Vol.	**$3,717**	

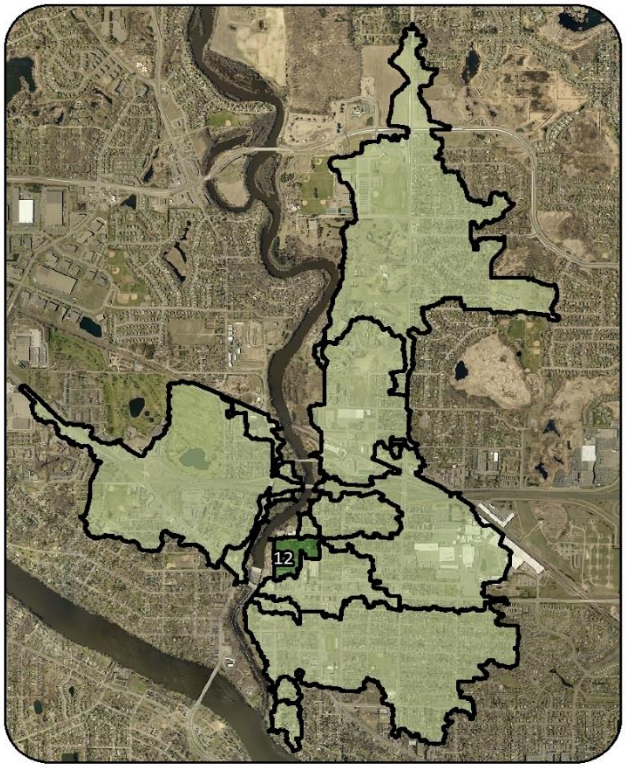
*Indirect Cost: (50 hours at $73/hour)

**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Catchment A-12

Existing Catchment Summary	
Acres	17.6
Dominant Land Cover	Commercial
Parcels	145
Volume (acre-feet/yr)	12.4
TP (lb/yr)	9.0
TSS (lb/yr)	3,427



CATCHMENT DESCRIPTION

Catchment A-12 includes portions of Harrison Street, Golf Street, 2nd Avenue, and 3rd Avenue in downtown Anoka. Stormwater runoff generated on the commercial, institutional, and multi-family residential properties of the catchment is quickly intercepted by municipal storm sewers and directed to a subsurface treatment device west of the intersection of 2nd Avenue and Harrison Street. Once stormwater leaves this device it is almost immediately discharged to the Rum River.

EXISTING STORMWATER TREATMENT

The hydrodynamic device located just west of the 2nd Avenue and Harrison Street intersection was installed during a recent roadway reconstruction and treats the entire 17.6-acre catchment. The only other form of stormwater treatment in the catchment is street cleaning, provided by the City of Anoka two times per month. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	2			
	BMP Types	1 Hydrodynamic Device, Street Cleaning			
	TP (lb/yr)	11.4	2.4	21%	**9.0**
	TSS (lb/yr)	4,694	1,267	27%	**3,427**
	Volume (acre-feet/yr)	12.4	0.0	0%	**12.4**

PROPOSED RETROFITS OVERVIEW

No retrofits were proposed in this catchment.

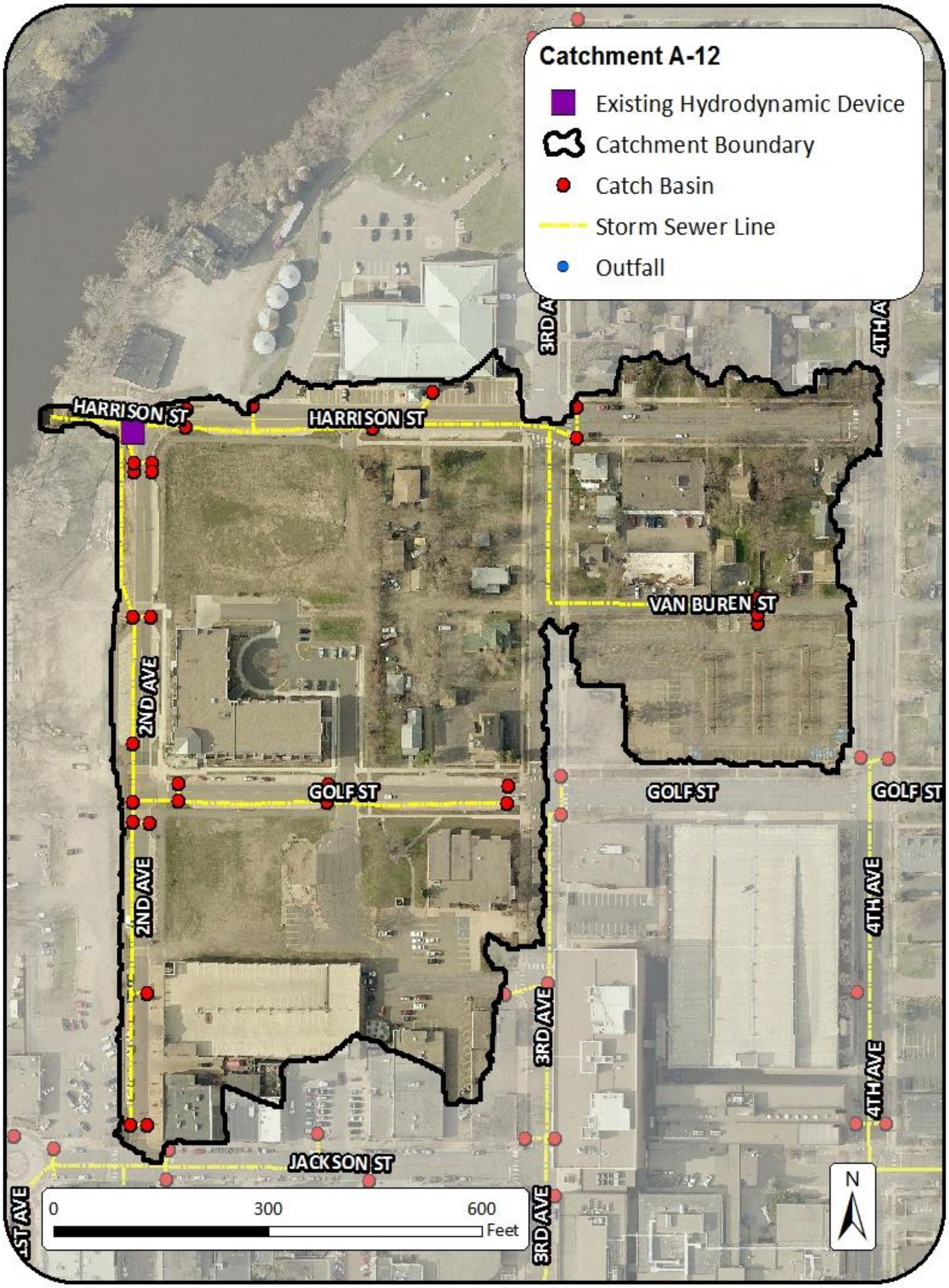
RETROFITS CONSIDERED BUT REJECTED

Permeable pavement was considered for the county-owned property between 3rd Avenue and 4th Avenue north of Golf Street. The practice was removed from consideration during conversations with City officials as the County intends to use this parking lot for future building development, not as its current use for street-level parking.

Bioretention practices, including curb-cut rain gardens and boulevard bioswales, were considered to supplement treatment provided by the hydrodynamic device and to reduce peak flows. These were not proposed as a retrofit option as the number of surface catch basins meant that drainage areas to each basin were too small to make the project cost-effective.

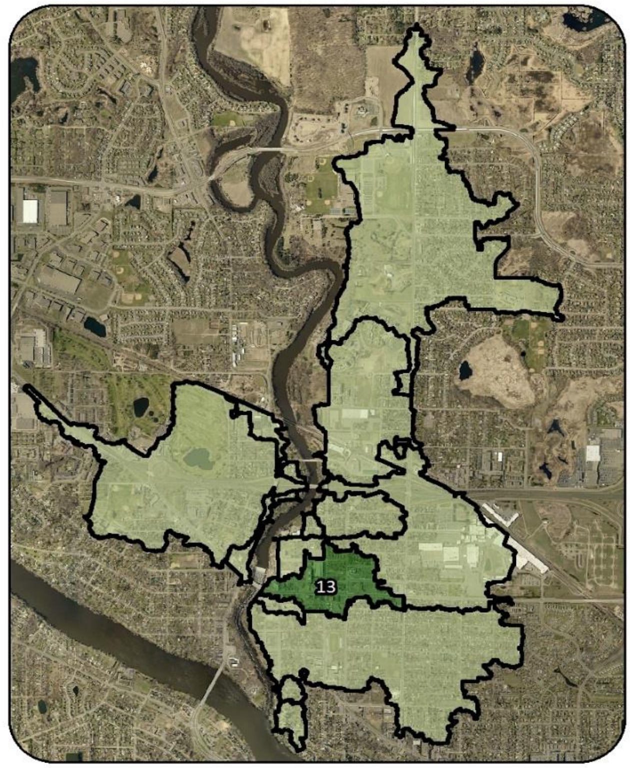
Therefore, the map below was included solely to provide additional detail of the catchment boundary, associated land uses, and streets.

RETROFIT RECOMMENDATIONS



Catchment A-13

Existing Catchment Summary	
Acres	65.8
Dominant Land Cover	Commercial
Parcels	214
Volume (acre-feet/yr)	6.3
TP (lb/yr)	4.3
TSS (lb/yr)	1,971



CATCHMENT DESCRIPTION

Catchment A-13 is the southernmost catchment in the eastern drainage network. It includes most of downtown Anoka, and is the most heavily-paved catchment in this analysis. Land use in the catchment is predominantly commercial and institutional. Publically-owned properties in this catchment include both the Anoka County Government Center and portions of the Anoka City Hall.

EXISTING STORMWATER TREATMENT

Stormwater runoff generated within the catchment flows to municipal and county storm sewers, eventually discharging into the Rum River south of Main Street. No catchment-wide treatment is available besides street cleaning, performed by the City of Anoka two times per month. Two small infiltration basins are located on the Anoka Middle School property, but only treat runoff from the school buildings and parking lot. Present-day stormwater pollutant loading and treatment is summarized in the table below.

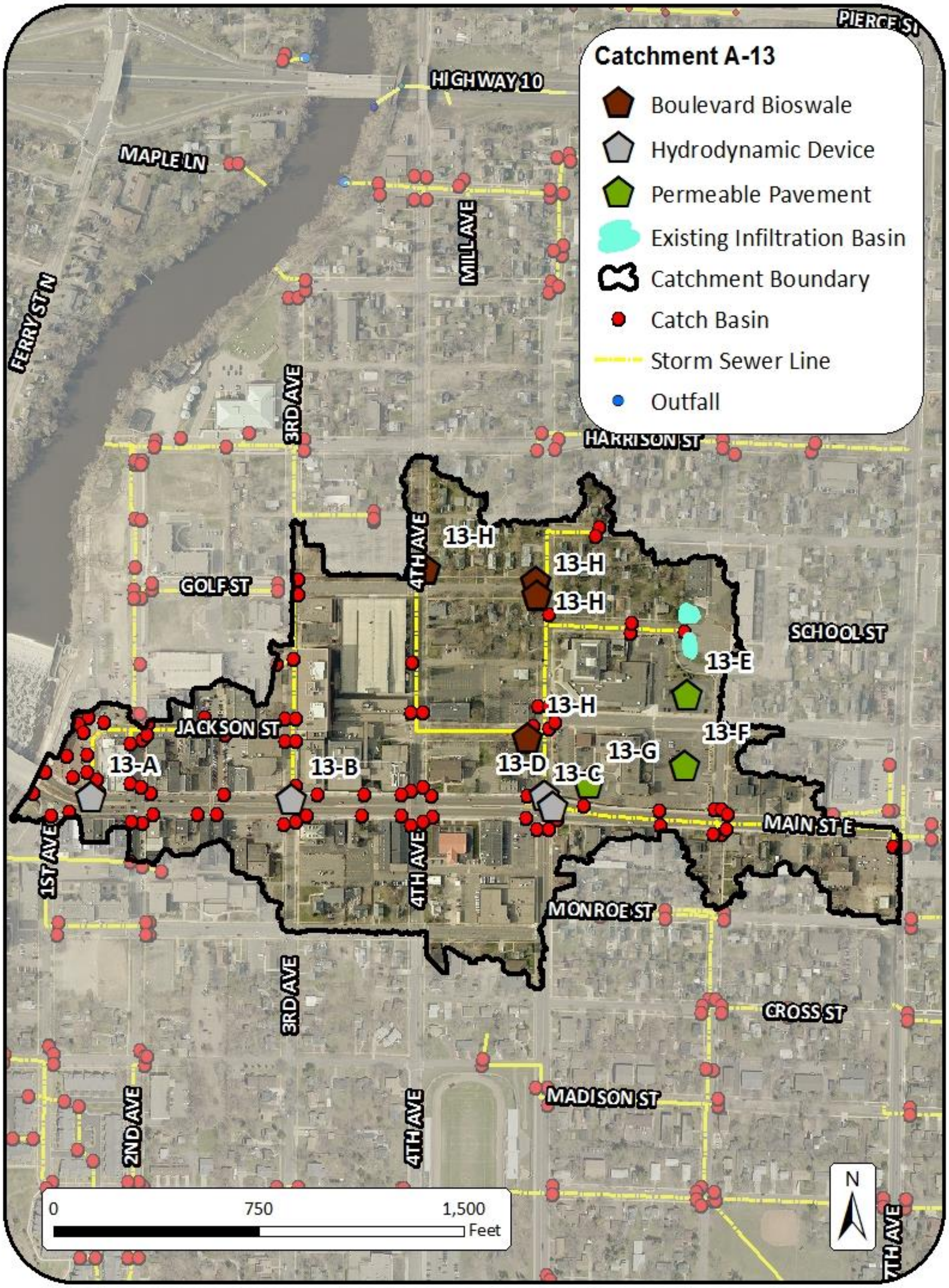
	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	**Number of BMPs**	3			
	BMP Types	2 Infiltration Basins, Street Cleaning			
	TP (lb/yr)	54.5	6.2	11%	**48.3**
	TSS (lb/yr)	24,065	3,437	14%	**20,628**
	Volume (acre-feet/yr)	65.3	1.2	2%	**64.1**

PROPOSED RETROFITS OVERVIEW

Four hydrodynamic devices were proposed to treat storm sewer lines along Main Street, 5th Avenue, 3rd Avenue, and the Anoka City Hall. These devices were proposed in locations with drainage areas less than 10 acres to reduce resuspension from high peak flows. Bioretention practices were also proposed in the form of boulevard bioswales (up to four).

Permeable pavement was also proposed on three parking lots on the St. Steven's Church and School properties. This practice would look to increase volume, TSS, and TP retention prior to discharge into the Rum River.

RETROFIT RECOMMENDATIONS



Project ID: 13-A

Main St. & 1st Ave.
Hydrodynamic Device

Drainage Area – 4.6 acres
Location – Main Street and 1st Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed at the intersection of Main Street and 1st Avenue. This device would accept runoff from the commercial properties and would provide additional treatment just before the catchment discharges into the Rum River.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.5	1.0%
	TSS (lb/yr)	272	1.3%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2016)	**$55,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,977**	
	30-yr Average Cost/1,000lb-TSS	**$9,149**	
	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: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

Project ID: 13-B

Main St. & 3rd Ave.
Hydrodynamic Device

Drainage Area – 6.4 acres
Location – Main Street and 3rd Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed at the intersection of Main Street and 3rd Avenue. This device would accept runoff from the Anoka County Government Center.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	8	ft diameter
	TP (lb/yr)	0.5	1.0%
	TSS (lb/yr)	285	1.4%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$54,000	
	Total Estimated Project Cost (2016)	**$55,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$4,977**	
	30-yr Average Cost/1,000lb-TSS	**$8,731**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

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

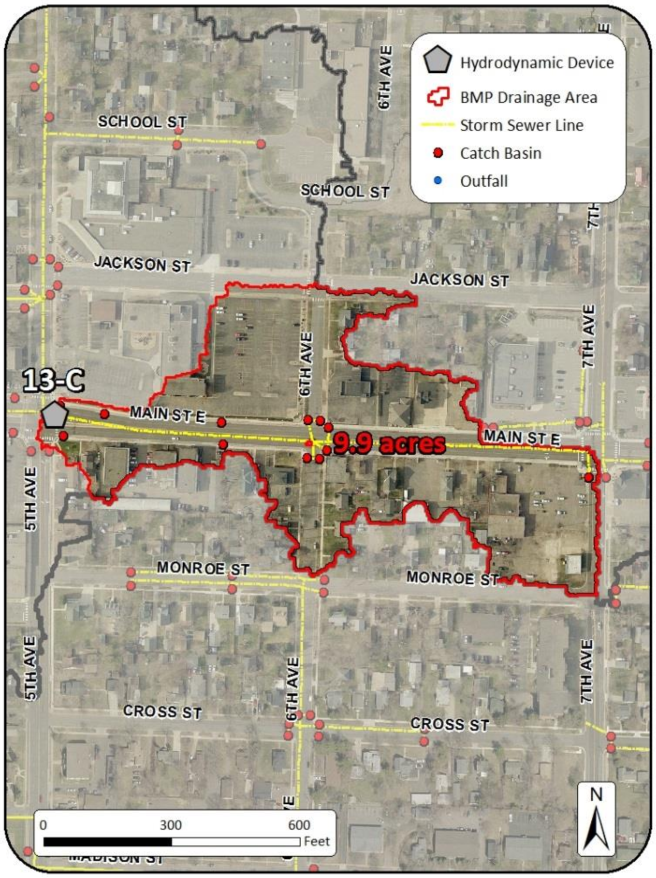
**Direct Cost: ($36,000 for materials) + ($18,000 for labor and installation costs)

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

Project ID: 13-C

Main St. & 5th Ave.
Hydrodynamic Device

Drainage Area – 9.9 acres
Location – Main Street and 5th Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed for Main Street at 5th Avenue to accept runoff from the eastern portion of the catchment. This portion of the catchment is composed of a school property, residential properties, and commercial properties.



	Hydrodynamic Device		
	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.9	1.9%
	TSS (lb/yr)	427	2.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	Administration & Promotion Costs*	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	30-yr Average Cost/lb-TP	**$4,765**	
	30-yr Average Cost/1,000lb-TSS	**$10,043**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

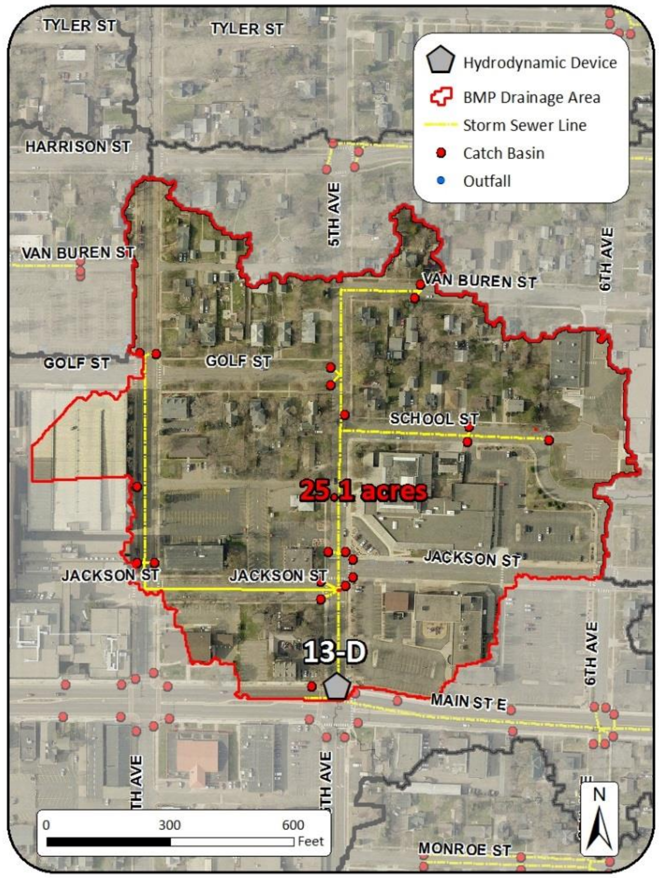
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 13-D

5th Ave. & Main St.
Hydrodynamic Device



Drainage Area – 25.1 acres
Location – 5th Avenue and Main Street
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed for 5th Avenue at Main Street to accept runoff from the northern portion of the catchment. This portion of the catchment is composed of a school property, residential properties, and commercial properties.

	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	1.4	2.9%
	TSS (lb/yr)	644	3.1%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$3,063**	
	30-yr Average Cost/1,000lb-TSS	**$6,659**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

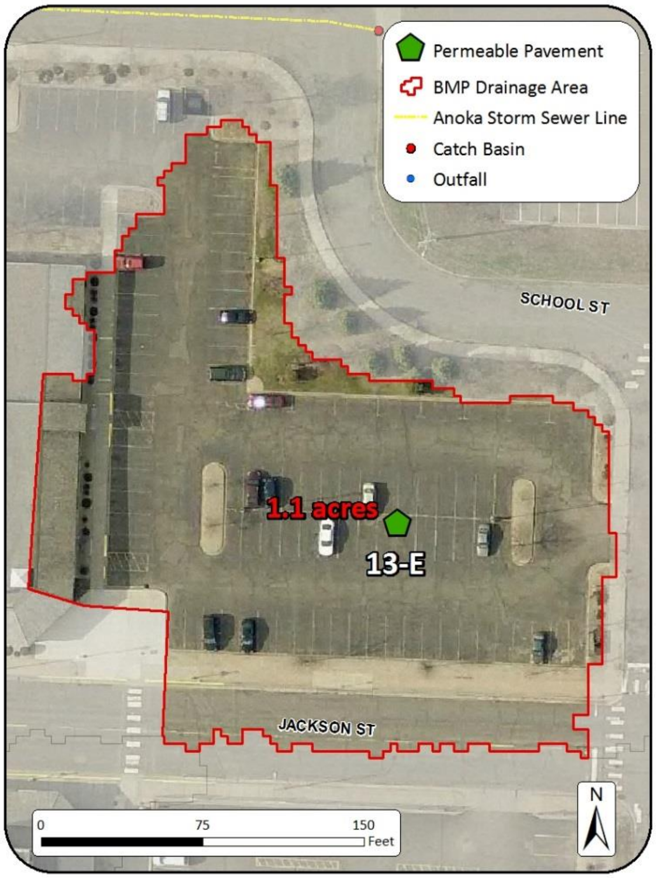
*Indirect Cost: (24 hours at $73/hour)

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

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

Project ID: 13-E

St. Stephen's Catholic Church.
Permeable Pavement



Drainage Area – 1.1 acres
Location – Jackson Street and School Street
Property Ownership – Private
Site Specific Information – Permeable pavement is proposed for the parking lot of St. Stephen's Catholic Church. This could be a favorable option as permeable pavement allows for the treatment of a large surface area with minimal impact on the usable space. In order to treat the 1.1-acre drainage area, 15,900 sq.-ft. of permeable pavement is proposed.

	Permeable Pavement		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMP	15,900	sq-ft
	TP (lb/yr)	0.9	8.7%
	TSS (lb/yr)	320	6.6%
	Volume (acre-feet/yr)	0.9	7.3%
Cost	**Administration & Promotion Costs***	$2,920	
	Design & Construction Costs**	$159,876	
	Total Estimated Project Cost (2016)	**$162,796**	
	Annual O&M***	$11,925	
Efficiency	**30-yr Average Cost/lb-TP**	**$19,279**	
	30-yr Average Cost/1,000lb-TSS	**$54,224**	
	30-yr Average Cost/ac-ft Vol.	**$19,279**	

*Indirect Cost: 40 hours at $73/hour

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

***($0.75/sq-ft for routine maintenance)

Project ID: 13-F

St. Stephen's Catholic School Permeable Pavement

Drainage Area – 1.9 acres
Location – Jackson Street and 6th Avenue
Property Ownership – Private
Site Specific Information – Permeable pavement is proposed for the eastern parking lot of St. Stephen's Catholic School. This could be a favorable option as permeable pavement allows for the treatment of a large surface area with minimal impact on the usable space. In order to treat the 1.9-acre drainage area, 27,900 sq.-ft. of permeable pavement is proposed.

Permeable Pavement

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	27,900	sq-ft
	TP (lb/yr)	1.6	15.4%
	TSS (lb/yr)	562	11.6%
	Volume (acre-feet/yr)	1.6	12.9%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$279,876	
	Total Estimated Project Cost (2016)	**$282,796**	
	Annual O&M***	$20,925	
Efficiency	30-yr Average Cost/lb-TP	**$18,970**	
	30-yr Average Cost/1,000lb-TSS	**$54,006**	
	30-yr Average Cost/ac-ft Vol.	**$18,970**	

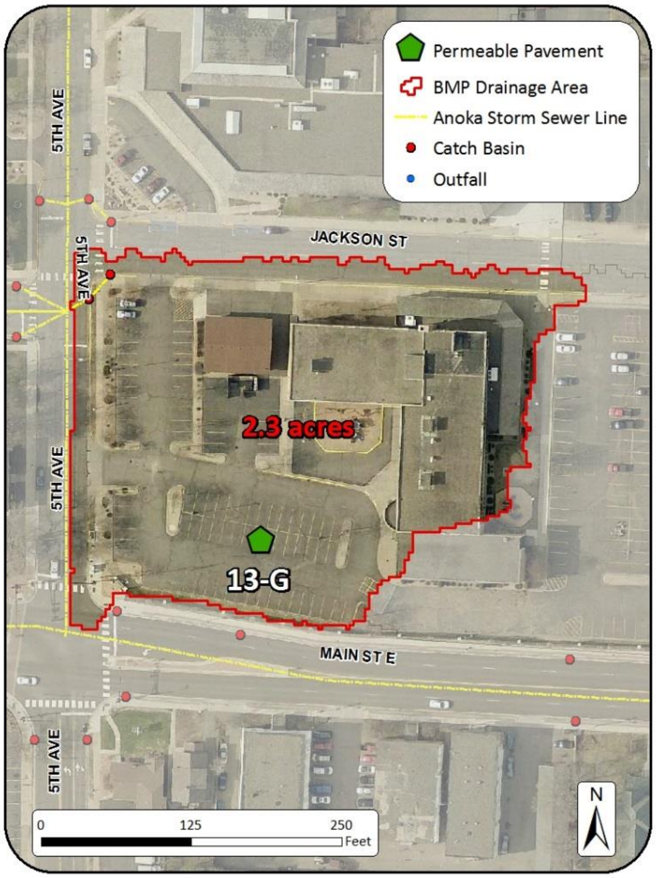
*Indirect Cost: 40 hours at $73/hour

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

***($0.75/sq-ft for routine maintenance)

Project ID: 13-G

St. Stephen's Catholic School
Permeable Pavement



Drainage Area – 2.3 acres
Location – Jackson Street and 6th Avenue
Property Ownership – Private
Site Specific Information – Permeable pavement is proposed for the western parking lot of St. Stephen's Catholic School. This could be a favorable option as permeable pavement allows for the treatment of a large surface area with minimal impact on the usable space. In order to treat the 2.3-acre drainage area, 34,000 sq.-ft. of permeable pavement is proposed.

Permeable Pavement

	Cost/Removal Analysis	New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMP	34,000	sq-ft
	TP (lb/yr)	1.9	18.3%
	TSS (lb/yr)	672	13.9%
	Volume (acre-feet/yr)	1.9	15.3%
Cost	Administration & Promotion Costs*	$2,920	
	Design & Construction Costs**	$340,876	
	Total Estimated Project Cost (2016)	**$343,796**	
	Annual O&M***	$25,500	
Efficiency	30-yr Average Cost/lb-TP	**$19,453**	
	30-yr Average Cost/1,000lb-TSS	**$55,000**	
	30-yr Average Cost/ac-ft Vol.	**$19,453**	

*Indirect Cost: 40 hours at $73/hour

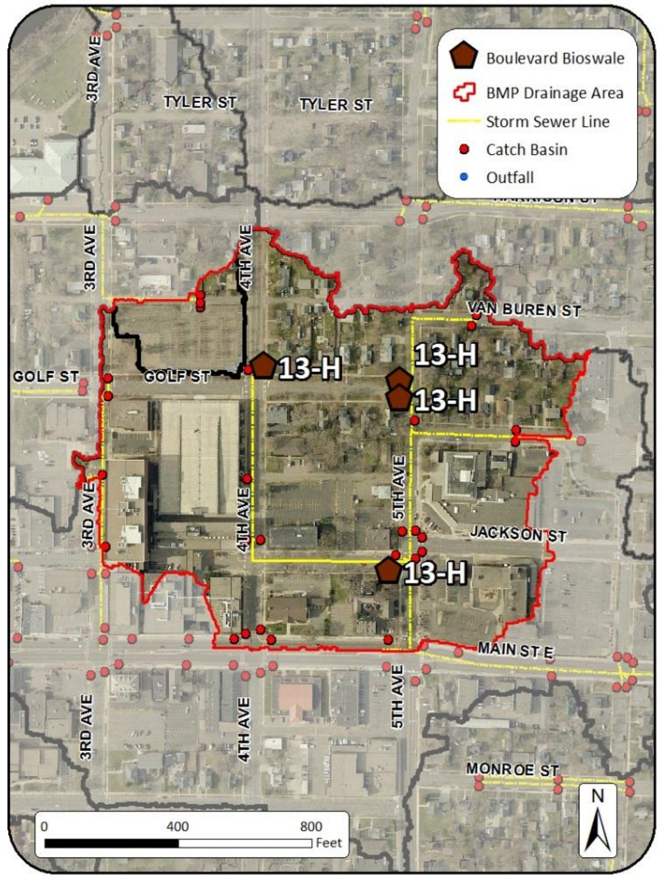
**Direct Cost: ($10/sq-ft for materials and labor) + (12 hours at $73/hour for design)

***($0.75/sq-ft for routine maintenance)

Project ID: 13-H

Boulevard Bioswales

Drainage Area – 0.5 acres
Location – Various locations throughout catchment
Property Ownership – Public
Site Specific Information – Boulevard bioswales are proposed for installation, preferably in the northern portion of the catchment. Locations for up to four bioswales are sited, where they will serve to treat runoff primarily from residential properties. The table below shows the estimated cost and pollutant removal amounts based on treatment of a 0.5-acre drainage area.



	Cost/Removal Analysis	2.5"/hr Infilt. Rate	
		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	80	sq-ft
	TP (lb/yr)	0.1	1.0%
	TSS (lb/yr)	22	0.5%
	Volume (acre-feet/yr)	0.1	0.8%
Cost	Administration & Promotion Costs*	$3,650	
	Design & Construction Costs**	$4,876	
	Total Estimated Project Cost (2016)	**$8,526**	
	Annual O&M***	$225	
Efficiency	30-yr Average Cost/lb-TP	**$5,092**	
	30-yr Average Cost/1,000lb-TSS	**$23,072**	
	30-yr Average Cost/ac-ft Vol.	**$5,092**	

*Indirect Cost: (50 hours at $73/hour)

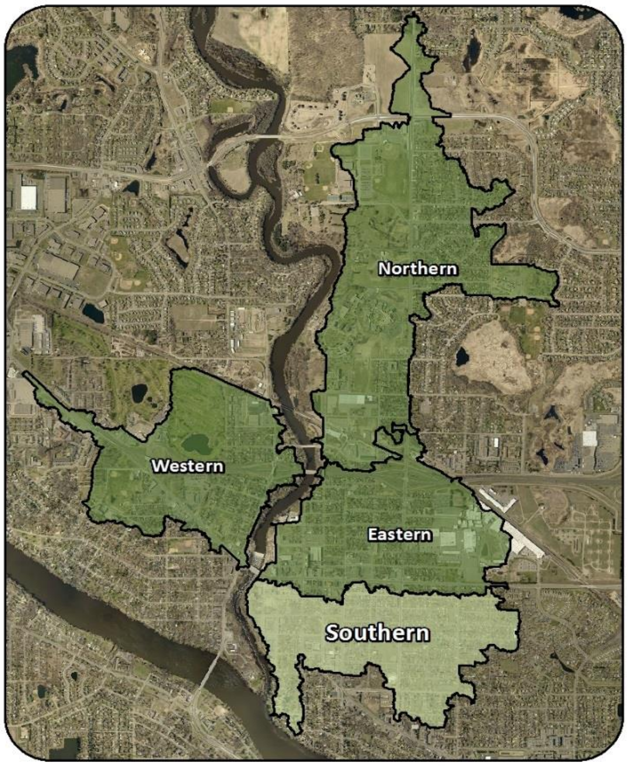
**Direct Cost: ($50/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

***Per BMP: ($150/year for 10-year rehabilitation)+ ($75/year for routine maintenance)

Southern Drainage Network

Catchment ID	Page
A-14	118
A-15	122
A-16	126
A-17	130

Existing Network Summary	
Acres	302.7
Dominant Land Cover	Residential
Volume (ac-ft/yr)	148.2
TP (lb/yr)	142.9
TSS (lb/yr)	44,377



DRAINAGE NETWORK SUMMARY

The southern drainage network consists of catchments A-14, A-15, A-16, and A-17. These catchments comprise all areas in the City of Anoka draining to the Rum River south of Main Street. The four Rum River outfalls are located west of 1st Avenue about 200' south of Main Street (A-14) and at Adam's Street (A-15), Washington Street. (A-16), and Oakwood Drive (A-17). The southern drainage network is predominantly residential housing unlike the other three drainage networks, which have a much larger variety of land uses.

EXISTING STORMWATER TREATMENT

The only form of network-wide treatment is street cleaning performed by the City of Anoka twice monthly in Catchment A-14 and two times annually in Catchment A-15, A-16, and A-17. Only two other forms of treatment exist in the network. The first is a treatment system in Catchment A-15 at 2nd Avenue and Adams Street which includes a series of sedimentation chambers as well as a retention pond.

Catchment A-14

Existing Catchment Summary	
Acres	7.8
Dominant Land Cover	Commercial
Parcels	45
Volume (acre-feet/yr)	8.3
TP (lb/yr)	6.4
TSS (lb/yr)	2,636

CATCHMENT DESCRIPTION

Catchment A-14 includes areas of downtown Anoka south of Main Street along 1st Avenue, 2nd Avenue, 3rd Avenue, and Monroe Street. The catchment includes all geographic area draining to an outfall along the Rum River about 200' south of Main Street. Stormwater runoff is primarily overland east of 2nd Avenue, but is then collected through a series of municipal storm sewer pipes, and discharged at the Rum River outfall west of 1st Avenue.

EXISTING STORMWATER TREATMENT

No stormwater treatment exists in this catchment besides street cleaning, conducted two times per month by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	**Number of BMPs**	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	7.2	0.8	11%	**6.4**
	TSS (lb/yr)	3,108	472	15%	**2,636**
	Volume (acre-feet/yr)	8.3	0.0	0%	**8.3**

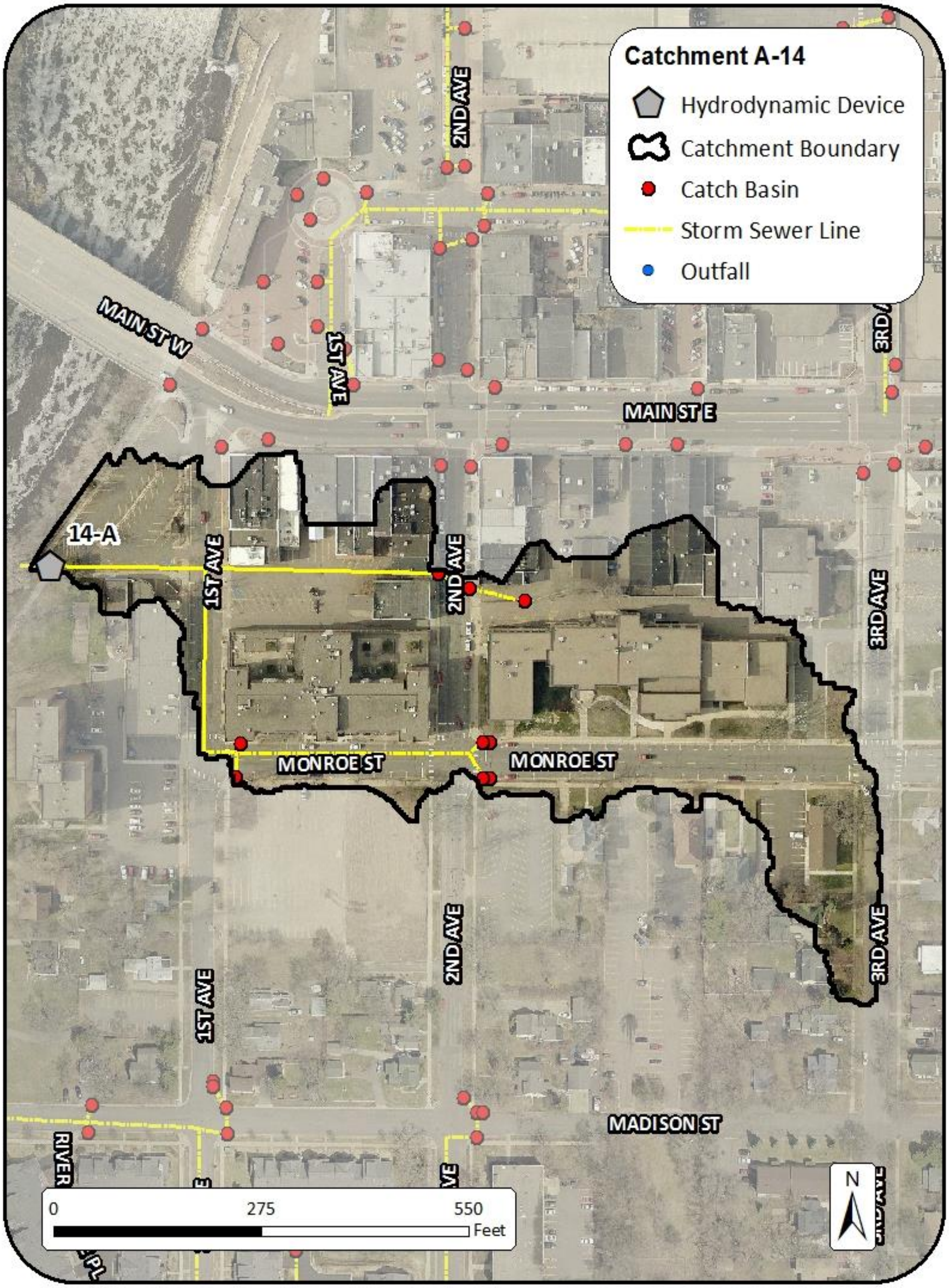
PROPOSED RETROFITS OVERVIEW

A single hydrodynamic device was proposed upstream of the outfall to the Rum River. If properly designed and installed, this structure should be able to treat nearly all of the surficial area of this catchment.

RETROFITS CONSIDERED BUT REJECTED

Bioretention practices, specifically boulevard bioswales, were considered but were not proposed as insufficient space exists within boulevards of this catchment to accommodate a practice. Due to the limited space, subsurface practices were instead proposed.

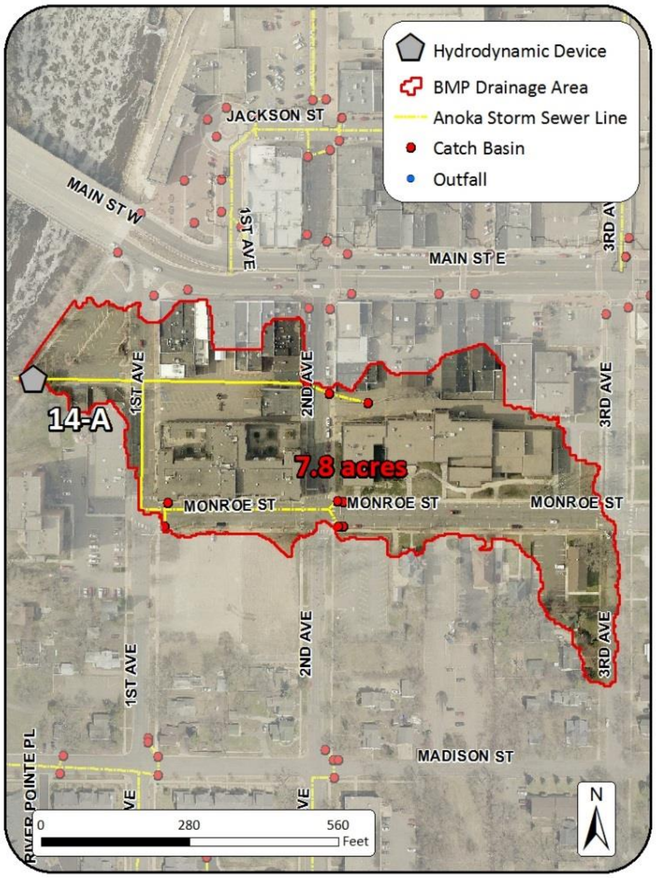
RETROFIT RECOMMENDATIONS



Project ID: 14-A

1st Avenue.
Hydrodynamic Device

Drainage Area – 7.8 acres
Location – Parking lot off 1st Avenue
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed for the parking lot west of 1st Avenue and south of Main Street. This device would accept and treat runoff from the entire catchment.



	Hydrodynamic Device		
	Cost/Removal Analysis	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1	
	Total Size of BMPs	10	ft diameter
	TP (lb/yr)	0.8	12.5%
	TSS (lb/yr)	385	14.6%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$5,361**	
	30-yr Average Cost/1,000lb-TSS	**$11,139**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

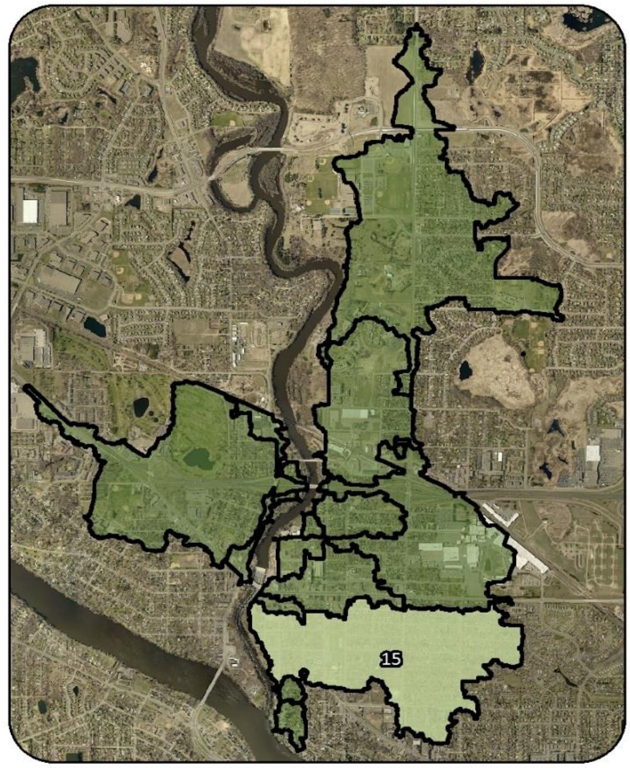
*Indirect Cost: (24 hours at $73/hour)

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

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

Catchment A-15

Existing Catchment Summary	
Acres	275.9
Dominant Land Cover	Residential
Parcels	845
Volume (acre-feet/yr)	131.8
TP (lb/yr)	125.3
TSS (lb/yr)	38,609



CATCHMENT DESCRIPTION

Catchment A-15 is the largest catchment in the southern drainage network, extending from the Coon Rapids municipal boundary in the east to the Rum River in the west and from Main Street in the north to Southview Road in the south. The catchment is predominantly single-family residential, but includes larger publically-owned parcels such as the Anoka High School football field, Middle School for the Arts, and Aquatic Center and privately owned multifamily developments.

Stormwater runoff generated within the catchment is collected quickly from street catch basins and conveyed to the Rum River. The catchment includes areas of downtown Anoka south of Main St. along 1st Avenue, 2nd Avenue, 3rd Avenue, and Monroe Street. The catchment includes all geographic areas draining to an outfall along the Rum River about 200' south of Main Street. Stormwater runoff is primarily overland east of 2nd Avenue, but is then collected through a series of municipal storm sewer pipes, and discharged at the Rum River outfall west of 1st Avenue.

EXISTING STORMWATER TREATMENT

Stormwater runoff generated within the catchment is collected quickly from roadway catch basins and conveyed to a stormwater treatment system on Adams Street west of 2nd Avenue. Upon entering the system stormwater is first passed through a grit chamber, which is a series of baffles and trash racks acting as sedimentation cells. Once through this structure stormwater is discharged into a retention pond, which subsequently outlets into the Rum River. The only other form of stormwater treatment in this catchment is street cleaning, conducted two times per year by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	**Number of BMPs**	5			
	BMP Types	3 Hydrodynamic Devices, 1 Pond, Street Cleaning			
	TP (lb/yr)	163.3	38.0	23%	**125.3**
	TSS (lb/yr)	54,890	16,281	30%	**38,609**
	Volume (acre-feet/yr)	134.6	2.8	2%	**131.8**

PROPOSED RETROFITS OVERVIEW

Infiltration practices were pursued in areas outside of the Drinking Water Supply Management Areas. Up to ten curb-cut rain gardens were proposed in the residential neighborhood east of 5th Avenue and south of Jefferson Street. This neighborhood was chosen due to its sandy soils, relatively small slopes, and older infrastructure. Recent roadway improvements to the north increased the density of catch basins, which can make curb-cut rain garden projects less beneficial by decreasing potential drainage areas.

A pair of hydrodynamic devices were proposed along tertiary storm sewer lines on 5th Avenue and Jefferson Street. Drainage areas to each of these devices were kept below ten acres to limit peak stormwater volume discharge to each device as high flows can promote the resuspension of accumulated sediment.

RETROFITS CONSIDERED BUT REJECTED

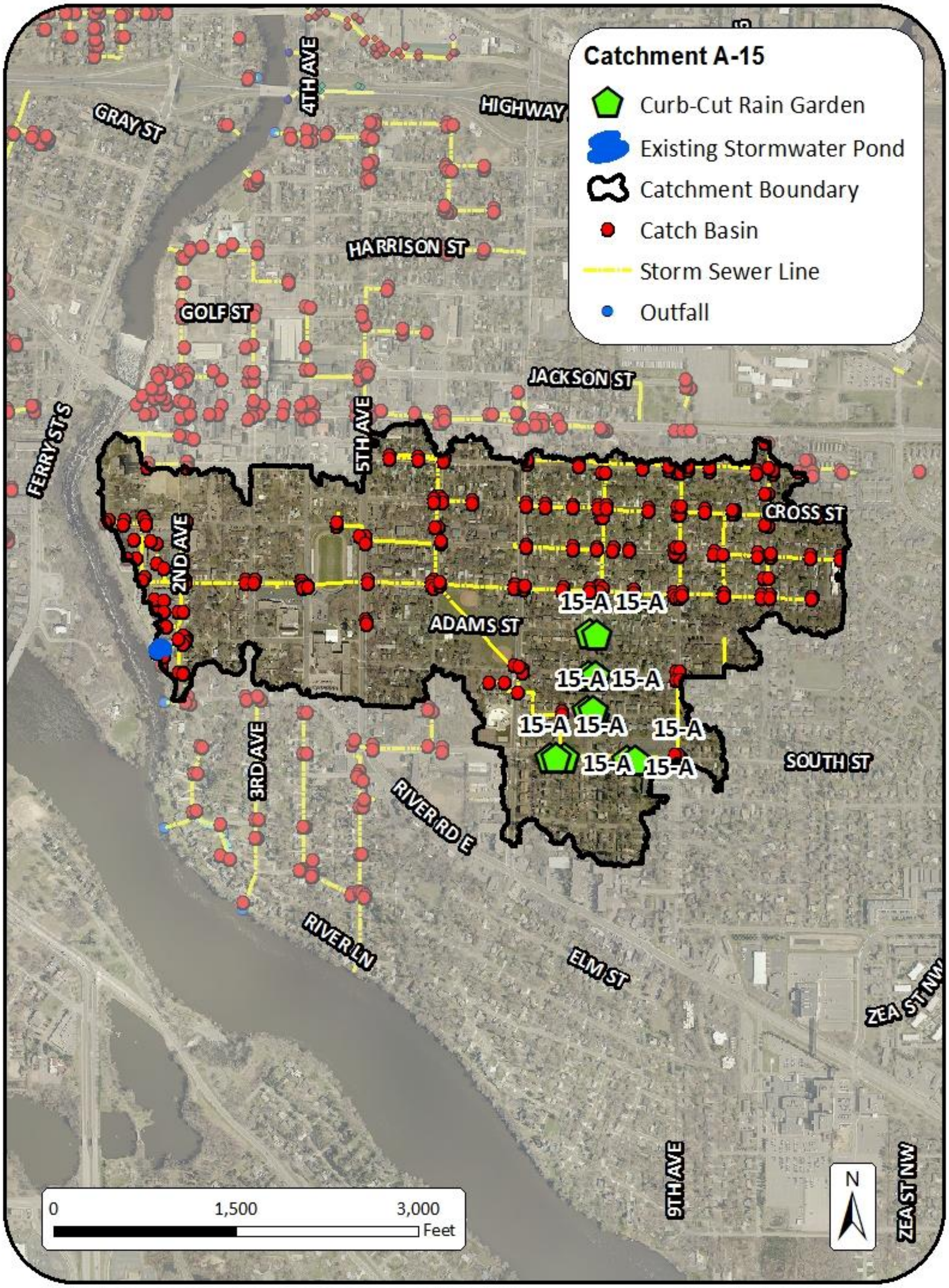
Permeable pavement opportunities sited at public, school, and church properties throughout the Adams Street catchment were removed due to the risk of contamination to local groundwater resources. The Minnesota Department of Health Wellhead Protection Area (WHPA) throughout most of the Adams Street catchment has a high risk for aquifer vulnerability. Because long-term paved parking areas can be sources for heavy metals, hydrocarbons, and road salt this location was removed as a potential area for an infiltration practice such as permeable pavement.

Similarly, underground infiltration practices located at two city-owned properties (the baseball fields west of 7th Avenue and north of Brisbin Street, and the open green space east of 7th Avenue and north of South Street) were removed from consideration because of their location relative to the WHPA within an area of high groundwater vulnerability.

A pair of hydrodynamic devices were also proposed along tertiary storm sewer lines on 5th Avenue and Jefferson Street. Drainage areas to each of these devices were kept below ten acres to limit peak stormwater volume discharge to each device as high flows can promote the resuspension of accumulated sediment. However, after modeling these devices showed to remove minimal TP and TSS.

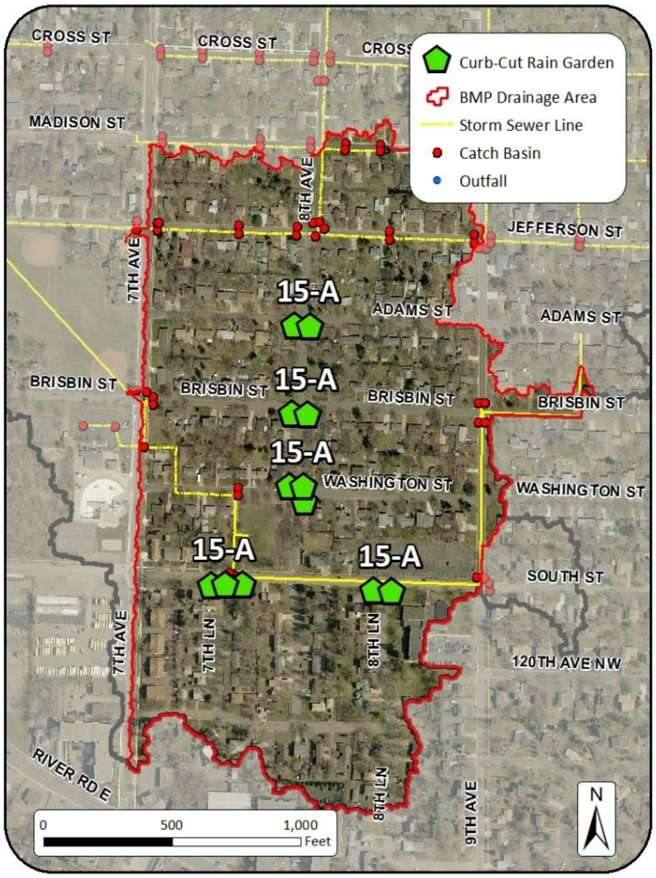
Lastly, a stormwater reuse practice on the high school football field was also excluded from consideration as increased infiltration at this site from repurposed stormwater would likely require filtering and tertiary treatment that would deem the practice cost-prohibitive. Because this practice also lies within the Emergency Response Area (area where time of travel for infiltrated water from the ground surface to the aquifer is within 1 year) the installation of any infiltration practice is not recommended.

RETROFIT RECOMMENDATIONS



Project ID: 15-A

Curb-Cut Rain Gardens



Drainage Area – 1.5 – 15 acres
Location – Various locations in southeastern portion of catchment
Property Ownership – Private
Site Specific Information – Single-family lots in the catchment provide various locations for curb-cut rain gardens to treat stormwater pollutants originating from private property. Considering typical landowner participation rates, scenarios with one, five, and ten rain gardens were analyzed to treat the drainage area.

Curb-Cut Rain Garden

	Cost/Removal Analysis	New Treatment	% Reduction	New Treatment	% Reduction	New Treatment	% Reduction
Treatment	Number of BMPs	1		5		10	
	Total Size of BMPs	250	sq-ft	1,250	sq-ft	2,500	sq-ft
	TP (lb/yr)	0.4	0.4%	2.2	1.8%	4.4	3.5%
	TSS (lb/yr)	135	0.3%	671	1.7%	1,343	3.5%
	Volume (acre-feet/yr)	0.4	0.3%	1.9	1.4%	3.7	2.8%
Cost	Administration & Promotion Costs*	$8,468		$11,972		$16,352	
	Design & Construction Costs**	$7,376		$36,880		$73,760	
	Total Estimated Project Cost (2016)	**$15,844**		**$48,852**		**$90,112**	
	Annual O&M***	$225		$1,125		$2,250	
Efficiency	30-yr Average Cost/lb-TP	**$1,883**		**$1,252**		**$1,194**	
	30-yr Average Cost/1,000lb-TSS	**$5,579**		**$4,103**		**$3,912**	
	30-yr Average Cost/ac-ft Vol.	**$1,931**		**$1,480**		**$1,413**	

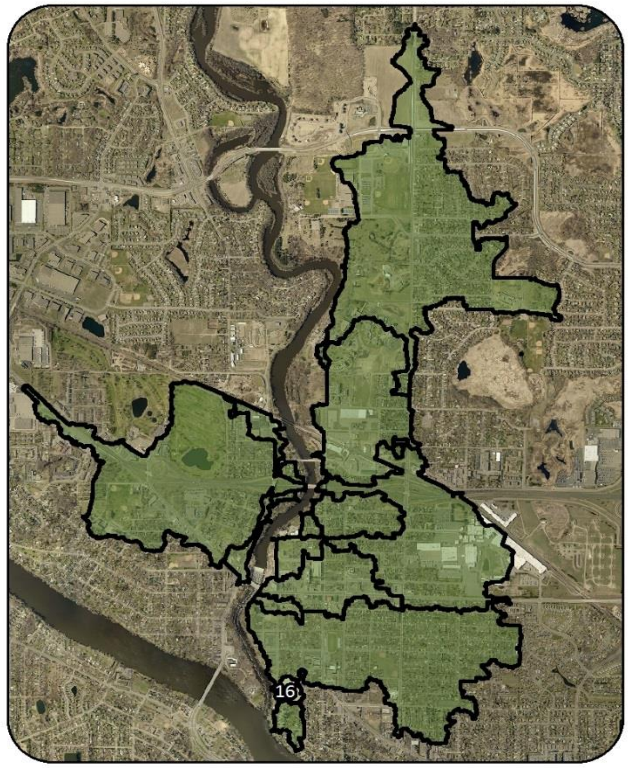
*Indirect Cost: (104 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

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

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

Catchment A-16

Existing Catchment Summary	
Acres	6.7
Dominant Land Cover	Residential
Parcels	19
Volume (acre-feet/yr)	2.8
TP (lb/yr)	3.8
TSS (lb/yr)	1,066



CATCHMENT DESCRIPTION

Catchment A-16 is defined by all of the geographical area draining stormwater to the Washington Street outfall. This outfall collects stormwater from a single storm sewer line located at the intersection of Oakwood Drive and Washington Street and discharges it into the Rum River 150' west of the intersection. This catchment is the smallest in the southern network and provides drainage from less than 20 single family residential properties. Soils within the historic Rum River floodplain (along and west of Oakwood Drive) are sandy loams, while soils east of Oakwood Drive are predominantly coarse and sandy.

EXISTING STORMWATER TREATMENT

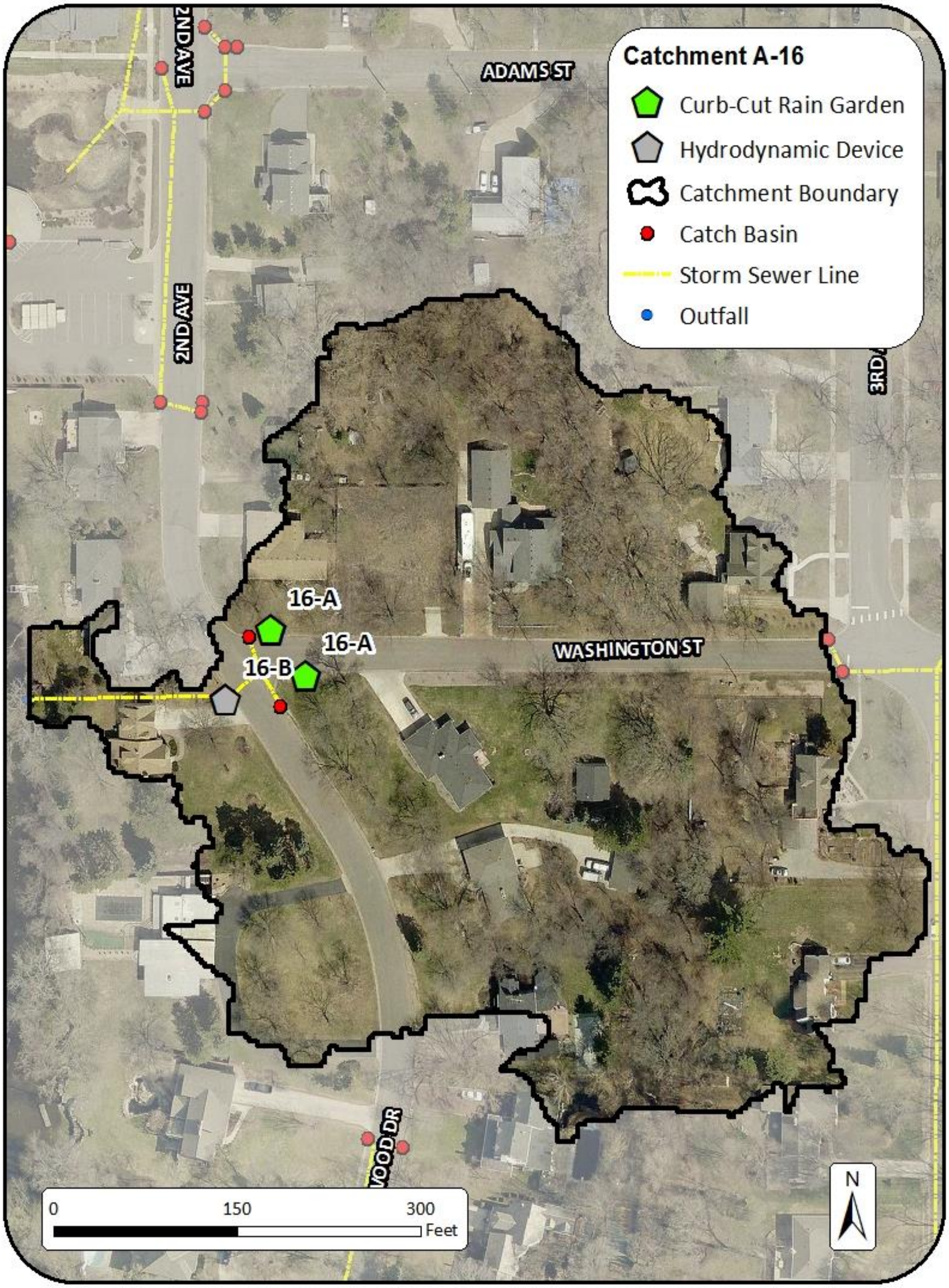
The only form of stormwater treatment in this catchment is street cleaning, conducted two times per year by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	**Number of BMPs**	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	4.1	0.3	7%	**3.8**
	TSS (lb/yr)	1,208	142	12%	**1,066**
	Volume (acre-feet/yr)	2.8	0.0	0%	**2.8**

PROPOSED RETROFITS OVERVIEW

A hydrodynamic device and a pair of curb-cut rain gardens are proposed to provide treatment to stormwater prior to discharge to the Rum River. The curb-cut rain gardens are proposed just upstream of catch basins to maximize drainage area to each basin. The hydrodynamic device should be installed such that it treats all catch basins at the Oakwood Drive and Washington Street intersection.

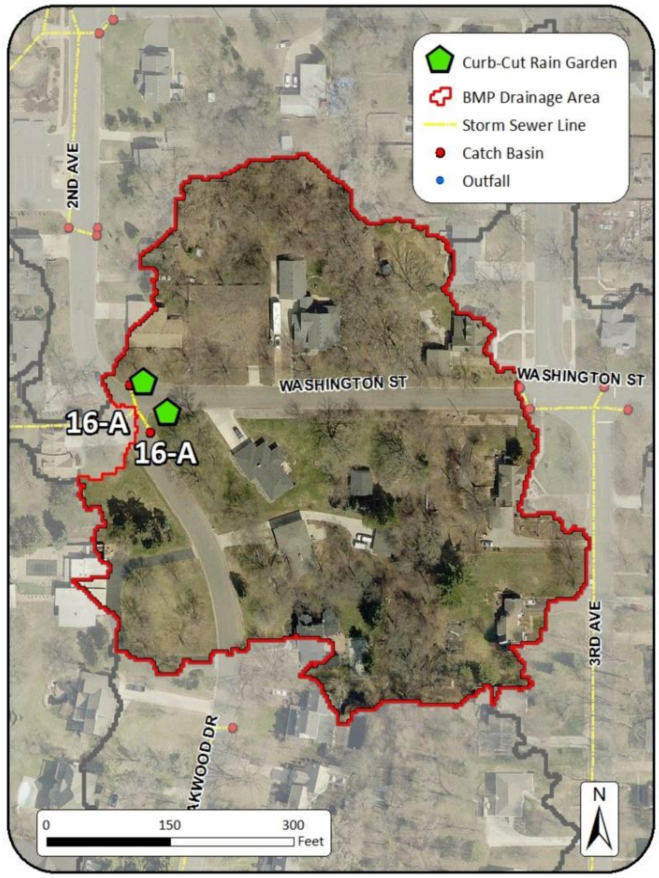
RETROFIT RECOMMENDATIONS



Project ID: 16-A

Washington St.
Curb-Cut Rain Gardens

Drainage Area – 1.5 – 3 acres
Location – Washington Street and Oakwood Drive
Property Ownership – Private
Site Specific Information – Single-family lots in the catchment provide locations for curb-cut rain gardens to treat stormwater pollutants originating from private property. Preferably the rain gardens would be placed on private properties at the western end of Washington Street at Oakwood Drive in order to treat a larger drainage area. Considering typical landowner participation rates, scenarios with one and two rain gardens were analyzed to treat the drainage area.



	Curb Cut Rain Garden				
	Cost/Removal Analysis	**New Treatment**	**% Reduction**	**New Treatment**	**% Reduction**
Treatment	**Number of BMPs**	1		2	
	Total Size of BMPs	250	sq-ft	500	sq-ft
	TP (lb/yr)	0.5	13.2%	1.0	26.3%
	TSS (lb/yr)	157	14.7%	315	29.5%
	Volume (acre-feet/yr)	0.4	13.9%	0.8	27.8%
Cost	**Administration & Promotion Costs***	$1,606		$2,482	
	Design & Construction Costs**	$7,376		$14,752	
	Total Estimated Project Cost (2016)	**$8,982**		**$17,234**	
	Annual O&M***	$225		$450	
Efficiency	**30-yr Average Cost/lb-TP**	**$1,049**		**$1,024**	
	30-yr Average Cost/1,000lb-TSS	**$3,340**		**$3,252**	
	30-yr Average Cost/ac-ft Vol.	**$1,369**		**$1,339**	

*Indirect Cost: (10 hours at $73/hour base cost) + (12 hours/BMP at $73/hour)

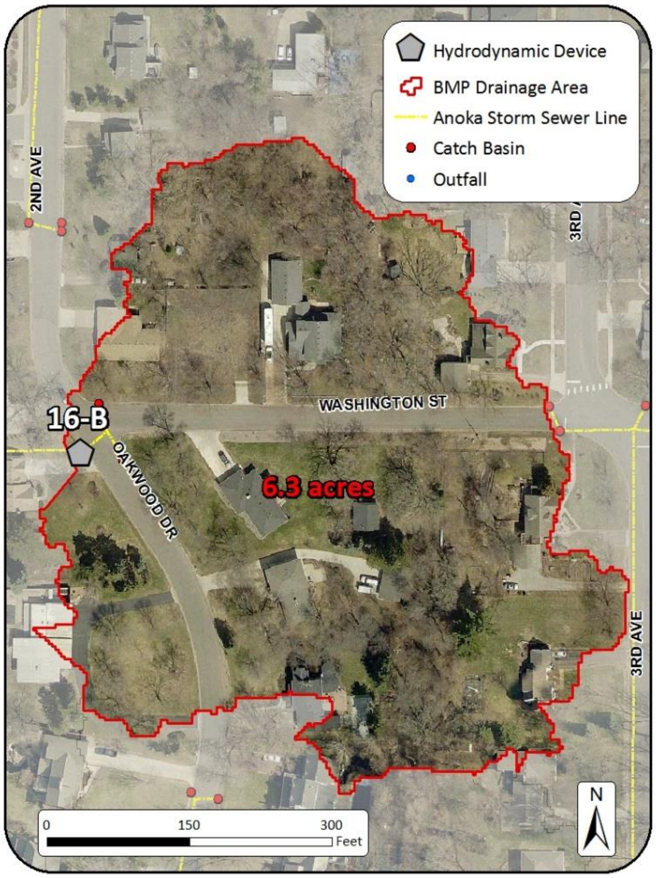
**Direct Cost: ($26/sq-ft for materials and labor) + (12 hours/BMP at $73/hour for design)

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

Project ID: 16-B

Oakwood Dr. & Washington St. Hydrodynamic Device

Drainage Area – 6.3 acres
Location –Oakwood Drive and Washington Street
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed for Oakwood Drive at Washington Street. A device at this location would capture and treat runoff from almost the entire catchment. The catchment is composed of all 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)	0.4	10.5%
	TSS (lb/yr)	163	15.3%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$10,721**	
	30-yr Average Cost/1,000lb-TSS	**$26,309**	
	30-yr Average Cost/ac-ft Vol.	**N/A**	

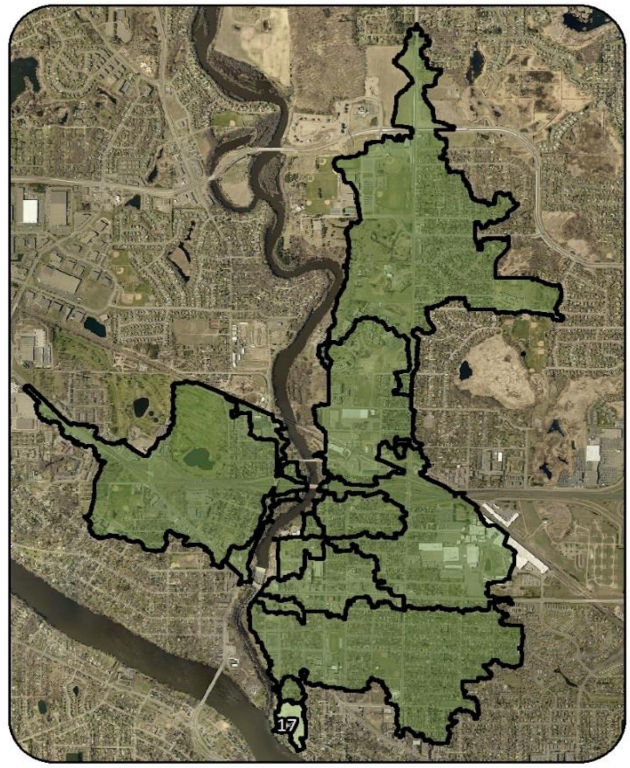
*Indirect Cost: (24 hours at $73/hour)

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

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

Catchment A-17

Existing Catchment Summary	
Acres	12.5
Dominant Land Cover	Residential
Parcels	32
Volume (acre-feet/yr)	5.3
TP (lb/yr)	7.4
TSS (lb/yr)	2,066



CATCHMENT DESCRIPTION

Catchment A-17 is the southernmost catchment in this analysis. Stormwater generated within the catchment drains to municipal storm sewer lines along Oakwood Drive and Oakwood Lane and is conveyed to an outfall which discharges near the confluence of the Rum River with the Mississippi River. Land use within the catchment is solely single family residential. Soils transition from coarse and sandy Hubbard soils in the east to silty loam Becker soils in the west.

EXISTING STORMWATER TREATMENT

The only existing BMP in this catchment is street cleaning, which is conducted two times per year by the City of Anoka. Present-day stormwater pollutant loading and treatment is summarized in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	Number of BMPs	1			
	BMP Types	Street Cleaning			
	TP (lb/yr)	8.0	0.6	8%	**7.4**
	TSS (lb/yr)	2,334	268	11%	**2,066**
	Volume (acre-feet/yr)	5.3	0.0	0%	**5.3**

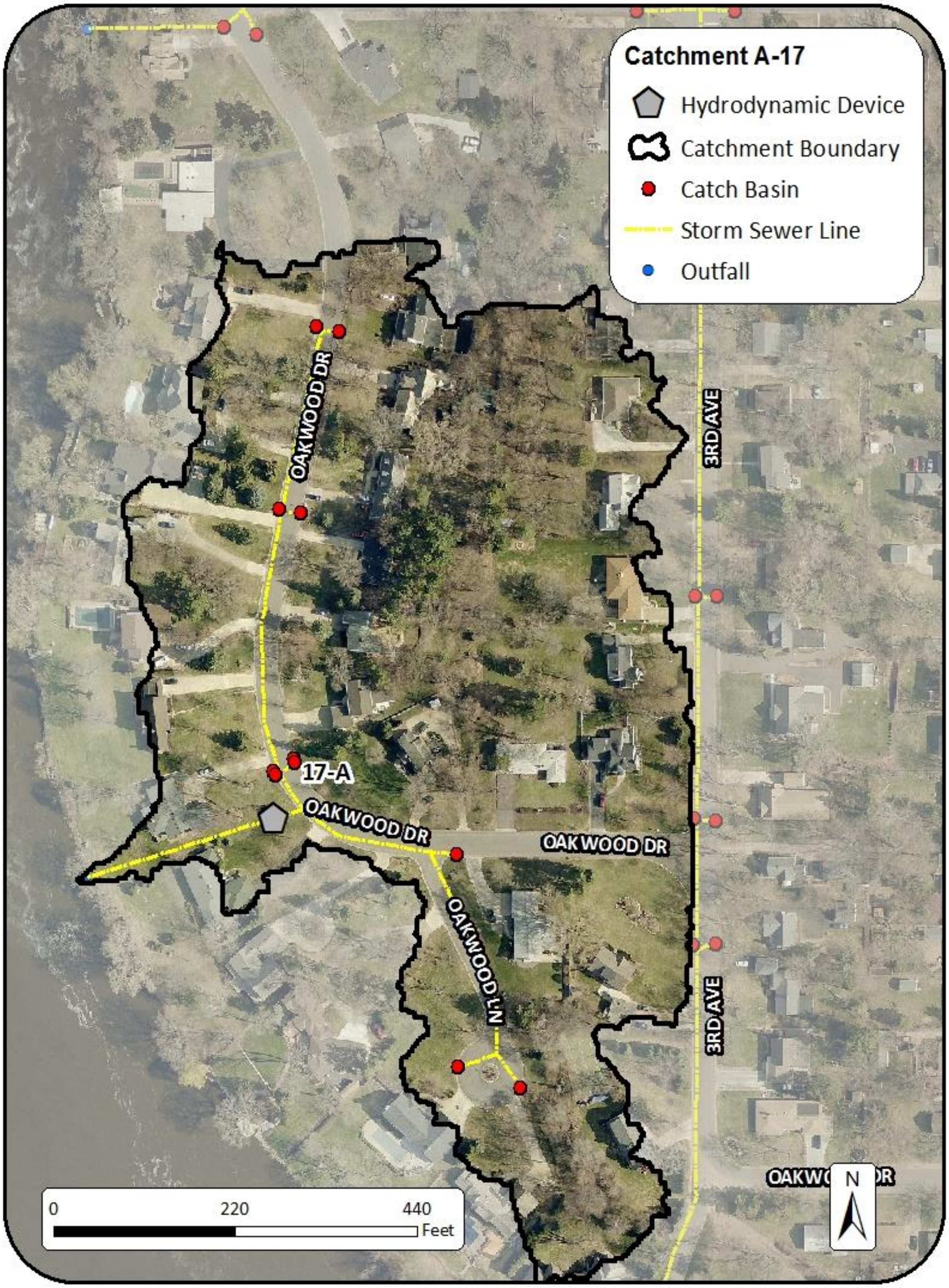
PROPOSED RETROFITS OVERVIEW

A single hydrodynamic device was proposed along the Oakwood Drive storm sewer line. Installation of this device should try to include drainage from each of the catch basins within Catchment A-17 along Oakwood Drive.

RETROFITS CONSIDERED BUT REJECTED

Bioretention basins, specifically curb-cut rain gardens, were considered in this catchment but were not proposed as the drainage area to each basin was not enough to offset the cost of installation, making the practice cost-prohibitive.

RETROFIT RECOMMENDATIONS



Project ID: 17-A

Oakwood Drive
Hydrodynamic Device

Drainage Area – 11.9 acres
Location –Oakwood Drive and Oakwood Lane
Property Ownership – Public
Site Specific Information – A hydrodynamic device is proposed for Oakwood Drive. A device at this location would capture and treat runoff from almost the entire catchment. The catchment is composed of all 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)	0.6	8.1%
	TSS (lb/yr)	244	11.8%
	Volume (acre-feet/yr)	0.0	0.0%
Cost	**Administration & Promotion Costs***	$1,752	
	Design & Construction Costs**	$108,000	
	Total Estimated Project Cost (2016)	**$109,752**	
	Annual O&M***	$630	
Efficiency	**30-yr Average Cost/lb-TP**	**$7,147**	
	30-yr Average Cost/1,000lb-TSS	**$17,575**	
	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: (3 cleanings/year)*(3 hours/cleaning)*($70/hour)

References

Erickson, A.J., and J.S. Gulliver. 2010. *Performance Assessment of an Iron-Enhanced Sand Filtration Trench for Capturing Dissolved Phosphorus*. University of Minnesota St. Anthony Falls Laboratory Engineering, Environmental and Geophysical Fluid Dynamics Project Report No. 549. Prepared for the City of Prior Lake, Prior Lake, MN.

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Schueler, T., D. Hirschman, M. Novotney, and J. Zielinski. 2007. *Urban Stormwater Retrofit Practices. Manual 3, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection*. Ellicott City, MD.

Weiss, P.T., J.S. Gulliver, A.J. Erickson. 2005. The Cost and Effectiveness of Stormwater Management Practices. Minnesota Department of Transportation.

Appendix A – Modeling Methods

The following sections include WinSLAMM model details for each type of best management practice modeled for this analysis.

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 10.2.0 was used for this analysis to estimate volume and pollutant loading and reductions. Additional inputs for WinSLAMM are provided in Table 10.

Table 10: 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 the state (MNDOT), county (Anoka County), and the City of Anoka. The practices listed below were included in the existing conditions model.

Infiltration Basin

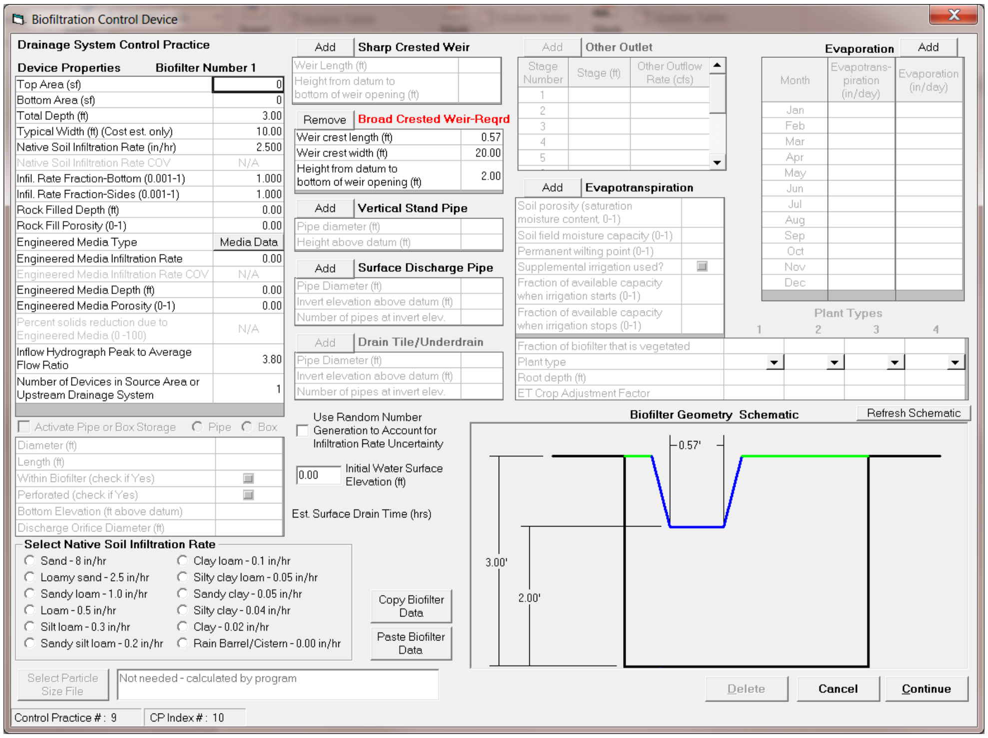

Figure 12: Infiltration Basin at Greenhaven Road in A-3 (WinSLAMM).

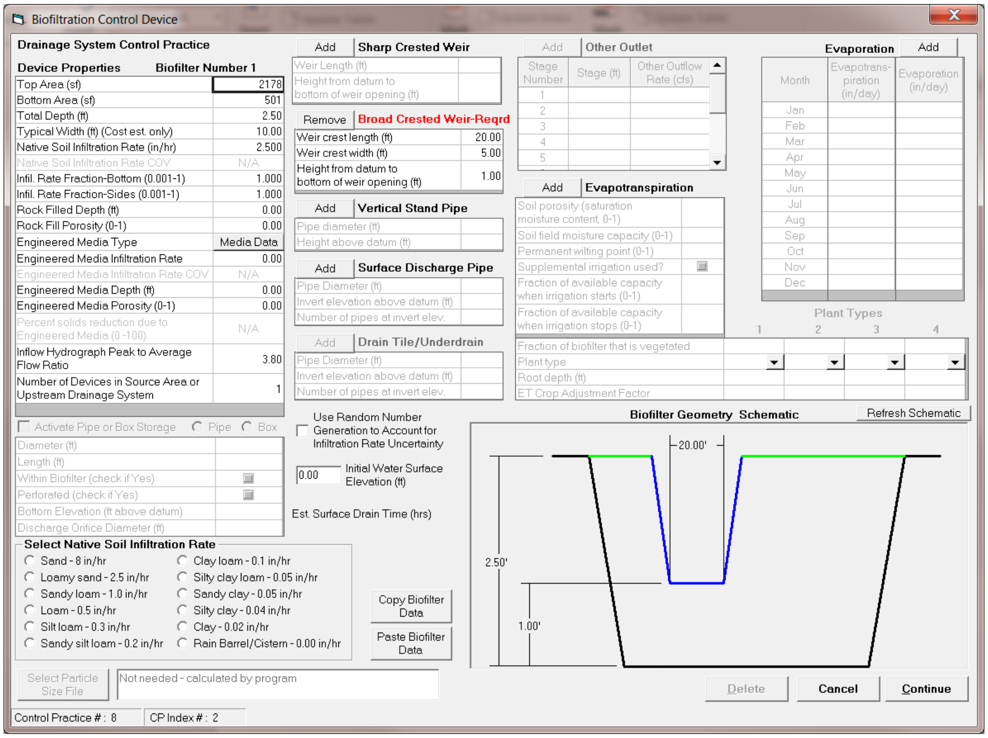

Figure 13: Infiltration Basin at Anoka Middle School for the Arts (Northern Basin) in A-13 (WinSLAMM).

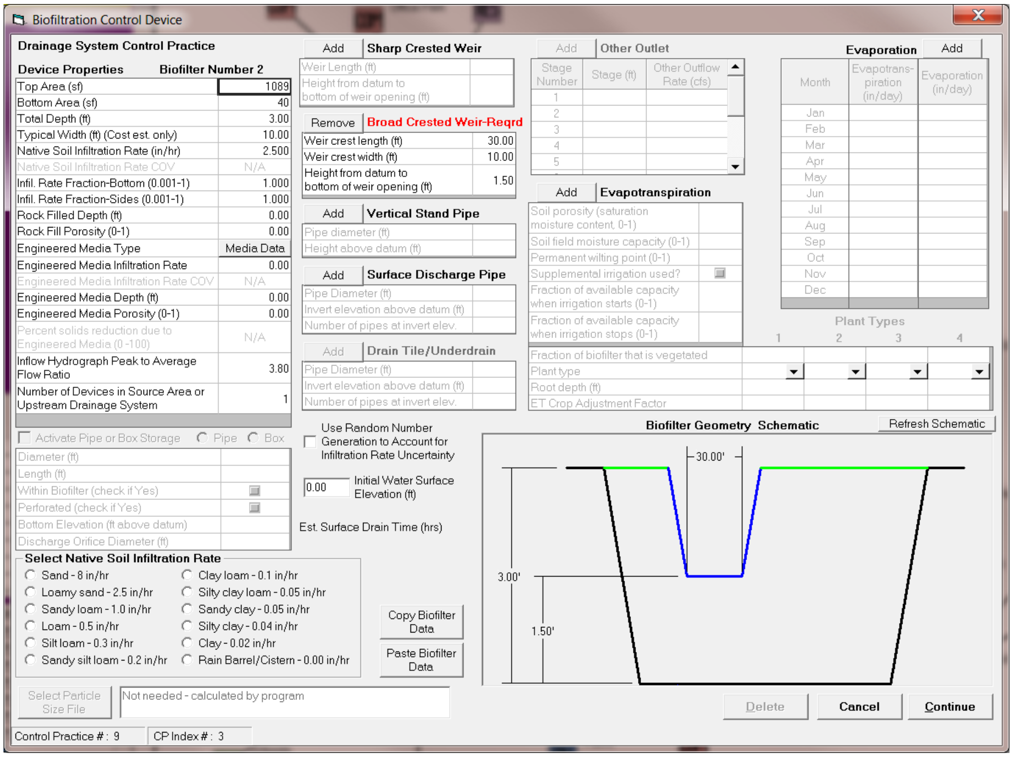

Figure 14: Infiltration Basin at Anoka Middle School for the Arts (Southern Basin) in A-13 (WinSLAMM).

Hydrodynamic Device

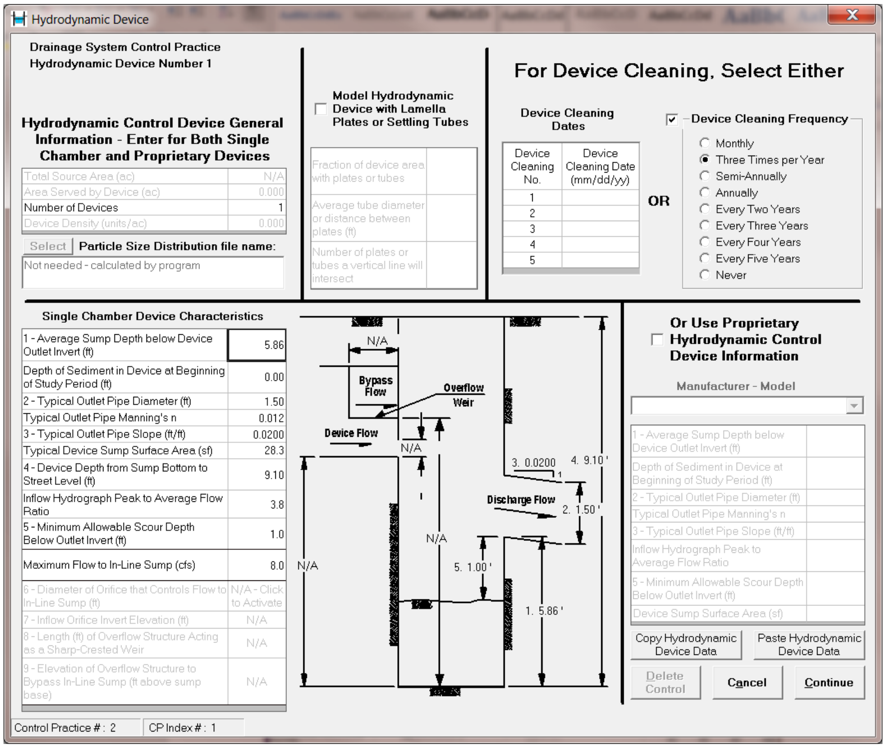

Figure 15: Hydrodynamic Device at Maple Avenue in A-2 (WinSLAMM).

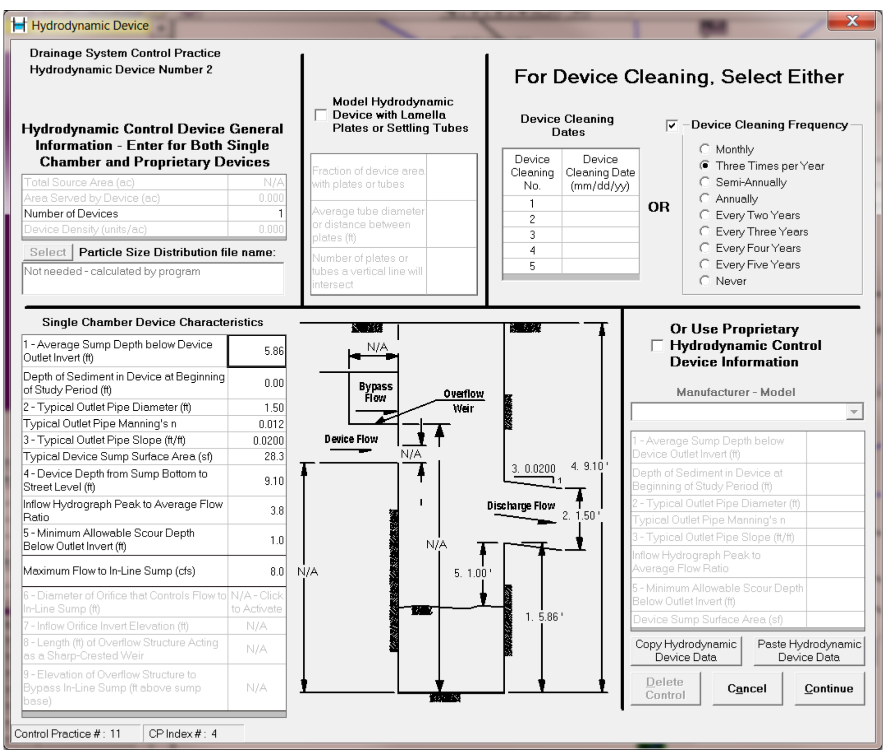

Figure 16: Hydrodynamic Device at Branch Avenue in A-3 (WinSLAMM).

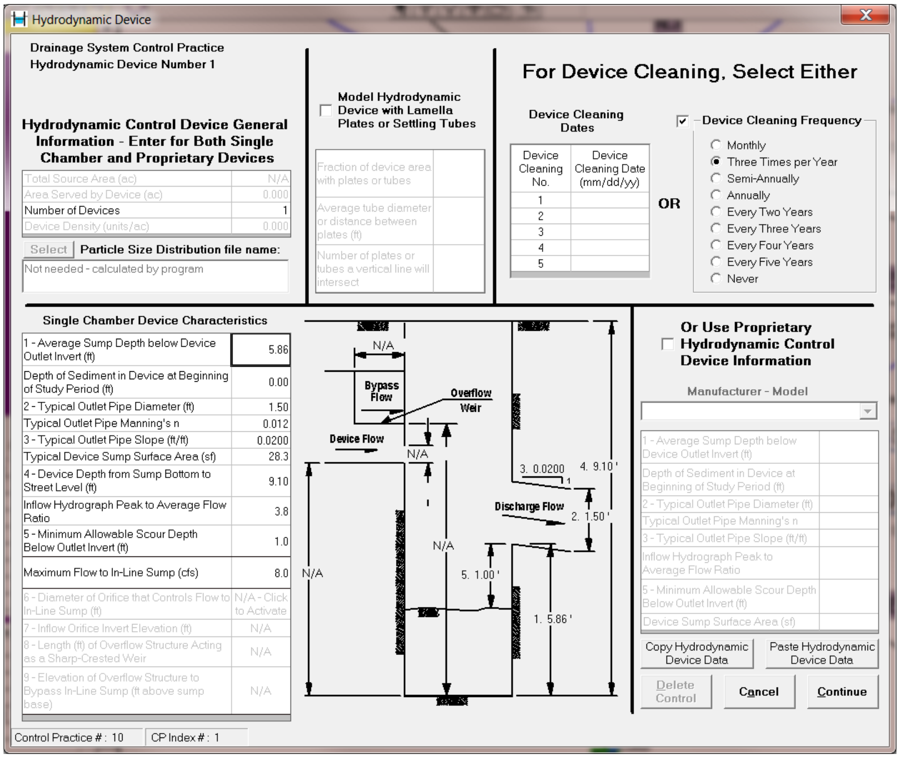

Figure 17: Hydrodynamic Device at Wingfield Alley in A-3 (WinSLAMM).

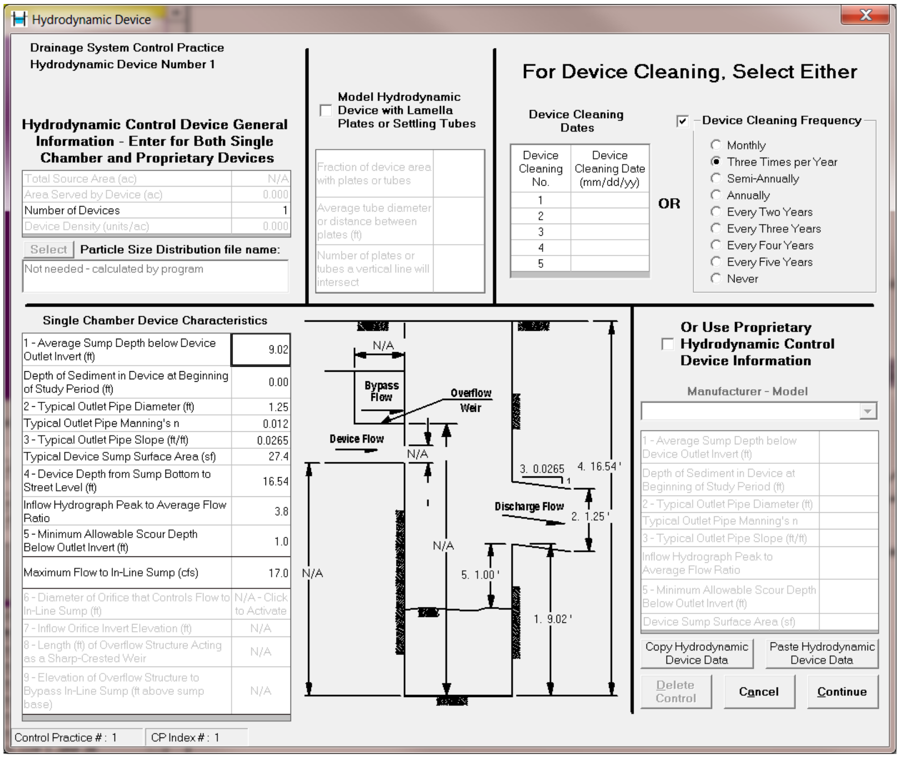

Figure 18: Hydrodynamic Device at Ferry Street in A-5 (WinSLAMM).

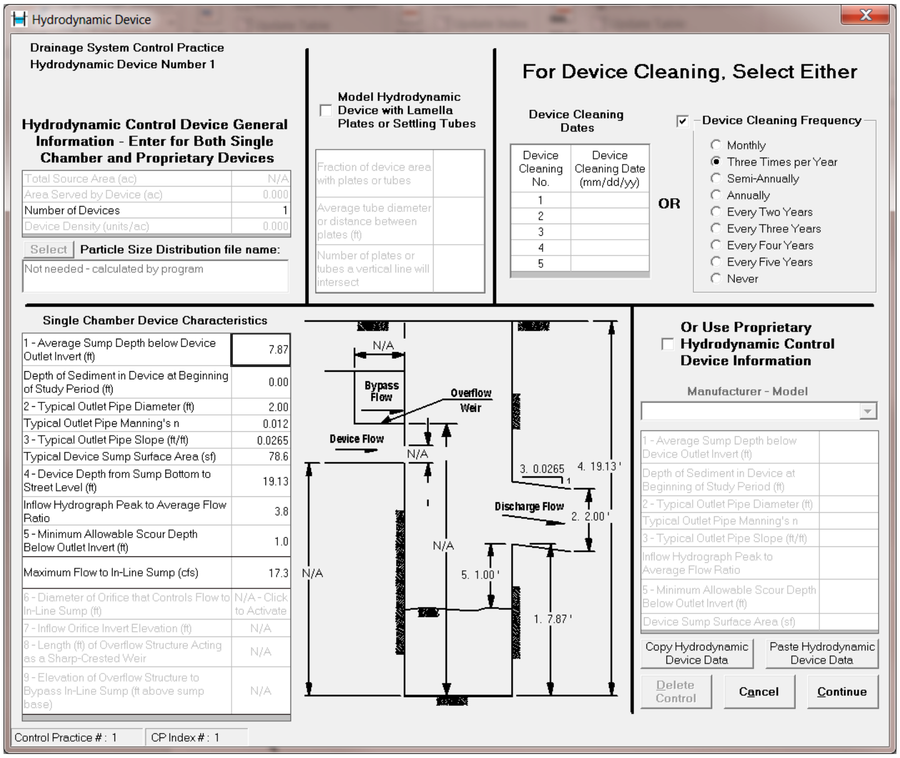

Figure 19: Hydrodynamic Device at Main Street in A-6 (WinSLAMM).

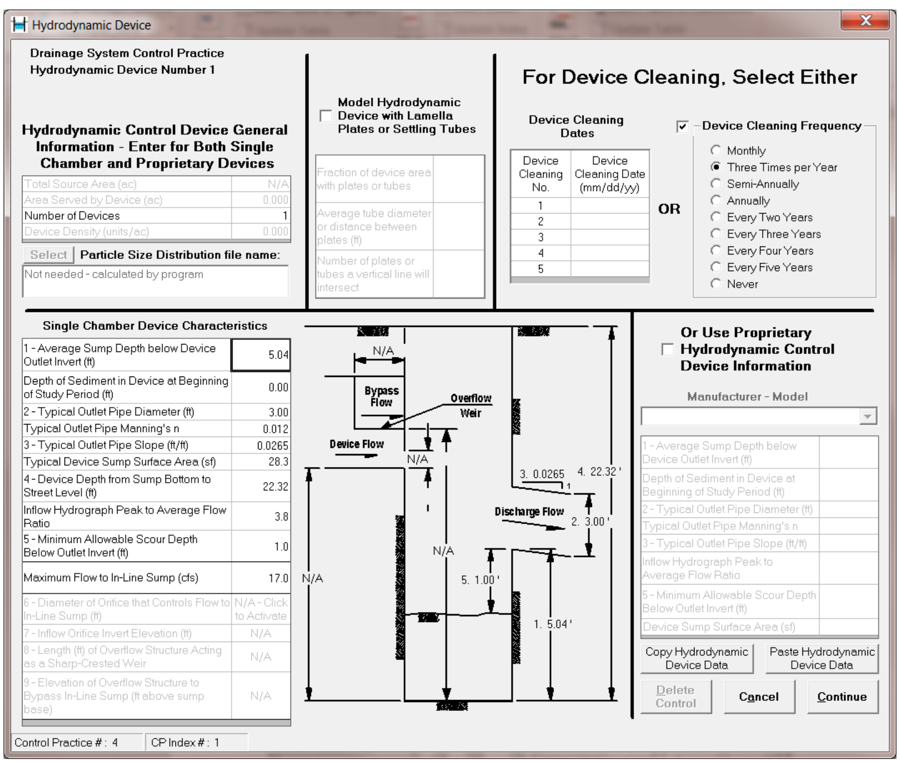

Figure 20: Hydrodynamic Device at Water Avenue and Taylor Street in A-10 (WinSLAMM).

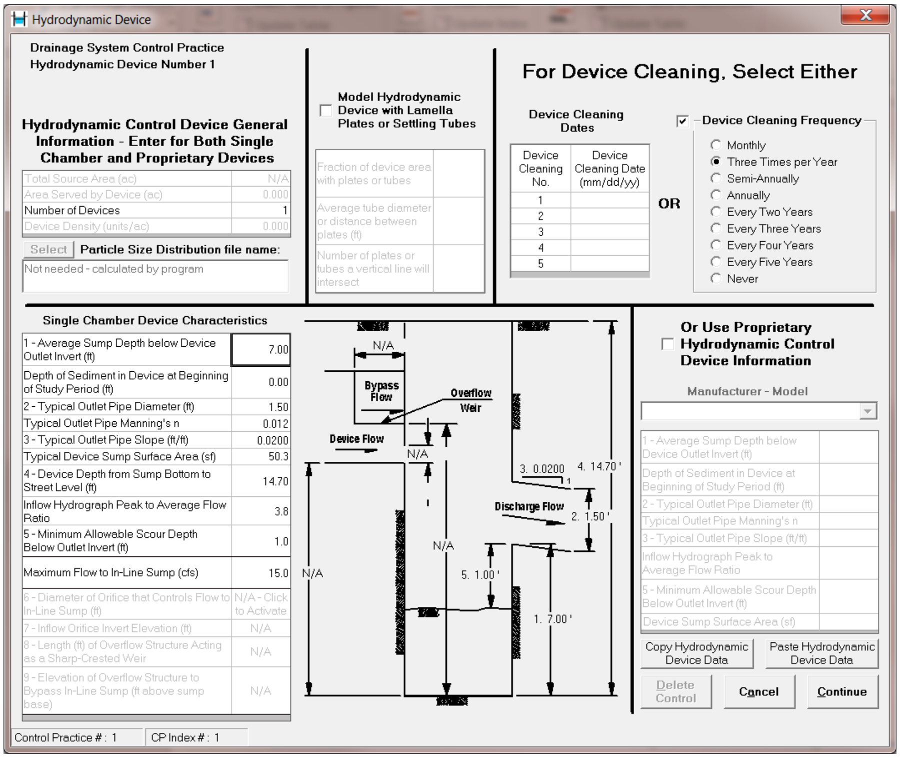

Figure 21: Hydrodynamic Device at Polk Street and 3rd Avenue in A-11 (WinSLAMM).

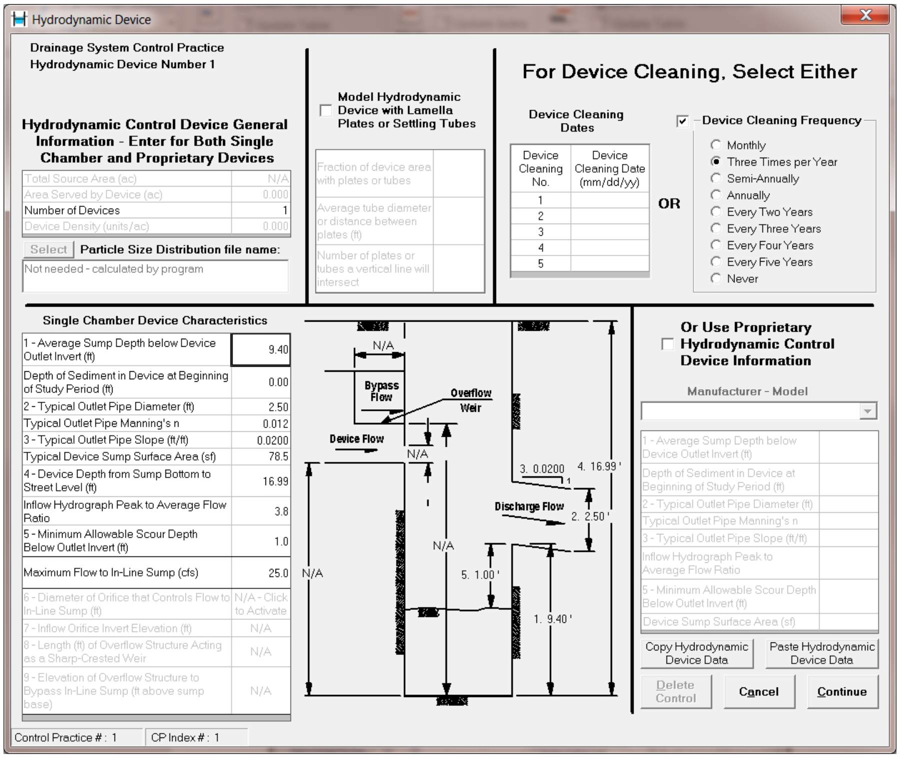

Figure 22: Hydrodynamic Device at Harrison Street and 2nd Avenue in A-12 (WinSLAMM).

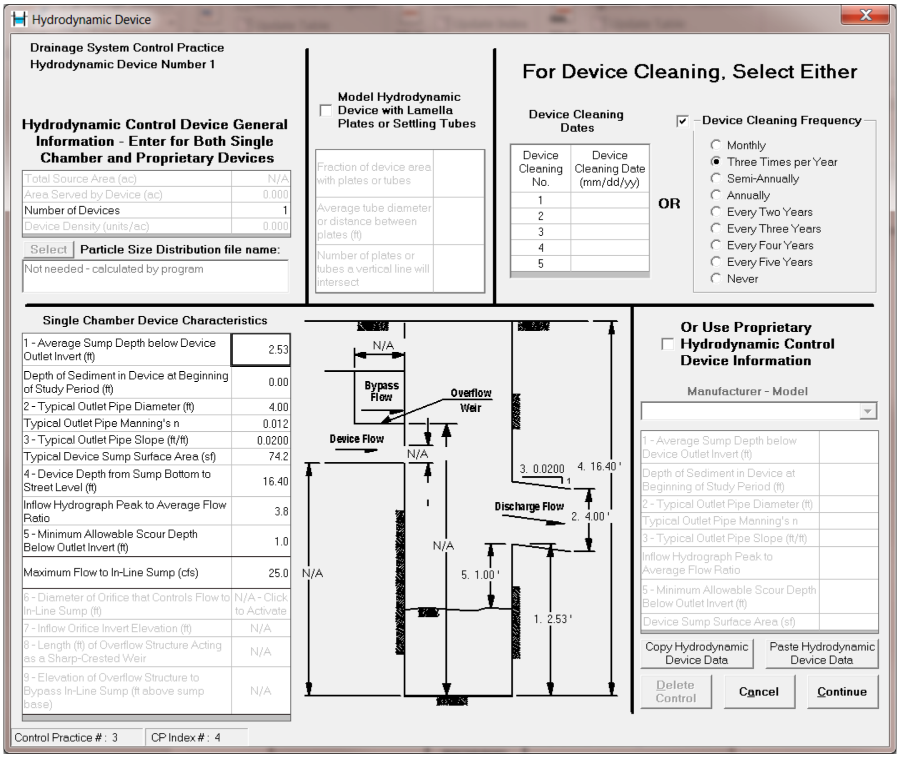

Figure 23: Hydrodynamic Device (1 of 3) at Adams Street and 2nd Avenue in A-15 (WinSLAMM).

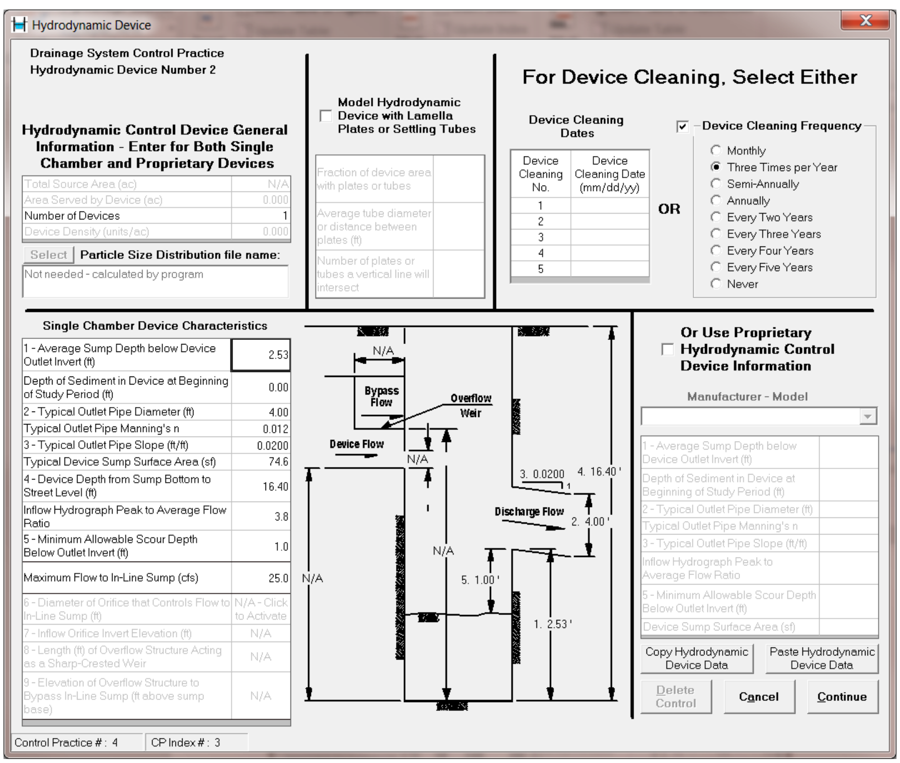

Figure 24: Hydrodynamic Device (2 of 3) at Adams Street and 2nd Avenue in A-15 (WinSLAMM).

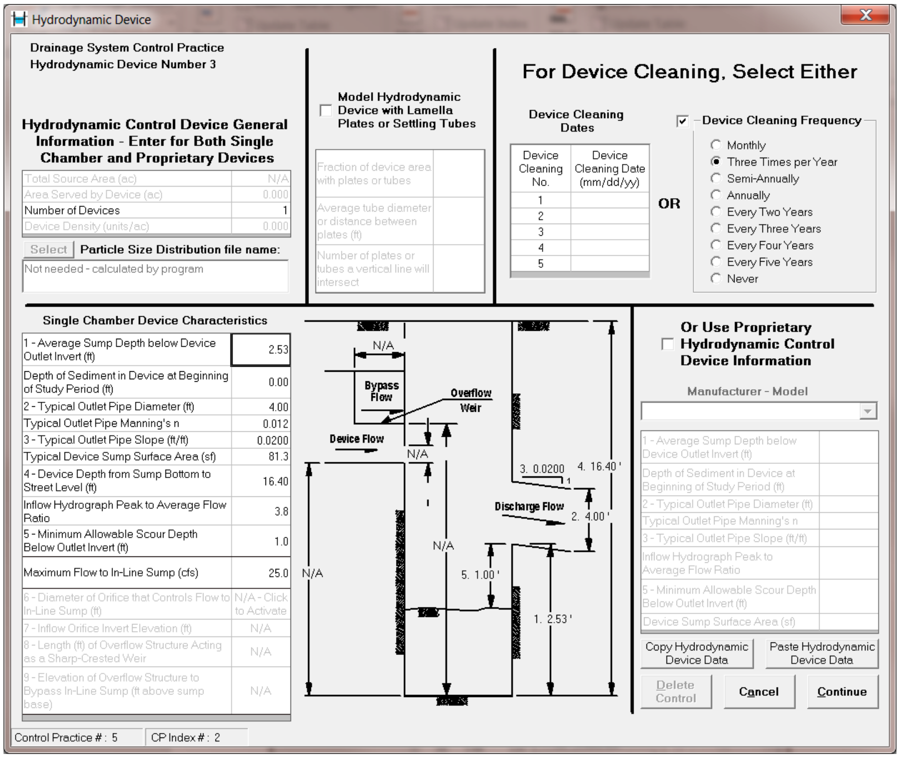

Figure 25: Hydrodynamic Device (3 of 3) at Adams Street and 2nd Avenue in A-15 (WinSLAMM).

Ponds

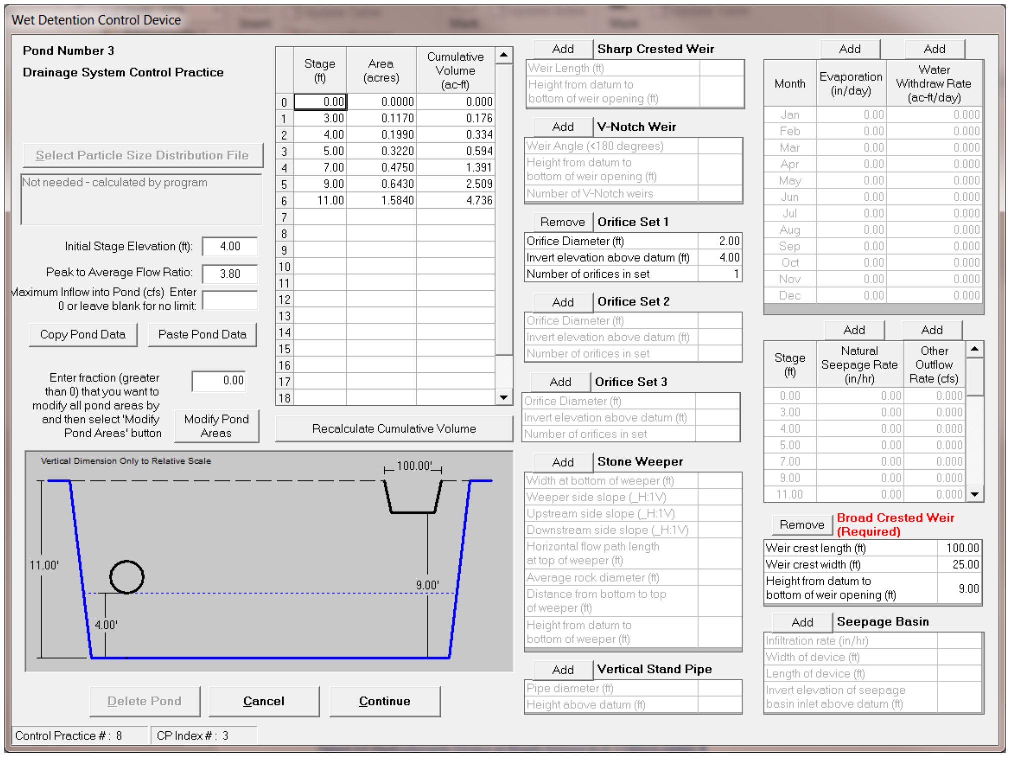

Figure 26: Stormwater Pond at Car Dealership in A-3 (WinSLAMM).

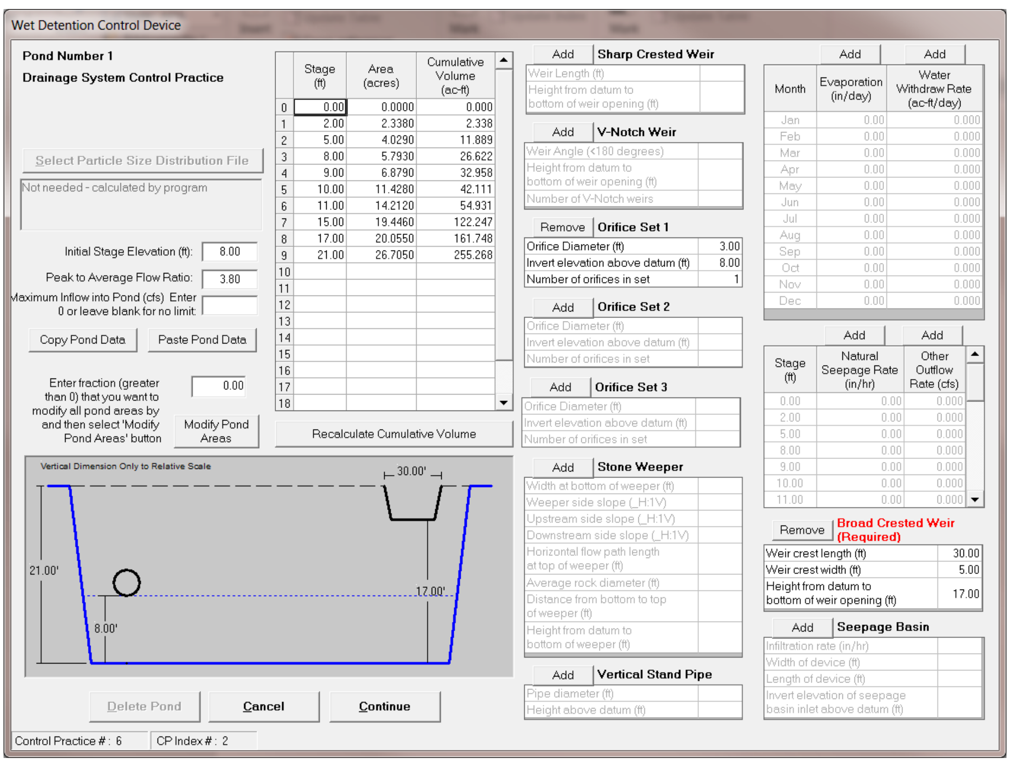

Figure 27: Stormwater Pond at Green Haven Golf Course in A-3 (WinSLAMM).

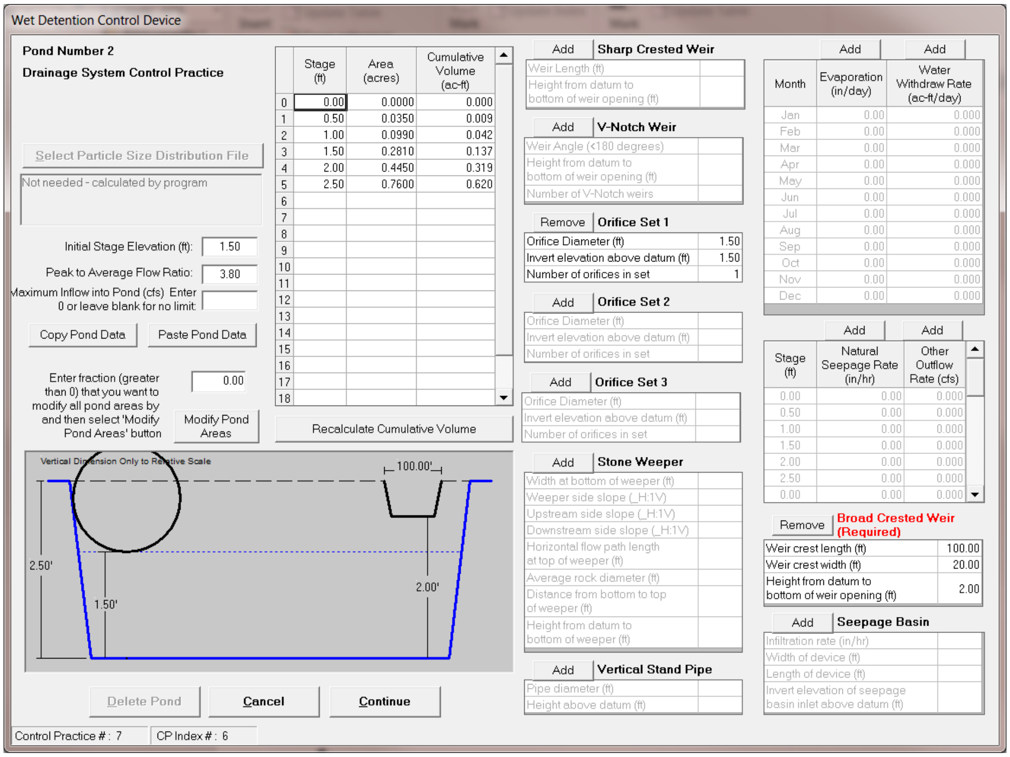

Figure 28: Stormwater Pond at Ward Park in A-3 (WinSLAMM).

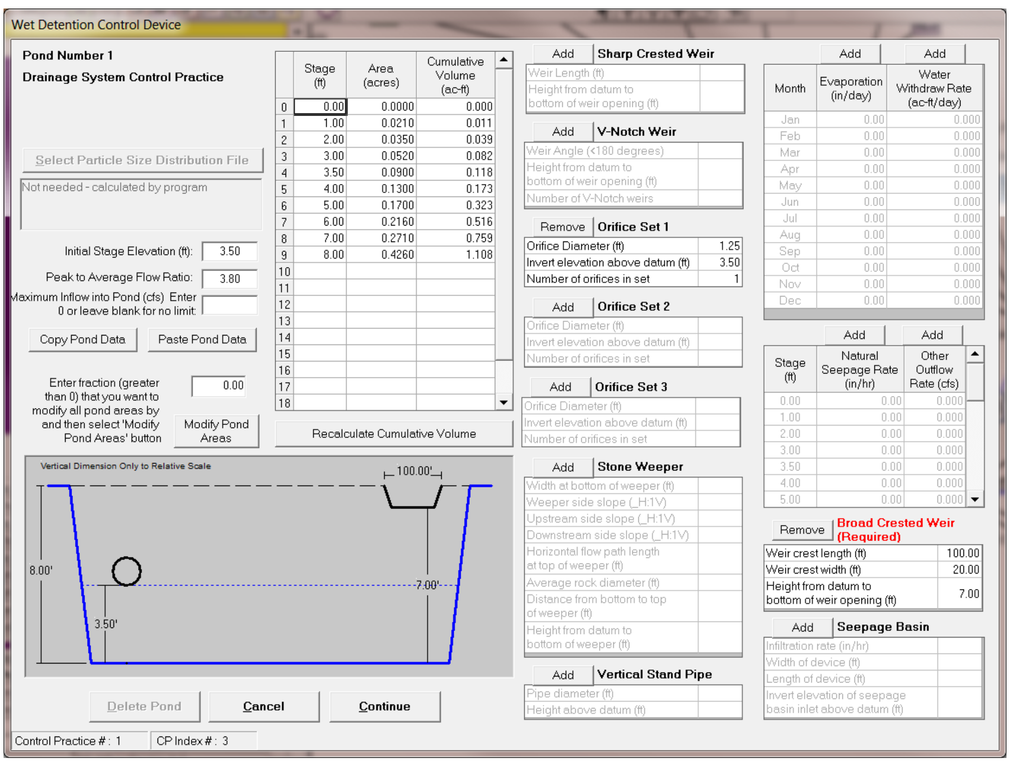

Figure 29: Stormwater Pond at 7th Avenue (NW) in A-7 (WinSLAMM).

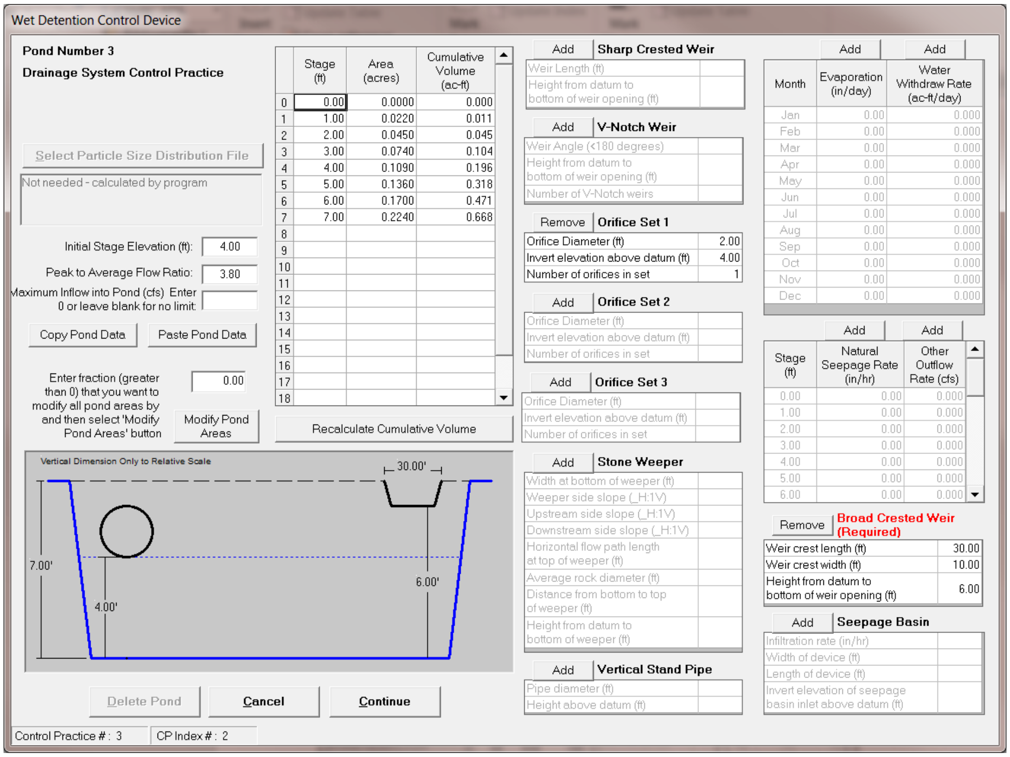

Figure 30: Stormwater Pond at 7th Avenue (SW) in A-7 (WinSLAMM).

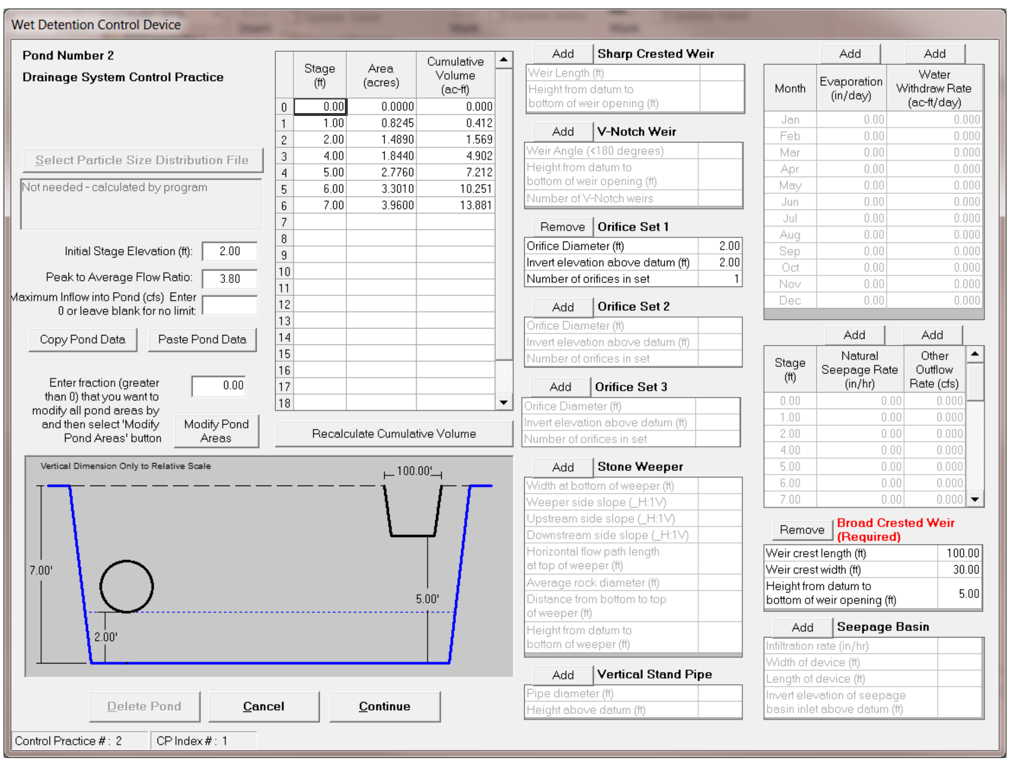

Figure 31: Stormwater Pond at Anoka Regional Treatment Center in A-7 (WinSLAMM).

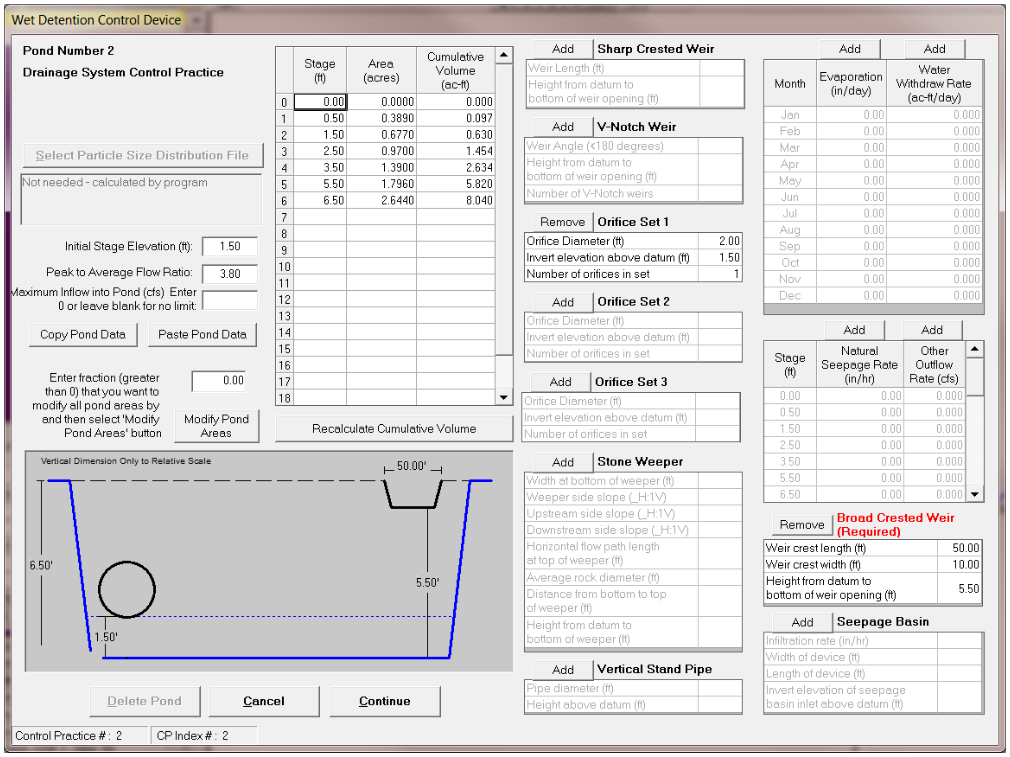

Figure 32: Stormwater Pond at Anoka Development in A-8 (WinSLAMM).

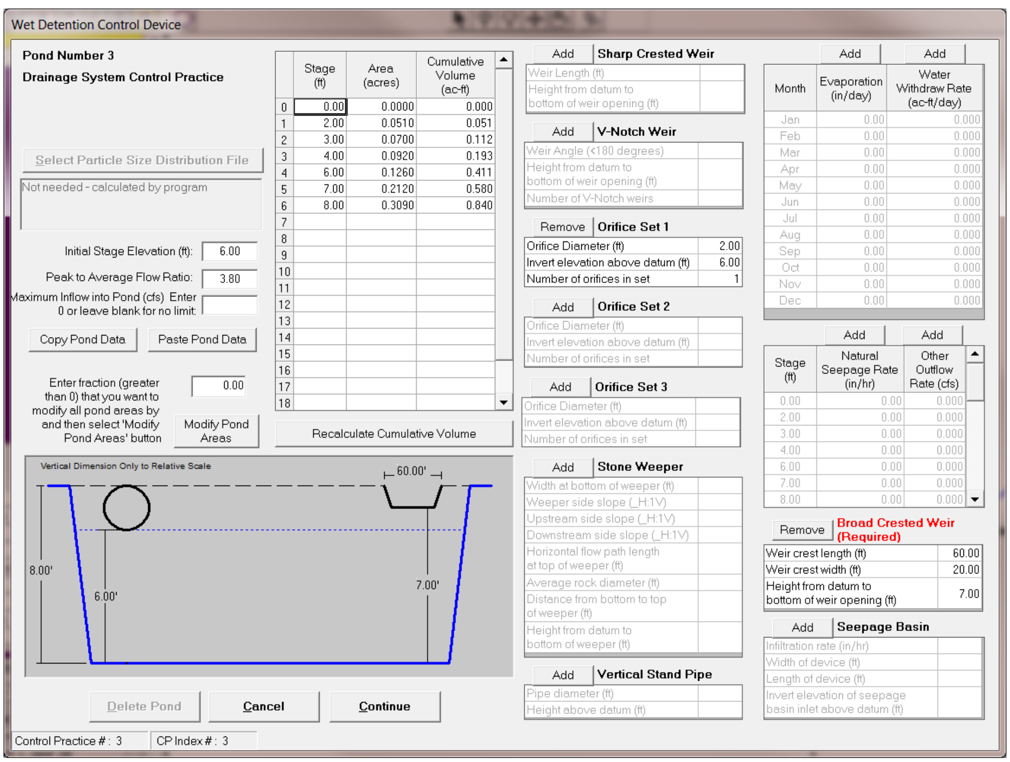

Figure 33: Stormwater Pond at The Homestead at Anoka in A-8 (WinSLAMM).

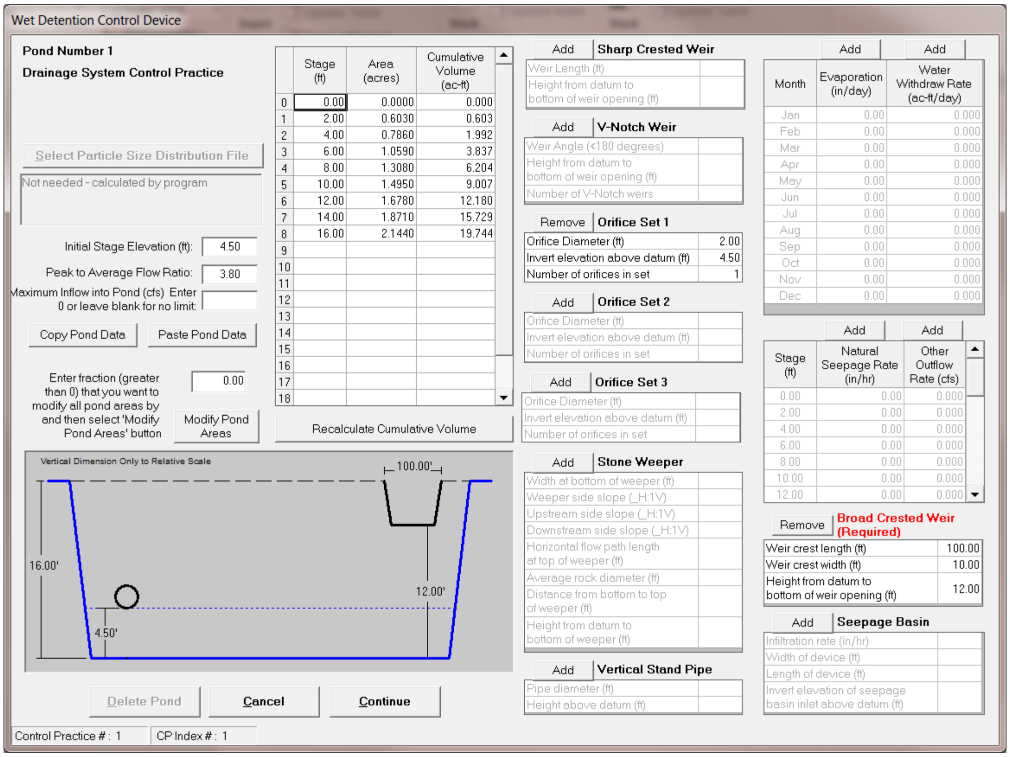

Figure 34: Stormwater Pond at 4th Avenue and Grant Street in A-8 (WinSLAMM).

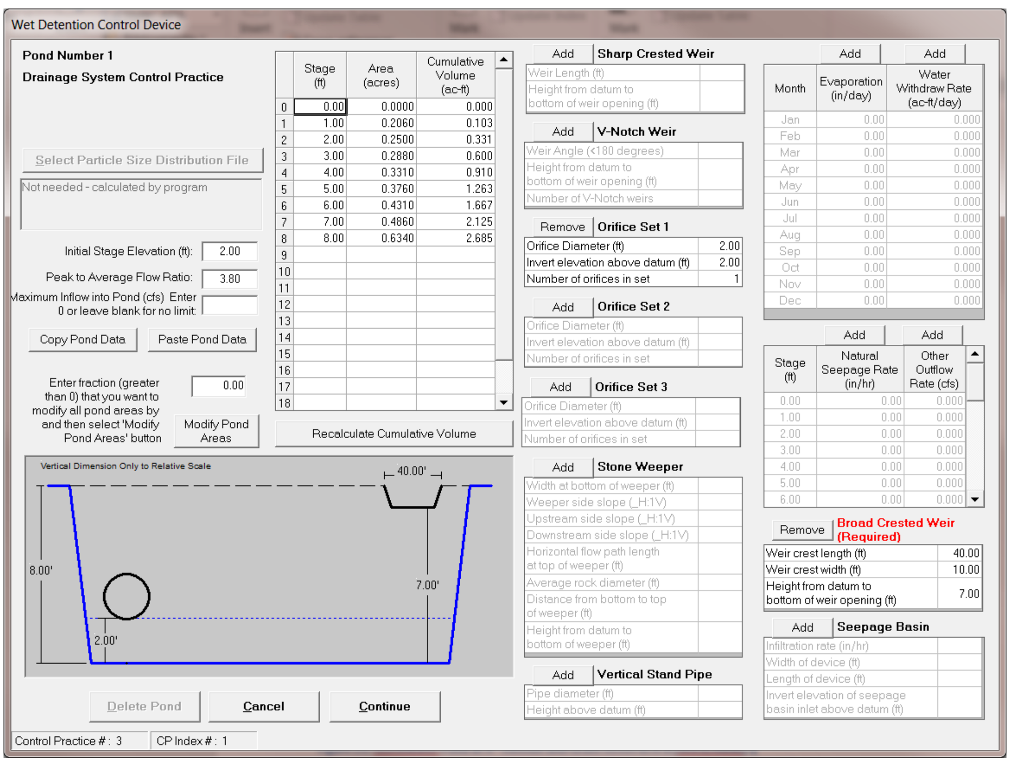

Figure 35: Stormwater Pond at Federal Cartridge Corporation parking lot in A-9 (WinSLAMM).

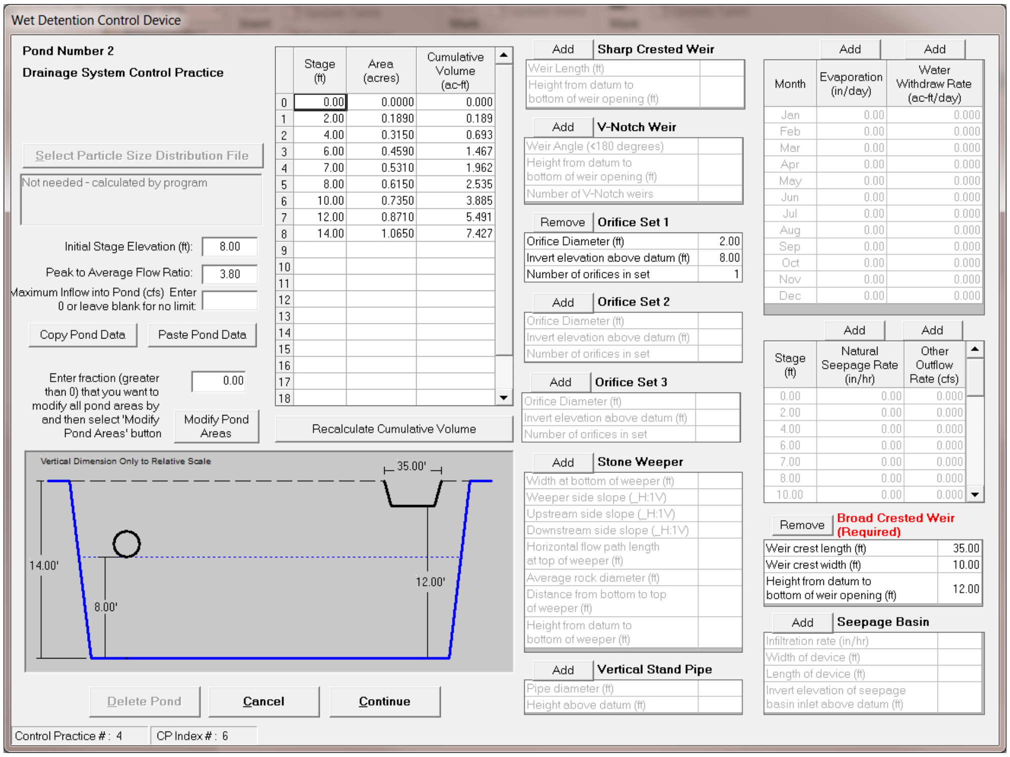

Figure 36: Stormwater Pond at Pentair Property in A-9 (WinSLAMM).

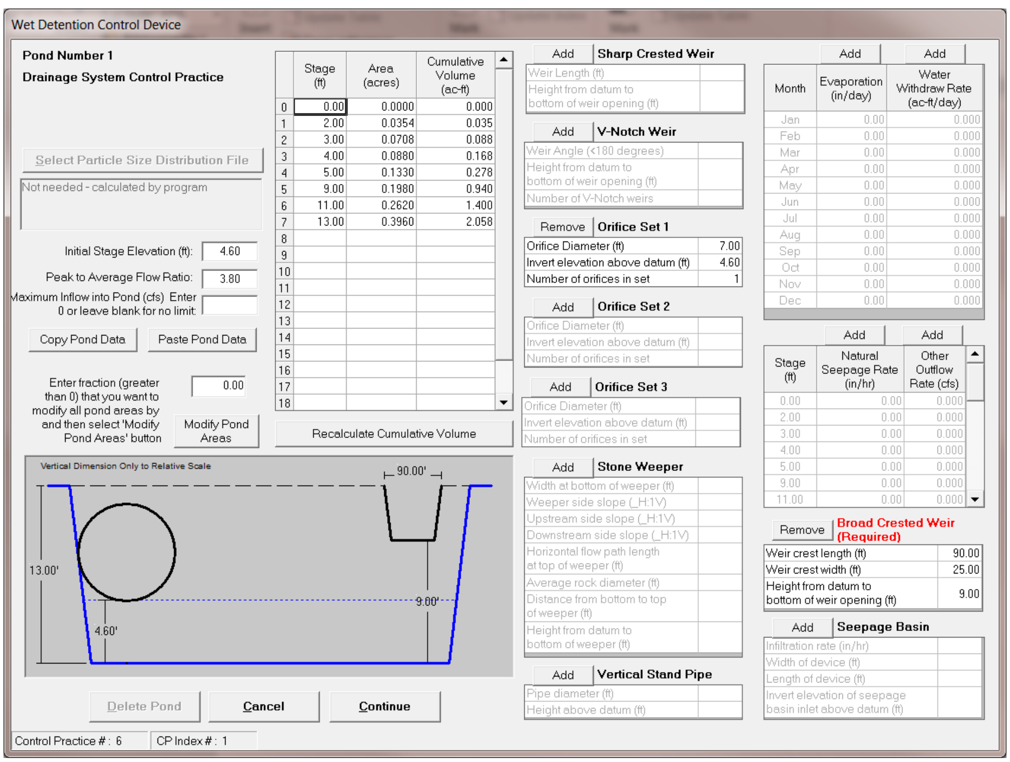

Figure 37: Stormwater Pond at Adams Street and 2nd Avenue in A-15 (WinSLAMM).

Street Cleaning

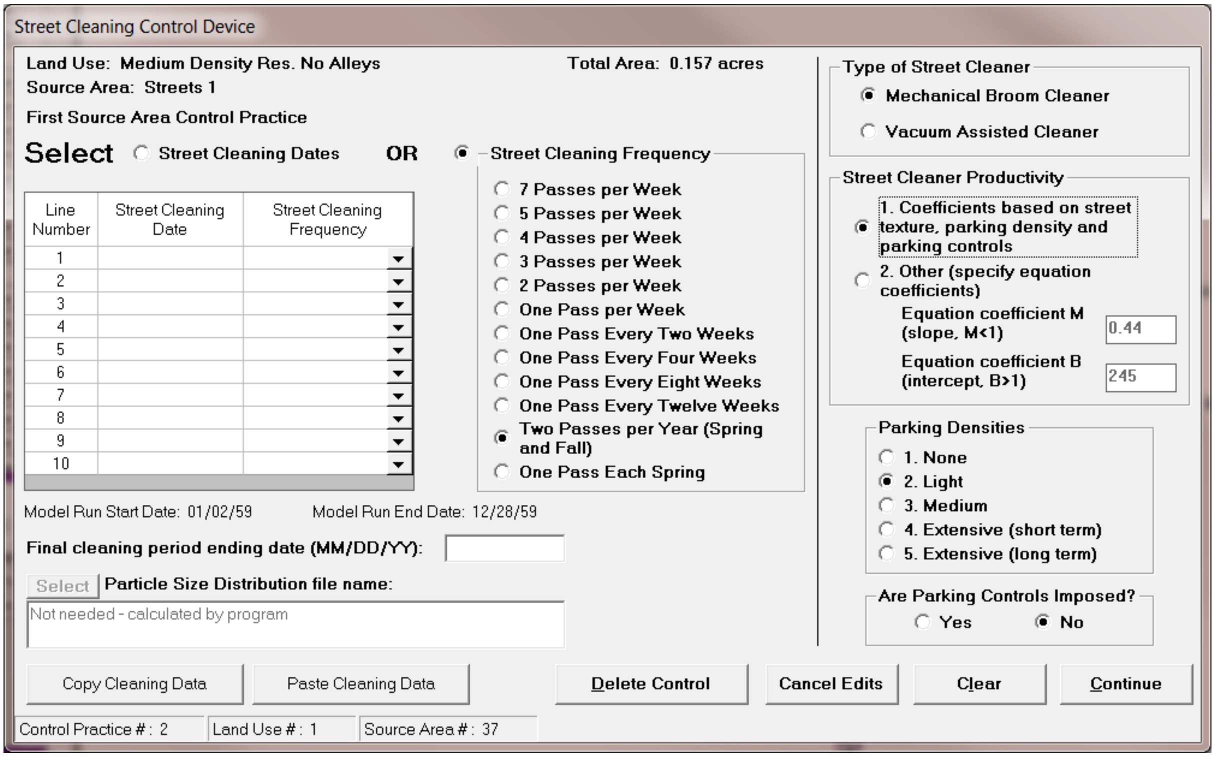

Figure 38: Street cleaning parameters used in A-1 to A-11 and in A-15 to A-17 (WinSLAMM).

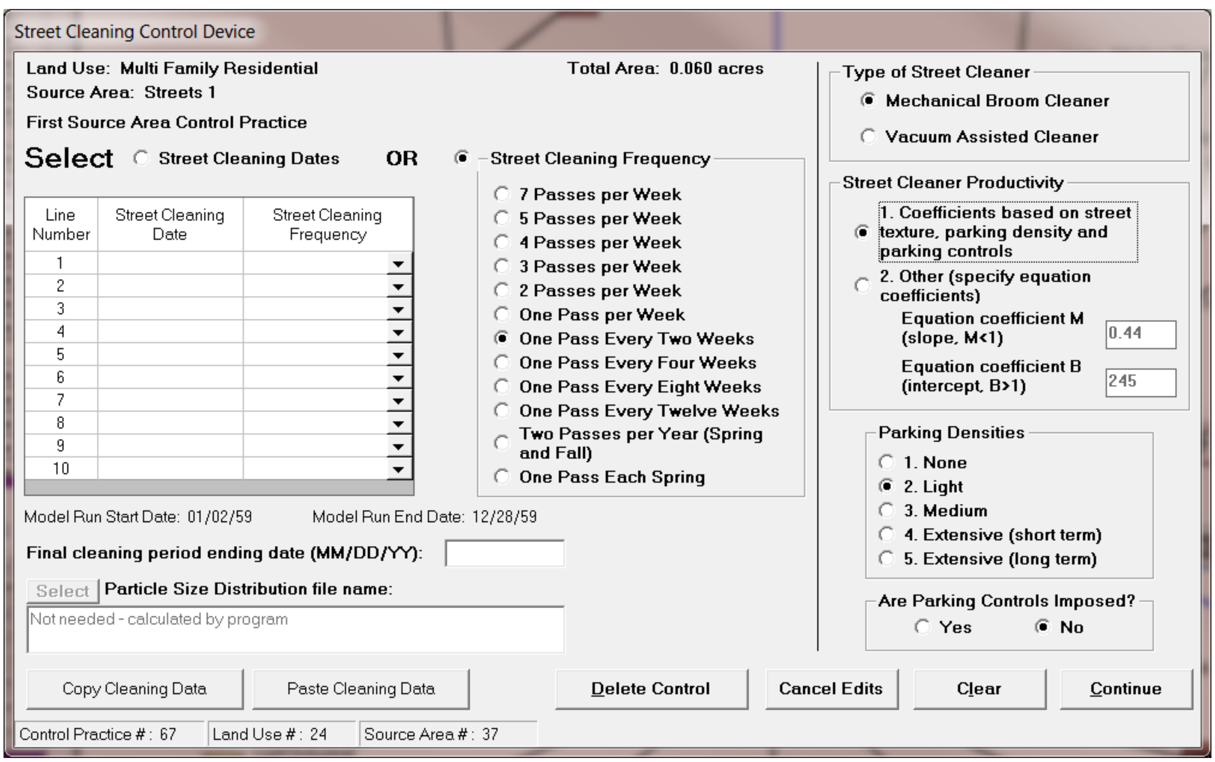

Figure 39: Street cleaning parameters used in A-12 to A-14 (WinSLAMM).

Proposed Conditions

Curb-Cut Rain Garden

Curb-cut rain gardens were modeled as drainage area control practices within WinSLAMM. Each was modeled without an underdrain based on available soil information. If based on soil tests it is determined that an underdrain would be necessary, then estimated reductions for volume, TP, and TSS will be lower.

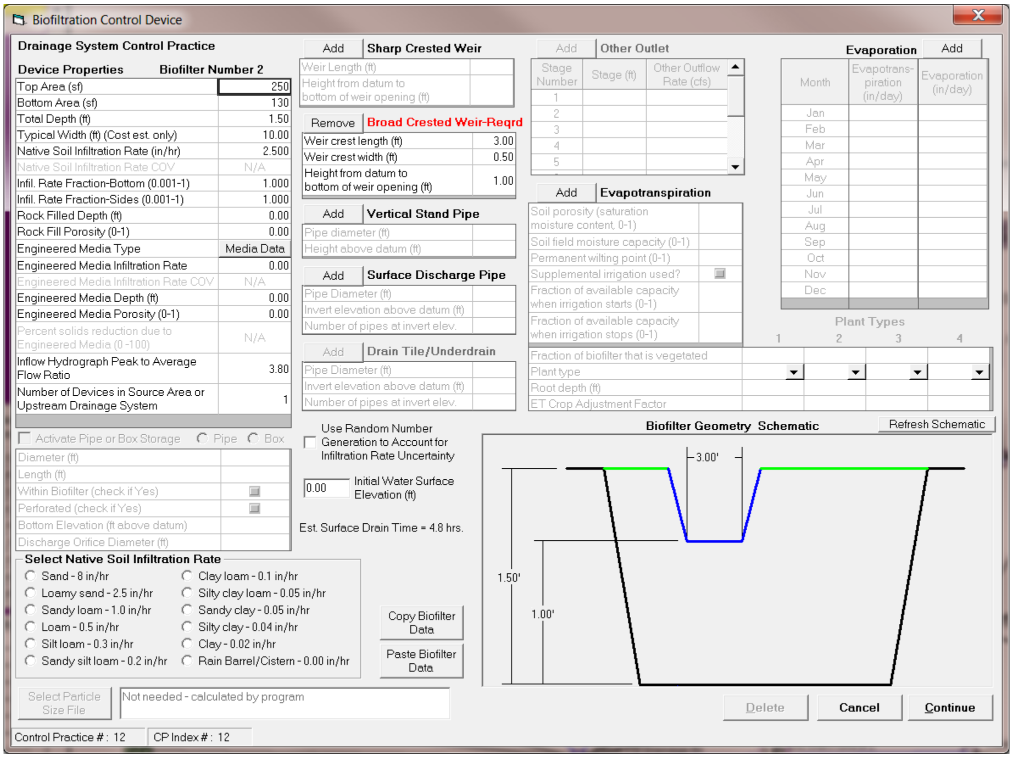

Figure 40: Curb-cut Rain Garden (WinSLAMM)

Infiltration Basin

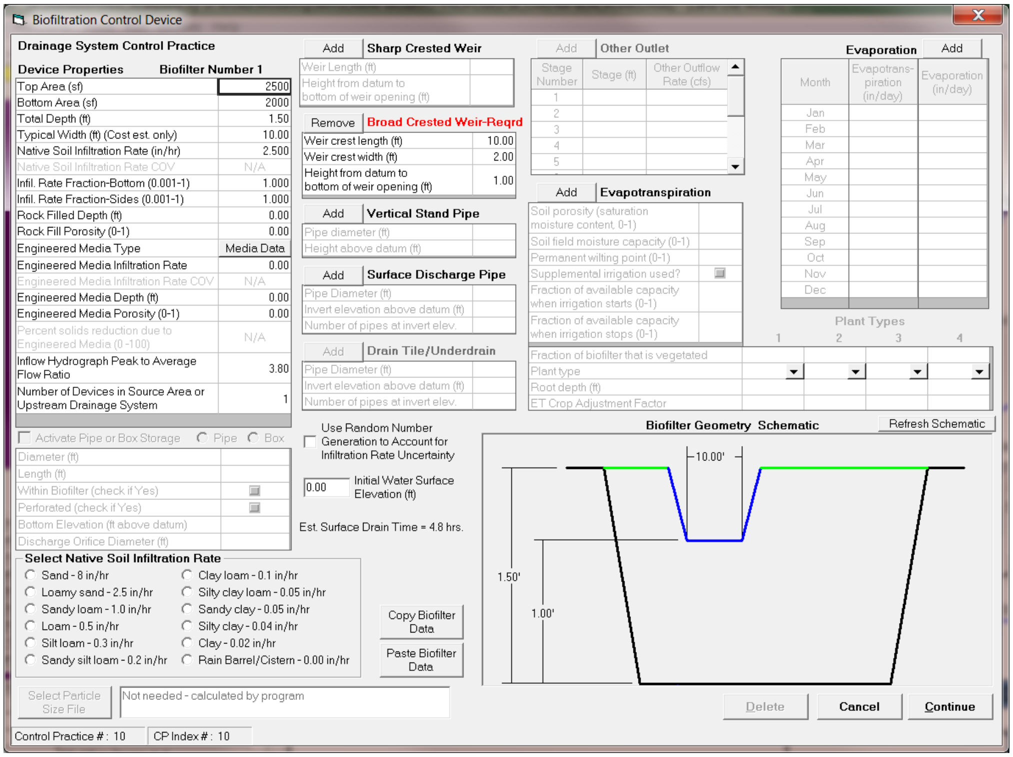

Figure 41: Infiltration Basin (2,500 sq.-ft.) in A-7 (WinSLAMM).

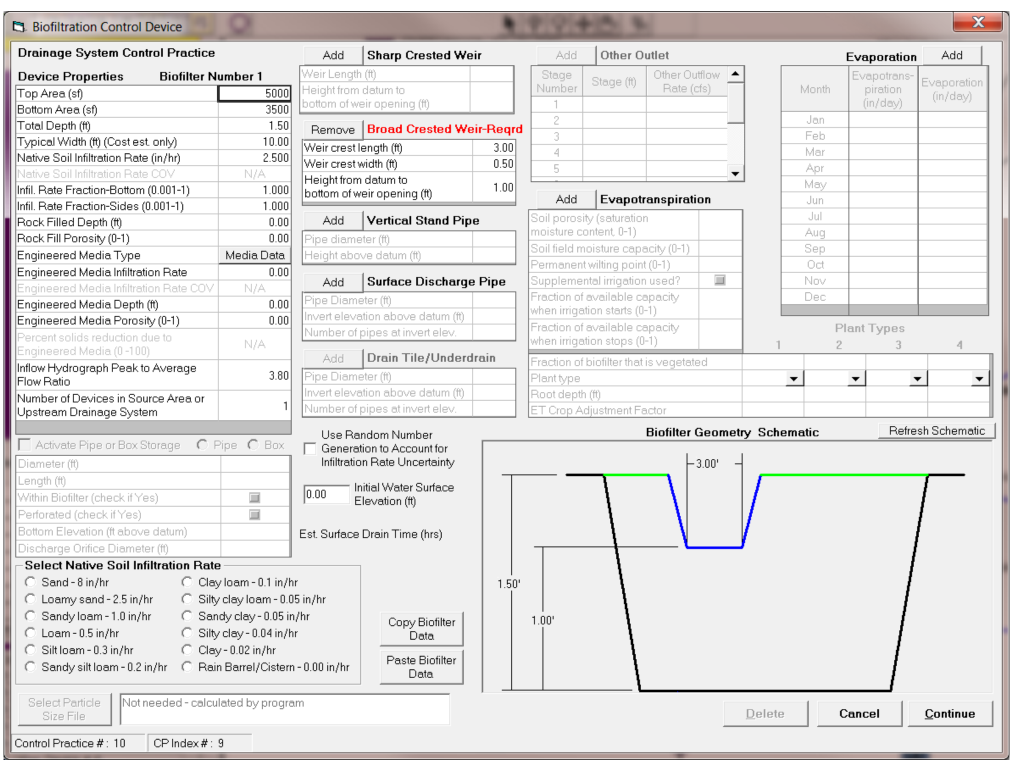

Figure 42: Infiltration Basin (5,000 sq.-ft.) in A-7 (WinSLAMM).

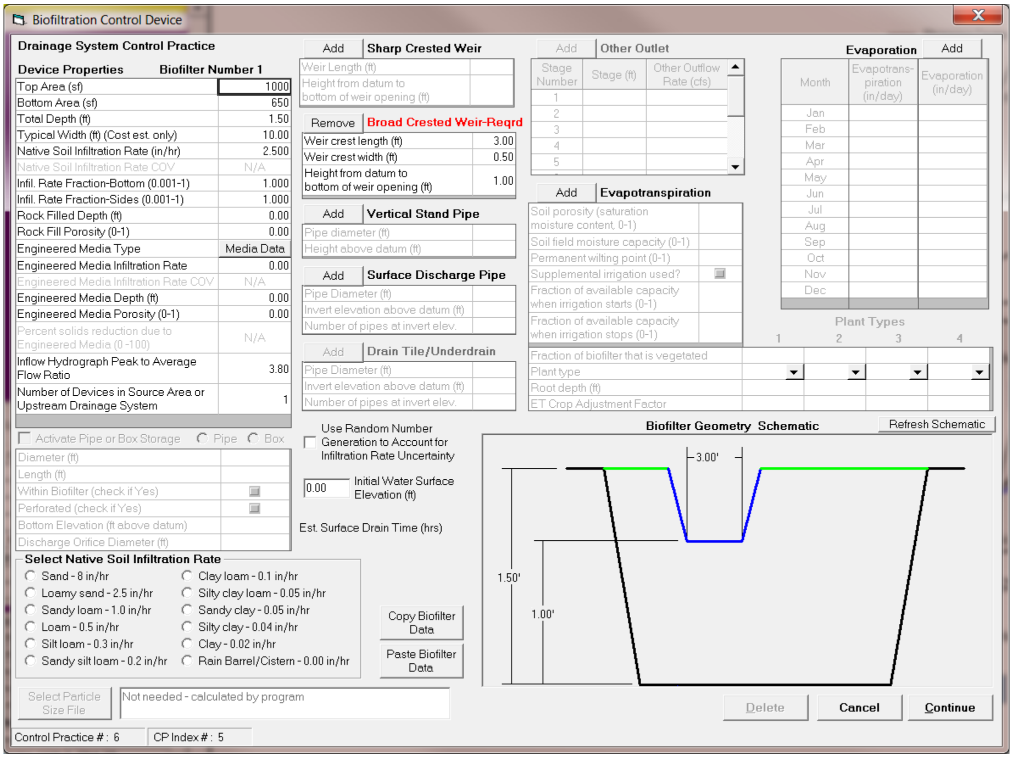

Figure 43: Infiltration Basin (1,000 sq.-ft.) in A-9 (WinSLAMM).

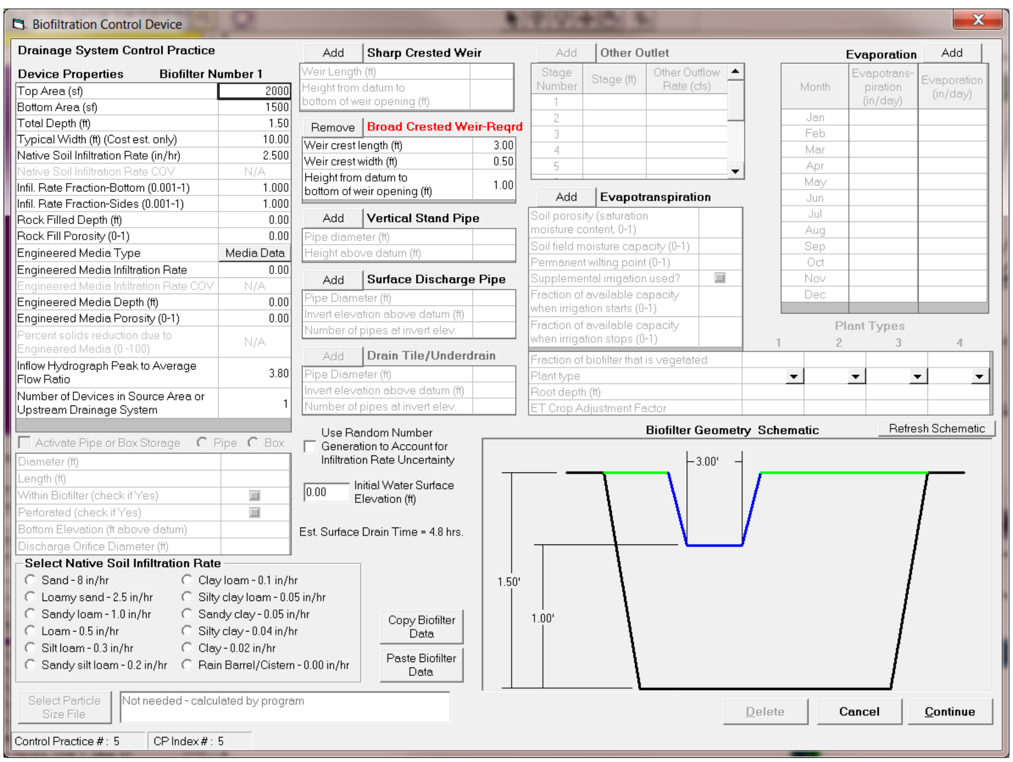

Figure 44: Infiltration Basin (2,000 sq.-ft.) in A-10 (WinSLAMM).

Hydrodynamic Device

Table 11: Hydrodynamic Device Sizing Criteria

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

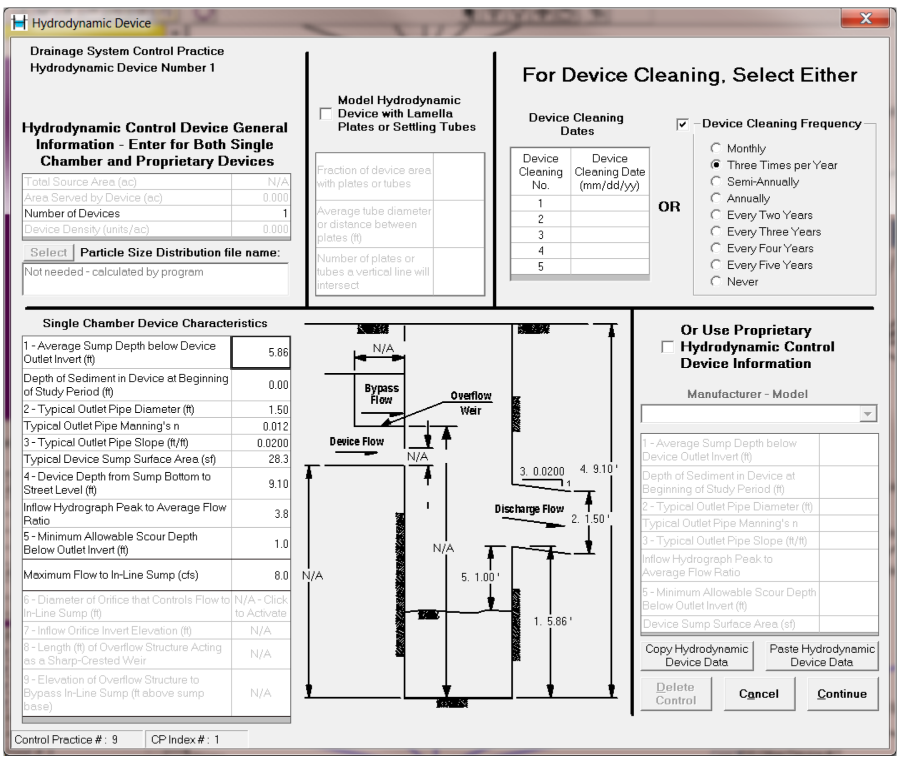

Figure 45: Hydrodynamic Device - 6' diameter (WinSLAMM).

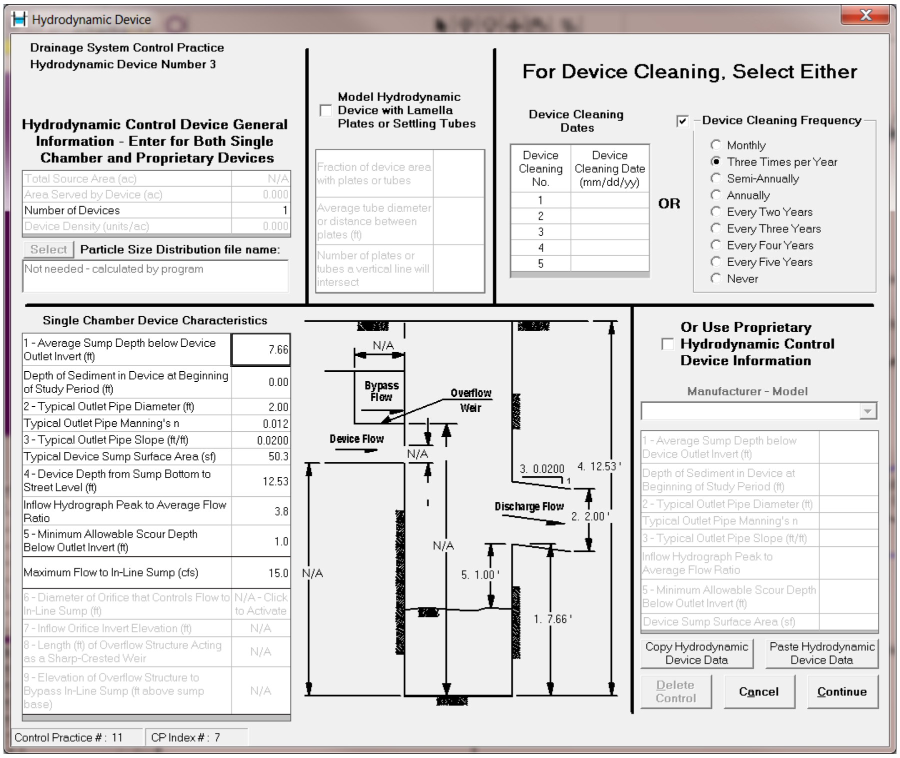

Figure 46: Hydrodynamic Device - 8' diameter (WinSLAMM).

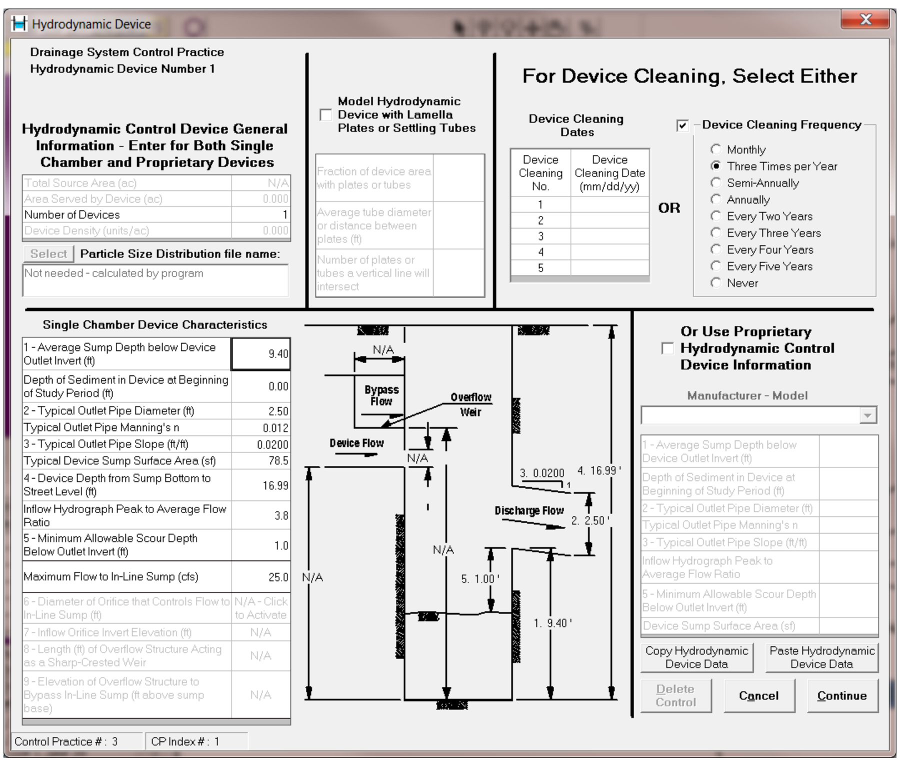

Figure 47: Hydrodynamic Device - 10' diameter (WinSLAMM).

Ponds

Ponds were proposed in the landscape where sufficient drainage area could sustain a permanent pool of water. 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 drainage area.

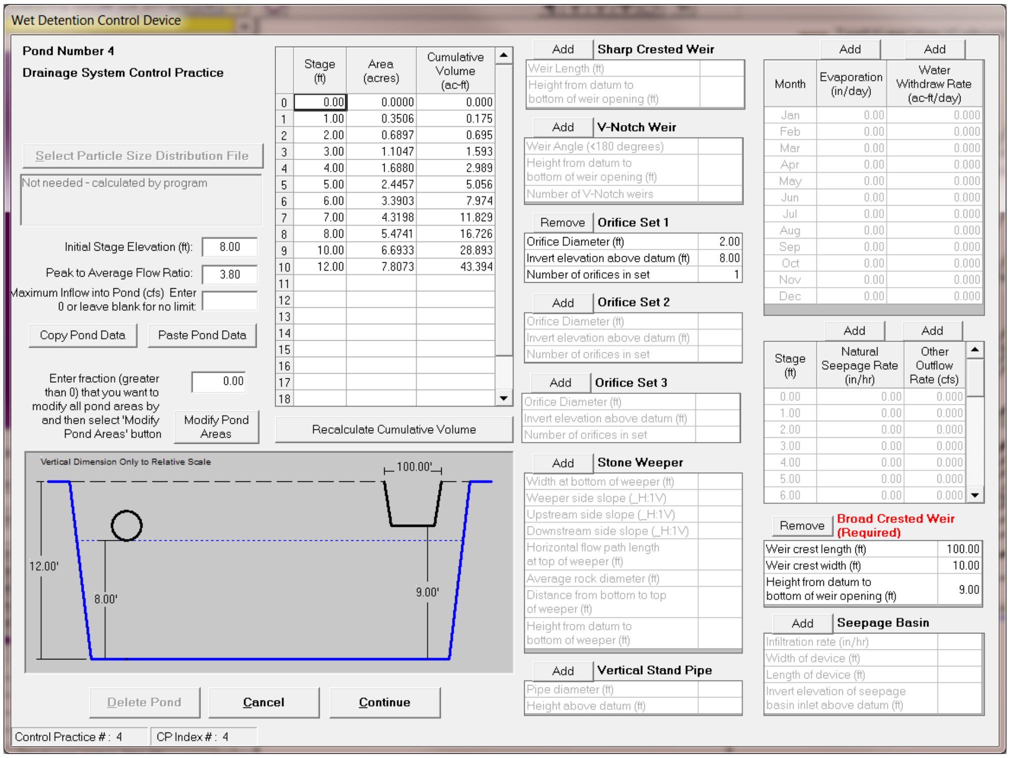

Figure 48: Stormwater Pond (Larger Drainage) at A-7(WinSLAMM).

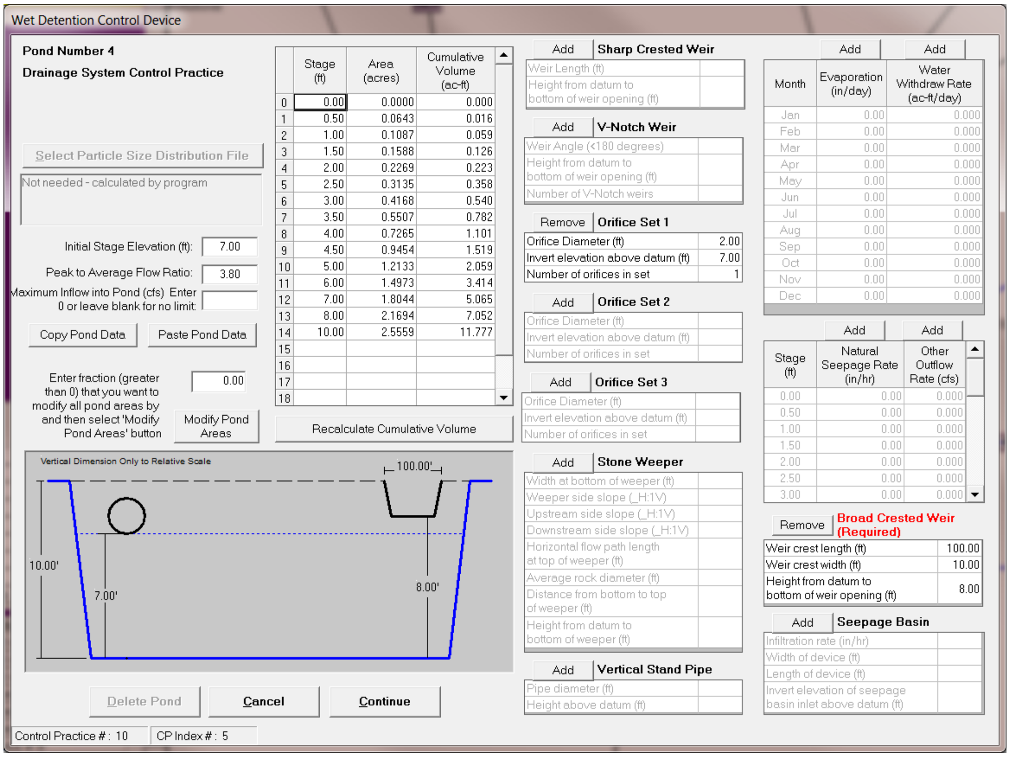

Figure 49: Stormwater Pond (Smaller Drainage) at A-7 (WinSLAMM).

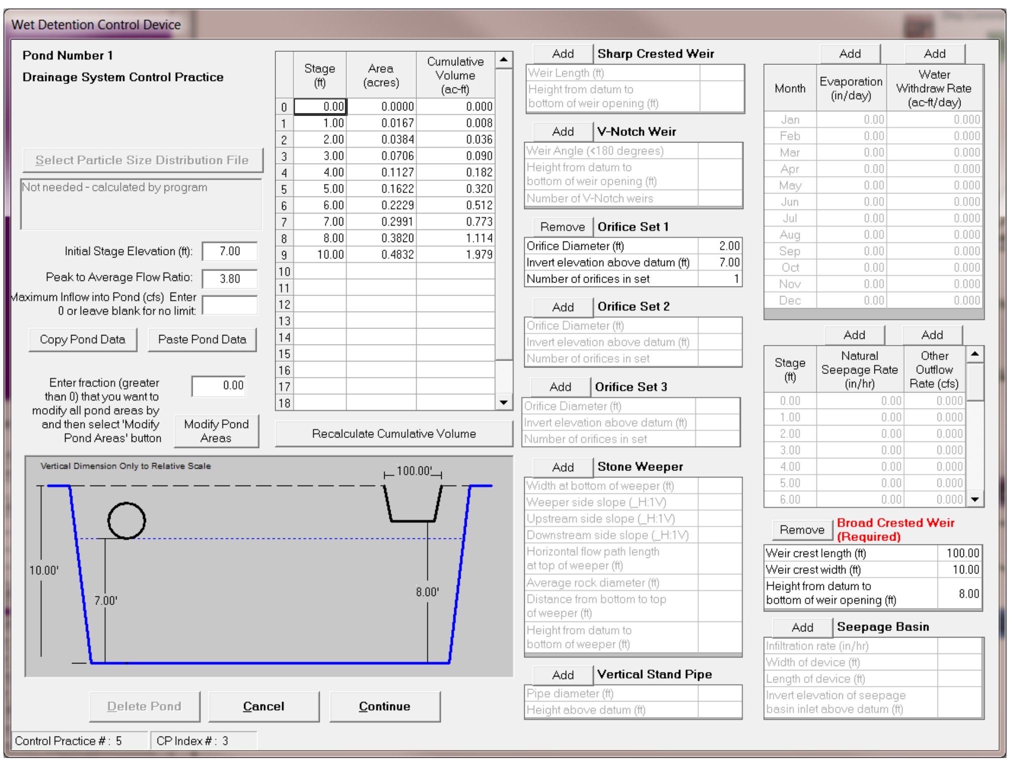

Figure 50: Stormwater Pond at Rudy Johnson Park at A-10 (WinSLAMM).

Iron Enhanced Sand Filter

Wet ponds, by design, allow for sediments and other bound pollutants to drop out of suspension. This practice, though, often allows dissolved pollutants to advect through the system untreated. Iron-enhanced sand filters (IESF) can be retrofitted to or installed with wet ponds to treat this dissolved load.

During a storm event, the pond increases from its permanent-pond stage to its flood stage. The IESF is designed to accept input from the wet pond during storm events, allowing for infiltration of water through its iron rich media, where dissolved pollutants (particularly dissolved phosphorus (DP)) adsorb to the iron filings. DP is then retained within the media while the stormwater can seep into an underdrain. Lastly, the underdrain discharges downstream of the wet pond. IESFs can be installed without ponds, although it is recommended that some form of pretreatment is available to remove sediment, which can deposit within the pore space of the filter and clog the practice over time.

There is currently no drainage practice input for these features in WinSLAMM. As they behave similarly to a bioretention cell, they can be modeled as such. But, as they often operate in tandem with stormwater ponds, estimating when and how much water and pollutants they will receive can be problematic. WinSLAMM was utilized to estimate what percentage of the stormflow could be treated by the filter. Stormflow input into the practice is most dependent upon the volume which can be passed through the system's underdrains. Stormflow treated by the device is a function of total area, depth, infiltration rate, and engineered media characteristics.

Field tests of installed sand trenches conducted by the University of Minnesota concluded that a sand media mixed with 5% iron filings is capable of retaining 80% (or more) of the DP load of stormwater flowing through the media (Erickson and Gulliver, 2010). Thus, DP retention by the IESF can be estimated by the equation,

$$P_{RET} = 0.8 * [P_{IN}] * q_S$$

where P_{RET} is the DP load removed by the IESF, $[P_{IN}]$ is the concentration of the DP input, and q_S is the volume of stormflow passing through the IESF. q_S is a function of the storm event duration and intensity, stormwater pond storage (if in-line with a pond), and IESF storage volume (bottom area, top area, and depth). The 0.8 multiplier assumes the IESF removes 80% of the DP load.

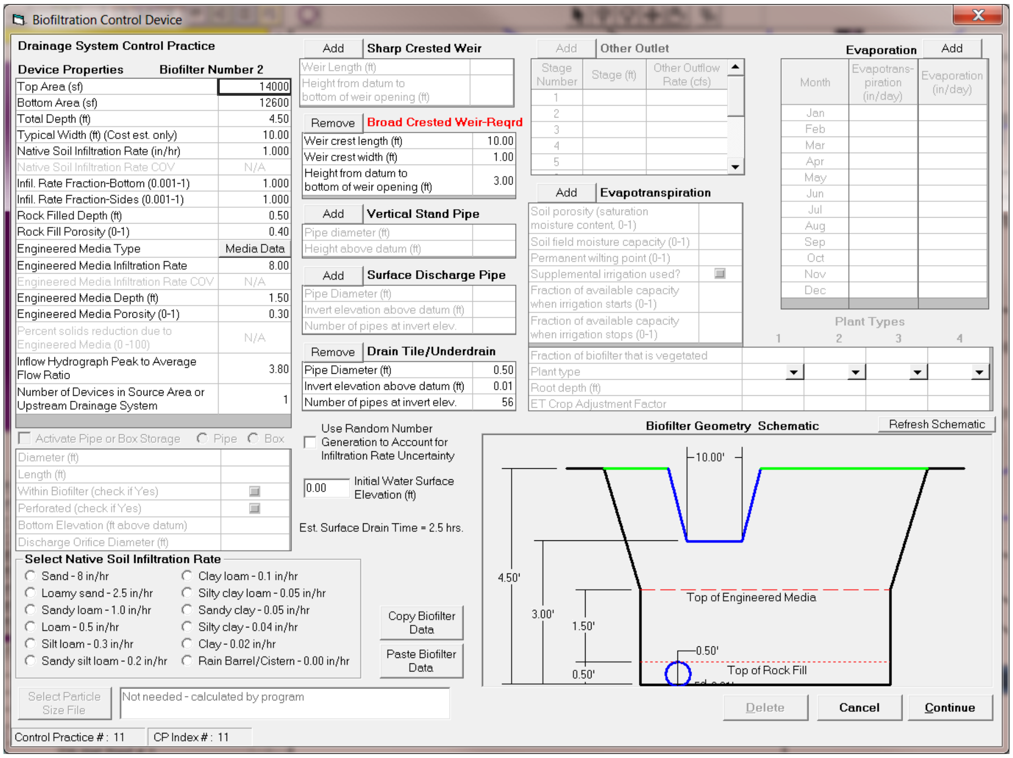

Figure 51: Iron Enhanced Sand Filter Pond Bench at Golf Course Pond in A-3 (WinSLAMM).

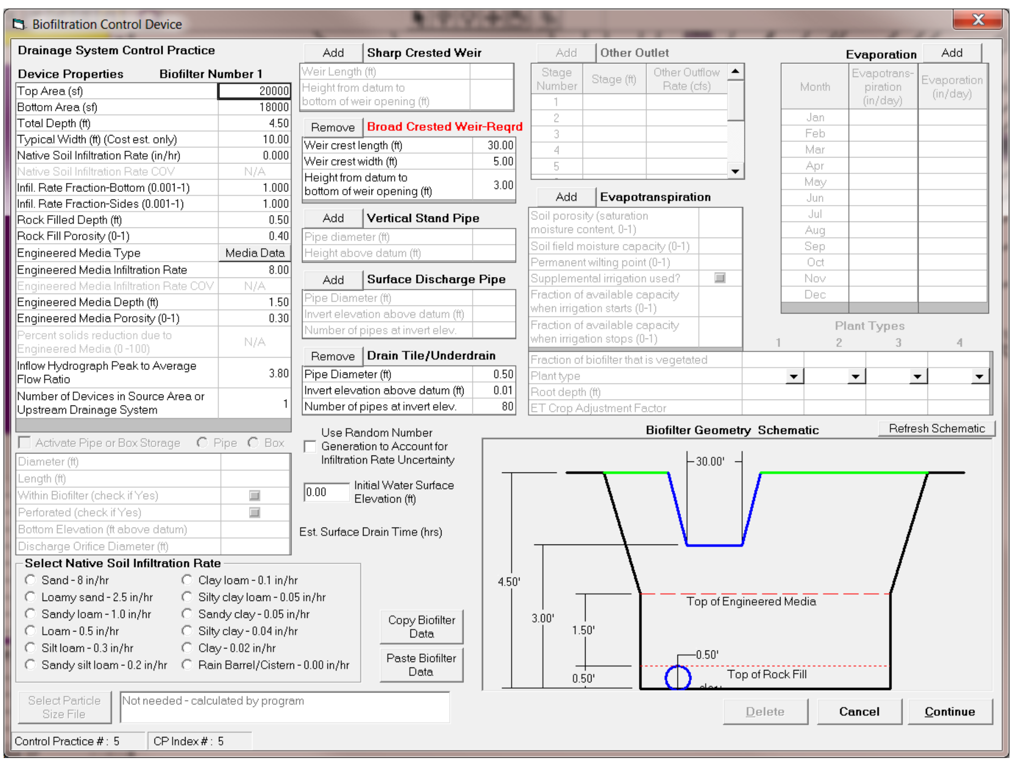

Figure 52: Iron Enhanced Sand Filter Pond Bench at proposed larger drainage pond in A-7 (WinSLAMM).

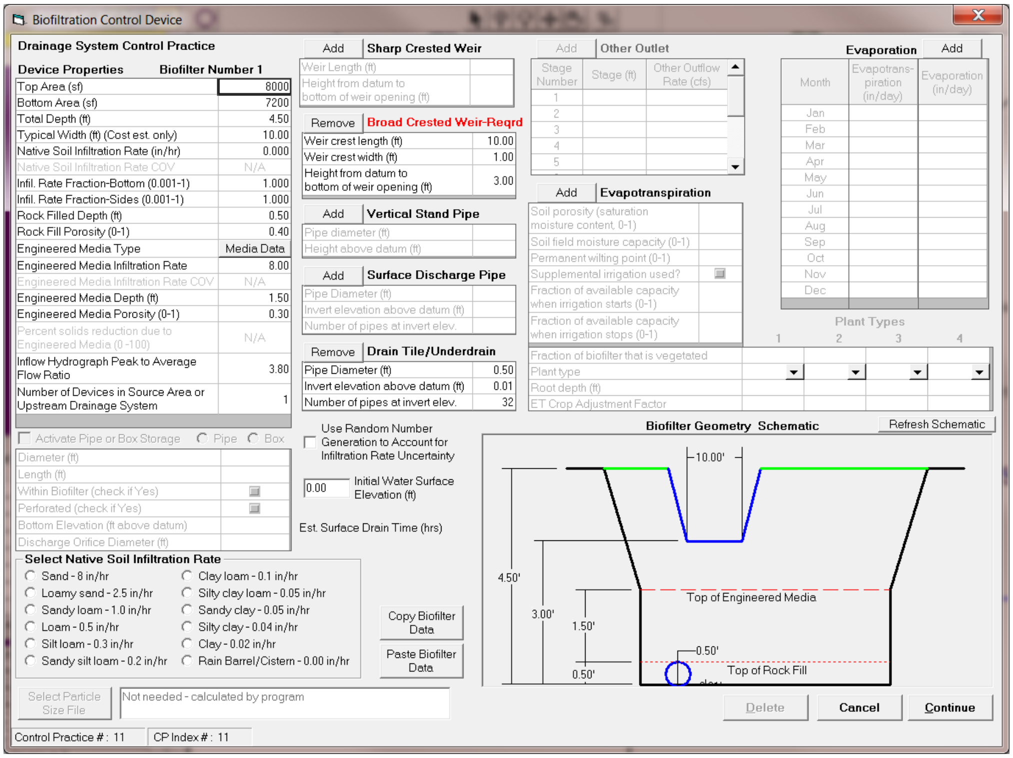

Figure 53: Iron Enhanced Sand Filter Pond Bench at the proposed smaller drainage pond in A-7 (WinSLAMM).

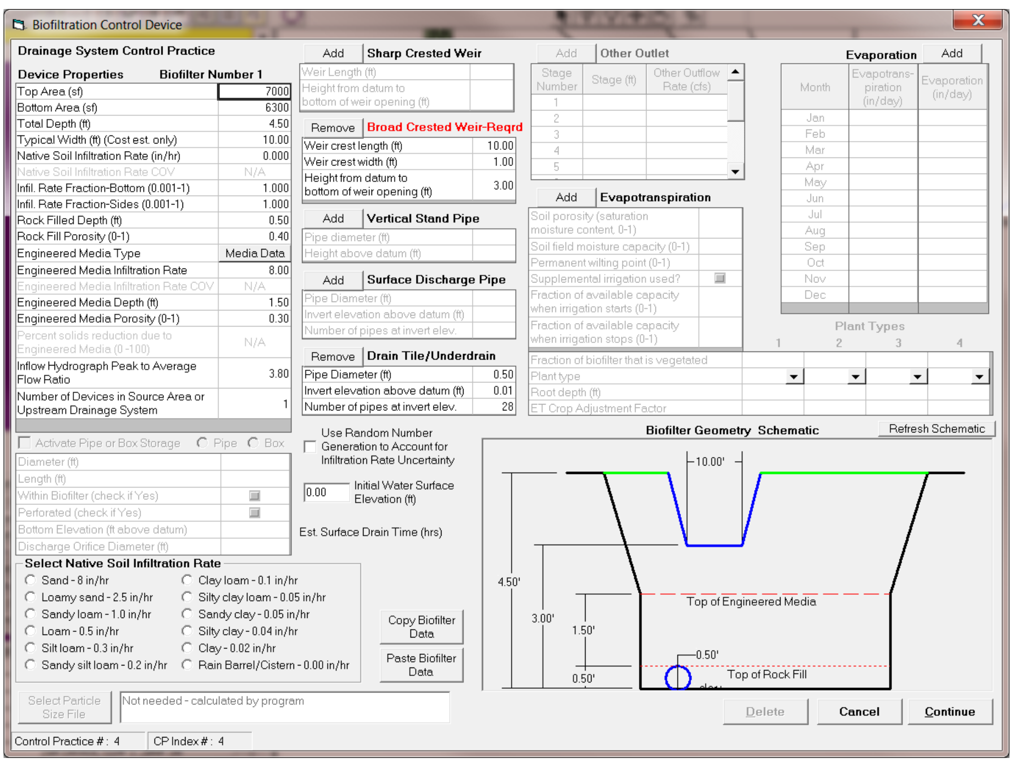

Figure 54: Iron Enhanced Sand Filter Pond Bench at 4th Avenue and Grant Street Pond in A-8 (WinSLAMM).

Permeable Pavement

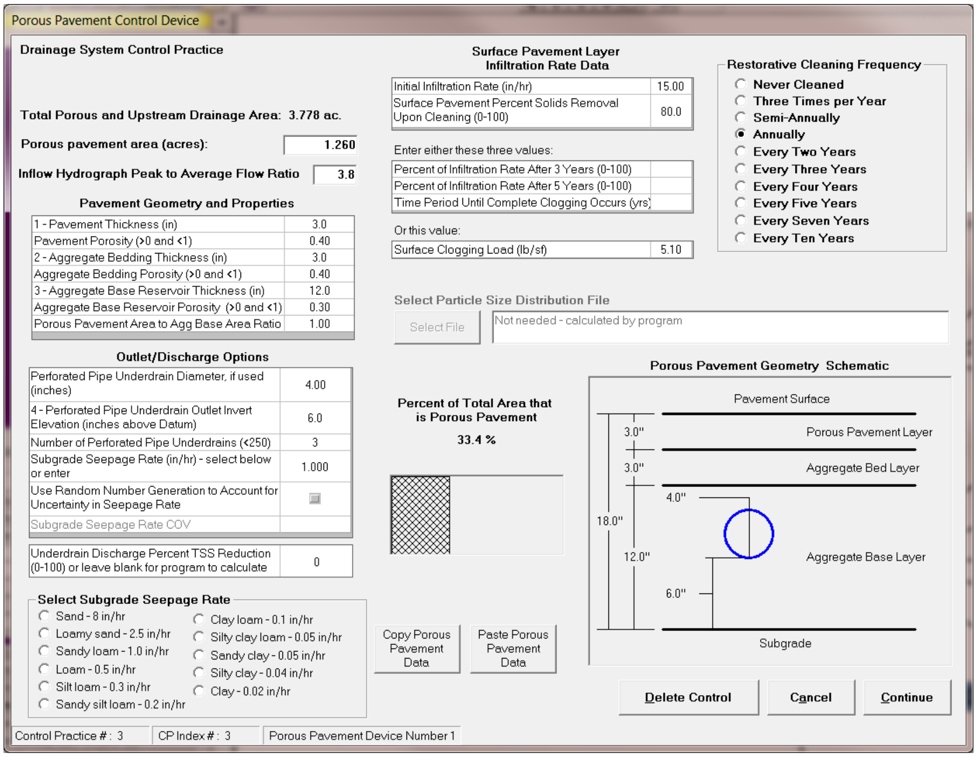

Figure 55: Permeable Pavement in A-1 (WinSLAMM).

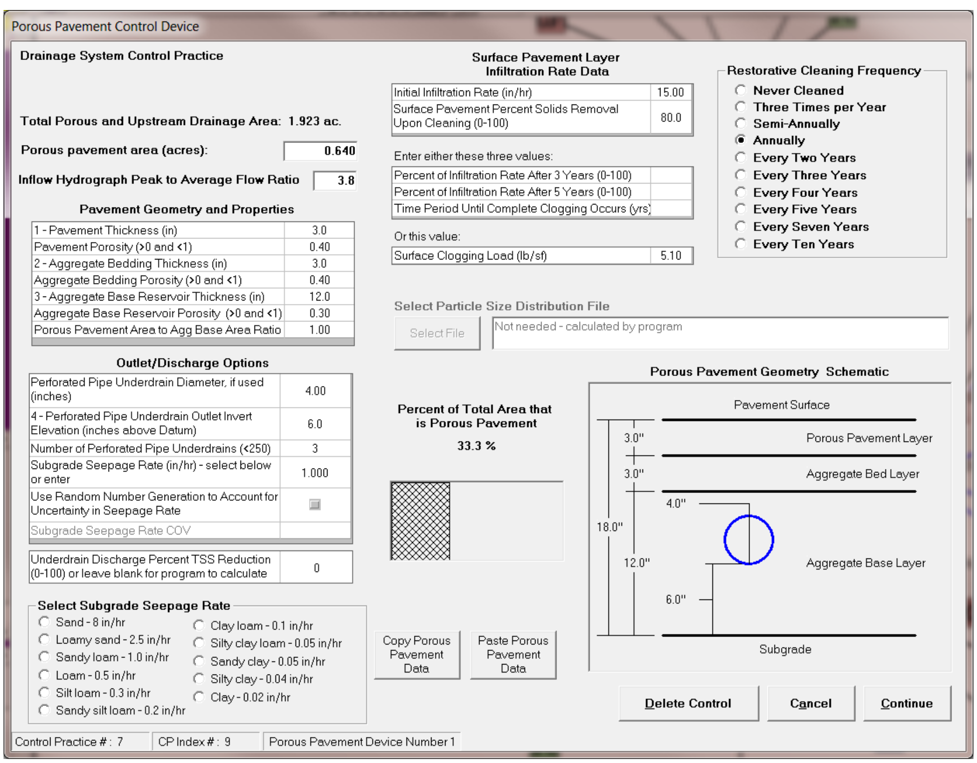

Figure 56: Permeable Pavement at St. Stephen's Catholic School eastern parking lot in A-13 (WinSLAMM).

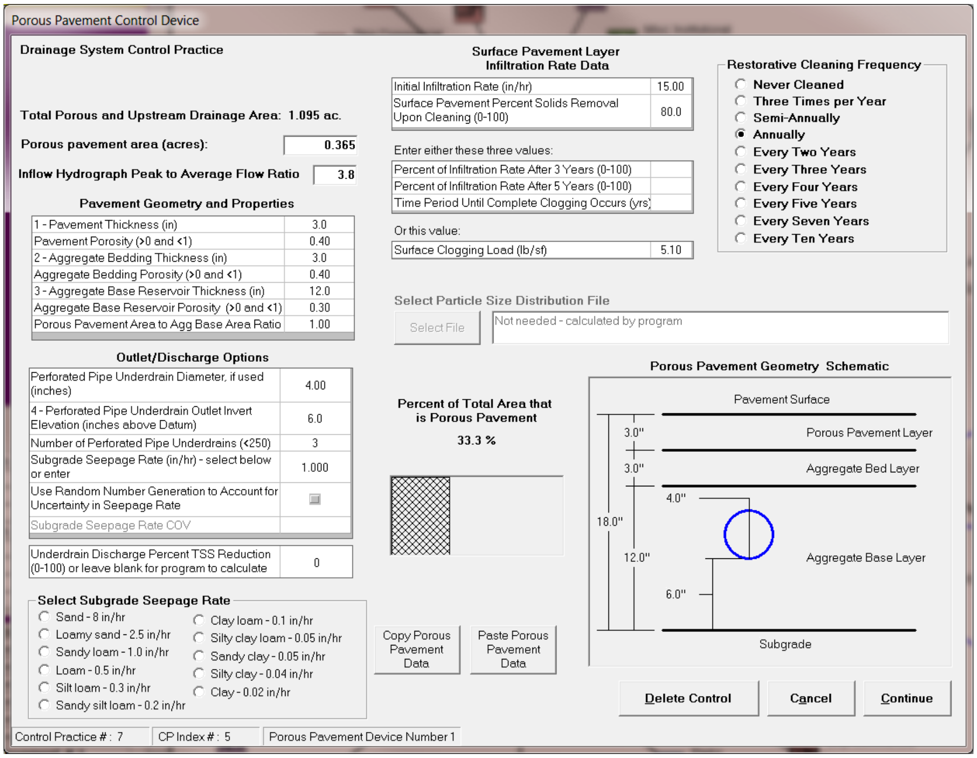

Figure 57: Permeable Pavement at St. Stephen's Catholic Church Parking Lot in A-13 (WinSLAMM).

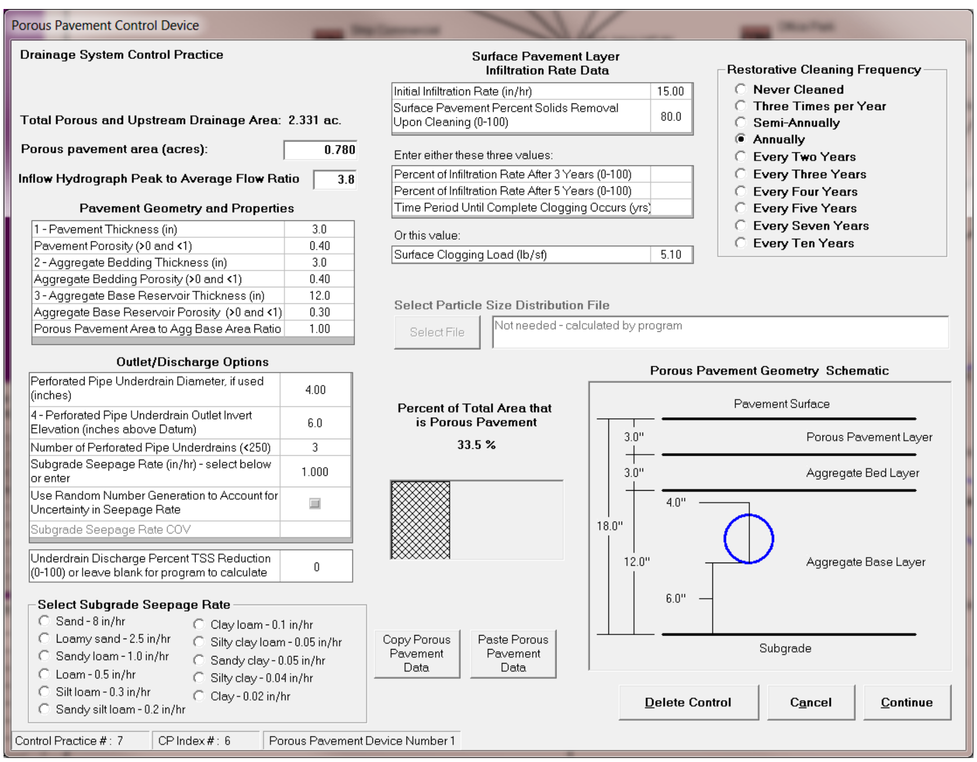

Figure 58: Permeable Pavement at St. Stephen's Catholic School western parking lot in A-13 (WinSLAMM).

Stormwater Reuse

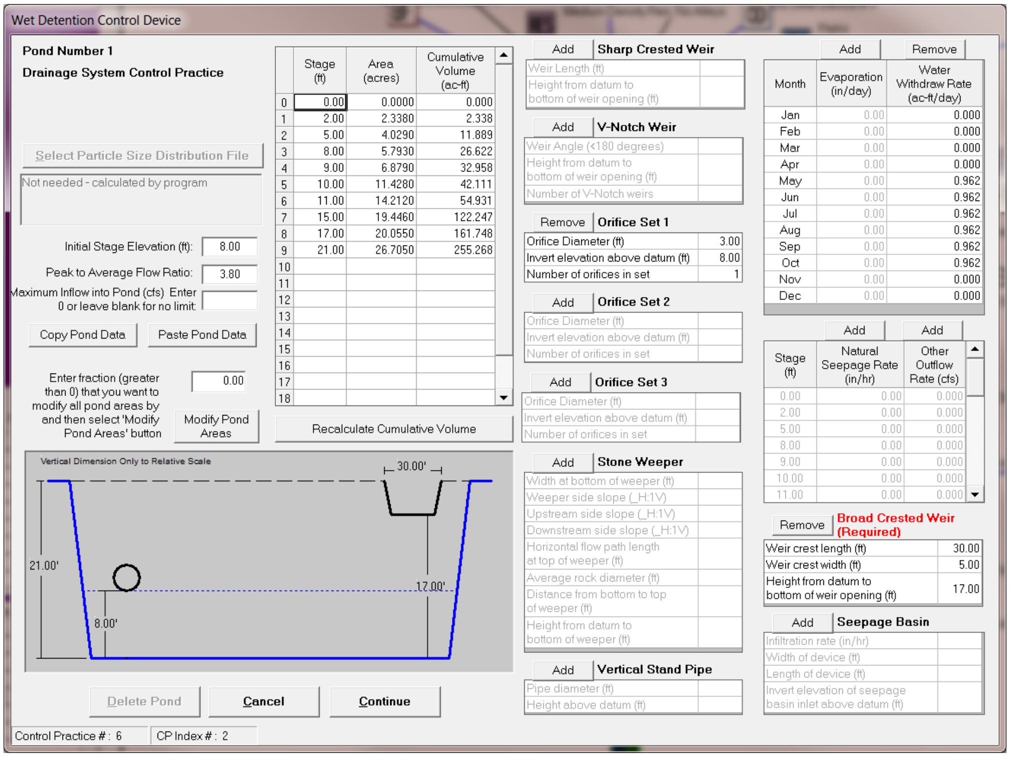

Figure 59: Stormwater Reuse at Green Haven Golf Course Pond in A-3 (WinSLAMM).

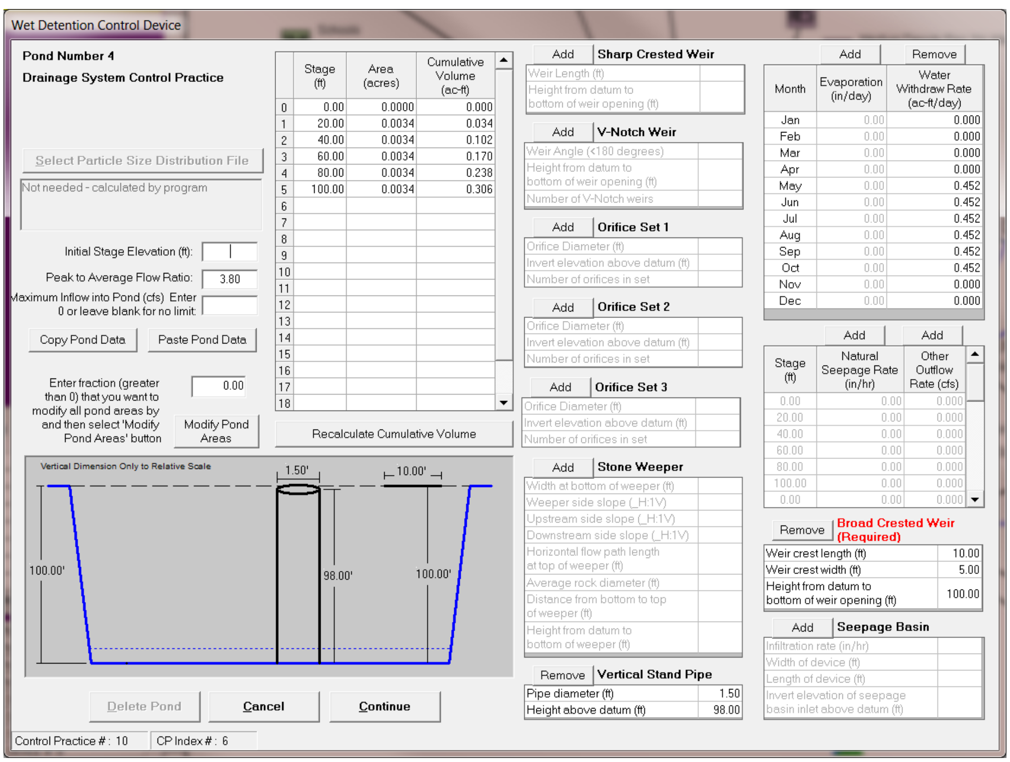

Figure 60: Stormwater Reuse in A-7 (WinSLAMM).

Boulevard Bioswale

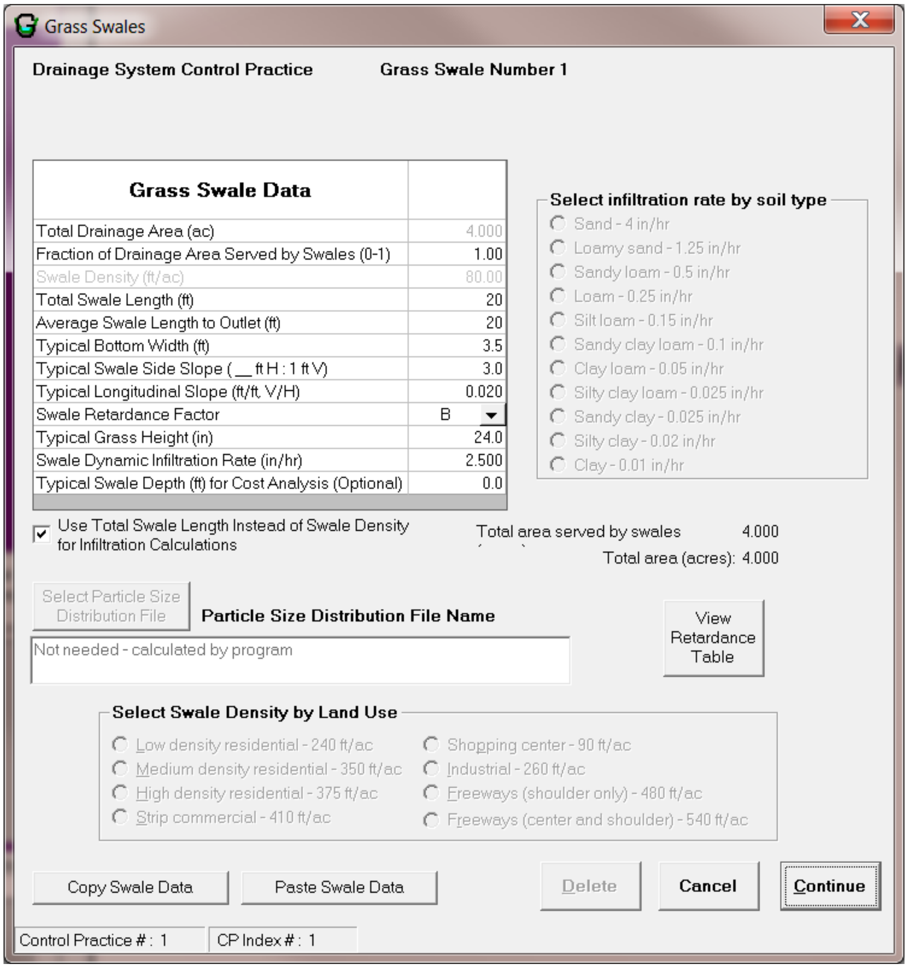

Figure 61: Boulevard Bioswale – not site specific (WinSLAMM).

Appendix B – Project Cost Estimates

Introduction

The 'Cost Estimates' section on page 10 explains the elements of cost that were considered and the amounts and assumptions that were used. In addition, each project type concludes with budget assumptions listed in the footnotes. This appendix is a compilation of tables that shows in greater detail the calculations made and quantities used to arrive at the cost estimates for practices where the information provided elsewhere in the document is insufficient to reconstruct the budget. This section includes ponds, iron enhanced sand filters, and stormwater reuse.

Ponds

Table 12: Catchment A-7 – New Pond (Smaller Drainage)

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
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 12.50	11,455	$ 143,183.75
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
Property Purchase		$ 100,000.00	1	$ 100,000.00
		Total for project =		$ 353,183.75

Table 13: Catchment A-7 – New Pond (Larger Drainage)

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
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 12.50	46,787	$ 584,837.50
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
Property Purchase		$ 100,000.00	1	$ 100,000.00
		Total for project =		$ 794,837.50

Table 14: Catchment A-8 – Pond Modification at 4th Avenue and Grant Street Pond

Activity	Units	Unit Price	Quantity	Unit Price
Feasibility Study and Project Design	Each	$ 15,000.00	1	$ 15,000.00
Mobilization	Each	$ 10,000.00	1	$ 10,000.00
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
Existing Infrastructure Retrofit	Each	$ 5,000.00	1	$ 5,000.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Site Restoration	Each	$ 10,000.00	1	$ 10,000.00
	Project Total Before Excavation =			$ 85,000.00

Activity	Management Levels		
	1	2	3
Soil To Excavate (cu-yds)	12,000	12,000	12,000
Cost To Excavate ($/cu-yd)	$20	$35	$50
Cost To Excavate (Total $)	$240,000	$420,000	$600,000
Other Construction Costs ($)	$85,000	$85,000	$85,000
Total Project Cost ($)	$325,000	$505,000	$685,000

Table 15: Catchment A-10 – New Pond at Rudy Johnson Park

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
Site Prep	Each	$ 10,000.00	1	$ 10,000.00
Excavation	cu-yards	$ 12.50	1,810	$ 22,625.00
Outlet Control Structure	Each	$ 10,000.00	1	$ 10,000.00
Existing Infrastructure Retrofit	Each	$ 50,000.00	1	$ 50,000.00
Site Restoration/Revegetation	Each	$ 5,000.00	1	$ 5,000.00
Property Purchase		$ 100,000.00	1	$ 100,000.00
		Total for project =		$ 232,625.00

Iron Enhanced Sand Filters

Table 16: Catchment A-3 – IESF Pond Bench at Green Haven Golf Course Pond

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (owned by City of Anoka)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	2,074	$ 82,960.00
IESF Materials and Installation	sq-ft	$ 17.00	14,000	$ 238,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 437,960.00

Table 17: Catchment A-7 – IESF Pond Bench (Smaller Drainage Pond)

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (owned by State of Minnesota)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	1,185	$ 47,400.00
IESF Materials and Installation	sq-ft	$ 17.00	8,000	$ 136,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 300,400.00

Table 18: Catchment A-7 – IESF Pond Bench (Larger Drainage Pond)

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (owned by State of Minnesota)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	2,963	$ 118,516.00
IESF Materials and Installation	sq-ft	$ 17.00	20,000	$ 340,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 575,516.00

Table 19: Catchment A-8 – IESF at 4th Avenue and Grant Street.

Activity	Units	Unit Price	Quantity	Unit Price
Design/Bidding/Construction Oversight	Each	$ 40,000.00	1	$ 40,000.00
Mobilization	Each	$ 20,000.00	1	$ 20,000.00
Land Acquisition (owned by City of Anoka)	acres	$ -	0	$ -
Clearing, Removal of Existing Infrastructure, and Pond Dewatering	Each	$ 12,000.00	1	$ 12,000.00
Common Excavation & Disposal	cu-yards	$ 40.00	1,037	$ 41,480.00
IESF Materials and Installation	sq-ft	$ 17.00	7,000	$ 119,000.00
Outlet/Inlet Control Structures	Each	$ 30,000.00	1	$ 30,000.00
Site Restoration	Each	$ 15,000.00	1	$ 15,000.00
		Total for project =		$ 277,480.00

Stormwater Reuse

Table 20: Catchment A-3 –Stormwater Reuse at Green Haven Golf Course Pond

Activity	Price
Project Planning	$ 30,000.00
Easement	$ 45,000.00
Design, Surveying and Permitting	$ 85,000.00
Construction Oversight	$ 30,000.00
Monitoring	$ 20,000.00
Construction	$ 390,000.00
Total for project =	$ 600,000.00

Table 21: Catchment A-7– Stormwater Reuse System

Activity	Price
Project Planning	$ 30,000.00
Easements	$ 75,000.00
Design, Surveying and Permitting	$ 85,000.00
Construction Oversight	$ 40,000.00
Monitoring	$ 20,000.00
Cisterns	$ 250,000.00
Construction	$ 450,000.00
Total for project =	$ 950,000.00

Appendix C – Volume Reduction Ranking Tables

Introduction

Volume reduction was not identified as a primary reduction target during the scoping phase of this project. This section is intended to serve as a quick reference if questions related to volume reduction arise. Projects are ranked based on cost per acre-foot of volume reduced.

Table 22: Cost-effectiveness of retrofits with respect to volume reduction. Projects 1 - 16. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ ac-ft Vol./year (30-year)1
1	3-E	52	Stomwater Reuse	Green Haven Golf Course Pond	A-3	18.2	3,409	46.4	$608,760.00	$3,000.00	$503.00
2	7-D	69	Infiltration Basin	Colfax Ave. and Blackoaks Ln.	A-7	9.6	3,256	8.1	$118,796.00	$225.00	$515.00
3	7-E	70	Infiltration Basin	Sunny Ln.	A-7	1.7	676	1.8	$22,796.00	$225.00	$547.00
4	10-C	97	Infiltration Basin	5th Ave. and Polk St.	A-10	2.6	808	2.1	$43,796.00	$225.00	$803.00
5	8-A	80	Curb-Cut Rain Garden	Various locations in catchment	A-8	0.7-0.8	190-301	0.7-1.1	$17,234.00	$450.00	$931-$1,394
6	1-A	38	Curb-Cut Rain Garden	Ferry St. and Front Ave.	A-1	0.5	187	0.5	$8,982.00	$225.00	$1,090.00
7	16-A	128	Curb-Cut Rain Garden	Washington St.	A-16	0.5-1.0	157-315	0.4-0.8	$8,982-$17,234	$225-$450	$1,339-$1,369
8	7-A	66	Curb-Cut Rain Garden	Various locations in catchment	A-7	0.5-8.1	153-2,539	0.4-6.2	$15,844-$147,876	$225-$3,825	$1,407-$1,931
9	3-A	48	Curb-Cut Rain Garden	Various locations in catchment	A-3	0.5-3.5	157-1,089	0.4-2.7	$15,844-$65,356	$225-$1,575	$1,410-$2,052
10	15-A	125	Curb-Cut Rain Garden	Various locations in catchment	A-15	0.4-4.4	135-1,343	0.4-3.7	$15,844-$90,112	$225-$2,250	$1,413-$1,931
11	9-A	87	Curb-Cut Rain Garden	Various locations in catchment	A-9	0.5-2.0	155-623	0.4-1.5	$15,844-$40,600	$225-$900	$1,465-$1,931
12	7-G	72	Stomwater Reuse	38th Ave. and 7th Ave.	A-7	17.5	5,987	18.7	$958,760.00	$3,000.00	$1,869.00
13	9-E	91	Boulevard Bioswale	Various locations in catchment	A-9	0.2	112	0.2	$8,526.00	$225.00	$2,482.00
14	7-F	71	Boulevard Bioswale	Various locations in catchment	A-7	0.2	61	0.1	$8,526.00	$225.00	$3,704.00
15	11-A	102	Boulevard Bioswale	3rd Ave.	A-11	0.1	49	0.1	$8,526.00	$225.00	$3,717.00
16	2-A	44	Boulevard Bioswale	Maple Ave.	A-2	0.2	55	0.1	$8,526.00	$225.00	$3,859.00

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

Table 23: Cost-effectiveness of retrofits with respect to volume reduction. Projects 17 - 32. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ ac-ft Vol./year (30-year)1
17	10-D	98	Boulevard Bioswale	Various locations in catchment	A-10	0.1	52	0.1	$8,526.00	$225.00	$4,302.00
18	13-H	116	Boulevard Bioswale	Various locations in catchment	A-13	0.1	22	0.1	$8,526.00	$225.00	$5,092.00
19	1-C	40	Permeable Pavement	Anoka-Hennepin Education Center	A-1	2.9	1,325	3.5	$552,656.00	$41,165.00	$17,044.00
20	13-F	114	Permeable Pavement	St. Stephen's Catholic School	A-13	1.6	562	1.6	$282,796.00	$20,925.00	$18,970.00
21	13-E	113	Permeable Pavement	St. Stephen's Catholic Church	A-13	0.9	320	0.9	$162,796.00	$11,925.00	$19,279.00
22	13-G	115	Permeable Pavement	St. Stephen's Catholic School	A-13	1.9	672	1.9	$343,796.00	$25,500.00	$19,453.00
48	1-B	39	Hydrodynamic Device	Ferry St.	A-1	1	584	0	$109,752.00	$630.00	N/A
48	3-B	49	Hydrodynamic Device	Main St. and State Ave.	A-3	0.5	280	0	$55,752.00	$630.00	N/A
48	3-C	50	Hydrodynamic Device	Main St. and State Ave.	A-3	0.6	302	0	$55,752.00	$630.00	N/A
48	3-D	51	IESF Bench	Green Haven Golf Course Pond	A-3	10.4	0	0	$282,955.00	$3,214.00	N/A
48	4-A	55	Hydrodynamic Device	Maple Ln.	A-4	0.3	113	0	$28,752.00	$630.00	N/A
48	7-B	67	Hydrodynamic Device	38th Ln. and 8th Ave.	A-7	1.2	491	0	$109,752.00	$630.00	N/A
48	7-C	68	Hydrodynamic Device	7th Ave.	A-7	0.8	383	0	$109,752.00	$630.00	N/A
48	7-H1	73	New Pond	7th Ave.	A-7	111.6	54,558	0.9	$802,138.00	$5,500.00	N/A
48	7-H2	74	New Pond	7th Ave.	A-7	31.5	13,452	0.4	$360,484.00	$1,800.00	N/A
48	7-I1	75	IESF Bench	7th Ave.	A-7	26.6	0	0	$580,991.00	$4,591.00	N/A

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

Table 24: Cost-effectiveness of retrofits with respect to volume reduction. Projects 33 – 48. TP and TSS reductions are also shown. For more information on each project refer to either the Catchment Profile or BMP Descriptions pages in this report. Volume and pollutant reduction benefits cannot be summed with other projects that provide treatment for the same source area.

Project Rank	Project ID	Page Number	Retrofit Type	Retrofit Location	Catchment	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Probable Project Cost	Estimated Annual Operations & Maintenance	Estimated cost/ ac-ft Vol./year (30-year)1
48	7-I2	76	IESF Bench	7th Ave.	A-7	7.2	0	0	$305,875.00	$1,837.00	N/A
48	8-B	81	Pond Modification	4th Ave. and Grant St.	A-8	10.5	6,443	0	$330,840-$690,840	$1,300.00	N/A
48	8-C	82	IESF Bench	4th Ave. and Grant St.	A-8	7.2	0	0	$282,955.00	$1,607.00	N/A
48	9-B	88	Hydrodynamic Device	7th Ave. and Pierce St.	A-9	1.2	686	0	$109,752.00	$630.00	N/A
48	9-C	89	Hydrodynamic Device	7th Ave. and Harrison St.	A-9	1	407	0	$109,752.00	$630.00	N/A
48	9-D	90	Hydrodynamic Device	Main St. and 8 1/2 Ave.	A-9	1.1	777	0	$109,752.00	$630.00	N/A
48	10-A	95	Hydrodynamic Device	6th Ave. and Taylor St.	A-10	0.5	211	0	$109,752.00	$630.00	N/A
48	10-B	96	Hydrodynamic Device	5th Ave. and Taylor St.	A-10	0.5	195	0	$109,752.00	$630.00	N/A
48	10-E	99	New Pond	Rudy Johnson Park	A-10	4	1,712	0.1	$239,925.00	$300.00	N/A
48	13-A	109	Hydrodynamic Device	Main St. and 1st Ave.	A-13	0.5	272	0	$55,752.00	$630.00	N/A
48	13-B	110	Hydrodynamic Device	Main St. and 3rd Ave.	A-13	0.5	285	0	$55,752.00	$630.00	N/A
48	13-C	111	Hydrodynamic Device	Main St. and 5th Ave.	A-13	0.9	427	0	$109,752.00	$630.00	N/A
48	13-D	112	Hydrodynamic Device	5th Ave. and Main St.	A-13	1.4	644	0	$109,752.00	$630.00	N/A
48	14-A	121	Hydrodynamic Device	Parking lot off 1st Ave.	A-14	0.8	385	0	$109,752.00	$630.00	N/A
48	16-B	129	Hydrodynamic Device	Oakwood Dr. and Washington St.	A-16	0.4	163	0	$109,752.00	$630.00	N/A
48	17-A	133	Hydrodynamic Device	Oakwood Dr.	A-17	0.6	244	0	$109,752.00	$630.00	N/A

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

Appendix D – Soil Information

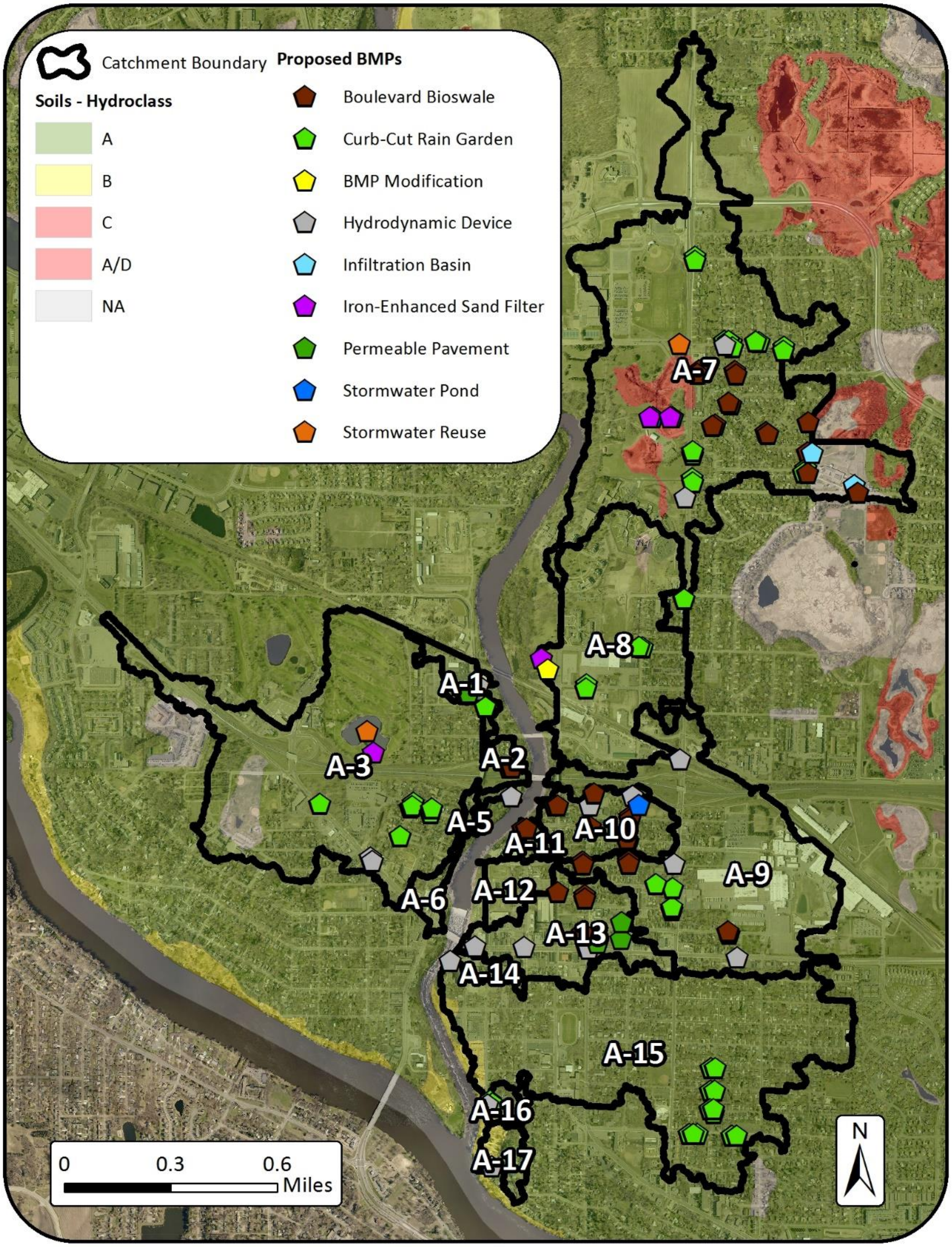

Figure 62: Soil hydroclass and proposed retrofit locations in the City of Anoka.

Appendix E –Wellhead Protection Areas

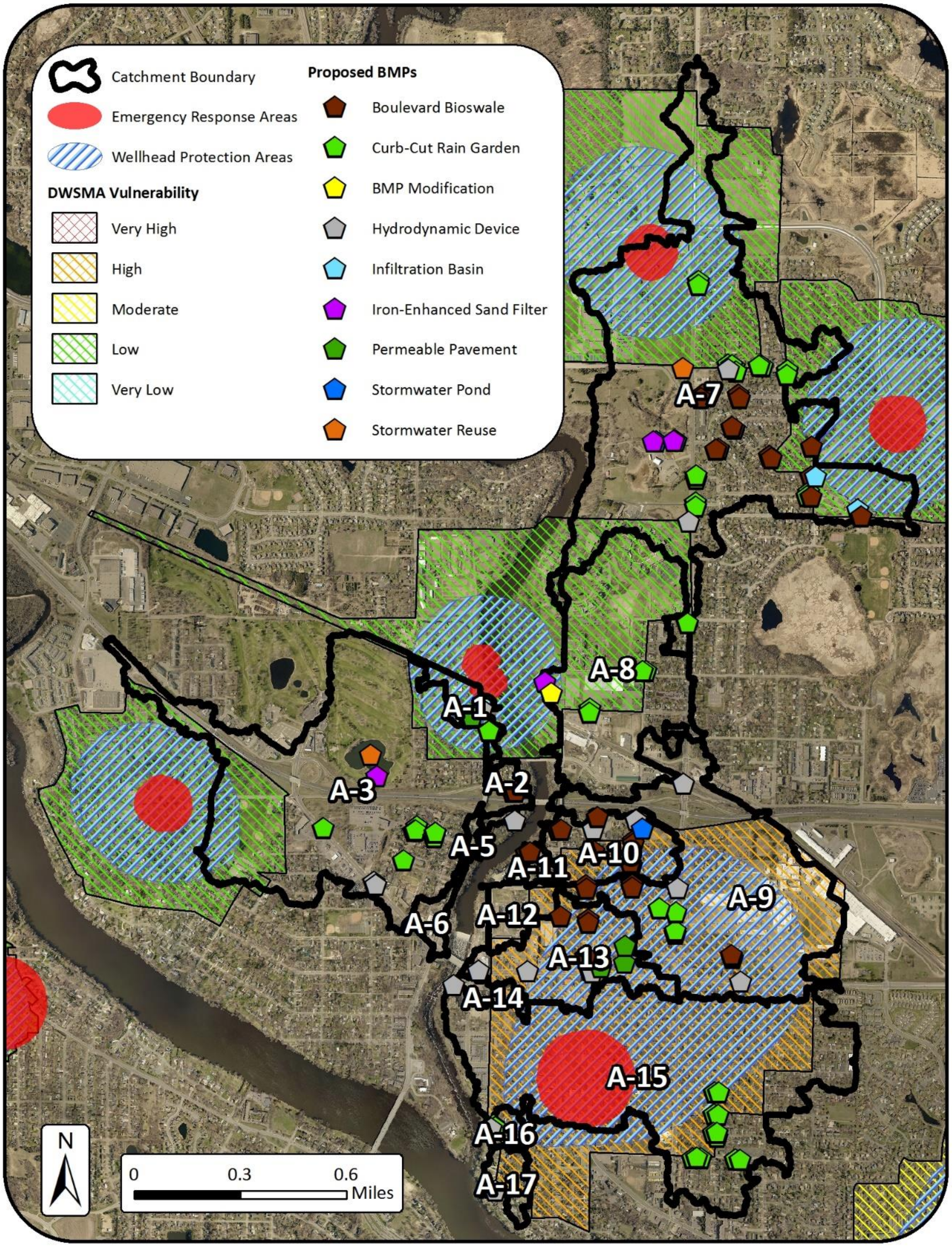

Figure 63: Wellhead protection areas and proposed retrofit locations in the City of Anoka.