



City of Ramsey Stormwater Retrofit Analysis

Prepared by:



CITY OF RAMSEY AND

LOWER RUM RIVER WATERSHED MANAGEMENT ORGANIZATION

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Cover photo: Historical and 2014 aerial photographs of subwatersheds analyzed in this report that drain to either the Mississippi (top pictures) or Rum River (bottom pictures).

Disclaimer: At the time of printing, this report identifies and ranks potential BMPs for selected subwatersheds in the City of Ramsey that drain to the Mississippi or 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, the City of Ramsey, or the Lower Rum River Watershed Management Organization.

Executive Summary

The City of Ramsey and 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 either the Mississippi or Rum River. The subwatersheds are located along the southern City boundary (Mississippi River) and the eastern City boundary (Rum River) 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 Mississippi and Rum Rivers 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.

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,
- Bioswales,
- Current BMP modification,
- Iron-enhanced sand filter check dams,
- Iron-enhanced sand filter pond benches, and

- Hydrodynamic devices.

If all of these practices were installed, significant volume and pollutant reductions could be accomplished. However, funding limitations and landowner interest make this 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 will need to be weighed by resource managers when selecting projects to pursue.

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

The 448 acre target study area was divided into 16 catchments and two drainage networks (groups of catchments draining to a common point) based on drainage patterns influenced by topography and stormwater infrastructure. The Mississippi River network consists of seven catchments (320 acres), and the Rum River network consists of nine catchments (128) acres. Based on WinSLAMM model results, the Mississippi River network contributes an estimated 101 acre-feet of runoff, 28,083 pounds of TSS, and 85 pounds of TP annually to the Mississippi River. The Rum River network contributes an estimated 61 acre-feet of runoff, 19,764 pounds of TSS, and 63 pounds of TP annually to the Rum River.

The tables in the Project Ranking and Selection section (pages 14 - 17) 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 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 16 catchments distributed between two 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 drainage to a common waterbody (i.e. Mississippi River or 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 Ramsey. 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 Ramsey and discharge to either the Mississippi or Rum Rivers. Those discharging to the Mississippi River are located along the southern boundary of Ramsey primarily between Ramsey Blvd. NW on the west and Tungsten St. NW on the east. The railroad tracks just north of US-10 serve as much of the northern boundary. The total area of the seven catchments that comprise the Mississippi River network is 320 acres. The nine catchments discharging to the Rum River are located on the eastern boundary of the City primarily between Alpine Dr. NW on the north and Bunker Lake Blvd. NW on the south. All catchments are primarily east of St. Francis Blvd. NW. The total area of the nine catchments that comprise the Rum River network is 128 acres.

These catchments were selected for analysis because they drain to high priority waterbodies, and existing treatment in many of the catchments was lacking. Therefore, stormwater retrofits may provide cost-effective options for additional treatment of runoff, thereby improving water quality in the Mississippi and Rum Rivers.

The catchments analyzed are urbanized. Development throughout the City of Ramsey 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 Mississippi and Rum Rivers, as it was historically. However, the runoff is now captured by catch basins and directed underground before being discharged to the Mississippi and Rum Rivers via stormwater pipe.

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 Ramsey 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 Mississippi and Rum Rivers. 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 directly into the Mississippi and Rum Rivers. 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 16 catchments included in this analysis.

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 Mississippi and Rum Rivers.

Desktop analysis involves computer-based scanning of the subwatershed for potential retrofit catchments and/or specific sites. This step also identifies areas that don’t need to be analyzed because of existing stormwater infrastructure or disconnection from the target water body. Accurate GIS data are extremely valuable in conducting the desktop retrofit analysis. Some of the most important GIS

layers include: 2-foot or finer topography (Light Detection and Ranging [LiDAR] was used for this analysis), surface hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the stormwater drainage infrastructure (with invert elevations).

Field investigation is conducted after potential retrofits are identified in the desktop analysis to evaluate each site and identify additional opportunities. During the investigation, the drainage area and surface stormwater infrastructure mapping data 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.

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 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. This process resulted in a model that included estimates of the acreage of each type of source area (roof, road, lawn, etc.) in each catchment.

Once the “base” model was established, an “existing conditions” model was created by incorporating notable existing stormwater treatment practices in the catchment for which data were available from the City of Ramsey (Figure 1 and Figure 2). For example, street cleaning with mechanical or vacuum street sweepers, stormwater treatment ponds, and others were included in the “existing conditions” model if information was available.

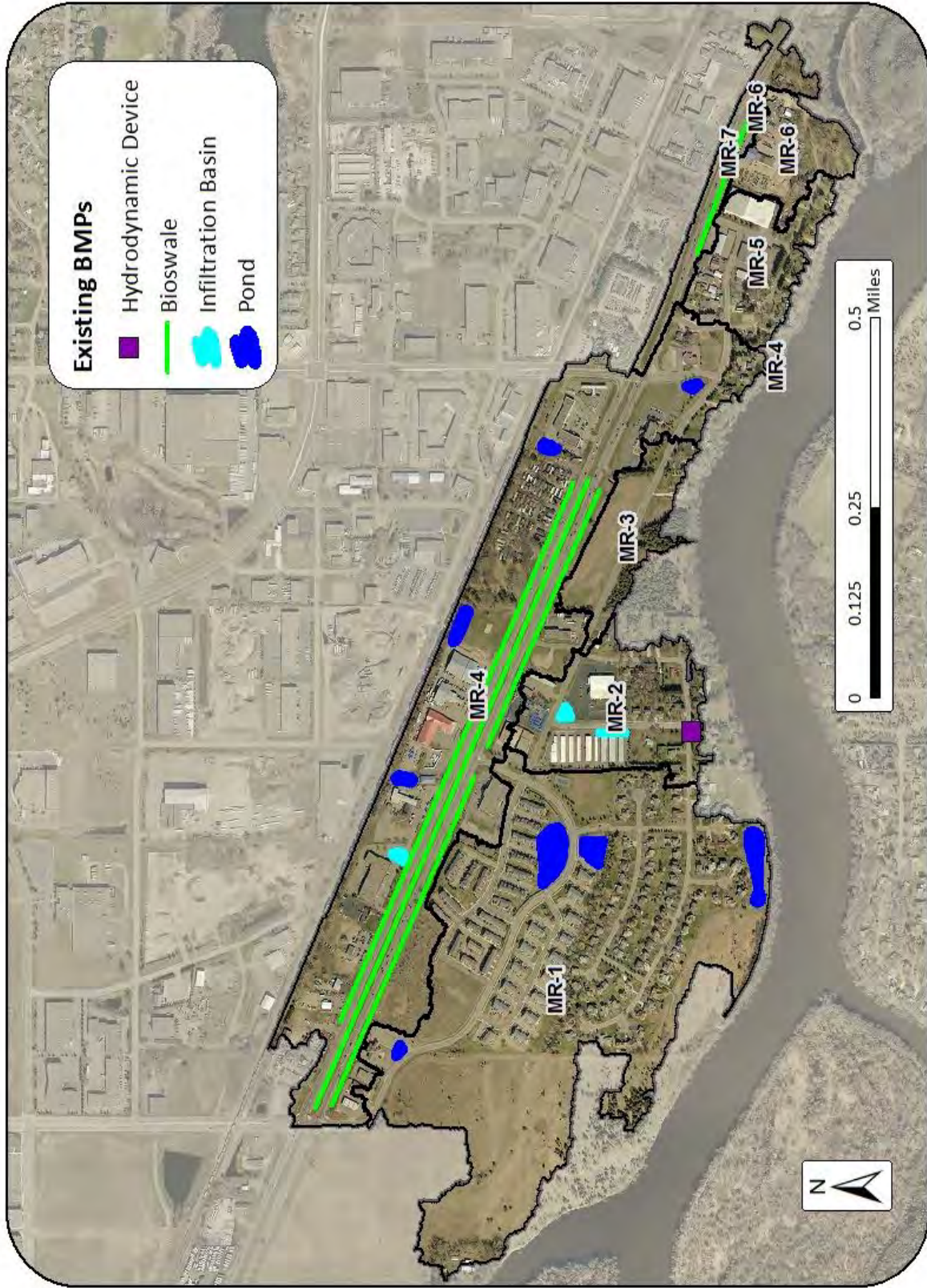


Figure 1: Mississippi River network-wide map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included where applicable in catchments within the network.



Figure 2: Rum River network-wide map showing existing BMPs included in the WinSLAMM model. Street sweeping is not shown on the map but was included where applicable in catchments within the network.

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.

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.

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

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

Project Ranking and Selection

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

Project Ranking

If all identified practices were installed (Figure 3 and Figure 4), significant pollution reduction could be accomplished. However, funding limitations and landowner interest will be a limiting factor in implementation. The tables on the following pages rank all modeled projects by cost-effectiveness. Tables were separated by drainage network (i.e. Mississippi River or Rum River), and projects were ranked in two ways:

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

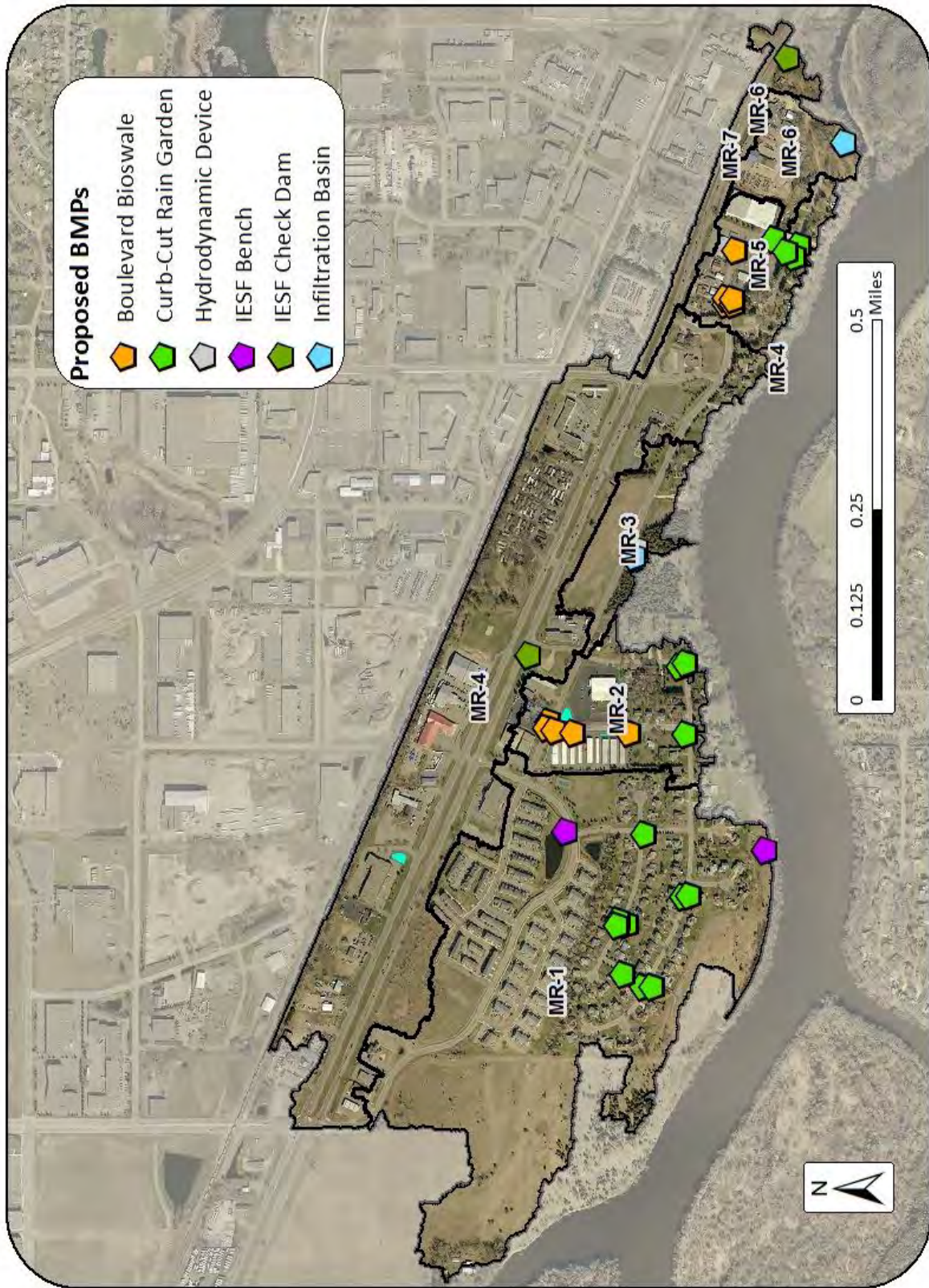


Figure 3: Mississippi River network-wide map showing all proposed retrofits.

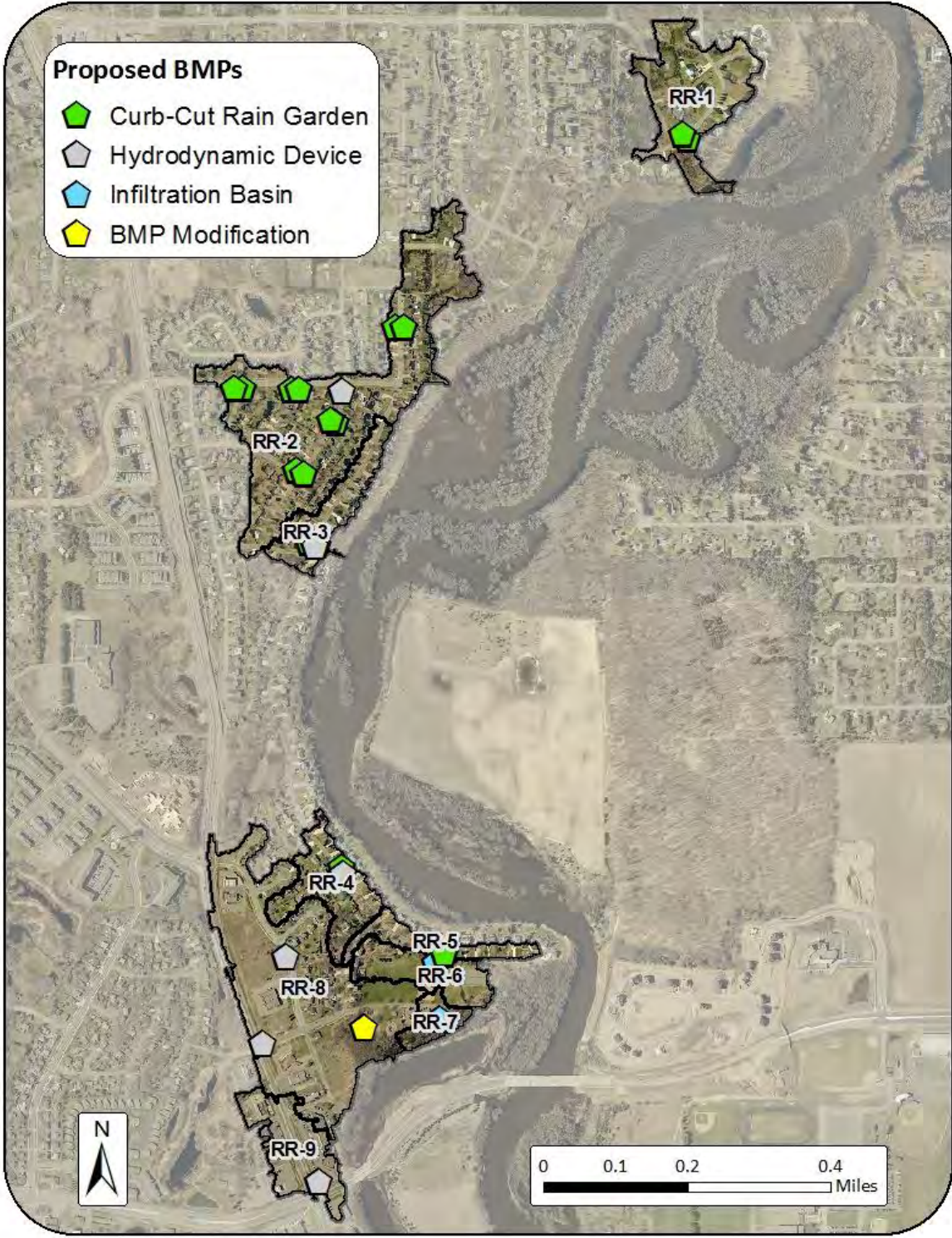


Figure 4: Rum River network-wide map showing all proposed retrofits.

Table 2: Mississippi River Network. Cost-effectiveness of retrofits with respect to TP reduction. 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	MR6-A	57	Infiltration Basin	Southeastern Portion of MR6	MR6	3.6 - 4.9	2,110 - 2,836	3.8 - 5.4	\$43,796 - \$83,796	\$225	\$468 - \$616
2	MR3-A	44	Infiltration Basin	Riverdale Dr.	MR3	2.5 - 3.0	867-1,034	2.2-2.7	\$33,796 - \$53,796	\$225	\$541 - \$673
3	MRS-A	52	Curb-Cut Rain Garden	Tungsten St. and Rivilyn Ave.	MRS	0.4-0.5	155-249	0.4-0.6	\$8,982	\$225	\$1,049 - \$1,311
4	MR1-C	36	IESF Bench	Hematite Cir. and Garnet St.	MR1	7.6	0	0.0	\$235,035	\$1,377	\$1,212
5	MR2-A	40	Curb-Cut Rain Garden	Ebony St. and 137th Ave.	MR2	0.4-1.2	112-336	0.3-0.9	\$8,982 - \$26,946	\$225 - \$675	\$1,311
6	MR1-A	34	Curb-Cut Rain Garden	Various locations in MR1	MR1	0.8-2.3	166-493	1.5-3.3	\$32,348 - \$81,860	\$675 - \$2,025	\$2,033 - \$2,192
7	MR1-B	35	IESF Bench	Feldspar St. and Garnet St.	MR1	2.4	0	0.0	\$143,475	\$459	\$2,202
8	MRS-B	53	Boulevard Bioswales	Riverdale Dr.	MRS	0.1	61	0.1	\$8,526	\$225	\$2,603
9	MR2-B	41	Boulevard Bioswales	Riverdale Dr. and Ebony St.	MR2	0.1	61	0.1	\$8,526	\$225	\$3,395
10	MR7-A	60	IESF Check Dam	US-10	MR7	0.2	15	0.0	\$15,448	\$365	\$4,526
11	MR4-A	49	IESF Check Dam	US-10	MR4	0.2	15	0.0	\$15,448	\$365	\$4,549
12	MRS-C	54	Hydrodynamic Device	Tungsten St. and Rivilyn Ave.	MRS	0.9	682	0.0	\$109,752	\$630	\$4,765
13	MR3-B	45	Hydrodynamic Device	Riverdale Dr.	MR3	0.4	211	0.0	\$109,752	\$630	\$10,721

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

Table 3: Mississippi River Network. Cost-effectiveness of retrofits with respect to TSS reduction. 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	MR6-A	57	Infiltration Basin	Southeastern Portion of MR6	MR6	3.6 - 4.9	2,110 - 2,836	3.8 - 5.4	\$43,796 - \$83,796	\$225	\$799 - \$1,064
2	MR3-A	44	Infiltration Basin	Riverdale Dr.	MR3	2.5 - 3.0	867-1,034	2.2-2.7	\$33,796 - \$53,796	\$225	\$1,559 - \$1,952
3	MR5-A	52	Curb-Cut Rain Garden	Tungsten St. and Rivlyn Ave.	MR5	0.4-0.5	155-249	0.4-0.6	\$8,982	\$225	\$2,106 - \$3,383
4	MR2-A	40	Curb-Cut Rain Garden	Ebony St. and 137th Ave.	MR2	0.4-1.2	112-336	0.3-0.9	\$8,982 - \$26,946	\$225 - \$675	\$4,682
5	MR5-B	53	Boulevard Bioswales	Riverdale Dr.	MR5	0.1	61	0.1	\$8,526	\$225	\$4,839
6	MR5-C	54	Hydrodynamic Device	Tungsten St. and Rivlyn Ave.	MR5	0.9	682	0.0	\$109,752	\$630	\$6,288
7	MR2-B	41	Boulevard Bioswales	Riverdale Dr. and Ebony St.	MR2	0.1	61	0.1	\$8,526	\$225	\$8,526
8	MR1-A	34	Curb-Cut Rain Garden	Various locations in MR1	MR1	0.8-2.3	166-493	1.5-3.3	\$32,348 - \$81,860	\$675 - \$2,025	\$9,642 - \$10,562
9	MR3-B	45	Hydrodynamic Device	Riverdale Dr.	MR3	0.4	211	0.0	\$109,752	\$630	\$20,324
10	MR7-A	60	IESF Check Dam	US-10	MR7	0.2	15	0.0	\$15,448	\$365	\$58,662
11	MR4-A	49	IESF Check Dam	US-10	MR4	0.2	15	0.0	\$15,448	\$365	\$59,056
13	MR1-B	35	IESF Bench	Feldspar St. and Garnet St.	MR1	2.4	0	0.0	\$143,475	\$459	N/A
13	MR1-C	36	IESF Bench	Hematite Cir. and Garnet St.	MR1	7.6	0	0.0	\$235,035	\$1,377	N/A

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

Table 4: Rum River Network. Cost-effectiveness of retrofits with respect to TP reduction. 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	RR6-A	83	Infiltration Basin	142nd LN.	RR6	4.2 - 4.8	1,139 - 1,267	2.6 - 2.9	\$63,796 - \$83,796	\$225	\$560 - \$629
2	RR3-A	71	Curb-Cut Rain Garden	Waco St.	RR3	0.6 - 0.7	188 - 204	0.5	\$8,982	\$225	\$749 - \$874
3	RR8-A	89	Pond Modification	Rivers Bend Park	RR8	7.7	3,672	0.2	\$140,840 - \$215,840	\$900	\$779 - \$1,203
4	RR1-A	64	Curb-Cut Rain Garden	Oneida St.	RR1	0.4 - 0.5	111 - 118	0.6 - 0.7	\$8,982	\$225	\$1,049 - \$1,311
4	RR4-A	75	Curb-Cut Rain Garden	Waco St.	RR4	0.4 - 0.5	122 - 155	0.3 - 0.4	\$8,982	\$225	\$1,049 - \$1,311
6	RR2-A	67	Curb-Cut Rain Garden	Various locations in RR2	RR2	0.5 - 5.0	155 - 1,551	0.4 - 3.8	\$15,844 - \$90,112	\$225 - \$2,250	\$1,051 - \$1,506
7	RR5-A	79	Curb-Cut Rain Garden	142nd LN.	RR5	0.37 - 0.43	110 - 129	0.26 - 0.30	\$8,982	\$225	\$1,220 - \$1,417
8	RR7-A	86	Infiltration Basin	Rivers Bend Park Parking Lot	RR7	0.20 - 0.32	59 - 72	0.12 - 0.15	\$7,796 - \$9,796	\$225	\$1,724 - \$2,424
9	RR9-A	94	Hydrodynamic Device	St. Francis Blvd. and Bunker Lake Blvd.	RR9	0.7	364	0.0	\$55,752	\$630	\$3,555
10	RR4-B	76	Hydrodynamic Device	Waco St.	RR4	0.5	200	0.0	\$55,752	\$630	\$4,977
11	RR5-B	80	Hydrodynamic Device	142nd LN.	RR5	0.3	111	0.0	\$28,752	\$630	\$5,295
12	RR2-B	68	Hydrodynamic Device	Xkimo St.	RR2	0.8	322	0.0	\$109,752	\$630	\$5,361
13	RR3-B	72	Hydrodynamic Device	Waco St.	RR3	0.4	167	0.0	\$55,752	\$630	\$6,221
14	RR8-B	90	Hydrodynamic Device	142nd Ave.	RR8	0.2	108	0.0	\$28,752	\$630	\$7,942
15	RR8-C	91	Hydrodynamic Device	Xkimo St.	RR8	0.5	220	0.0	\$109,752	\$630	\$8,577

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

Table 5: Rum River Network. Cost-effectiveness of retrofits with respect to TSS reduction. 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	RR8-A	89	Pond Modification	Rivers Bend Park	RR8	7.7	3,672	0.2	\$140,840 - \$215,840	\$900	\$1,633 - \$2,522
2	RR6-A	83	Infiltration Basin	142nd LN.	RR6	4.2 - 4.8	1,139 - 1,267	2.6 - 2.9	\$63,796 - \$83,796	\$225	\$2,065 - \$2,382
3	RR4-A	75	Curb-Cut Rain Garden	Waco St.	RR4	0.4 - 0.5	122 - 155	0.3 - 0.4	\$8,982	\$225	\$3,383 - \$4,298
4	RR2-A	67	Curb-Cut Rain Garden	Various locations in RR2	RR2	0.5 - 5.0	155 - 1,551	0.4 - 3.8	\$15,844 - \$90,112	\$225 - \$2,250	\$3,387 - \$4,859
5	RR3-A	71	Curb-Cut Rain Garden	Waco St.	RR3	0.6 - 0.7	188 - 204	0.5	\$15,844	\$225	\$3,692 - \$4,006
6	RR5-A	79	Curb-Cut Rain Garden	142nd LN.	RR5	0.37 - 0.43	110 - 129	0.26 - 0.30	\$8,982	\$225	\$4,065 - \$4,767
7	RR1-A	64	Curb-Cut Rain Garden	Oneida St.	RR1	0.4 - 0.5	111 - 118	0.6 - 0.7	\$8,982	\$225	\$4,444 - \$4,724
8	RR9-A	94	Hydrodynamic Device	St. Francis Blvd. and Bunker Lake Blvd.	RR9	0.7	364	0.0	\$55,752	\$630	\$6,836
9	RR7-A	86	Infiltration Basin	Rivers Bend Park Parking Lot	RR7	0.20 - 0.32	59 - 72	0.12 - 0.15	\$7,796 - \$9,796	\$225	\$7,660 - \$8,218
10	RR4-B	76	Hydrodynamic Device	Waco St.	RR4	0.5	200	0.0	\$55,752	\$630	\$12,442
11	RR2-B	68	Hydrodynamic Device	Xkimo St.	RR2	0.8	322	0.0	\$109,752	\$630	\$13,318
12	RR5-B	80	Hydrodynamic Device	142nd LN.	RR5	0.3	111	0.0	\$28,752	\$630	\$14,310
13	RR8-B	90	Hydrodynamic Device	142nd Ave.	RR8	0.2	108	0.0	\$28,752	\$630	\$14,707
14	RR3-B	72	Hydrodynamic Device	Waco St.	RR3	0.4	167	0.0	\$55,752	\$630	\$14,901
15	RR8-C	91	Hydrodynamic Device	Xkimo St.	RR8	0.5	220	0.0	\$109,752	\$630	\$19,493

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 TP and/or TSS 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
- Iron-Enhanced Sand Filter Pond Bench
- Iron-Enhanced Sand Filter Check Dam
- Modification to an Existing Pond

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 6).

Table 6: 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 redirect it into shallow roadside basins. These curb-cut rain gardens can provide treatment for impervious surface runoff from one to many properties and can be located anywhere sufficient space is available. Because curb-cut rain gardens capture water that is already part of the stormwater drainage system, they are more likely to provide higher benefits. Generally, curb-cut rain gardens were proposed in areas without sufficient existing stormwater treatment and located immediately up-gradient of a catch basin serving a large drainage area. Bioinfiltration was solely proposed (as opposed to biofiltration) as the available soil information suggested infiltration rates could be sufficient to allow complete draw-down within 24-48 hours following a storm event (Figure 5).

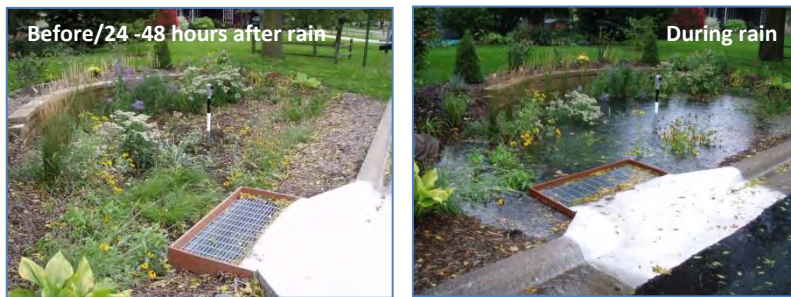


Figure 5: Rain garden before/after and during a rainfall event

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 garden at years 10 and 20. Annual maintenance was assumed to be completed by the landowner of the property at which the rain garden could be installed.

Boulevard Bioswale (NSS-E1)

One option for retrofitting a stormwater BMP within an existing boulevard is a bioswale. This practice is similar to the boulevard 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 6). Unlike rain gardens, these practices are typically much shallower (1-3” in depth) and have a curb-cut inlet and outlet (Figure 6). Although many rain gardens have outlets in the form of underdrains or risers, the bioswale outlet allows for a



Figure 6: Right-of-way bioswale installed in New York City (NYC Environmental Protection, 2013)

nearly continuous flow of 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 7). 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 ($\leq 3''$). Additional model inputs are noted in Appendix A.

Table 7: 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 would allow stormwater runoff to fill the basin and be filtered by the soil and vegetation.

Probable project cost includes installation of the project as well as promotion, administrative, and design costs, all in 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 7). 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 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.

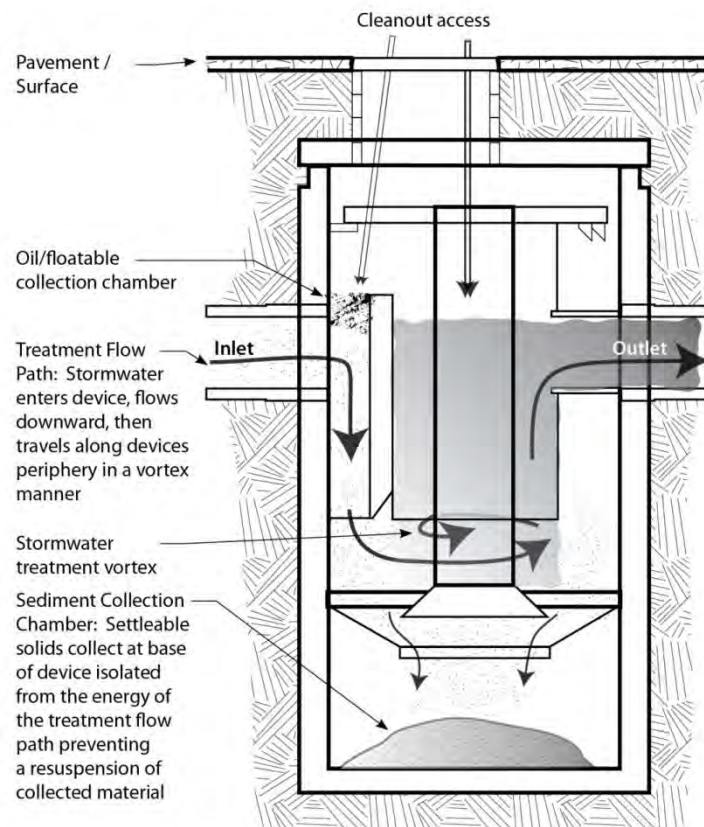


Figure 7: Schematic of a typical hydrodynamic device

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 8)". Locally, this practice has also gone by the name "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 8 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.

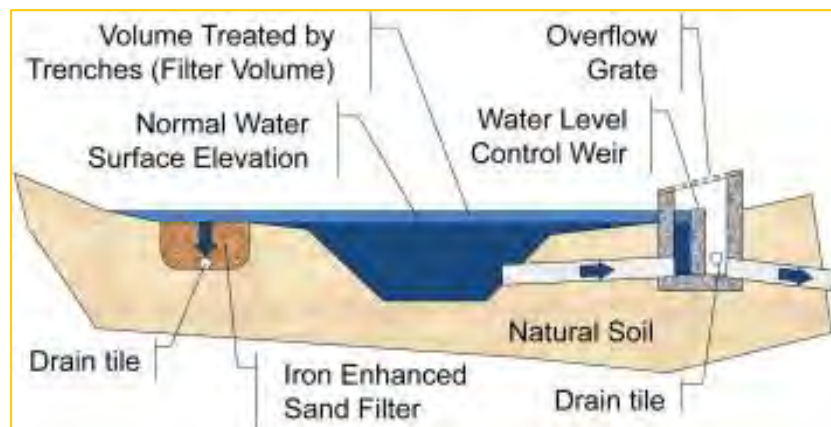


Figure 8: Iron Enhanced Sand Filter Concept (Erickson & Gulliver, 2010)

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.

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.

Iron Enhanced Sand Filter Check Dam

Permeable check dams provide additional treatment for pollutants within ditches and grassed waterways through two processes. First, the dams act as a barrier to flow through the channel, allowing sediment and particulate pollutants to drop out of solution upstream of the dam. This promotes infiltration and evaporation of stormwater as well. Second, any water retained behind the dam can seep through a sand filter located within the rock dam. The sand, mixed with iron filings (similar to an IESF pond bench), creates an opportunity for dissolved pollutant species to be filtered out of the stormwater runoff.



Figure 9: Rock check dams in a small ditch
(www.casfm.org/stormwater_committee/LID-Summary.htm)

These practices are often installed in a series, from two to a dozen practices depending on the length and slope of the ditch or waterway (Figure 9). For short ditch lengths a single check dam is often sufficient. The dams include an inner sand filter mixed with iron filings. The ratio of iron filings to sand should be between 5-8% by weight and these should be mixed thoroughly prior to installation. The sand-iron mix should be encased within a permeable membrane allowing for flow in and out of the filter. This filter is surrounded by rocks to promote settling and inhibit clogging of the filter.

It is recommended that these dams are installed such that the buried rock toe of the upstream dam is at the same elevation as the top of any downstream dams (Figure 10). This reduces the likelihood of scouring downstream of dams as water flowing over the dam intercepts ponded water rather than erodible soil. Also, the top of the most upstream dam should be installed below the outlet elevation of any pipe draining to the practice to ensure water does not back up into the upstream storm sewer infrastructure.

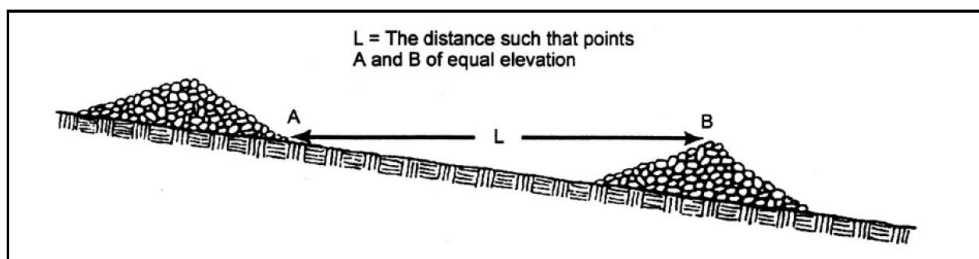


Figure 10: Check dam schematic (MPCA 2000)

The pollutant removal potential of permeable check dams was estimated using WinSLAMM. The ponding volume behind the dams was determined using LIDAR. Based on results of other IESFs, it was assumed that 80% of DP flowing through the dam was retained (Erickson & Gulliver, 2010). 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.

Modification to an Existing Pond

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

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

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

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

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

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

Catchment Profiles



Figure 11: The 448 acre drainage area was divided into 2 drainage networks, which were subdivided into a total of 16 catchments for this analysis. Catchment profiles on the following pages provide additional information.

Rum River Drainage Network

Catchment ID	Page
RR-1	62
RR-2	65
RR-3	69
RR-4	73
RR-5	77
RR-6	81
RR-7	84
RR-8	87
RR-9	92

Existing Network Summary	
Acres	127.7
Dominant Land Cover	Residential
Volume (ac-ft/yr)	61.3
TP (lb/yr)	62.5
TSS (lb/yr)	19,764



DRAINAGE NETWORK SUMMARY

This network includes all of the catchments that discharge to the Rum River explored in this analysis. Catchments were chosen based on each major outfall to the Rum River and were named in order from north to south using the ‘RR’ designator for ‘Rum River’. The outfalls are located (from north to south) at 153rd Ave. and Oneida St. (Catchment RR-1), 149th Ave. and Waco St. (RR-2), 147th Ln. and Waco St. (RR-3), Waco St. east of 143rd Ave. (RR-4), 142nd Ln south of Waco St. (RR-5), Rivers Bend Park north of the parking lot (RR-6) and south of the parking lot (RR-7), 142nd Ave. (RR-8), and Bunker Lake Blvd. (RR-9).

These nine catchments have a wide variety of land uses, including single-family and multi-family residential, commercial, parkland, and industrial. Soils are generally sandy, and range from fine sand loams (Becker series) to coarse sands (Duelm series).

EXISTING STORMWATER TREATMENT

Catchment boundaries and research areas within the Rum River drainage network were specifically chosen to locate and assess areas which were not already receiving stormwater treatment from constructed ponds and basins or wetlands. Only three existing BMPs were present within the nine catchments modeled. Two of these existing BMPs, stormwater retention ponds P19E304 in Catchment RR-1 and P25216 in Catchment RR-8, treat their entire respective catchments. The third BMP, street cleaning, is provided network-wide across all municipal streets by the City of Ramsey twice per year using mechanical sweepers. Additional detail for each of these BMPs is provided in the respective Catchment ID Pages.

Catchment RR-8

Existing Catchment Summary	
Acres	38.1
Dominant Land Cover	Residential
Parcels	68

CATCHMENT DESCRIPTION

This catchment contains a nearly even mix of single-family residential, commercial, and undeveloped land uses. Stormwater generated within this catchment is directed to a storm sewer network below 142nd Ave. which discharges into retention pond P25216 just east of Xkimo Street. The pond subsequently discharges into an oxbow lake adjacent to the Rum River.



EXISTING STORMWATER TREATMENT

Stormwater retention pond P25216 provides pollutant treatment for the entire 38-acre catchment. In addition to the pond, street cleaning is provided by the City of Ramsey twice per year with mechanical sweepers. Present-day stormwater pollutant loading and treatment is summarized in the table below.

<i>Existing Conditions</i>		Base Loading	Treatment	Net Treatment %	Existing Loading
<i>Treatment</i>	Number of BMPs	2			
	BMP Types	Stormwater Pond and Street Cleaning			
	TP (lb/yr)	19.0	2.9	15%	16.1
	TSS (lb/yr)	6,895	1,367	20%	5,528
	Volume (acre-feet/yr)	19.3	0.0	0%	19.3

PROPOSED RETROFITS OVERVIEW

Retention pond P25216 appears to be a natural depression which was retrofitted with an outlet control device to manage flow discharge. This pond could be modified to increase storage capacity to more sufficiently treat its developed drainage area.

Hydrodynamic devices were also proposed along the tertiary storm sewer lines on 142nd Ave and Xkimo St. These devices were purposefully sited to achieve contributing drainage areas of approximately 10 acres in size. This limits high peak discharges through the device that could cause sediment resuspension and decreased effectiveness.

RETROFIT RECOMMENDATIONS



Project ID: RR8-A

Rivers Bend Park Pond Modification

Drainage Area – 38.0 acres

Location – Rivers Bend Park south of 142nd Ave NW – Waco St. NW intersection

Property Ownership – Public

Site Specific Information – The existing pond, P25216 receives drainage from the entire catchment and is currently undersized to treat the contributing drainage area. An expansion and dredging of the pond is recommended to increase the permanent pool storage, thereby promoting sediment settling and phosphorus retention. Proposed increases in pond storage will increase permanent pool surface area from .11 acres to .82 acres and average ponding depth from 1 ft. to 6 ft. Cumulative pond storage volume could increase from an estimated 0.05 acre-feet to approximately 2.0 acre-feet.



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	3,100	cu-yards	3,100	cu-yards	3,100	cu-yards
	TP (lb/yr)	7.7	47.8%	7.7	47.8%	7.7	47.8%
	TSS (lb/yr)	3,672	66.4%	3,672	66.4%	3,672	66.4%
	Volume (acre-feet/yr)	0.2	1.0%	0.2	1.0%	0.2	1.0%
Cost	Administration & Promotion Costs*	\$5,840		\$5,840		\$5,840	
	Design & Construction Costs**	\$147,000		\$193,500		\$245,000	
	Total Estimated Project Cost (2016)	\$152,840		\$199,340		\$250,840	
	Annual O&M***	\$900		\$900		\$900	
Efficiency	30-yr Average Cost/lb-TP	\$779		\$980		\$1,203	
	30-yr Average Cost/1,000lb-TSS	\$1,633		\$2,055		\$2,522	
	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: RR8-B

142nd Ave.
Hydrodynamic Device

Drainage Area – 2.5 acres

Location – 142nd Ln. NW

Property Ownership – Public

Site Specific Information – A hydrodynamic device could be installed in-line with the storm sewer system to accept runoff from stormwater catch basins draining 142nd Ave NW and surrounding public and commercial properties.



Hydrodynamic Device			
Cost/Removal Analysis		New Treatment	% Reduction
Treatment	Number of BMPs	1	
	Total Size of BMPs	6 ft diameter	
	TP (lb/yr)	0.2	1.2%
	TSS (lb/yr)	108	2.0%
	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	\$7,942	
	30-yr Average Cost/1,000lb-TSS	\$14,707	
	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)

Project ID: RR8-C

Xkimo St.
Hydrodynamic Device

Drainage Area – 11.4 acres
Location – Xkimo St. NW
Property Ownership – Public
Site Specific Information – A hydrodynamic device could be installed in-line with the storm sewer system to accept runoff from stormwater catch basins draining Xkimo St. NW and the surrounding single-family residential and commercial properties.



Hydrodynamic Device			
		New Treatment	% Reduction
Cost/Removal Analysis			
Treatment	Number of BMPs	1	
	Total Size of BMPs	10 ft diameter	
	TP (lb/yr)	0.5	3%
	TSS (lb/yr)	220	4%
	Volume (acre-feet/yr)	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	\$19,493	
	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)

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