City of Isanti
Stormwater Retrofit Assessment

Prepared by:

ANOKA CONSERVATION DISTRICT

for the

CITY OF ISANTI

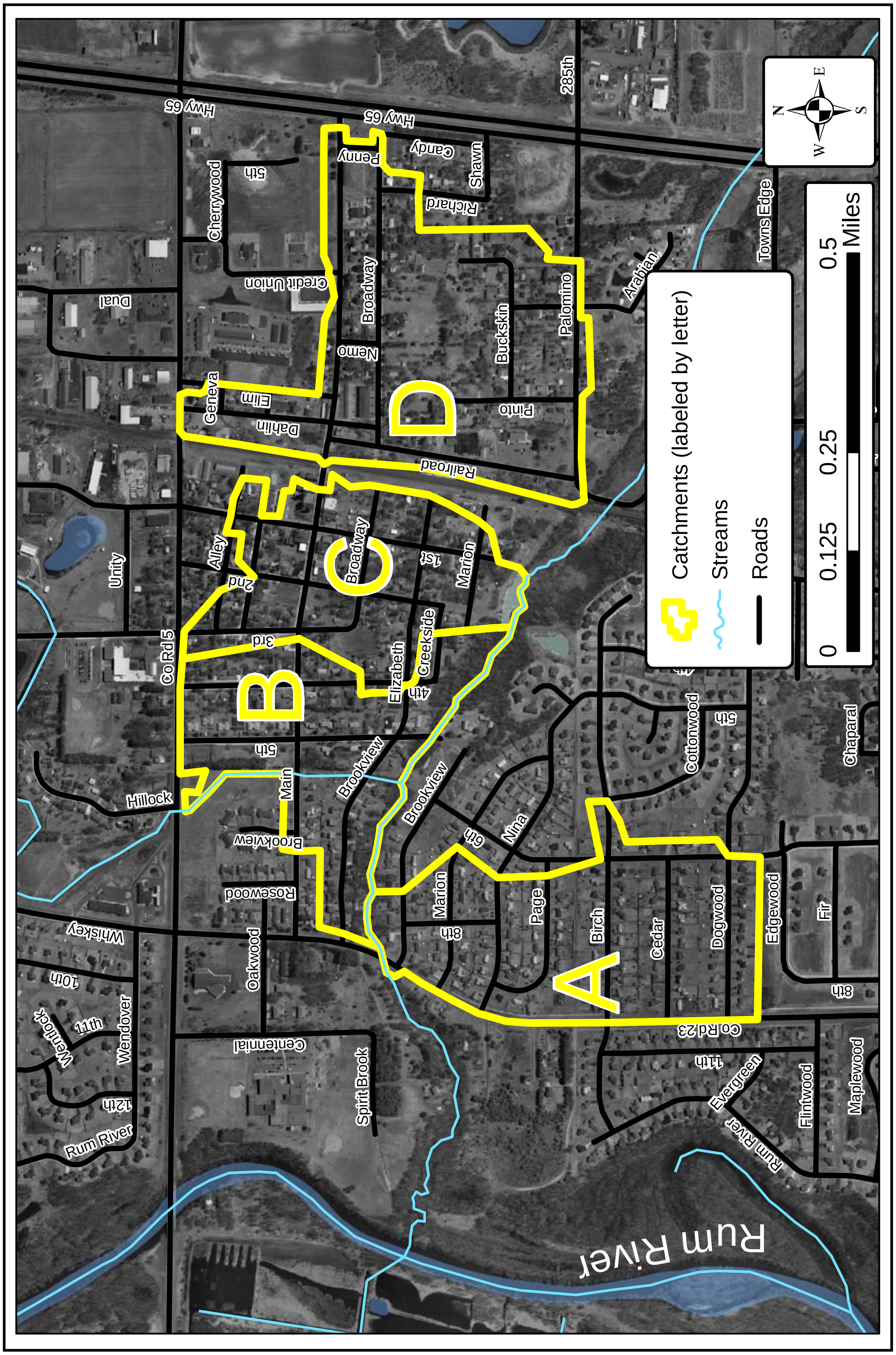
Project dollars provided by the Clean Water Fund (from the Clean Water, Land, and Legacy Amendment).

October, 2011

Cover photos: The Rum River in the City of Isanti. The City's stormwater conveyances discharge into the Rum River, and protecting the river's water quality is the focus of this report.

Contents

Map of stormwater catchment areas referred to in this report.



Executive Summary

This study provides recommendations for cost effectively improving treatment of stormwater from portions of the City of Isanti before it is discharged to the Rum River. The Rum River is regarded highly for its recreational qualities and scenic nature. While much of the City of Isanti discharges to the Rum River, only portions of the City were examined. Those examined are generally older areas built before modern-day stormwater treatment requirements. Some of these areas send stormwater to the river (via a creek) with little or no treatment. Generally, these are also the areas with the most impervious surfaces and land uses that are most likely to generate pollutants. We analyzed present day stormwater flows and treatment, and investigated projects to improve the quality of the water discharged to the Rum River.

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

We divided the study area, which was determined by city staff, into four drainage areas, or "catchments." For each catchment, we modeled stormwater volume and pollutants using the software WinSLAMM. First, we modeled existing conditions, including existing stormwater treatment practices. Currently, the 233 acre area contributes an estimated 85 acre feet of runoff, 92 pounds of phosphorus and 29,994 pounds of total suspended solids to the river each year. Then we modeled possible stormwater retrofits to estimate reductions in volume, total phosphorus (TP), and total suspended solids (TSS). Finally, we estimated the cost of each retrofit project, including 30-year lifespan operations and maintenance. Projects were ranked by cost effectiveness with respect to total phosphorus reduction.

Eight stormwater retrofit projects were identified. They included:

- Networks of curb cut rain gardens in each of three catchments,
- A large parking lot rain garden,
- Two modifications to an existing stormwater basins,
- Sand filters, and
- New stormwater ponds.

The table below summarizes potential projects. Potential projects are organized from most cost effective to least, based on cost per pound of total phosphorus removed.

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosphorus (TP) reduction. Total suspended solids (TSS) reduction is also shown. For more information on each project refer to the catchment profile pages later in this report.

Project ID	Catchment	Description (refer to catchment profile pages for more detail)	Optimal Project Sizing (lowest cost per lb phosphorus removed)	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Estimated Cost	Estimated cost per 1,000 lbs TSS/year (30-year)	Estimated cost per lb-TP/year (30-year)
1	D	Curb cut rain gardens. 4, 6, or 8 considered.	4 rain gardens	4.7 - 6.8	1,962 - 2,945	4.2 - 6.2	$20,380 - 38,940	$499 - 645	$208 - 280
2	B	Curb cut rain gardens. 6, 9 , or 12 considered.	6 rain gardens	6.5-8.5	1,983 - 2,637	5.3- 6.7	$29,660 - 57,500	$725 - 1,068	$220 - 332
3	A	Curb cut rain gardens. 6, 9 , or 12 considered.	6 rain gardens	5.4-7.7	1,684-2,408	4.2-6.1	$29,660 - 57,500	$855 - 1,170	$266 - 364
4	D	Outfall pond	only 80x100 ft size examined	12.2	6,218.0	0	$62,700 - 88,500	$690 - 973	$353 - 497
5	D	Federated Co-op basin - Add vertical riser to outlet	18" tall vertical riser	0.3	539.0	0	$1,560	$319	$611
6	D	Federated Co-op basin - Add vertical riser to outlet AND double basin area	18" tall vertical riser, only considered increasing basin width from 20-40 ft	0.4	635.0	0	$6,000	$504	$819
7	D	Rain garden at VFW parking lot	1000 sq ft rain garden	0.5	320.0	1	$23,960	$2,733	$1,648
8	D	Sand Filter at VFW parking lot	70 linear ft with water diversions	0.4	281.0	0	$20,410	$5,797	$4,077

Of the eight stormwater retrofits, the top five are recommended for serious consideration. These top five all have reasonably low cost per pound of pollutant captured. Aside from this ranking, the City will want to consider other factors when prioritizing projects for installation. Two projects in particular deserve special consideration. First, the addition of a vertical riser to an existing stormwater basin at the Federated Co-op Country Store ranked fifth at cost effectiveness for phosphorus capture, but is ranked first for solids capture and is the least expensive project. Second, the a new stormwater outfall pond for Catchment D ranks fourth at cost effectiveness for phosphorus capture and ranks second at suspended solids removal cost effectiveness, but this single project would capture far more pollutants than any of the other candidate projects. It would capture two times more solids and about 44% more phosphorus than the projects with the next highest pollutant removals.

If all of the top five stormwater retrofits are installed, the benefits to the Rum River would be significant. Nearly 30 pounds of phosphorus and over 12,000 pounds of suspended solids would be captured per year. This equates to a 32.6% reduction in phosphorus and 40% reduction in suspended solids being delivered to the Rum River from these portions of the City.

This report provides conceptual sketches or photos of recommended stormwater retrofitting projects. The intent is to provide an understanding of the approach. If a project is selected, site-specific designs must be prepared. This typically occurs after committed partnerships are formed to install the project. Committed partnerships must include willing landowners when installed on private property.

It is intended that the information in this report will not only help the City select projects, but also write effective grant applications for funding to install the projects.

About this Document

This Stormwater Retrofit Assessment is a watershed management tool to help prioritize stormwater retrofit projects by performance and cost effectiveness. This process helps maximize the value of each dollar spent.

Document Organization

This document is organized into three major sections, plus references and appendices. Each section is briefly described below.

Methods

The methods section outlines general procedures used when assessing the subwatershed. It overviews the processes of retrofit scoping, desktop analysis, retrofit reconnaissance investigation, cost/treatment analysis, and project ranking.

Catchment Profiles

The study areas in the City of Isanti were divided into stormwater catchments for the purpose of this assessment. Each catchment was given a unique ID letter. For each catchment, the following information is detailed:

Catchment Description

Within each catchment profile is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant and volume loads. A brief description of the land cover, stormwater infrastructure, and any other important general information is also described here. Existing stormwater practices are noted, and their estimated effectiveness presented.

Retrofit Recommendations

The recommendation section describes the conceptual retrofit(s) that were scrutinized. It includes tables outlining the estimated pollutant removals by each, as well as costs. A map provides promising locations for each retrofit approach.

Retrofit Ranking

This section ranks stormwater retrofit projects across all catchments to create a prioritized project list. The list is sorted by cost per pound of phosphorus removed for each project over the duration of 30 years. The final cost per pound of pollutant removed includes installation and maintenance costs.

There are many possible ways to prioritize projects, and the list provided in this report is merely a starting point. Other considerations for prioritizing installation may include:

- Non-target pollutant reductions
- Timing projects to occur with other road or utility work
- Project visibility
- Availability of funding
- Total project costs
- Educational value

References

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

Appendices

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

Methods

Selection of Subwatershed

Many factors are considered when choosing which subwatershed to assess for stormwater retrofits., but always focus on the drainage to an important lake, river, or stream. 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. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly. For some communities a stormwater assessment complements their MS4 stormwater permit. The focus is always on a high priority waterbody.

For this assessment, portions of the City of Isanti, Minnesota which drain to the Rum River were chosen for study. The Rum River is regarded highly for its recreational qualities and scenic nature. While much of the City of Isanti discharges to the Rum River, only portions of the City were examined. Those examined are generally older areas built before modern-day stormwater treatment requirements. Some of these areas send stormwater to the river (via a creek) with little or no treatment. Additionally, these are also the areas with the most impervious surfaces and land uses that are most likely to generate pollutants.

A portion of the study area was scheduled to undergo reconstruction of streets and sanitary sewers in mid-2011. This type of reconstruction and expansion of the storm sewer system is an opportune to install any additional stormwater treatment practices that are desired. Furthermore, in order to alleviate street flooding problems the street reconstruction project will add storm sewer in areas that previously had none, increasing the areas with a direct hydrological connection to the Rum River. While this water will be routed through the existing 2nd Avenue stormwater pond for treatment, we examined whether the pond had capacity to treat this new area (see page 24-25 for findings). We also scrutinized the entire reconstruction area for additional stormwater treatment recommendations. This catchment was analyzed in accelerated fashion so that the results would be available before the street reconstruction began.

Street ponding – An example of street ponding that is being alleviated in 2011 by the addition of storm sewer conveyances. This project also increases the area with a direct hydrological connection to the Rum River.


Before construction


During construction

Stormwater pollutants – Pollutants studied by this stormwater assessment were phosphorus and total suspended solids. Example sources include grass clippings (left), street grime (center), and runoff from rooftops, parking, and industrial (right).

Subwatershed Assessment Methods

The process used for this assessment is outlined below and was modified from the Center for Watershed Protection's *Urban Stormwater Retrofit Practices,* Manuals 2 and 3 (Schueler, 2005, 2007). Locally relevant design considerations were also incorporated into the process (*Minnesota Stormwater Manual*).

Step 1: Retrofit Scoping

Retrofit 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 assess in large subwatersheds, a focus area may be determined.

In this assessment, the focus area was specified by city staff. The study was restricted to certain areas south of County Road 5 and included downtown, older industrial areas, and residential neighborhoods. These are some of the oldest parts of town and therefore the most likely to have been built without modern day stormwater treatment practices. We divided this area into four catchments (drainage areas) using a combination of stormwater infrastructure maps and observed topography. Each catchment drains to a single outlet into a creek that then flows to the Rum River.

Targeted pollutants for this study were total phosphorus and total suspended solids. Total phosphorus is a nutrient commonly associated with stormwater that causes excessive algae production and low oxygen levels in lakes and rivers. Total suspended solids was also chosen as a target pollutant because it is also commonly associated with stormwater and causes turbidity in lakes and rivers. Suspended solids are also important because many other pollutants, such as heavy metals, are attached to the particles. Volume of stormwater was tracked throughout this study because it is necessary for pollutant loading calculations and retrofit project considerations.

Step 2: Desktop Retrofit Analysis

The 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 assessed because of existing stormwater infrastructure. 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, hydrology, soils, watershed/subwatershed boundaries, parcel boundaries, high-resolution aerial photography and the storm drainage infrastructure (with invert elevations).

For this assessment, digital records of stormwater infrastructure were obtained from the City of Isanti and utilized in GIS mapping software. High-resolution aerial photography and parcel boundaries were available from Isanti County. Fine topography data was not available.

Desktop retrofit analysis features to look for and associated potential stormwater retrofit projects.

Feature	Potential Retrofit Project
Existing Ponds	Add storage and/or improve water quality by excavating pond bottom, modifying riser, raising embankment, and/or modifying flow routing.
Open Space	New regional treatment (pond, bioretention).
Roadway Culverts	Add wetland or extended detention water quality treatment upstream.
Outfalls	Split flows or add storage below outfalls if open space is available.
Conveyance system	Add or improve performance of existing swales, ditches and non-perennial streams.
Large Impervious Areas (campuses, commercial, parking)	Stormwater treatment on site or in nearby open spaces.
Neighborhoods	Utilize right of way, roadside ditches, curb-cut rain gardens, or filtering systems to treat stormwater before it enters storm drain network.

Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through the desktop search, a field investigation was conducted to evaluate each site and identify additional opportunities. During the investigation, the drainage area and 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 reveal additional retrofit opportunities that went unnoticed during the desktop search.

General list of stormwater BMPs considered for each catchment/site.

Stormwater Treatment Options for Retrofitting		
Area Treated	Best Management Practice	Potential Retrofit Project
5-500 acres	Extended Detention	12-24 hr detention of stormwater with portions drying out between events (preferred over wet ponds). May include multiple cell design, infiltration benches, sand/peat/iron filter outlets and modified choker outlet features.
	Wet Ponds	Permanent pool of standing water with new water displacing pooled water from previous event.
	Wetlands	Depression less than 1-meter deep and designed to emulate wetland ecological functions. Residence times of several days to weeks. Best constructed off-line with low-flow bypass.
0.1-5 acres	Bioretention	Use of native sol, soil microbe and plant processes to treat, evapotranspirate, and/or infiltrate stormwater runoff. Facilities can either be fully infiltrating, fully filtering or a combination thereof.
	Filtering	Filter runoff through engineered media and passing it through an under-drain. May consist of a combination of sand, soil, compost, peat, and iron.
	Infiltration	A trench or sump that is rock-filled with no outlet that receives runoff. Stormwater is passed through a conveyance and pretreatment system before entering infiltration area.
	Swales	A series of vegetated, open channel practices that can be designed to filter and/or infiltrate runoff.
	Other	On-site, source-disconnect practices such as rain-leader disconnect rain gardens, rain barrels, green roofs, cisterns, stormwater planters, dry wells, or permeable pavements.

Step 4: Treatment Analysis/Cost Estimates

Sites most likely to be conducive to addressing the City's goals and appear to have simple-to-moderate design, installation, and maintenance were chosen for a cost/benefit analysis. Estimated costs included design, installation, and maintenance annualized across a 30-year period. Estimated benefits included are pounds of phosphorus and total suspended solids removed, though projects were ranked only by cost per pound of phosphorus removed annually.

Treatment analysis

Each proposed project's pollutant removal estimates were obtained using the stormwater model 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 is useful for determining the effectiveness of proposed stormwater control practices. It has detailed accounting of pollutant loading from various land uses, and allows the user to build a model "landscape" that reflects the actual landscape being considered. The user is allowed to place a variety of stormwater treatment practices that treat water from various parts of this landscape. It uses rainfall and temperature data from a typical year, routing stormwater through the user's model for each storm.

A "base" model was created which estimated pollutant loading from each catchment in its present-day state. To accurately model the land uses in each catchment, we delineated each land use in each catchment using ArcGIS, and assigned each a WinSLAMM standard land use file. A site specific land use file was created by adjusting total acreage and converting to "sand" soils to account for the sandy soils in the City of Isanti. For catchments with multiple standard land use files, these were combined using the software's batch processing capability. 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. For certain source areas critical to our models we verified that model estimates were accurate by calculating actual acreages in ArcGIS, and adjusting the model acreages if needed.

Once the "base" model was created, each proposed stormwater treatment practice was added to the model and pollutant reductions were generated. 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 we modeled each practice individually, and the benefits of projects may not be additive, especially if serving the same area. Reported treatment levels are dependent upon optimal site selection and sizing.

It should be noted that we used the stormwater modeling program P8 instead of WinSLAMM in catchment C. There, a newer stormwater pond is at the south end of 2nd Avenue just before the catchment outlets into the creek. This pond has a forebay and main basin which cannot be accurately modeled in WinSLAMM so P8 was used. We did use WinSLAMM to verify the P8 estimates of pollutant generation from the landscape were consistent between the models. We found the discrepancy between models was 4% for total phosphorus and 8% for suspended solids, which we felt was acceptable. In this report only the P8 results are presented, and the reader can know these are comparable to the WinSLAMM modeling used elsewhere in the report.

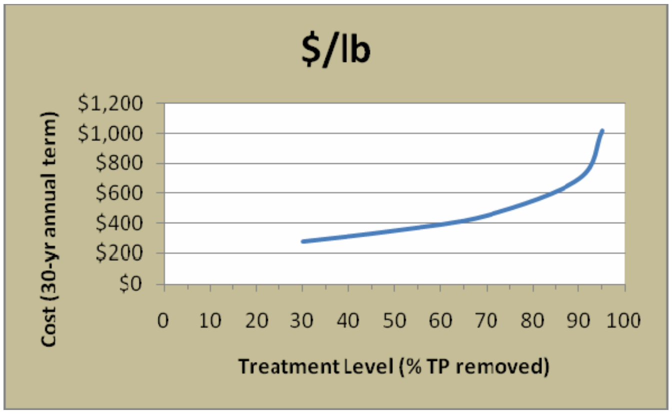
WinSLAMM stormwater computer model inputs

General WinSLAMM Model Inputs	
Parameter	**File/Method**
Land use acreage	ArcGIS
Precipitation/Temperature Data	Minneapolis 1959 – the rainfall year that best approximates 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.

Cost Estimates

Cost estimates were annualized costs that incorporated design, installation, installation oversight, and maintenance over a 30-year period. 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 assessment, and therefore cost estimates account for only general site considerations.

The costs associated with several different pollution reduction levels were calculated. Generally, more or larger practices result in greater pollution removal. However the costs of obtaining the highest levels of treatment are often prohibitively expensive (see figure). By comparing costs of different treatment levels, the city and/or watershed organization can best choose the project sizing that meets their goals.



Step 5: Evaluation and Ranking

The cost per pound of phosphorus treated was calculated for each potential retrofit project, and projects were ranked by this cost effectiveness measure. Only projects that seem realistic and feasible were considered. The recommended level was the level of treatment that would yield the greatest benefit per dollar spent while being considered feasible and not falling below a minimal amount needed to justify crew mobilization and outreach efforts. Local officials may wish to revise the recommended level based on water quality goals, finances, or public opinion.

Catchment Profiles

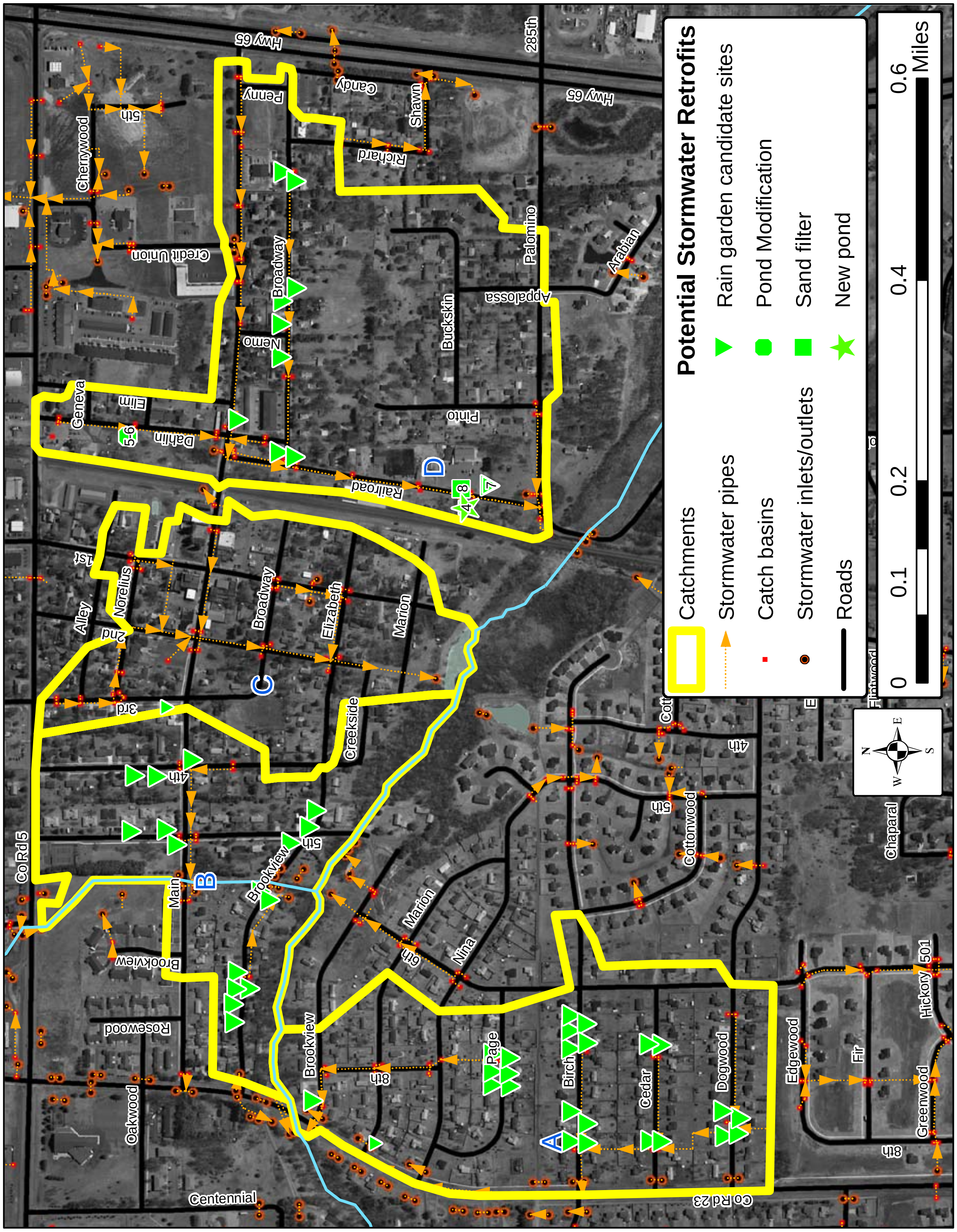
The following pages provide information for each stormwater catchment area analyzed. Each catchment profile includes:

- Summary of existing conditions, including existing stormwater infrastructure, and estimated pollutant export to the Rum River
- Map of the catchment
- Recommended stormwater retrofits, pollutant reductions, and costs.

Catchment profiles are provided for the four catchments analyzed. Please refer to the catchment summary map on the following page.

Following all of the catchment profiles is a summary table that ranks all projects in all catchments by cost effectiveness.

Map of stormwater catchment areas (A-D) and potential retrofit projects referred to in this report. The number on top of a potential project represents its ranking with respect to the cost per pound of total phosphorus removed per year, except that rain garden candidate sites are not individually ranked. Catchment profiles on the following pages provide additional detail.



Catchment A

Existing Catchment Summary	
Acres	60.21
Dominant Land Cover	Residential
Parcels	151
Volume (acre-feet/yr)	21.02
TP (lb/yr)	25.83
TSS (lb/yr)	7737.61

CATCHMENT DESCRIPTION

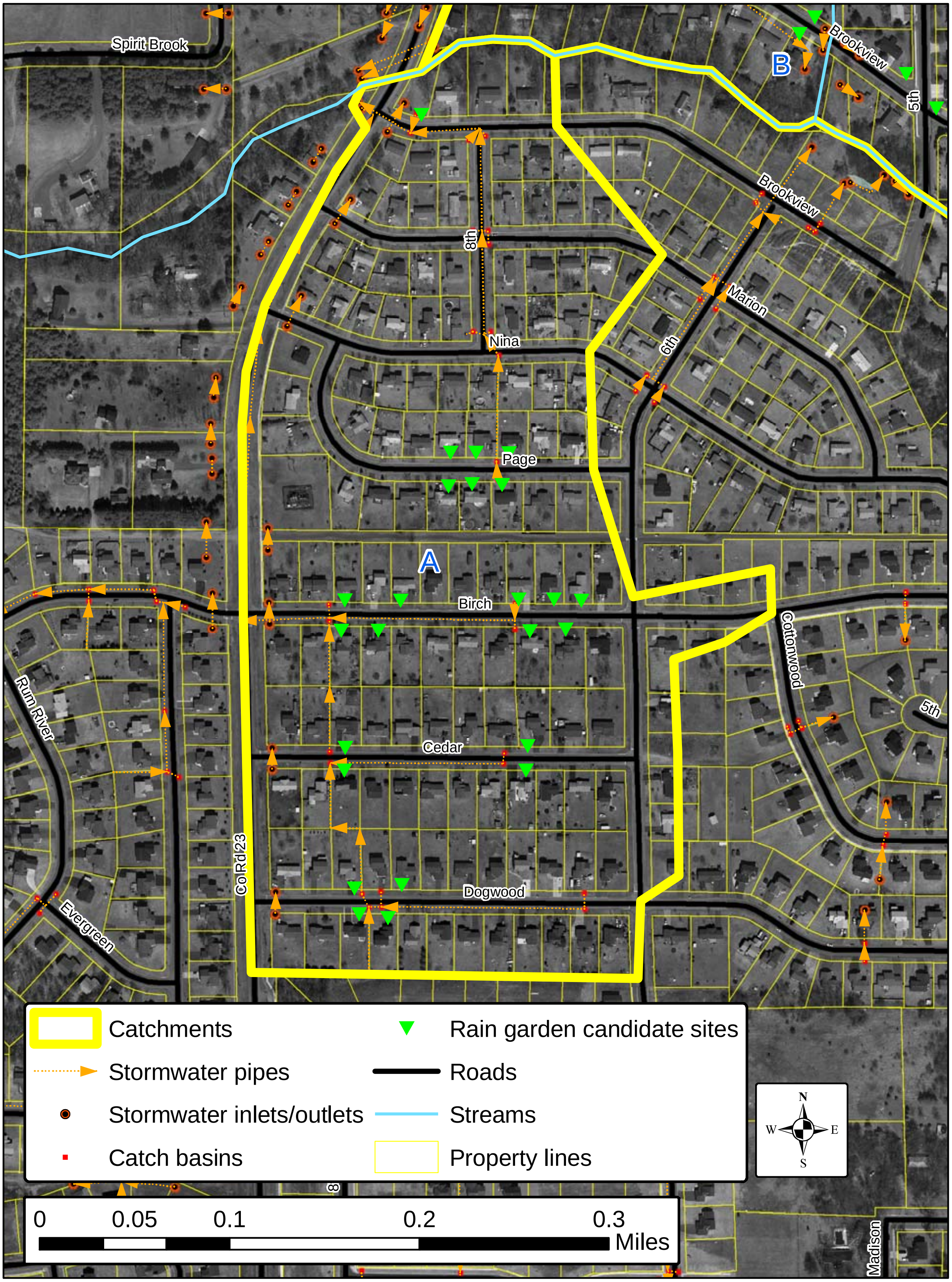
Catchment A is entirely medium density, single-family residential development. It is bordered on the west by Whiskey Road (CR 23) and on the east generally by 6th Avenue SW. All stormwater flows toward Whiskey Road, northward, and then outlets into the creek near the intersection of Whiskey Road and South Brookview Lane. The creek flows to the Rum River about 0.4 miles to the west.

EXISTING STORMWATER TREATMENT

There are two existing stormwater treatment practices within catchment A. First is street sweeping. The second is roadside ditch swales on the east side of Whiskey Road. These roadside ditch swales, are simply open channel conveyances for stormwater from 9.8 acres of the Whiskey Road surface and adjacent homes. Because of the vegetation in the swales and sandy soils they afford some treatment. Pollutant loads from this catchment to the Rum River after existing treatment are shown in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	33.3	7.4	22%	**25.8**
	TSS (lb/yr)	10,282	2,544.0	25%	**7,738**
	Volume (acre-feet/yr)	25.1	4.1	16%	**21.0**
	Number of BMP's	2			
	BMP Size/Description	Mechanical Street Sweeping (Spring and Fall) and Whiskey Road Swales			

CATCHMENT A MAP AND RETROFIT RECOMMENDATIONS



Proposed Project 3 - Curb-cut Rain Gardens
Drainage Area – 60.21 acres

Locations – See map for candidate rain garden locations

Property Ownership – Private

Description – This project ranked 3rd for cost effectiveness at removing phosphorus among all projects identified in this assessment. The proposed project is a network of curb-cut rain gardens installed in residential front yards. The rain gardens collect and infiltrate curbside stormwater flows until they fill. The gardens are designed to hold water for no more than 48 hours after a storm, but the ponding time is often much shorter in cities like Isanti with sandy soils. When the rain garden is full, water will bypass to a catch basin.

These rain gardens are best placed immediately up-gradient of catch basins, and where there are at least three developed properties up-gradient. 24 favorable sites have been identified (see map). These are clustered at locations that would treat water before it reaches nine catch basins; most locations would require only one rain garden to sufficiently treat stormwater flowing to the catch basin. A landowner who is willing to allow the rain garden and provide minor maintenance is required at each location. Understanding that not all landowners will find this acceptable, we've analyzed scenarios where 6, 9, and 12 rain gardens are installed (see table on following page).

The results indicate that it would be most cost effective to install six rain gardens (lowest cost per pound of phosphorus removed). After the first six rain gardens, the cost per pound of phosphorus removed increases. Still, the cost effectiveness of additional rain gardens is better than for many other proposed retrofits throughout this report.

See Appendix B for rain garden design options.

Conceptual and example images –

Before

After

Before rain

During rain

	Cost/Benefit Analysis	Project ID					
		6 Rain Gardens		9 Rain Gardens		12 Rain Gardens	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	5.4	39%	6.8	43%	7.7	46%
	TSS (lb/yr)	1,684	41%	2,127	45%	2,408	48%
	Volume (acre-feet/yr)	4.2	33%	5.4	38%	6.1	41%
	Number of BMP's	6		9		12	
	BMP Size/Description	1,500 sq ft		2,250 sq ft		3,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$27,210		$40,710		$54,210	
	Promotion & Admin Costs	$2,450		$2,870		$3,290	
	Total Project Cost	$29,660		$43,580		$57,500	
	Annual O&M	$450		$675		$900	
	Term Cost/1,000lb-TSS/yr	$855		$1,000		$1,170	
	Term Cost/lb-TP/yr	**$266**		**$313**		**$364**	

No other stormwater retrofits are recommended for Catchment A. While other practices might be beneficial, they are not practical in this fully-developed residential neighborhood.

Catchment B

Existing Catchment Summary	
Acres	46.45
Dominant Land Cover	Residential
Parcels	99
Volume (acre-feet/yr)	17.05
TP (lb/yr)	21.13
TSS (lb/yr)	6305.93

DESCRIPTION

Catchment B is primarily comprised of medium density residential development. It also includes parts of Mattson Park. Stormwater is directed through the curb-and-gutter system into the creek systems, which drain to the Rum River.

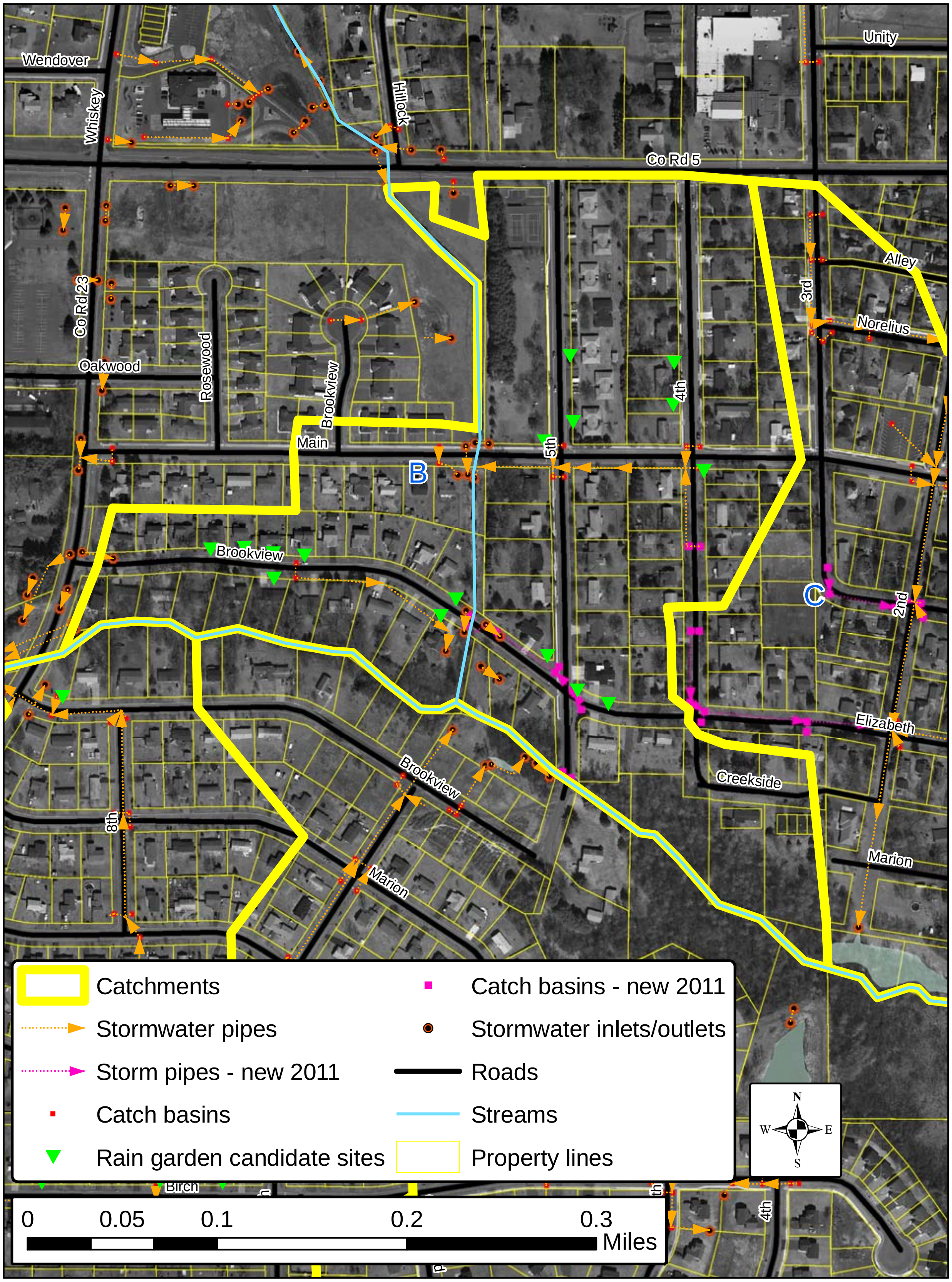
Part of Catchment B was subject to street and sewer reconstruction in 2011. This work began during this stormwater assessment. All analyses in the stormwater assessment are based on a post-construction alignment of stormwater infrastructure. The reconstruction work did not result in changes to the drainage area nor did it add stormwater treatment.

EXISTING STORMWATER TREATMENT

The only existing stormwater treatment in Catchment B is street sweeping. Estimated pollutant reductions by the existing stormwater treatment are shown in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	22.7	1.6	7%	**21.1**
	TSS (lb/yr)	6,981	674.8	10%	**6,306**
	Volume (acre-feet/yr)	17.0	0.0	0%	**17.0**
	Number of BMP's	1			
	BMP Size/Description	Mechanical Street Sweeping (Spring and Fall)			

CATCHMENT B MAP AND RETROFIT RECOMMENDATIONS



Proposed Project 2 **-** Curb-cut Rain Gardens
Drainage Area – 46.45 acres

Locations – See map

Property Ownership – Private, except one public (Mattson Park)

Description – This project ranked 2nd for cost effectiveness at removing phosphorus among all projects identified in this assessment. The proposed project is a network of curb-cut rain gardens installed in residential front yards. The rain gardens collect and infiltrate curbside stormwater flows until they fill. The gardens are designed to hold water for no more than 48 hours after a storm, but the ponding time is often much shorter in cities like Isanti with sandy soils. When the rain garden is full, water will bypass to a catch basin.

These rain gardens are best placed immediately up-gradient of catch basins, and where there are at least three developed properties up-gradient. 16 favorable sites have been identified (see map). These are clustered at locations that would treat water before it reaches 11 catch basins; most locations would require only one rain garden to sufficiently treat stormwater flowing to the catch basin. A landowner who is willing to allow the rain garden and provide minor maintenance is required at each location. Understanding that not all landowners will find this acceptable, we've analyzed scenarios where 6, 9, and 12 rain gardens are installed (see table on following page).

The results indicate that it would be most cost effective to install six rain gardens (lowest cost per pound of phosphorus removed). After the first six rain gardens, the cost per pound of phosphorus removed increases. Still, the cost effectiveness of these additional rain gardens is better than for many other proposed retrofits throughout this report.

See Appendix B for rain garden design options.

Conceptual and example images -

Before rain

During rain

	Cost/Benefit Analysis	Project ID					
		6 Rain Gardens		9 Rain Gardens		12 Rain Gardens	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	6.5	36%	7.2	38%	8.5	44%
	TSS (lb/yr)	1,983	38%	2,238	42%	2,637	47%
	Volume (acre-feet/yr)	5.3	31%	5.6	33%	6.7	39%
	Number of BMP's	6		9		12	
	BMP Size/Description	1,500 sq ft		2,250 sq ft		3,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$27,210		$40,710		$54,210	
	Promotion & Admin Costs	$2,450		$2,870		$3,290	
	Total Project Cost	$29,660		$43,580		$57,500	
	Annual O&M	$450		$675		$900	
	Term Cost/1,000lb-TSS/yr	$725		$951		$1,068	
	Term Cost/lb-TP/yr	**$220**		**$297**		**$332**	

Catchment C

Existing Catchment Summary	
Acres	45.75
Dominant Land Cover	Residential, Downtown
Parcels	119
Volume (acre-feet/yr)	8.03
TP (lb/yr)	5.10
TSS (lb/yr)	503.00

DESCRIPTION

Catchment C includes downtown Isanti and surrounding residential neighborhoods.

Portions of Catchment C were subject to street and sewer reconstruction in 2011. This work began during this stormwater assessment. All analyses in the stormwater assessment are based on a post-construction alignment of stormwater infrastructure. The reconstruction work did result in an increased area being served by storm sewer; previously those areas drained to the roadside and created street ponding issues at certain locations. After reconstruction this new area drains to the catchment's outfall pond, at the south end of 2nd Avenue (2nd Avenue pond).

EXISTING STORMWATER TREATMENT

While street sweeping does occur, the primary treatment for this catchment is a stormwater pond (2nd Avenue Pond) located at the outfall into the creek. A 2011 street reconstruction project is increasing the area that drains to this pond. We examined this pond's effectiveness at removing pollutants before and after the street reconstruction project. This was completed in spring 2011 so that any deficiencies could be addressed during the construction process. In our analyses, we asked, "does the 2nd Avenue pond have capacity to treat the new stormwater drainages being directed to it?"


2nd Avenue Pond.

The table on the following page compares pollutant removal efficiencies for the 2nd Avenue pond before and after the 2011 street reconstruction project (see table below). Total phosphorus (TP) removal efficiency is estimated at 84.9% before street reconstruction and 81.8% afterward. Total suspended solids (TSS) removal efficiency is estimated at 95.6% before street reconstruction and 94.1% afterward. These are high levels of pollutant removal. The differences in pollutant removal before and after construction are small. In our opinion, the 2nd Avenue pond does have the capacity to treat new drainage areas added by the reconstruction project.

Furthermore, the pond removes the majority of targeted pollutants. Catchment C discharges less volume, phosphorus (TP), and total suspended solids (TSS) than any of the other catchments studied.

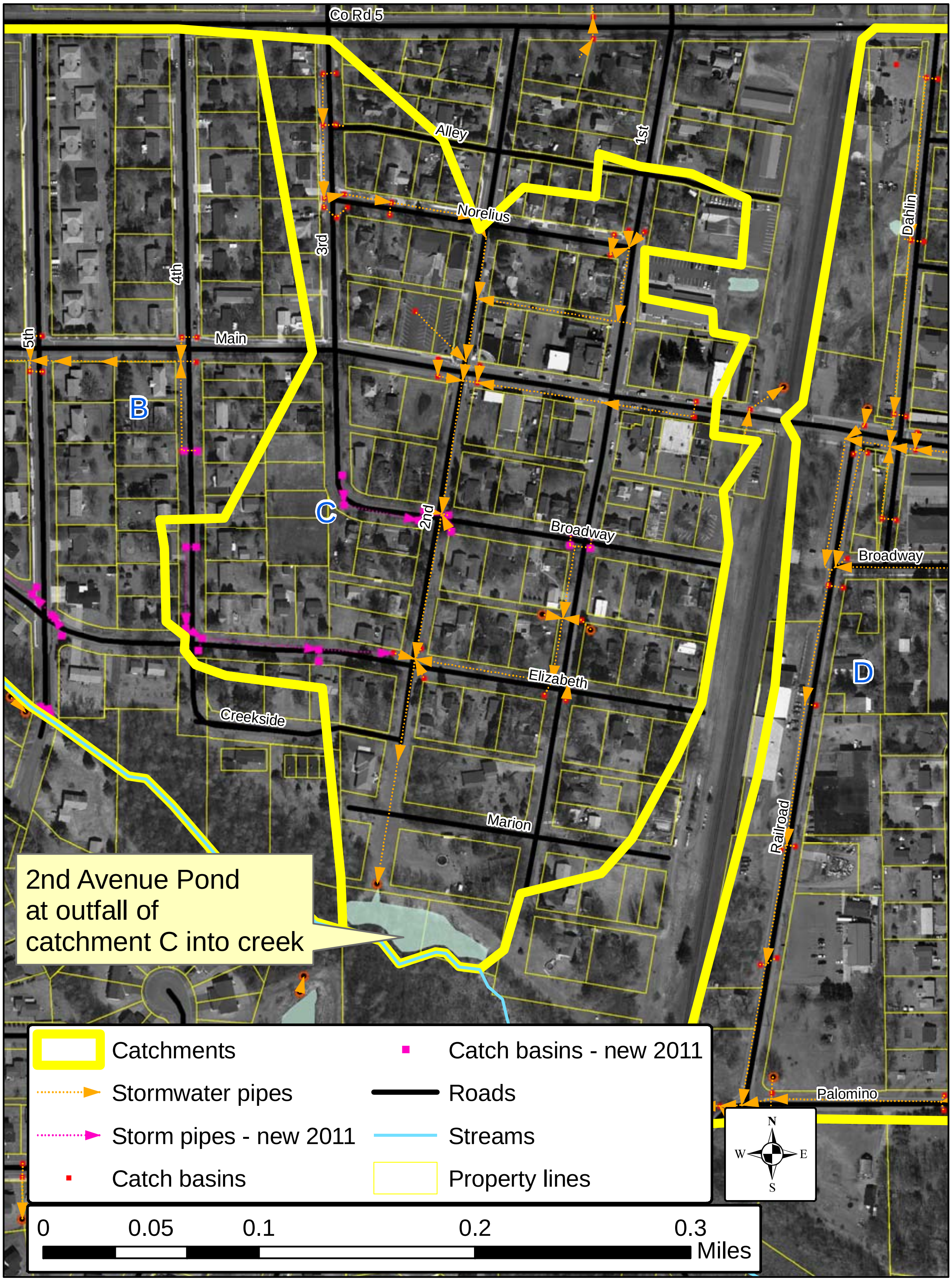
Compared to Catchment B, which had the next lowest pollutant discharge, Catchment C discharged one-twelfth the TSS and one-fourth the TP. Additional stormwater treatment would not be cost effective. Stormwater retrofitting efforts should focus on other catchments. No stormwater retrofits are recommended in Catchment C. The 2nd Avenue pond should be inspected and maintained at regular intervals to ensure high performance.

Comparison of treatment efficiency of the 2nd Avenue pond at the outfall of Catchment C (a) before and (b) after 2011 street and storm sewer reconstruction.

Before 2011 Street and Storm Sewer Reconstruction	Volume			TSS			TP		
	Inflow	Trapped	%reduction	Inflow	Trapped	%reduction	Inflow	Trapped	%reduction
Pipe IN	22.0	0.0	0.0%	7,231	0	0.0%	23.8	0.0	0.0%
Forebay	22.0	6.6	30.0%	7,231	5,441	75.2%	23.8	12.2	51.3%
Pond	15.4	9.5	61.7%	1,790	1,470	82.2%	11.4	8.0	70.2%
Pipe OUT	5.8	0.0	0.0%	319	0	0.0%	3.1	0.0	0.0%
Overall	22.0	16.1	73.2%	7,231	6,911	95.6%	23.8	20.2	84.9%

After 2011 Street and Storm Sewer Reconstruction	Volume			TSS			TP		
	Inflow	Trapped	%reduction	Inflow	Trapped	%reduction	Inflow	Trapped	%reduction
Pipe IN	25.3	0.0	0.0%	8,591	0	0.0%	28.0	0.0	0.0%
Forebay	25.3	6.7	26.5%	8,591	6,158	71.7%	28.0	13.1	46.8%
Pond	18.5	10.5	56.8%	2,433	1,930	79.3%	14.6	9.8	67.1%
Pipe OUT	8.0	0.0	0.0%	503	0	0.0%	4.5	0.0	0.0%
Overall	25.3	17.2	68.0%	8,591	8,088	94.1%	28.0	22.9	81.8%

CATCHMENT C MAP **No stormwater retrofits are proposed for this catchment because the existing outfall pond provides adequate stormwater treatment.**



Catchment D

Existing Catchment Summary	
Acres	80.28
Dominant Land Cover	Residential
Parcels	138
Volume (acre-feet/yr)	38.62
TP (lb/yr)	39.96
TSS (lb/yr)	15,447.90

DESCRIPTION

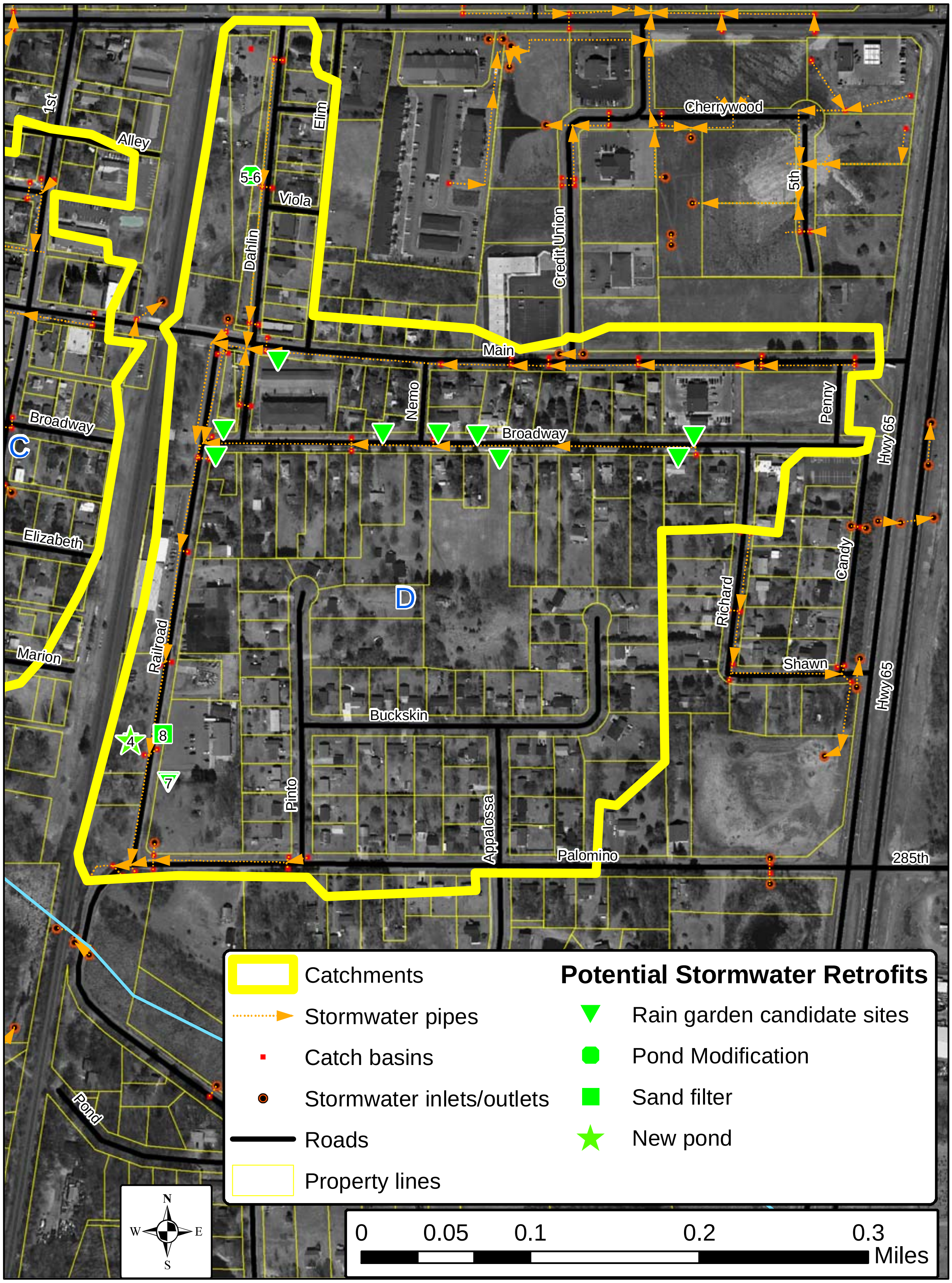
Catchment D includes single family residential, commercial, and retail parcels. Most of the area is served by curb-and-gutter stormwater conveyances, however residential areas along Buckskin, Pinto, and Appolossa Streets rely only on roadside infiltration. The stormwater conveyances in this catchment outlet into a creek at the south end of the catchment, near the intersection of Railroad Avenue and Palomino Road. The creek flows to the Rum River.

EXISTING STORMWATER TREATMENT

Existing stormwater treatment in Catchment D includes street sweeping and a small stormwater basin. The stormwater basin is located on the south side of the Federated Co-op Country Store. This new pond was built in approximately 2008 when the old Co-op buildings were replaced with new buildings and parking. It serves most of that rooftop and parking area. The pond is approximately 50x20ft with an inlet and outlet pipe. The outlet is the same diameter as the inlet and two feet lower, so this "pond" really behaves more like a 50 foot long swale; it does not detain water. Some sediment has accumulated in the basin's bottom, and is this slowing the infiltration rate within the basin. Estimated pollutant reductions by the existing stormwater treatment are shown in the table below.

	Existing Conditions	Base Loading	Treatment	Net Treatment %	Existing Loading
Treatment	TP (lb/yr)	42.3	2.3	6%	**40.0**
	TSS (lb/yr)	16,453	1,005.4	6%	**15,448**
	Volume (acre-feet/yr)	39.0	0.4	1%	**38.6**
	Number of BMP's	2			
	BMP Size/Description	Mechanical Street Sweeping (Spring and Fall) and Federated Co-operative Basin			

CATCHMENT D MAP AND RETROFIT RECOMMENDATIONS **Retrofits, except candidate rain garden sites, are labeled with their project ID number (cost effectiveness rank).**



Proposed Project 1 **-** Curb-cut Rain Gardens

Drainage Area – 80.28 acres

Locations – See map

Property Ownership – Private

Description – This project ranked 1st for cost effectiveness at removing phosphorus among all projects identified in this assessment. The proposed project is a network of curb-cut rain gardens. The rain gardens collect and infiltrate curbside stormwater flows until they fill. The gardens are designed to hold water for no more than 48 hours after a storm, but the ponding time is often much shorter in cities like Isanti with sandy soils. When the rain garden is full, water will bypass to a catch basin.

These rain gardens are best placed immediately up-gradient of catch basins, and where there are at least three developed properties up-gradient. Nine favorable sites have been identified (see map). Only two of these sites would duplicate each other (i.e. only one of these should be done). Of the nine sites, six have no sidewalk, making installation of a rain garden substantially easier. A landowner who is willing to allow the rain garden and provide minor maintenance is required at each location. Considering these factors, we've analyzed scenarios where 4, 6, or 8 rain gardens are installed (see table on following page).

The results indicate that it would be most cost effective to install four rain gardens (lowest cost per pound of phosphorus removed). Additional rain gardens would carry a higher price per pound of phosphorus removed than the first four gardens, but still a lower price than any of the other stormwater retrofits considered in this assessment.

See Appendix B for rain garden design options.

Conceptual and example images -

Before rain

During rain

	Cost/Benefit Analysis	Project ID					
		4 Rain Gardens		6 Rain Gardens		8 Rain Gardens	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	4.7	17%	6.1	20%	6.8	22%
	TSS (lb/yr)	1,962	18%	2,488	21%	2,945	24%
	Volume (acre-feet/yr)	4.2	12%	5.6	15%	6.2	17%
	Number of BMP's	4		6		8	
	BMP Size/Description	1,000 sq ft		1,500 sq ft		2,000 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$18,210		$27,210		$36,210	
	Promotion & Admin Costs	$2,170		$2,450		$2,730	
	Total Project Cost	$20,380		$29,660		$38,940	
	Annual O&M	$300		$450		$600	
	Term Cost/1,000lb-TSS/yr	$499		$578		$645	
	Term Cost/lb-TP/yr	**$208**		**$236**		**$280**	

Proposed Project 4 **-** New Catchment Outfall Pond
Drainage Area – 80.28 acres

Locations – See map

Property Ownership – Private, property purchase by public entity would be needed for this project

Description – This project ranked 4th for cost effectiveness at removing phosphorus among all projects identified in this assessment, and 2nd for cost effectiveness at removing suspended solids. While this alone is reason to consider installing this project, it is even more noteworthy that it would remove far more pollutants than any of the other projects. In fact, it would remove two times more solids and about 44% more phosphorus than the projects with the next highest pollutant removals. Because this single project would keep more pollutants out of the Rum River than any other project, it deserves serious consideration.

Larger wet detention ponds are often a cost effective means to treat the entire drainage area if placed just before the outfall into a waterbody. In catchment D, a publicly parcel located near the outfall into the creek is vacant (see map). This site at the NW quadrant of the intersection of Railroad Avenue and Palomino Street was considered for a wet detention pond.

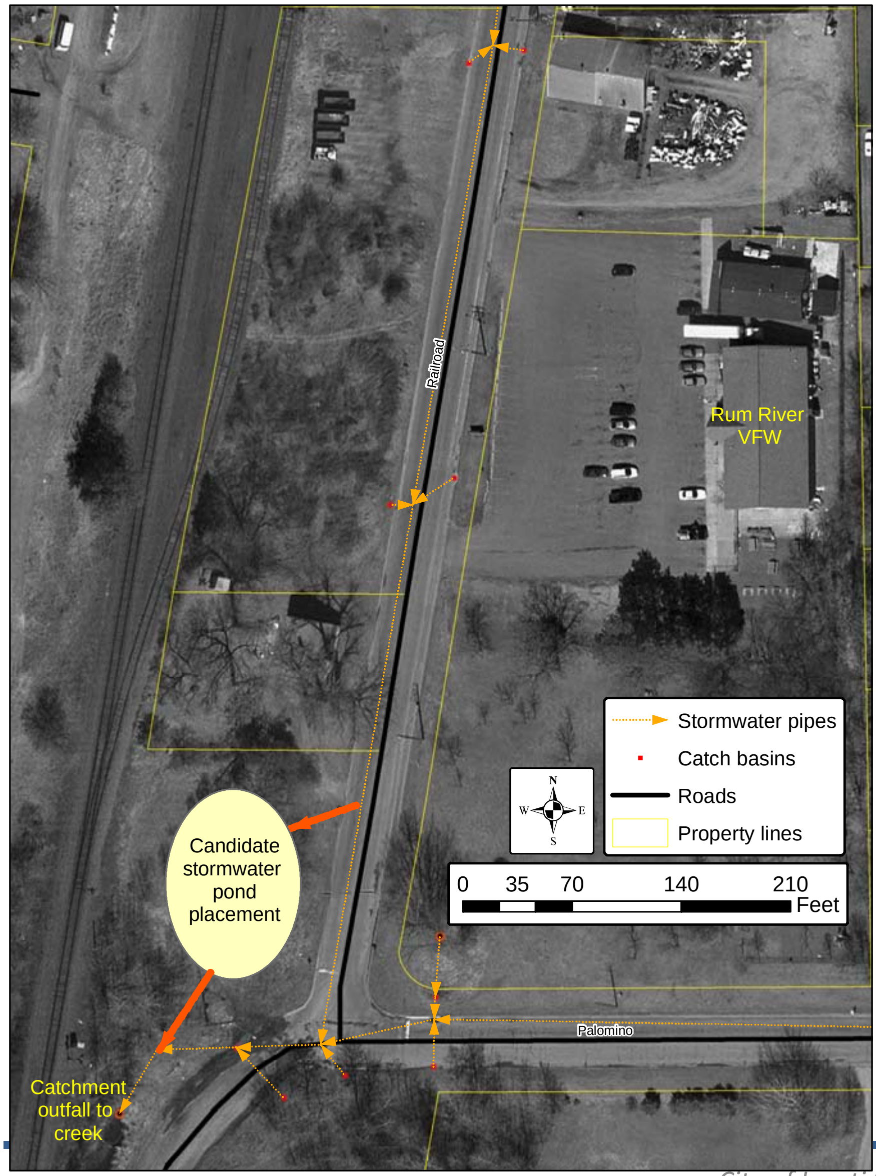
The property in question is located across the street and slightly south from the Rum River VFW Post, on the west side of Railroad Avenue. The parcel is over one acre in size. A 100x80 ft wet pond would fit this space. Such a pond with 3:1 side slopes and a five foot depth was modeled. Stormwater would be diverted to the pond from the underground storm water pipes that run under the roadway next to the site (see conceptual image below). The pond would discharge at the already-existing stormwater discharge point into the creek. In this way the pond would treat water from nearly all of Catchment D.

For the purposes of pond construction cost estimation, three levels of soils disposal were considered because the site is in an industrial area. They include:

> Level 1 – Dredged material suitable for fill or reuse on residential or recreational sites.
>
> Level 2 – Dredged material suitable for fill or reuse on industrial properties.
>
> Level 3 – Dredged material significantly contaminated and must be managed for specific contaminants present.

These three levels carry increasingly greater costs (see table below).

Conceptual images -



	Cost/Benefit Analysis	Network Treatment By BMP					
		Level 1 Soil Disposal		Level 2 Soil Disposal		Level 3 Soil Disposal	
		New trtmt	Net %	New trtmt	Net %	New trtmt	Net %
Treatment	TP (lb/yr)	12.2	19%	12.2	19%	12.2	19%
	TSS (lb/yr)	6,218	19%	6,218	19%	6,218	19%
	Volume (acre-feet/yr)	0.0	1%	0.0	1%	0.0	1%
	Number of BMP's	1-Pond excavated and hookup to storm sewer. Level 1 material disposal		1-Pond excavated and hookup to storm sewer. Level 2 material disposal		1-Pond excavated and hookup to storm sewer. Level 3 material disposal	
	BMP Size/Description	1,290	cubic yards	1,290	cubic yards	1,290	cubic yards
	BMP Type	Wet Pond		Wet Pond		Wet Pond	
Cost	Materials/Labor/Design	$62,700		$75,600		$88,500	
	Promotion & Admin Costs	$1,680		$1,960		$2,240	
	Total Project Cost	$64,380		$77,560		$90,740	
	Annual O&M	$2,146		$2,585		$3,025	
	Term Cost/1,000lb-TSS/yr	$690		$832		$973	
	Term Cost/lb-TP/yr	**$353**		**$425**		**$497**	

Proposed Project 5 – Add vertical riser to Federated Co-op pond

Drainage Area – 1.17 acres of Federated Co-op rooftop and parking lot

Location – South Side of Federated Co-op retail store.

Property Ownership – Federated Co-op

Existing basin

Description – The existing stormwater basin could perform more efficiently with minor retrofits. The basin receives water from the Federated Co-op Country Store rooftop and parking. Currently, it acts as a flow-through practice, like a 50 ft long swale, because the outlet pipe is two feet lower than the inlet pipe. The inlet and outlet pipes are sized the same, so it does not control discharge rates. Infiltration is limited to the small amount of water that can infiltrate in the 50 foot flow path within the basin, but infiltration is presently slowed by accumulated sediment. Two retrofit scenarios were examined.

The first potential pond retrofit is to add an elbow and vertical pipe (riser) to the basin outlet pipe (see sketch below). This project would result in ponding within the basin, causing some particle settling. Sanding water should infiltrate, provided bottom sediments are removed every 1-3 years. The height of the vertical riser should be about 1.8 feet, bringing the standing water level near that of the pond inlet pipe. The vertical riser should not be higher than this or it could cause water to back up in the inlet pipe. If water froze in the inlet pipe it could cause a blockage.

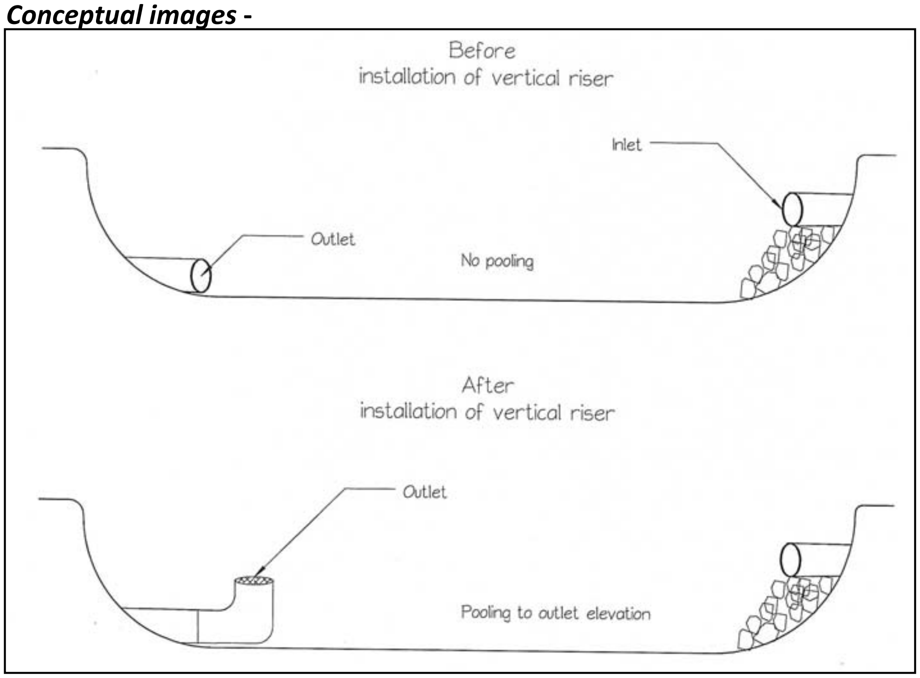
Adding a vertical riser to the basin was the 5th most cost effective retrofit identified in this assessment for removing phosphorus but the most effective for removing suspended solids. This is because the land uses draining to it do not produce a lot of phosphorus but do produce a fair amount of suspended solids. Considering this, and the fact that this retrofit is the least costly of all retrofits considered ($1,560 estimated), this project should be strongly considered for installation.

The second potential pond retrofit is to add a 1.8 ft tall vertical riser to the outlet pipe (as described above) and excavate to increase the basin width from 20 to 40 feet. This would double the pond area and volume, offering additional settling and infiltration. Increasing the pond sizing will be particularly beneficial if the pond is currently undersized for the flow volumes it receives.

Excavating to double the basin width is the 6th most cost effective retrofit identified in this assessment. We found that little additional treatment is achieved by doubling basin width. There is some benefit, but in terms of cost effectiveness, it is not recommended.

In any case, regular cleaning of accumulated sediment in the basin will help maintain its effectiveness. Accumulated sediment can become re-suspended during larger storms and flushed from the basin. Also, finer sediments can reduce the infiltration rate through the bottom of the basin. Excavation of accumulated sediments is assumed once every 5 years in the maintenance and operations cost estimation. The estimated cost of each cleaning, including material disposal, was $800.

Conceptual images -



	Cost/Benefit Analysis	Project ID			
		5 - Add vertical riser to outlet		6 - Add vertical riser to outlet AND double basin width	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	0.3	6%	0.4	6%
	TSS (lb/yr)	539	9%	635	10%
	Volume (acre-feet/yr)	0.3	2%	0.4	2%
	Number of BMP's	1		2	
	BMP Size/Description	1,000 sq ft		2,000 sq ft	
	BMP Type	Pond Retrofits		Pond Retrofits	
Cost	Materials/Labor/Design	$1,000		$5,440	
	Promotion & Admin Costs	$560		$560	
	Total Project Cost	$1,560		$6,000	
	Annual O&M	$120		$120	
	Term Cost/1,000lb-TSS/yr	$319		$504	
	Term Cost/lb-TP/yr	**$611**		**$819**	

Proposed Project 7– VFW Parking Lot Rain Garden

Drainage Area – 0.70 acres of VFW parking and roof

Location – VFW post on Railroad Avenue South, just north of Palomino St

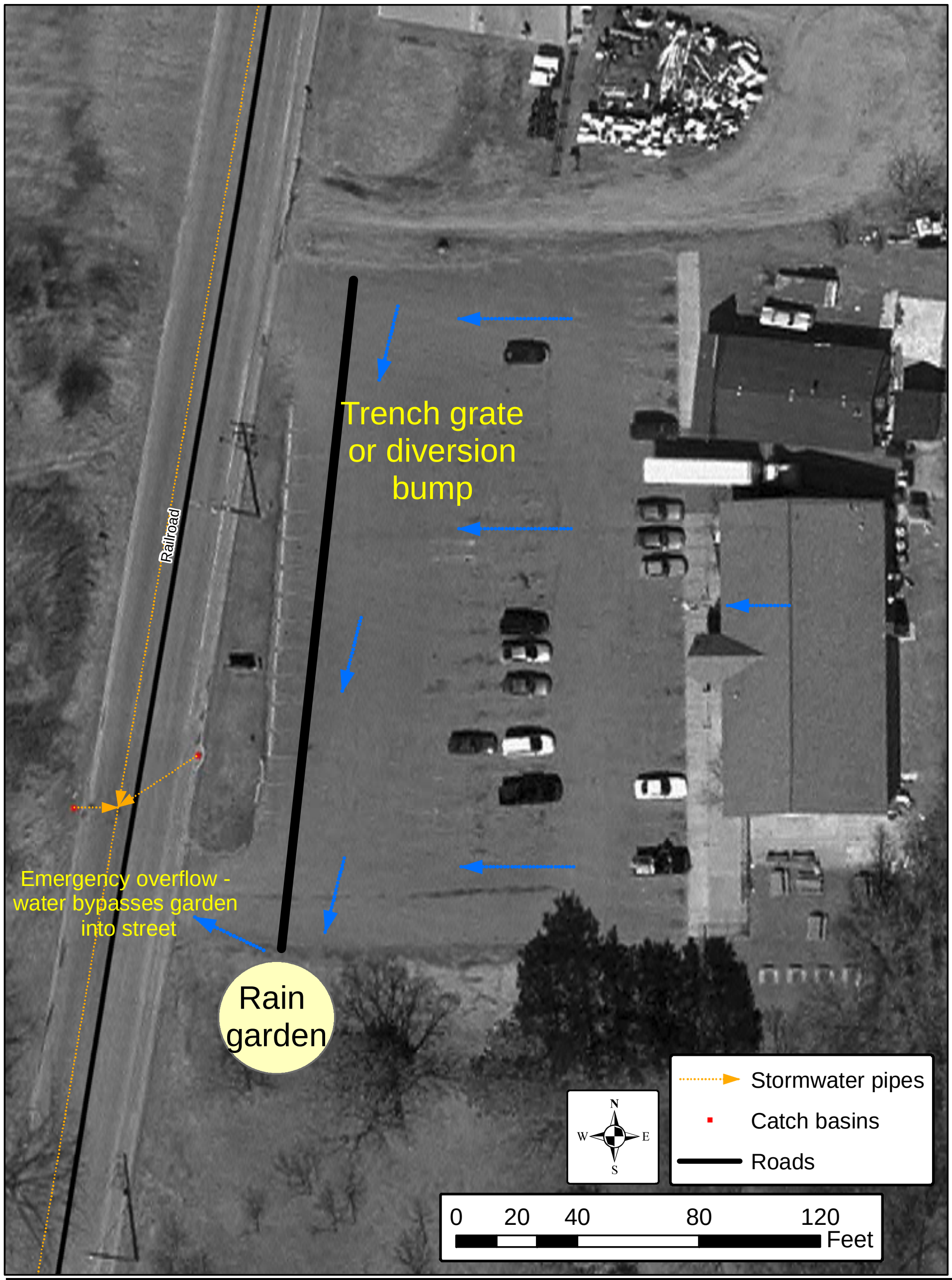
Property Ownership – Rum River VFW Post 2735

Description – This project ranked 7th for cost effectiveness at removing phosphorus among all projects identified in this assessment. The VFW parking lot is large (0.70 acres) and slopes toward Railroad Avenue. A single, large rain garden was considered for treating the parking area runoff and portion of the roof that drains onto the parking lot. This location was considered because of the large area of impervious surface and adjacent open space that could accommodate a rain garden. The image below show the possible placement of the rain garden. To divert water to the garden, a trench grate or diversion bump would need to be installed across the bottom of the parking lot, with a total length of approximately 200 feet. The rain garden basin could be sized as large as 2500 square feet, but smaller sizes of 500 and 1000 square feet were considered to find the optimal size.

We found that a 1000 square feet rain garden size produces the best cost effectiveness. Larger sizing will capture more pollutants, but the cost per pound of pollutant captured increases. Smaller sizing captures too few pollutants to be cost effective.

This practice ranks relatively low because it is serving a relatively small area that generates relatively little pollution, not because it's a poor performing practice.

Conceptual images -



Possible placement of a rain garden at Rum River VFW. A trench grate or diversion bump would be needed across the bottom of the entire parking lot to direct water toward the garden to the south. Rain garden size shown is 1,000 sq ft.

	Cost/Benefit Analysis	Project ID					
		500 sq ft Rain Garden		1000 sq ft Rain Garden		1500 sq ft Rain Garden	
		New trtmt	Net trtmt %	New trtmt	Net trtmt %	New trtmt	Net trtmt %
Treatment	TP (lb/yr)	0.4	7%	0.5	7%	0.6	7%
	TSS (lb/yr)	256	8%	320	8%	339	8%
	Volume (acre-feet/yr)	0.9	3%	1.0	3%	1.0	3%
	Number of BMP's	1		1		1	
	BMP Size/Description	500 sq ft		1,000 sq ft		1,500 sq ft	
	BMP Type	Complex Bioretention		Complex Bioretention		Complex Bioretention	
Cost	Materials/Labor/Design	$13,210		$22,210		$31,210	
	Promotion & Admin Costs	$1,400		$1,750		$1,750	
	Total Project Cost	$14,610		$23,960		$32,960	
	Annual O&M	$661		$75		$75	
	Term Cost/1,000lb-TSS/yr	$4,486		$2,733		$3,461	
	Term Cost/lb-TP/yr	**$2,732**		**$1,648**		**$2,096**	

Proposed Project 8 – VFW Parking Lot Perimeter Sand Filter

Drainage Area – 0.70 acres of VFW parking and roof

Location – VFW post on Railroad Avenue South, just north of Palomino St

Property Ownership – Rum River VFW Post 2735

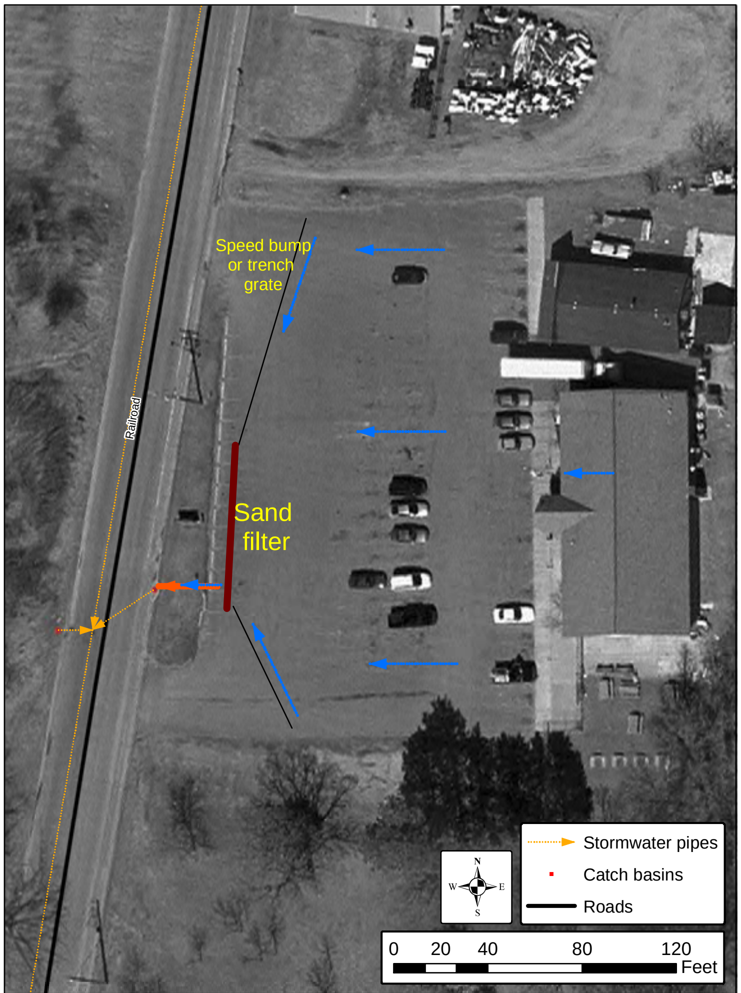
Description – This project ranked 8th (last) for cost effectiveness at removing phosphorus among all projects identified in this assessment. The cost is high and the amount of pollutants removed is low. This practice is not recommended.

Perimeter sand filters consist of two parallel, trench-like chambers typically installed along the lowest portion of a parking lot (see images below and Appendix A). Stormwater runoff enters the first chamber, which has a shallow permanent pool of water. Heavy solids are captured here before the water spills into the second trench, which contains a sand layer approximately 18-inches deep. Water infiltrates through the sand and is collected by an underdrain which delivers the treated water to the downstream stormwater conveyances. The sand may have iron filings added to improve dissolved phosphorus removal. Sand filters have the advantage of consuming no parking. A disadvantage of sand filters is that they do not reduce volume, but flooding is not an issue of high concern in Isanti. See appendix A for more details on the design of perimeter sand filters.

A 70 linear foot long sand filter would be sufficient to treat the 0.7 acre VFW parking lot before the water enters the curb-and-gutter system on Railroad Avenue. Because the parking lot is 200 feet long, speed bumps or trench grates would be needed to carry runoff toward the sand filter (see conceptual image below). This would be substantially less expensive than building the sand filter to span the entire parking lot. Ideal sand filter placement would be alongside the grassy island at the bottom (west side) of the parking lot. The outlet of the sand filter could be into the existing stormwater pipes under the street.

Addition of iron filings to improve removal of dissolved phosphorus is highly recommended and assumed in our analysis. A significant portion of phosphorus in stormwater is dissolved.

Conceptual images -



Possible placement of sand filter (maroon) at Rum River VFW. The filter should span the bottom of the parking lot. Speed bumps or trench grates (black) would be necessary to divert water toward the filter. The filter could then outlet to a pipe that connects to the existing city stormwater pipes (orange).

Typical sand filter. Source: Iowa Stormwater Partnership.

	Cost/Benefit Analysis	Project ID	
		VFW Parking Sand Filter	
		New trtmt	Net trtmt %
Treatment	TP (lb/yr)	0.4	6%
	TSS (lb/yr)	281	8%
	Volume (acre-feet/yr)	0.0	1%
	Number of BMP's	1	
	BMP Size/Description	70 linear ft	
	BMP Type	Perimeter Sand Filter	
Cost	Materials/Labor/Design	$19,010	
	Promotion & Admin Costs	$1,400	
	Total Project Cost	$20,410	
	Annual O&M	$951	
	Term Cost/1,000lb-TSS/yr	$5,797	
	Term Cost/lb-TP/yr	**$4,077**	

Retrofit Ranking

The table below summarizes the assessment results. Projects are ranked from best to worst cost effectiveness at removing phosphorus. Cost effectiveness at removing suspended solids is also shown, though projects are not ranked by this pollutant's removal.

Projects 1-5 are recommended, while projects 6-9 would not be a fruitful expenditure. The highest three ranked projects are curb cut rain gardens in each of three catchments. The fourth project is an outfall pond for catchment D that will remove a greater volume of pollutants than any of the other projects. The fifth project is modification of a small basin at the Federated Co-op Country Storm by adding a vertical riser. This is the least expensive project and while it ranks fifth at phosphorus removal it ranks first for solids capture. The remaining projects capture too little pollutants to justify the cost.

While all of the top five projects are worthwhile, the costs and placement should help the City choose efforts that best fit the City's goals and means. If all of the top five projects are installed, the benefits to the Rum River would be significant – nearly 30 pounds of phosphorus and over 12,000 pounds of suspended solids per year. This equates to a 32.6% reduction in phosphorus and 40% reduction in suspended solids being delivered to the Rum River from these portions of the City.

The benefits of each project were estimated if that project were installed alone, with no other projects upstream of it in the same catchment. Reported treatment levels are dependent upon optimal siting and sizing. More detail about each project can be found in the catchment profile pages of this report.

Summary of preferred stormwater retrofit opportunities ranked by cost-effectiveness with respect to total phosphorus (TP) reduction. Total suspended solids (TSS) reduction is also shown. For more information on each project refer to the catchment profile pages earlier in this report.

Project ID	Catchment	Description (refer to catchment profile pages for more detail)	Optimal Project Sizing (lowest cost per lb phosphorus removed)	TP Reduction (lb/yr)	TSS Reduction (lb/yr)	Volume Reduction (ac-ft/yr)	Estimated Cost	Estimated cost per 1,000 lbs TSS/year (30-year)	Estimated cost per lb-TP/year (30-year)
1	D	Curb cut rain gardens. 4, 6, or 8 considered.	4 rain gardens	4.7 - 6.8	1,962 - 2,945	4.2 - 6.2	$20,380 - 38,940	$499 - 645	$208 - 280
2	B	Curb cut rain gardens. 6, 9 , or 12 considered.	6 rain gardens	6.5-8.5	1,983 - 2,637	5.3- 6.7	$29,660 - 57,500	$725 - 1,068	$220 - 332
3	A	Curb cut rain gardens. 6, 9 , or 12 considered.	6 rain gardens	5.4-7.7	1,684-2,408	4.2-6.1	$29,660 - 57,500	$855 - 1,170	$266 - 364
4	D	Outfall pond	only 80x100 ft size examined	12.2	6,218.0	0	$62,700 - 88,500	$690 - 973	$353 - 497
5	D	Federated Co-op basin - Add vertical riser to outlet	18" tall vertical riser	0.3	539.0	0	$1,560	$319	$611
6	D	Federated Co-op basin - Add vertical riser to outlet AND double basin area	18" tall vertical riser, only considered increasing basin width from 20-40 ft	0.4	635.0	0	$6,000	$504	$819
7	D	Rain garden at VFW parking lot	1000 sq ft rain garden	0.5	320.0	1	$23,960	$2,733	$1,648
8	D	Sand Filter at VFW parking lot	70 linear ft with water diversions	0.4	281.0	0	$20,410	$5,797	$4,077

References

Minnesota Stormwater Steering Committee. 2005. *Minnesota Stormwater Manual.* Minnesota Pollution Control Agency. St. Paul, MN.

Schueler et. al. 2005. *Methods to Develop Restoration Plans for Small Urban Watersheds. Manual 2, Urban Subwatershed Restoration Manual Series*. Center for Watershed Protection. Ellicott City, MD.

Schueler et. al. 2007. *Urban Stormwater Retrofit Practices. Manual 3, Urban Subwatershed Restoration Manual Series. Center for Watershed Protection*. Ellicott City, MD.

Appendix A – Perimeter Sand Filter Concept Designs

Retrofit Concepts: *Perimeter Sand Filter*

Perimeter sand filters (Delaware filters) consist of two parallel trench-like chambers that are typically installed along the perimeter of a parking lot. Parking lot runoff enters the first chamber, which has a shallow permanent pool of water. The first trench captures heavy solids before the runoff spills into the second trench, which consists of a sand layer (typically 18" deep). Water infiltrates through the sand and is collected by an under-drain and delivered, ideally, to another stormwater BMP or existing stormsewer network. If both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet. The sand may have iron filings added to improve dissolved phosphorus removal.


Sand filter inspection, Iowa Stormwater Partnership

BENEFITS:

- Great for adjacent to large impervious areas like parking lots
- Remove up to 90 percent of total suspended solids, 55 percent of total phosphorous, and 35 percent of total nitrogen
- Can effectively treat hot-spot runoff
- Consume small amounts of land

COST:

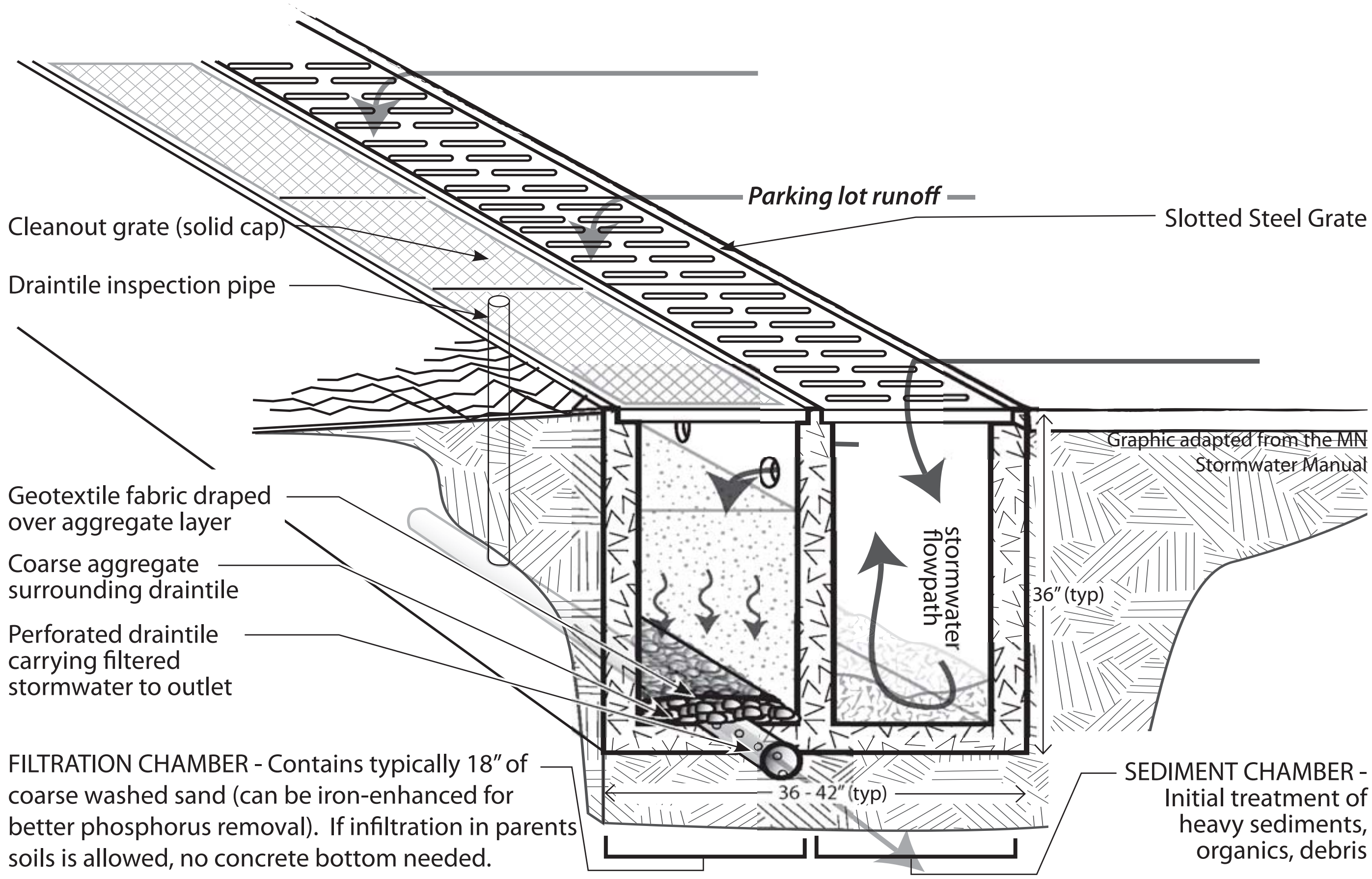
- Approximately $21.50 per cu ft of storage

CONCERNS:

- High maintenance burden (regular inspections for clogging, sand replacement, and removal of captured sediment)
- Not recommended for areas with high sediment content in stormwater or areas receiving significant clay/silt runoff
- Relatively costly

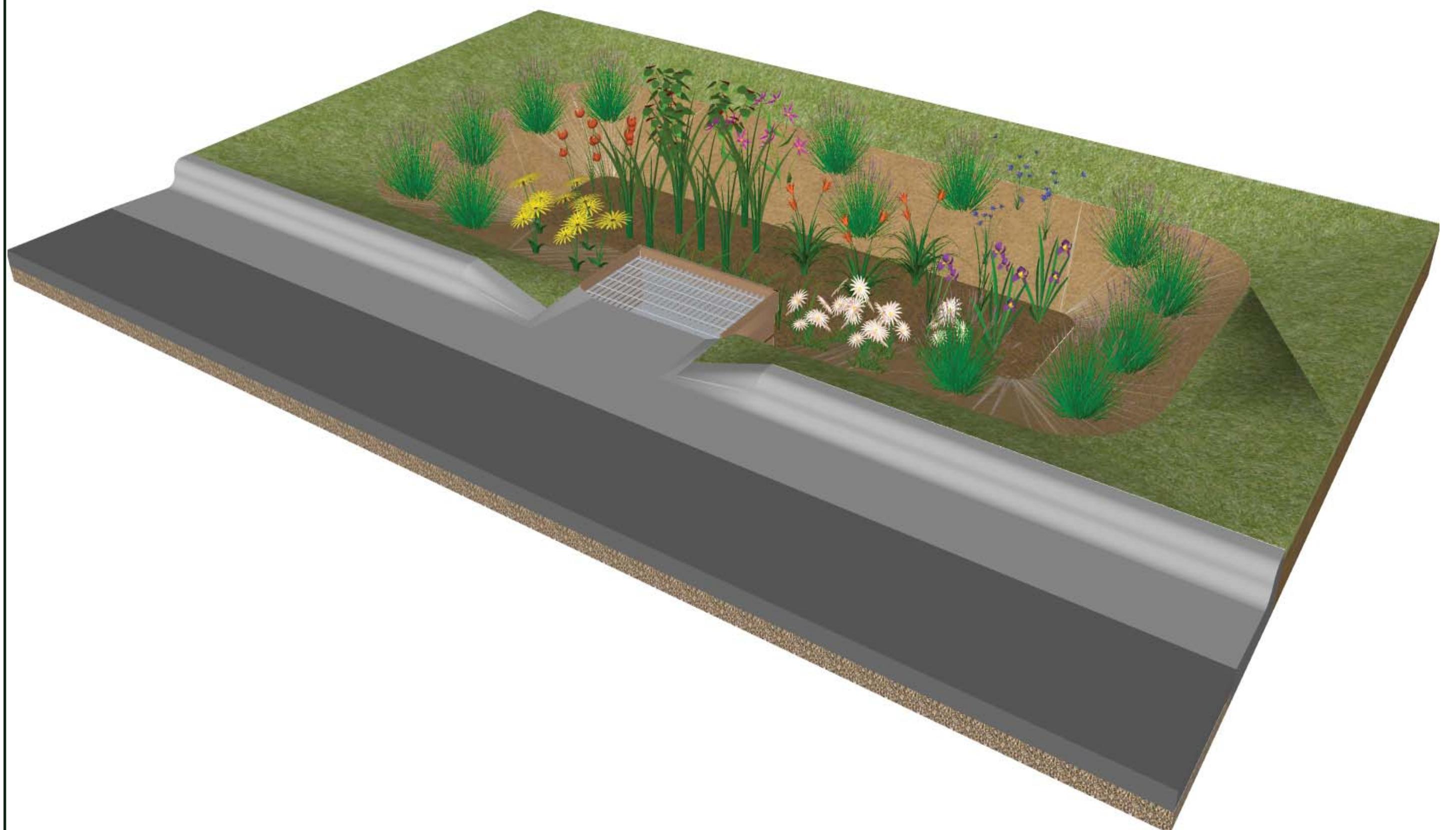
RECOMMENDED DRAINAGE AREA:

- Highly impervious sites up to 2 acres
- Approximately 100 linear feet treats 1 acre of impervious area



Appendix B – Rain Garden Concept Designs

ANOKA COUNTY CURB-CUT RAINGARDENS



Drawing rainwater from the street gutter reduces runoff and pollutants to local water bodies

ANOKA CONSERVATION DISTRICT

Prepared by the Anoka Conservation District in association with
the Metropolitan Conservation Districts

URBAN RAINWATER: SLOW IT DOWN AND SOAK IT UP

Under natural conditions the majority of rainwater falling on Anoka County would infiltrate the soil surface to be absorbed by plants or percolate more deeply into the soil to feed groundwater recharge and provide steady base-flow to streams and rivers. As land development has expanded more and more land is covered with impervious surfaces such as roads, parking lots and buildings. This conversion from native vegetation to impervious structure has greatly altered the hydrologic cycle and surface water ecology by greatly increasing runoff rates and effectively washing nutrient laden sediments and other pollutants into local surface waters. Treating and infiltrating urban rainwater as close to the point where it falls as possible is recognized as a vital and effective method for augmenting groundwater resources and reducing surface water quality impacts.

In dense residential ***sub-watersheds*** there is limited suitable public land on which to treat and infiltrate rainwater. In these situations utilizing private land and easements along roadways for treatment becomes an important tool for improving water quality. The curb and gutter system that channels rainwater quickly from your neighborhood can be disconnected with a ***curb-cut*** that directs rainwater from the street into a depressed ***raingarden***. This allows rainwater falling within the catchment area of the raingarden to return to the natural hydrologic cycle of ***infiltration*** and ***evapotranspiration***, effectively reducing downstream flooding, erosion and ***non-point source pollution***. An individual curb-cut raingarden may only mitigate for a small portion of urban runoff, however the treating the rainwater runoff close to its source is an essential strategy in hydrologic restoration and cumulatively curb-cut gardens can actualize significant benefits within an urbanized ***sub-watershed***.

The Anoka Conservation District has designed a set of curb-cut raingardens that can be applied to the physical conditions of your property and to your preference of garden shapes and plant selections. Each garden is designed to provide a water storage capacity of 100 cubic feet. Anoka Conservation

Photo by Rusty Schmidt

District has also designed a modular pretreatment box to be placed at the raingarden inlet to capture sediment and debris prior to water entering the garden. This pretreatment box is a vital component to the longevity and functionality of your raingarden.

Please utilize the key on page 4 to determine the basic design needs of your property and continue to the designated page to select your choice of plant palettes. Plant images are shown of pages 20 and 21.

curb-cut: A section of curb and gutter that has been reconstructed to convey stormwater into a filter strip, rain garden, or other stormwater management strategy.

evapotranspiration: The transfer of liquid water from the earth's surface to atmospheric water vapor as result of transpiration by plants and evaporation by solar energy and diffusion. Evapotranspiration can constitute a significant water "loss" from a watershed.

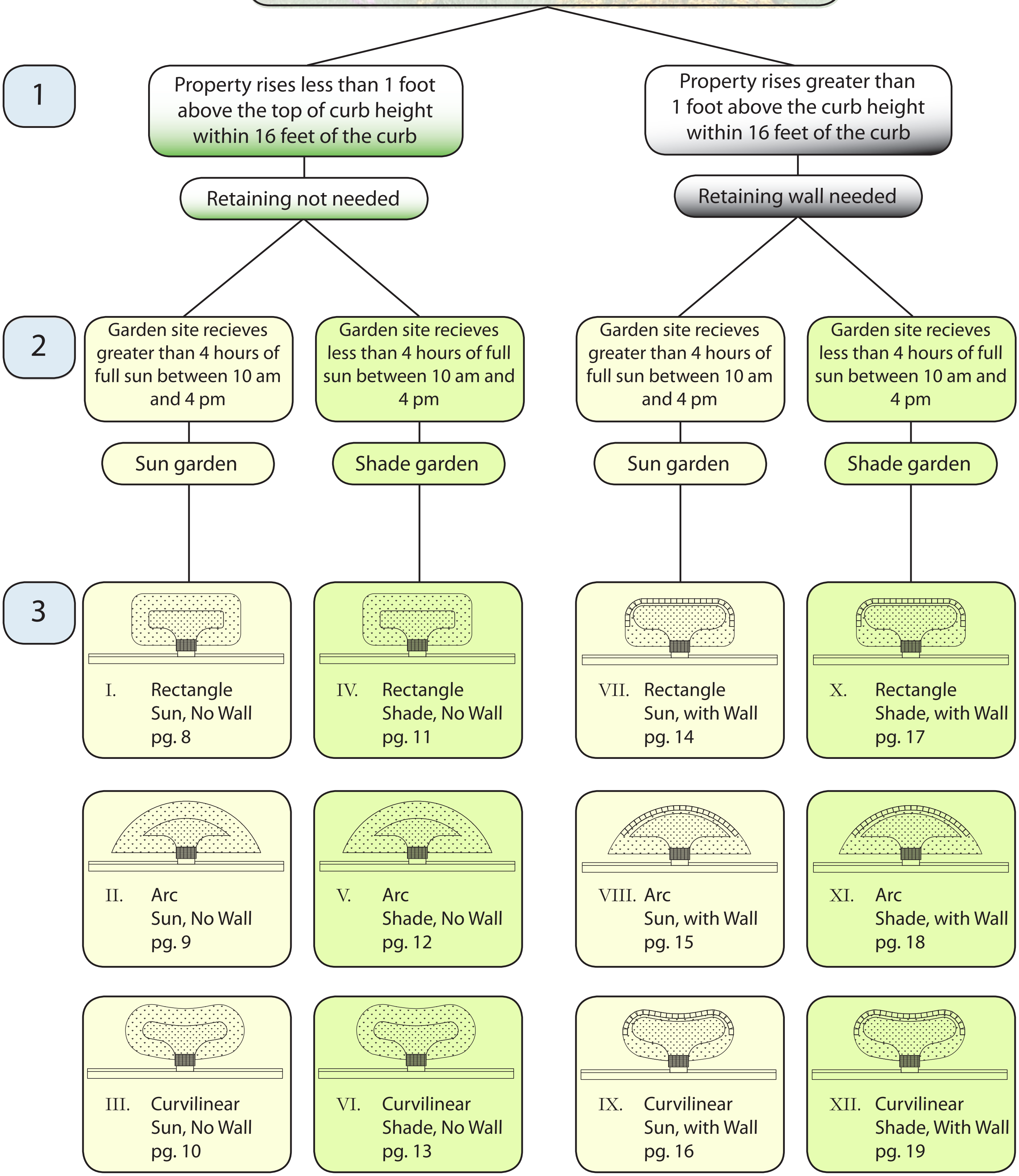
infiltration: Water moving through a permeable soil surface by the force of gravity and soil capillary action. The rate of infiltration is highly dependent on soil type. Infiltration rates within the Anoka Sand Plain are generally very high.

non-point source pollution: Rainwater runoff that has accumulated pollutant loads (nutrients, sediments, petrochemicals etc.) over a large dispersed area. As opposed to point source pollution that has a defined single source.

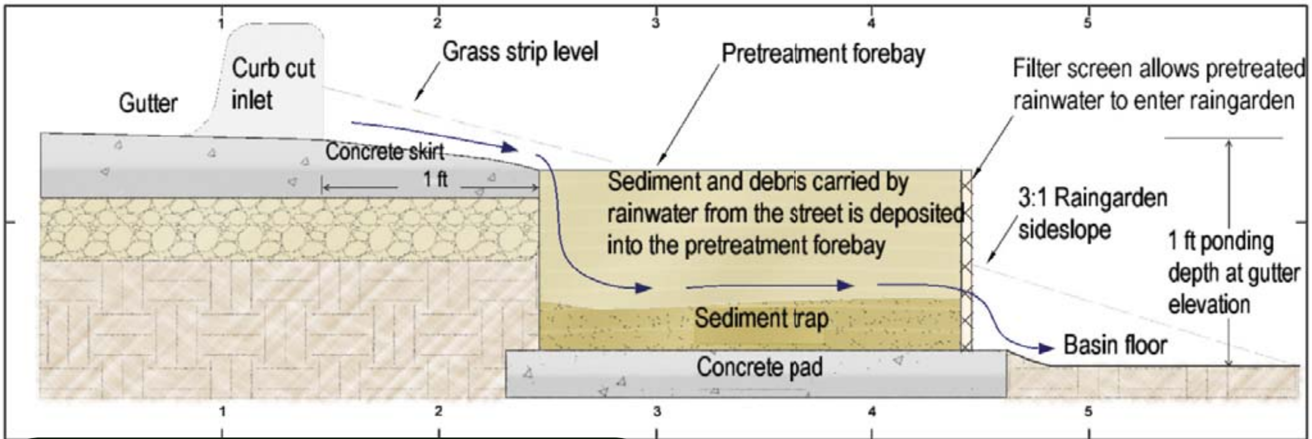
raingarden: A landscaped garden in a shallow depression that receives rainwater runoff from nearby impervious surfaces such as roofs, parking lots or streets. The purpose of a raingarden is to reduce peak runoff flows, increase groundwater recharge and improve water quality in our lakes, streams and wetlands. Peak flow reduction is achieved by temporarily staging runoff within the raingarden basin until it infiltrates into the soil surface or evaporates (typically within 24 hours). This process also increases the quantity and movement of soil water that may feed groundwater recharge. Infiltrated water quality is improved by reducing sediment, nutrient and other chemical pollutant loads through chemical and biological processes in the soil. Downstream water quality is improved in kind by offsetting erosive peak flows and by capturing and treating pollutants higher in the watershed.

sub-watersheds: A discreet portion of a larger watershed, typically less than 2500 acres. Sub-watersheds can be more effectively analyzed and managed for water quality with site scale treatments.

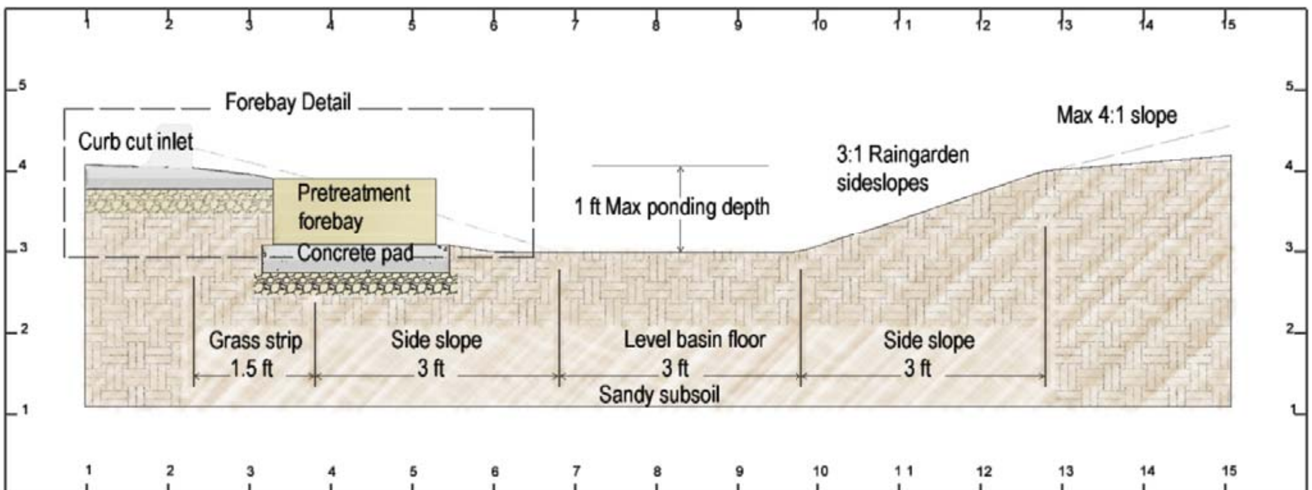
CHOOSE YOUR RAINGARDEN DESIGN



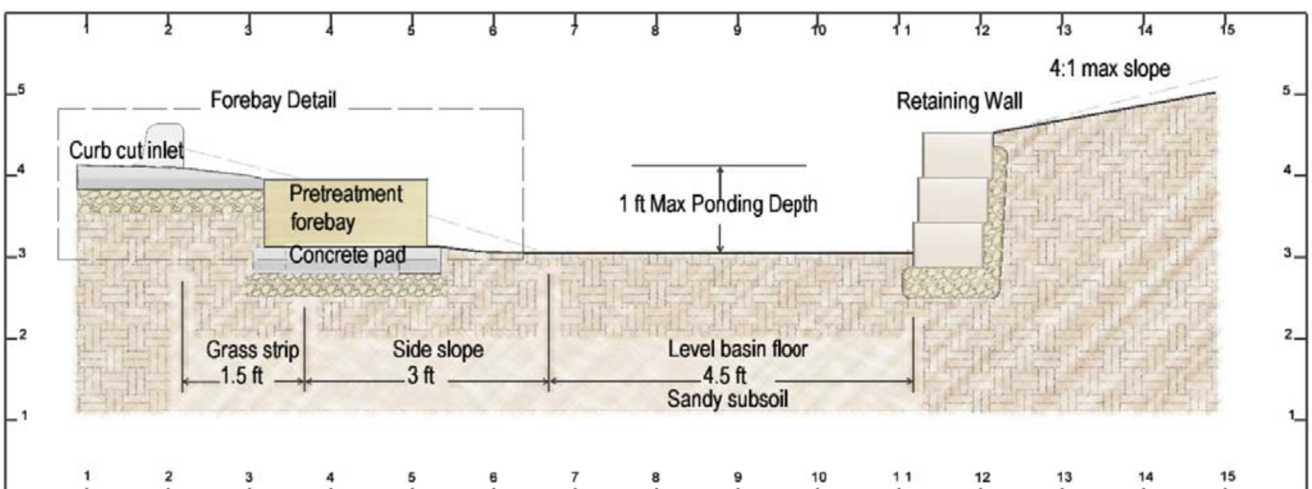
ANATOMY OF A CURB-CUT RAINGARDEN



PRETREATMENT FOREBAY

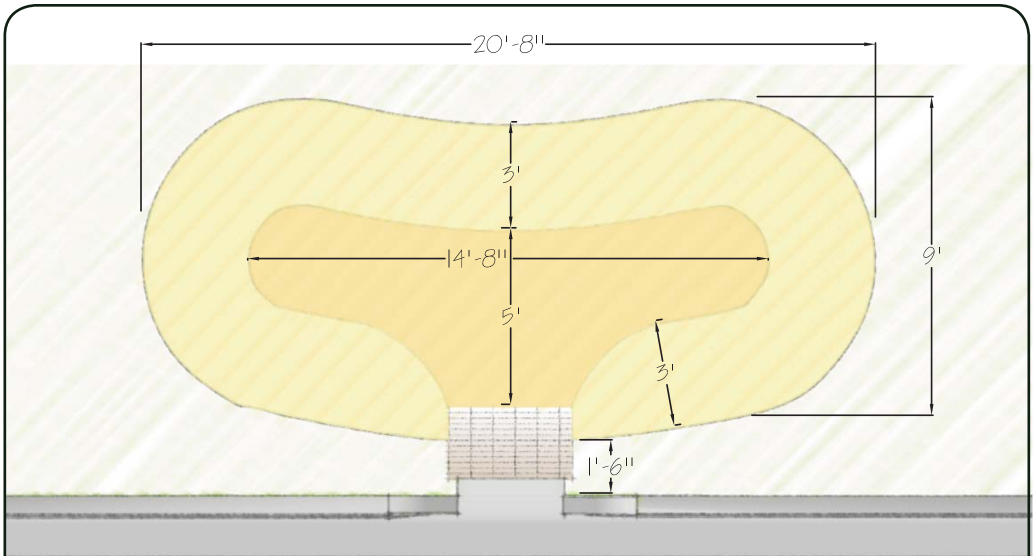


RAINGARDEN WITHOUT RETAINMENT

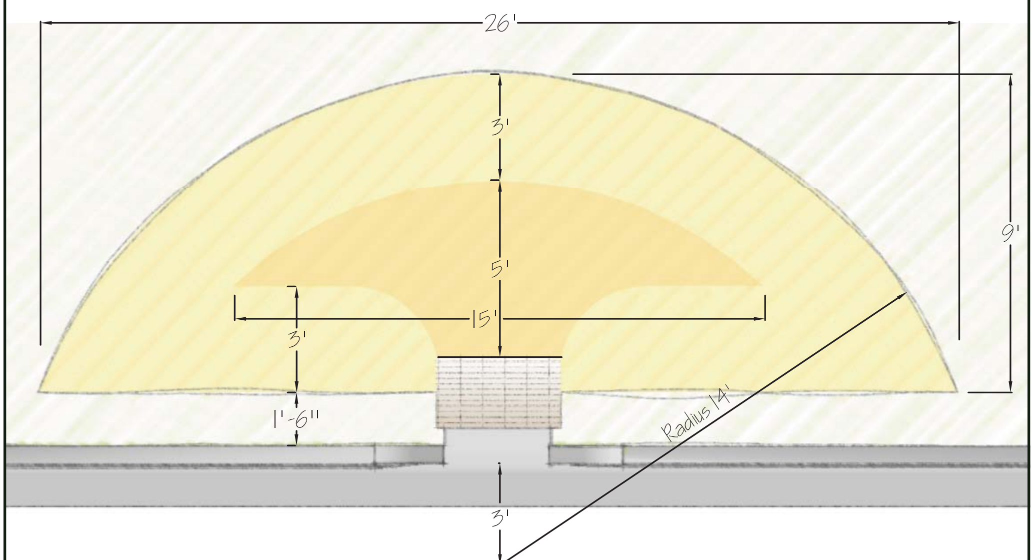


RAINGARDEN WITH RETAINING WALL

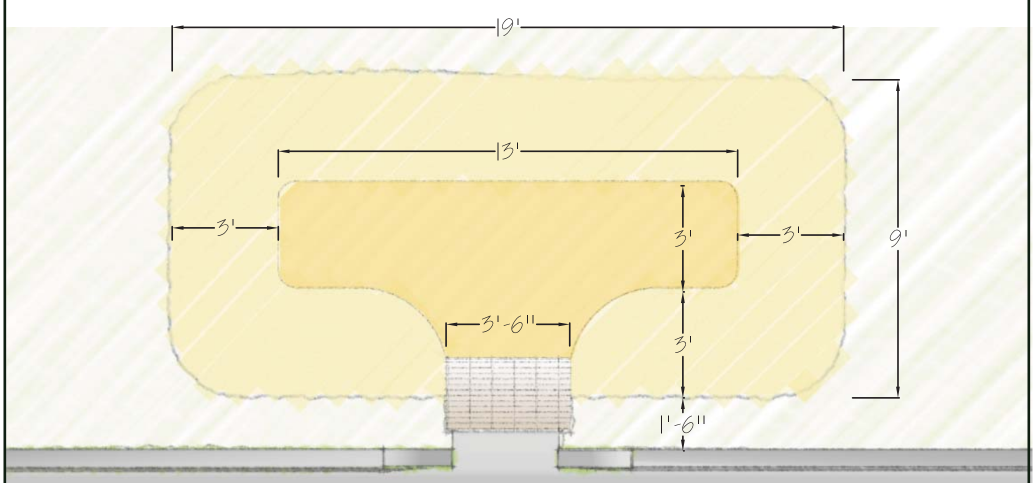
Raingarden Dimensions without a Retaining Wall



Curvilinear Garden



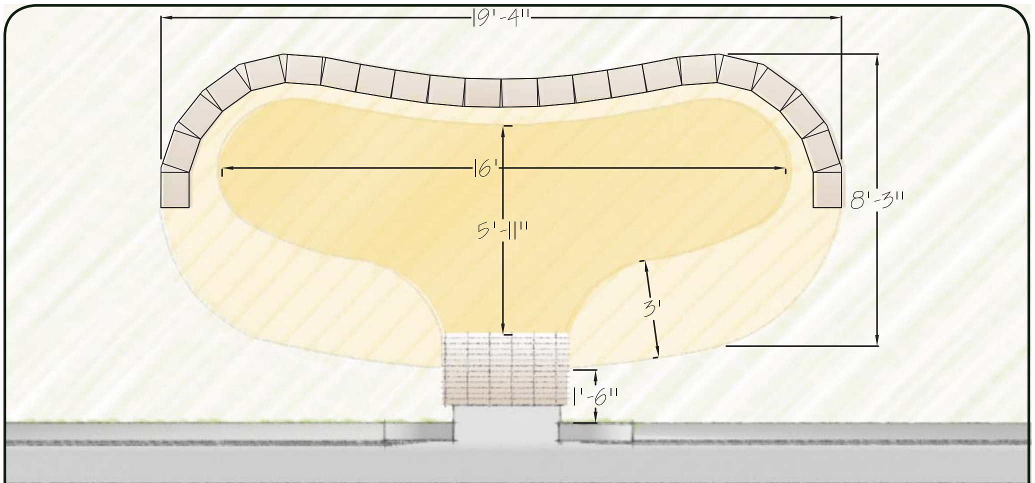
Arc Garden

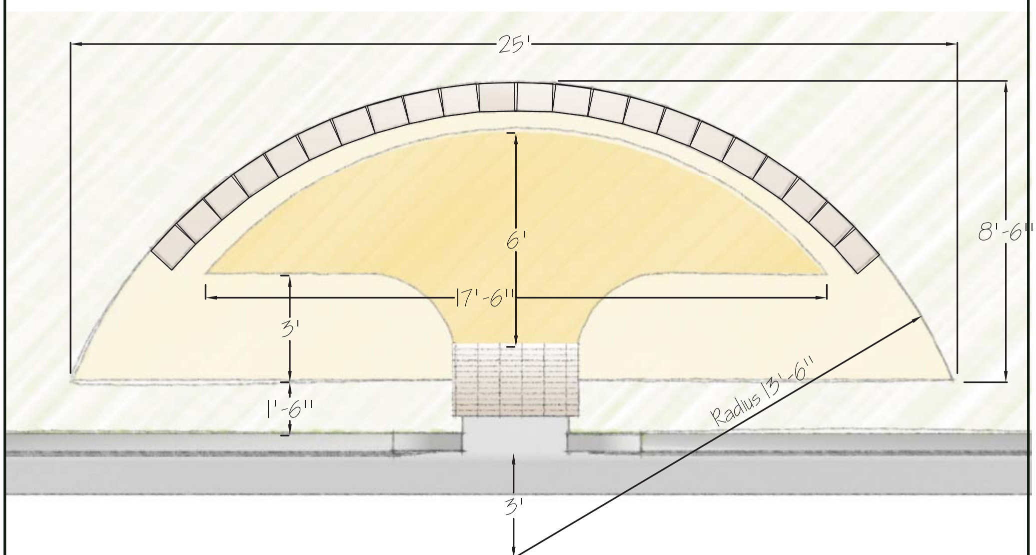


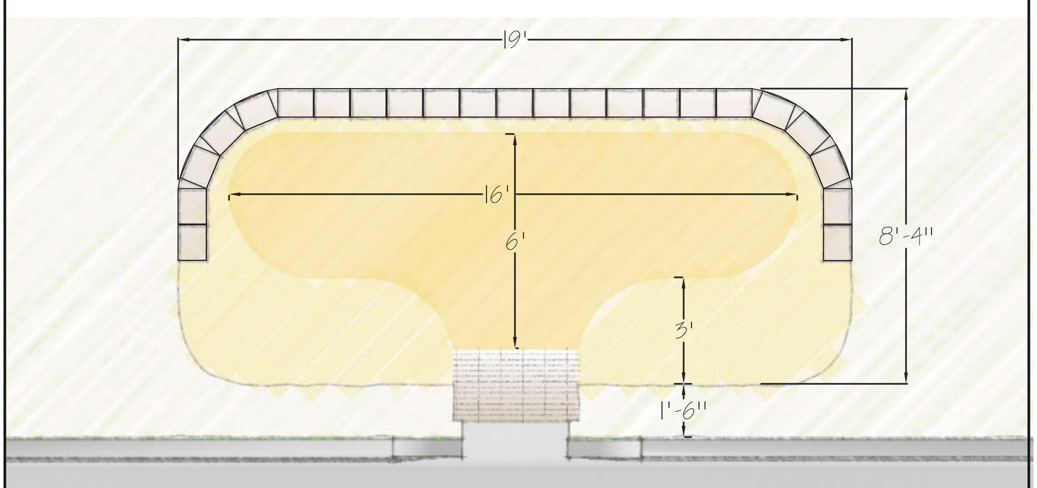
Rectangle Garden

The dimensions given are the minimum dimensions needed to achieve the storage volume required by this stormwater retrofit program. The level basin floor needs to be set 1 foot below the gutter elevation. The entire planting area should be covered with 3 inches of shredded hardwood mulch.

Raingarden Dimensions with a Retaining Wall

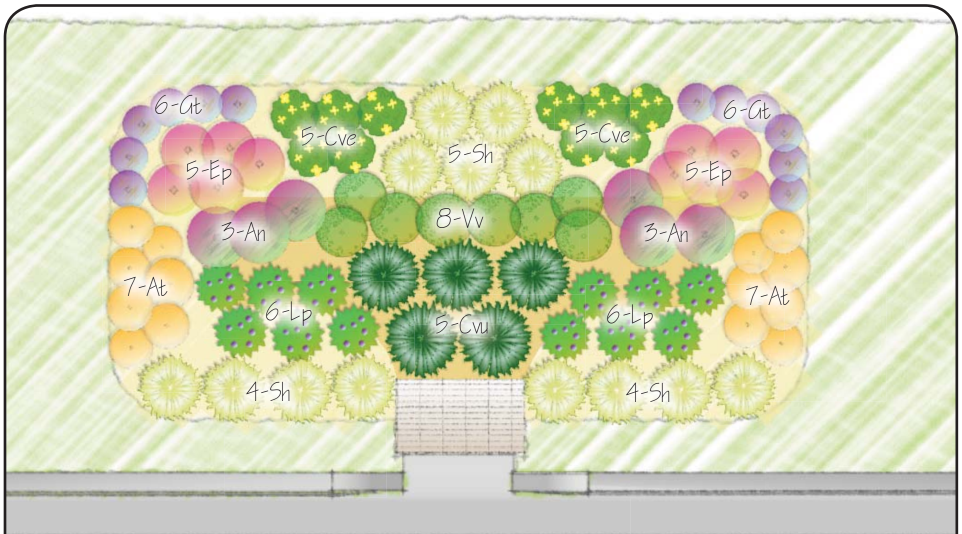




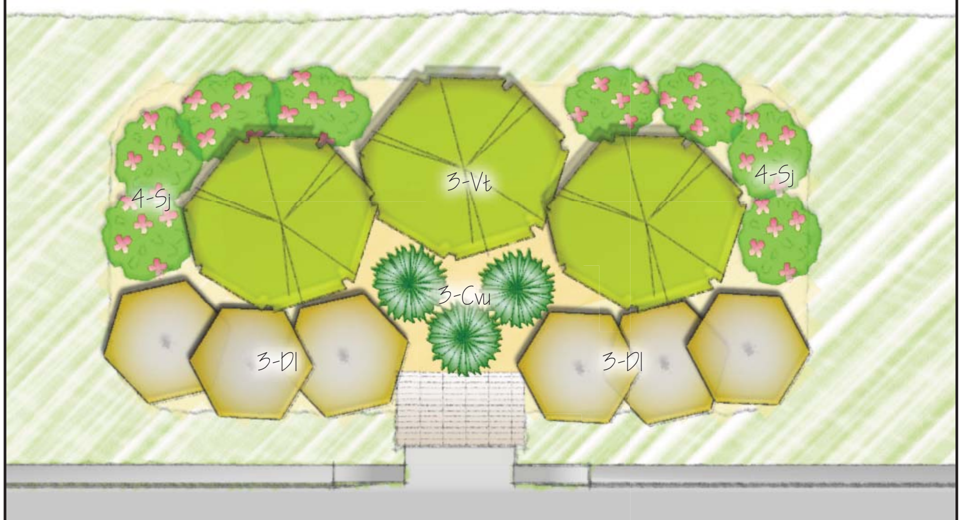


The dimensions given are the minimum dimensions needed to achieve the storage volume required by this stormwater retrofit program. The level basin floor needs to be set 1 foot below the gutter elevation. The entire planting area should be covered with 3 inches of shredded hardwood mulch.

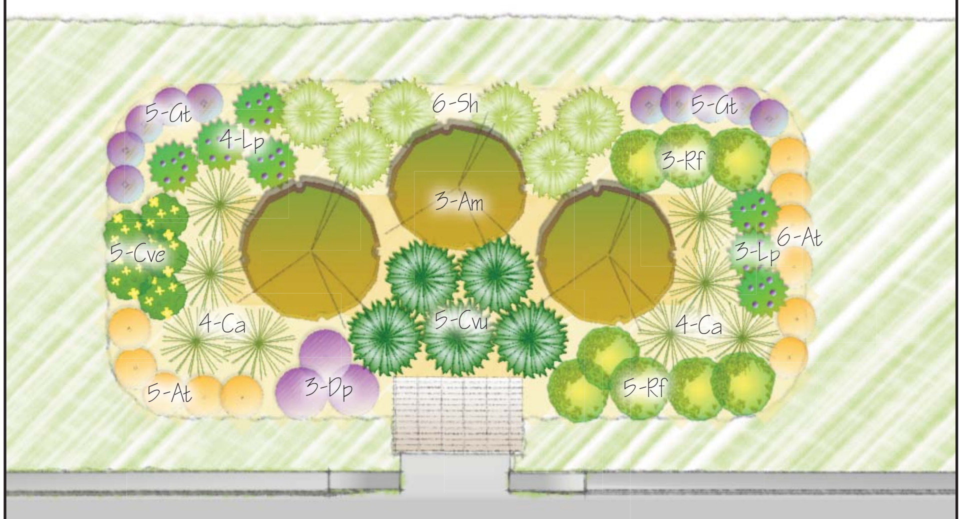
I. Rectangle Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

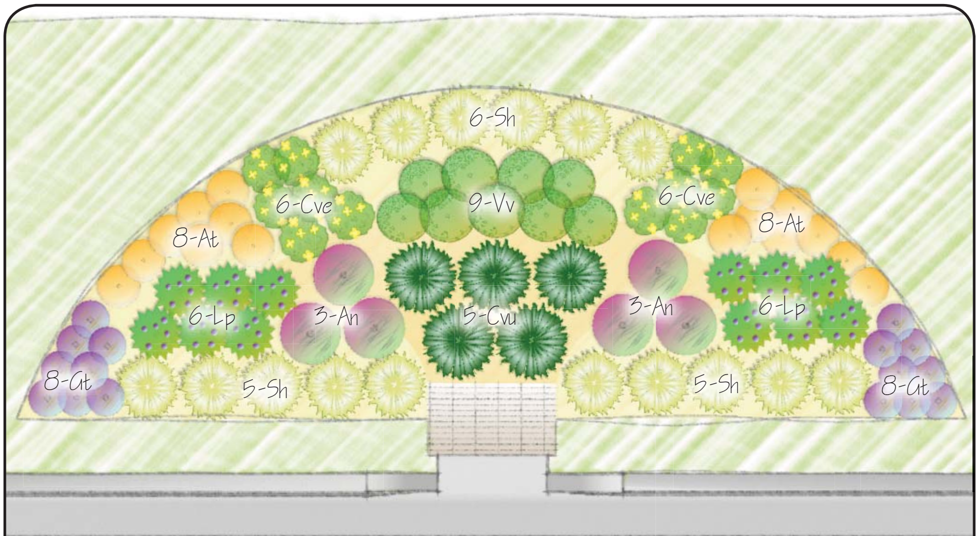


Mixed Shrub/Flower Garden

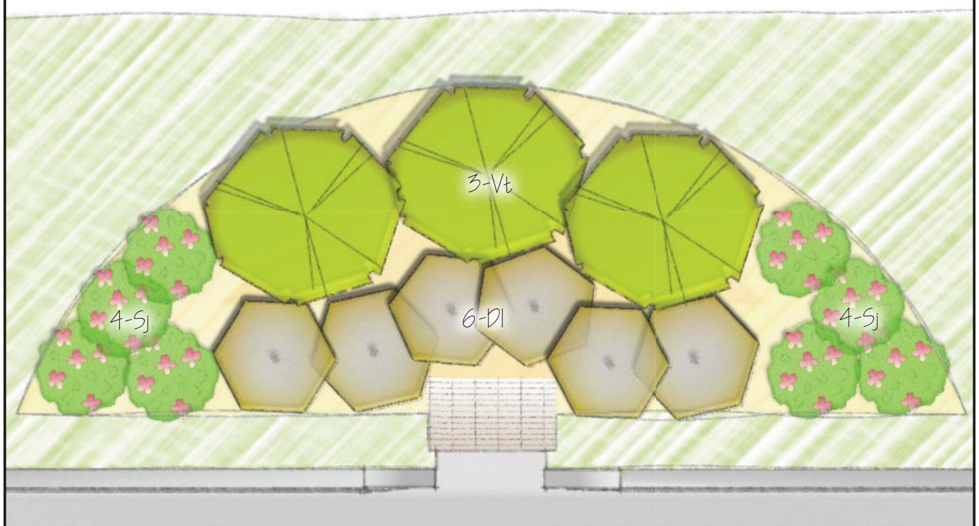
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dp	PURPLE PRARIE CLOVER *Dalea purpurea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Ep	PURPLE CONEFLOWER *Echinacea purpurea*
Gt	PRAIRIE SMOKE *Geum trifolium*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sj	DART'S RED SPIRAEA *Spiraea japonica*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

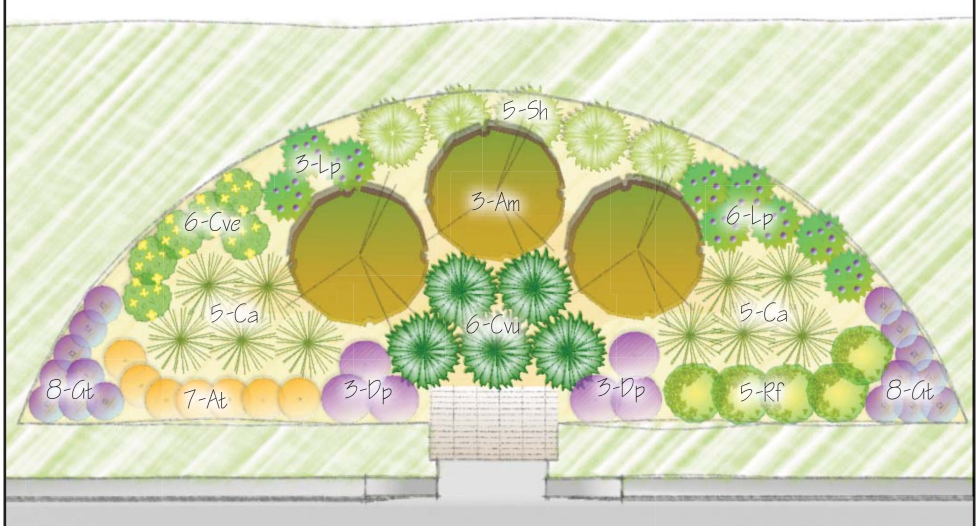
II. Arc Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

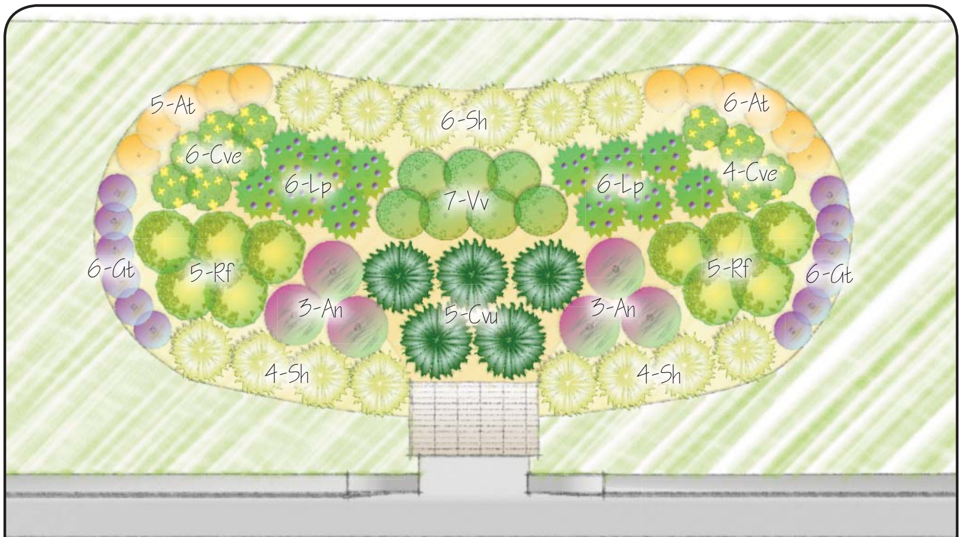


Mixed Shrub/Flower Garden

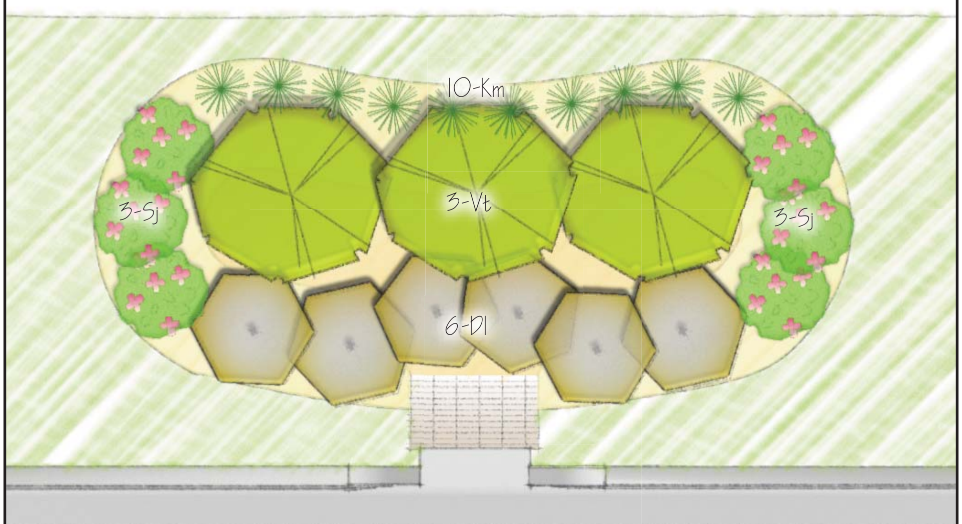
Plant Key

Am	BLACK CHOKEBERRY	*Aronia melonocarpa*
At	BUTTERFLY MILKWEED	*Asclepias tuberosa*
An	ASTER 'PURPLE DOME'	*Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS	*Calamagrostis acutifolia*
Cvu	FOX SEDGE	*Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM'	*Coreopsis verticillata 'Moonbeam'*
Dp	PURPLE PRARIE CLOVER	*Dalea purpurea*
Dl	DWARF BUSH HONEYSUCKLE	*Diervilla lonicera*
Ep	PURPLE CONEFLOWER	*Echinacea purpurea*
Gt	PRAIRIE SMOKE	*Geum trifolium*
Lp	PRAIRIE BLAZING STAR	*Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN	*Rudbeckia fulgida*
Sj	DART'S RED SPIRAEA	*Spiraea japonica*
Sh	PRAIRIE DROPSEED	*Sporobolis heterolepsis*
Vv	CULVERS ROOT	*Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM	*Viburnum trilobum 'compactum'*

III. Curvilinear Garden - Sunny Site - No Retaining Wall



Flowering Perennial Garden



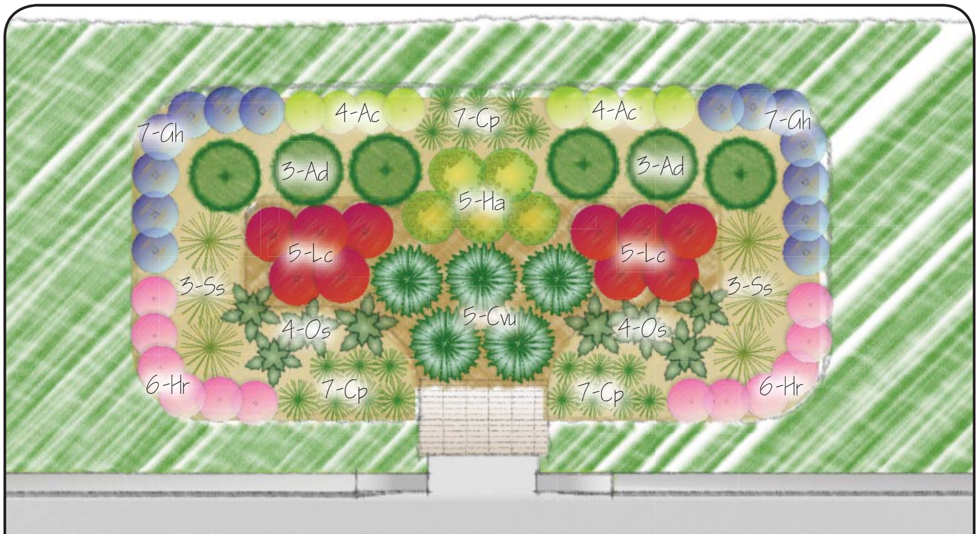
Shrub Garden

Mixed Shrub/Flower Garden

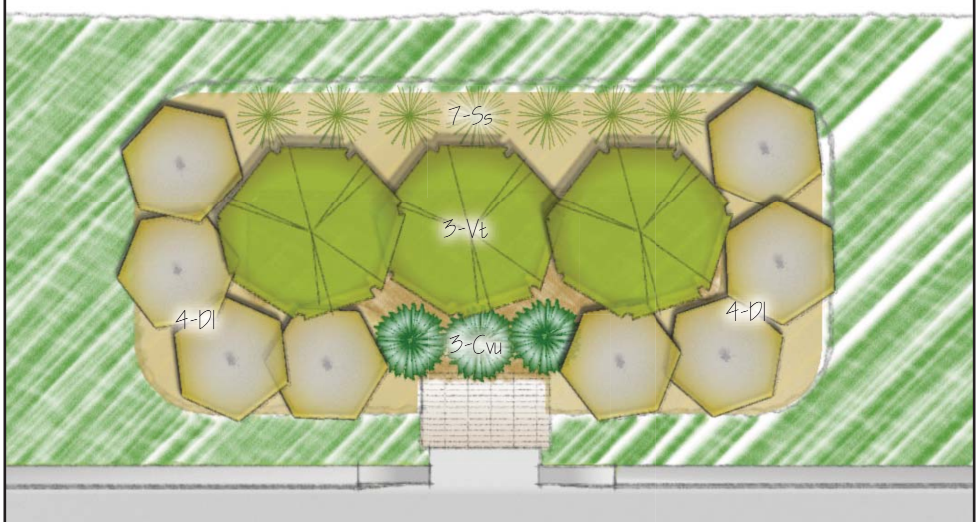
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cvu	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dp	PURPLE PRARIE CLOVER *Dalea purpurea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gt	PRAIRIE SMOKE *Geum trifolium*
Km	JUNE GRASS *Koeleria macrantha*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sj	DART'S RED SPIRAEA *Spiraea japonica*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

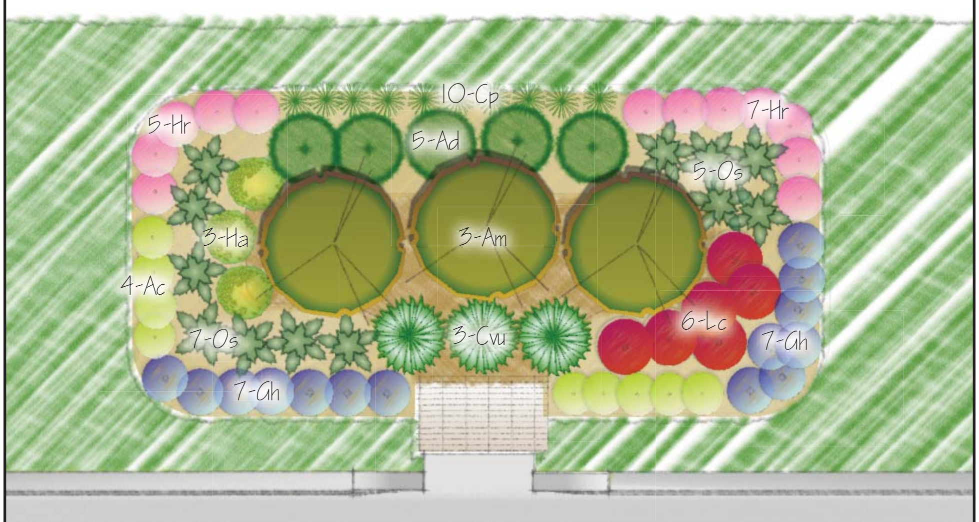
IV. Rectangle Garden - Shady Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

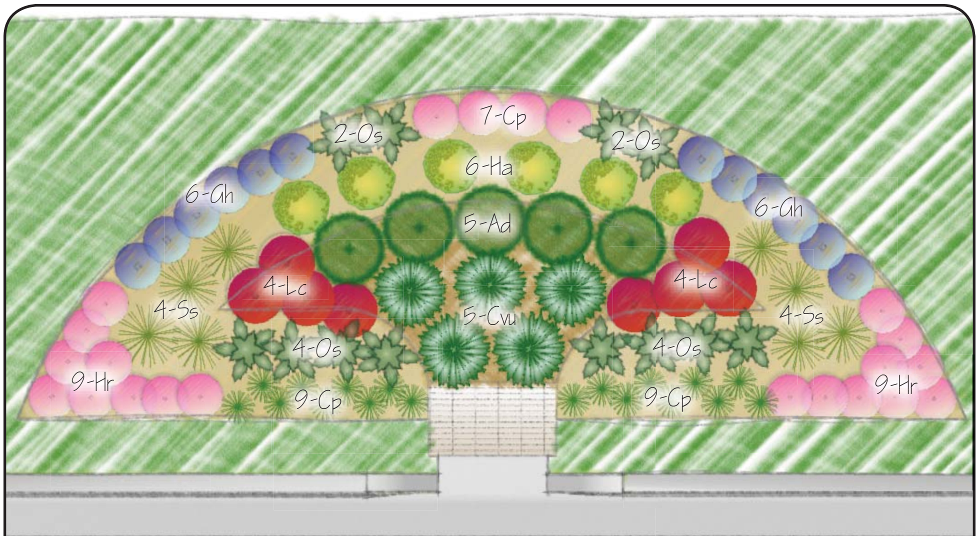


Mixed Shrub/Flower Garden

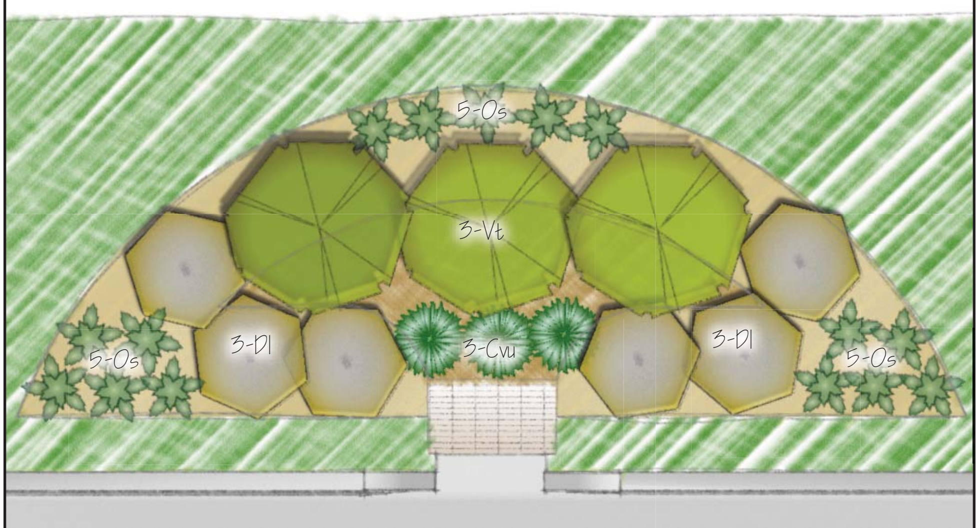
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ac	CANADA ANEMONE *Anemone canadensis*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

V. Arc Garden - Shady Site - No Retaining Wall



Flowering Perennial Garden



Shrub Garden

Mixed Shrub/Flower Garden

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Cvu	FOX SEDGE *Carex vulpinoidea*
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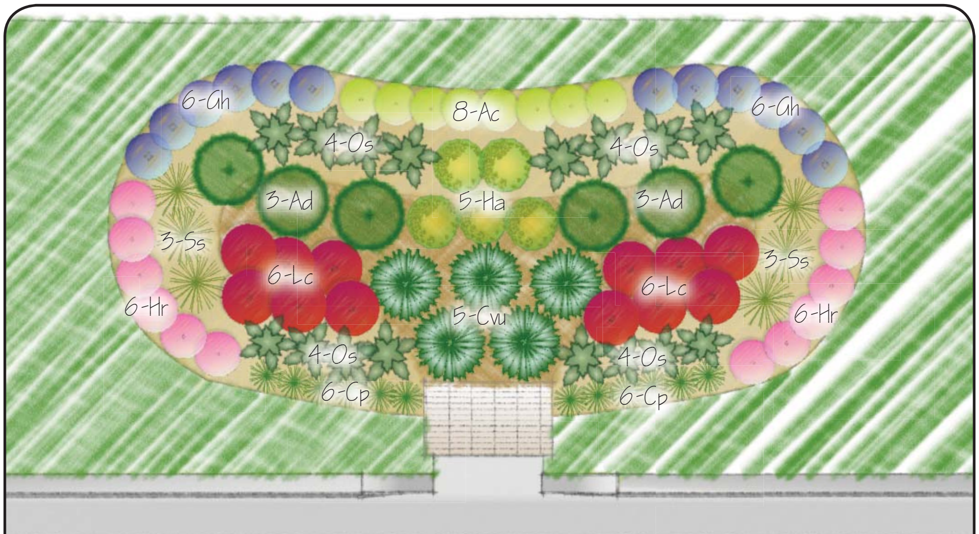
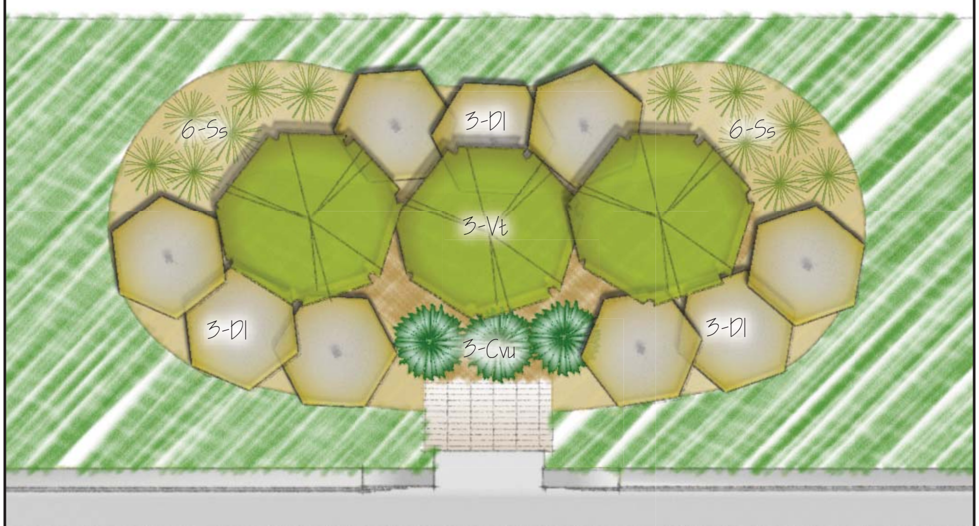
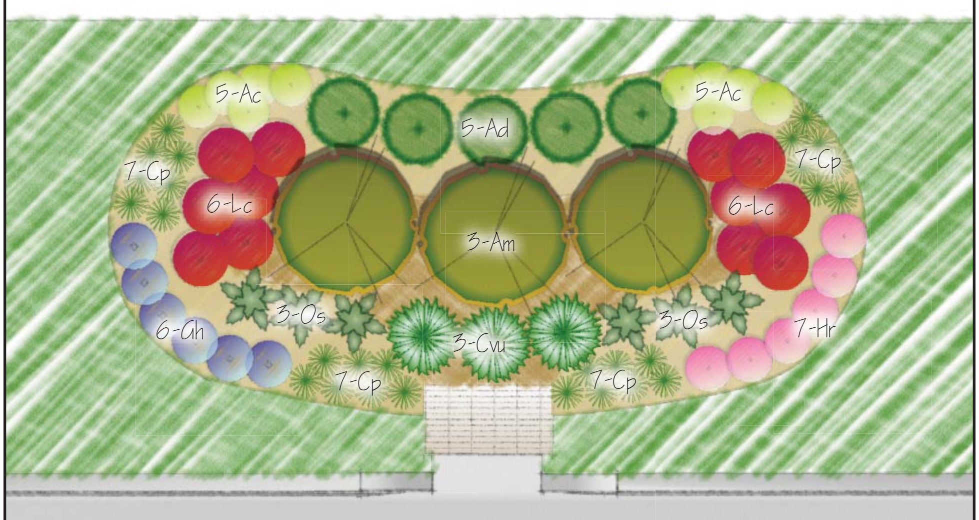
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*



Flowering Perennial Garden



Shrub Garden



Mixed Shrub/Flower Garden

Plant Key

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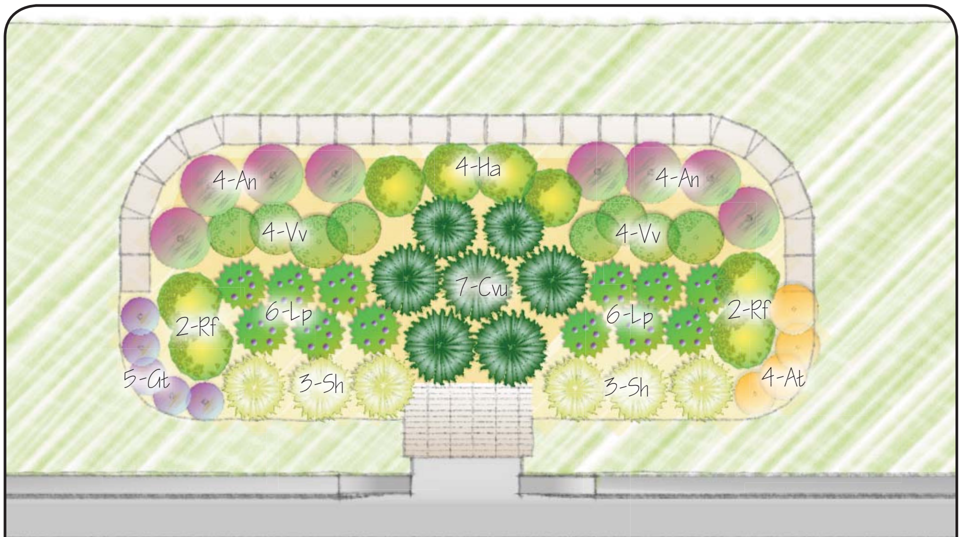
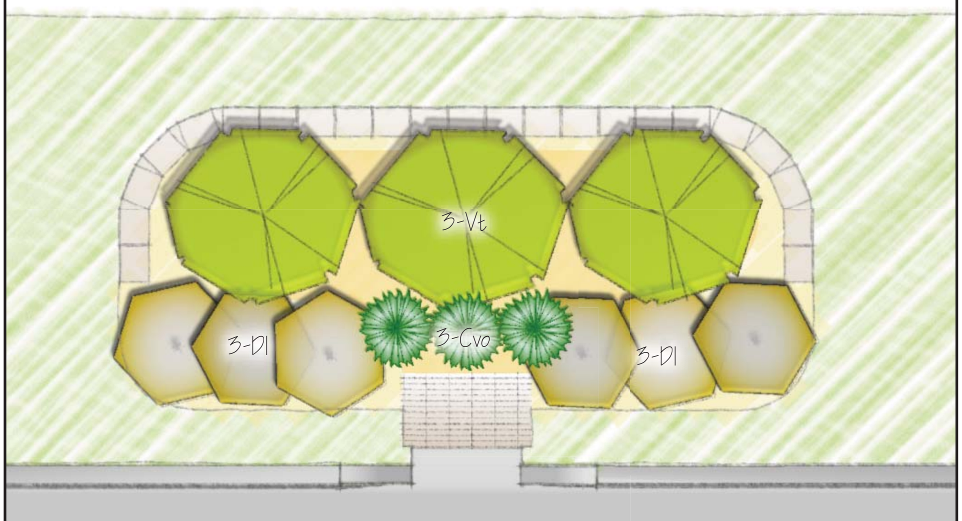
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

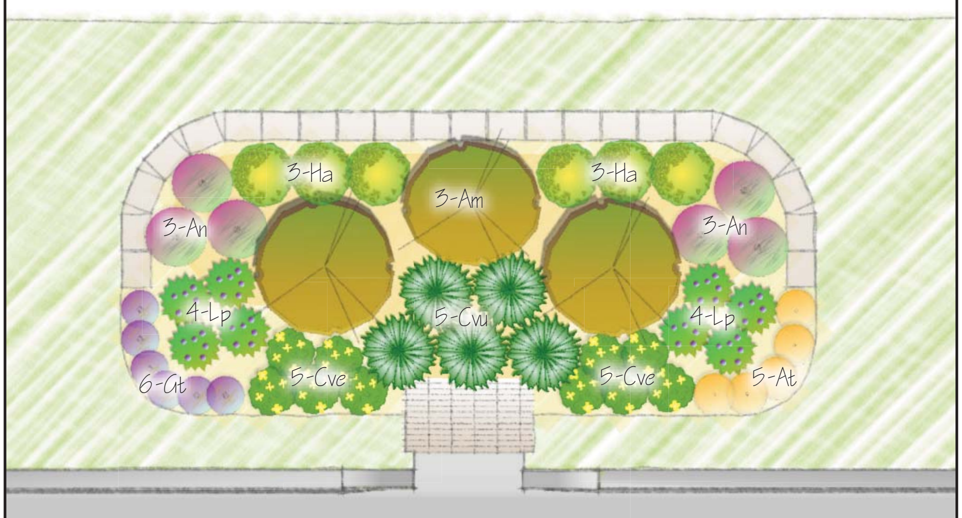
VII. Rectangle Ga rden - Sunny Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden

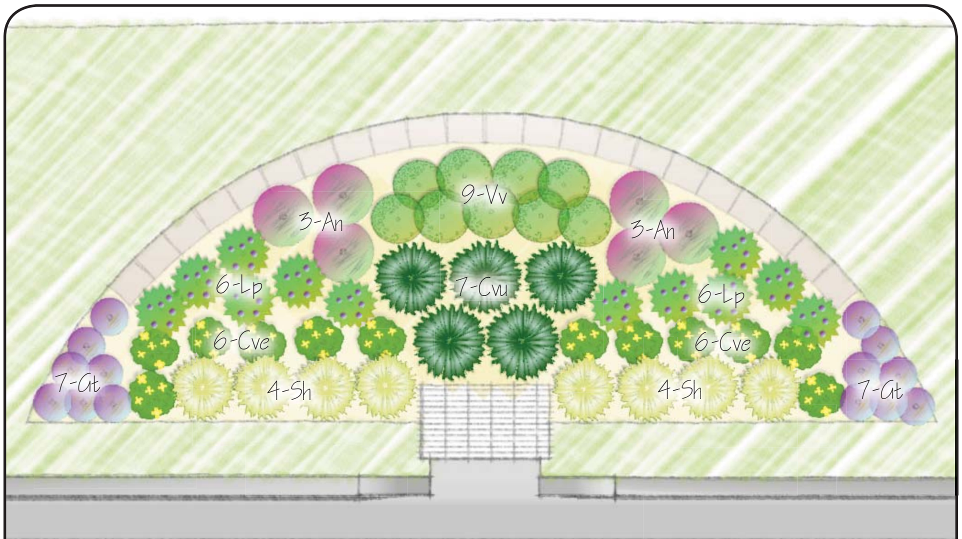


Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Cvu	FOX SEDGE *Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gt	PRAIRIE SMOKE *Geum trifolium*
Ha	SNEEZEWEED *Helenium autumnale*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Vronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

VIII. Arc Garden - Sunny Site - Retaining Wall



Flowering Perennial Garden

Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
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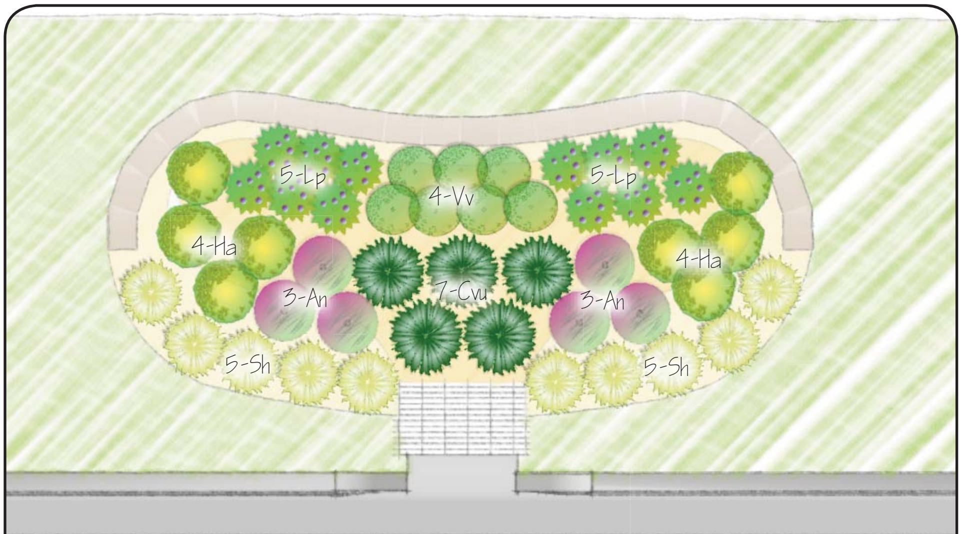
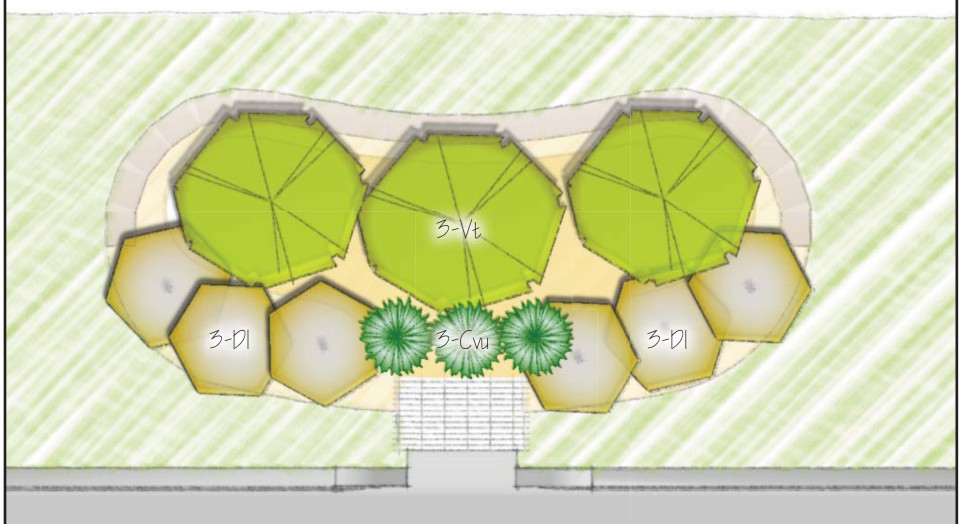
Cvu	FOX SEDGE *Carex vulpinoidea*
Cve	COREOPSIS 'MOONBEAM' *Coreopsis verticillata 'Moonbeam'*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gt	PRAIRIE SMOKE *Geum trifolium*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Sj	DART'S RED SPIRAEA *Spiraea japonica*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Veronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

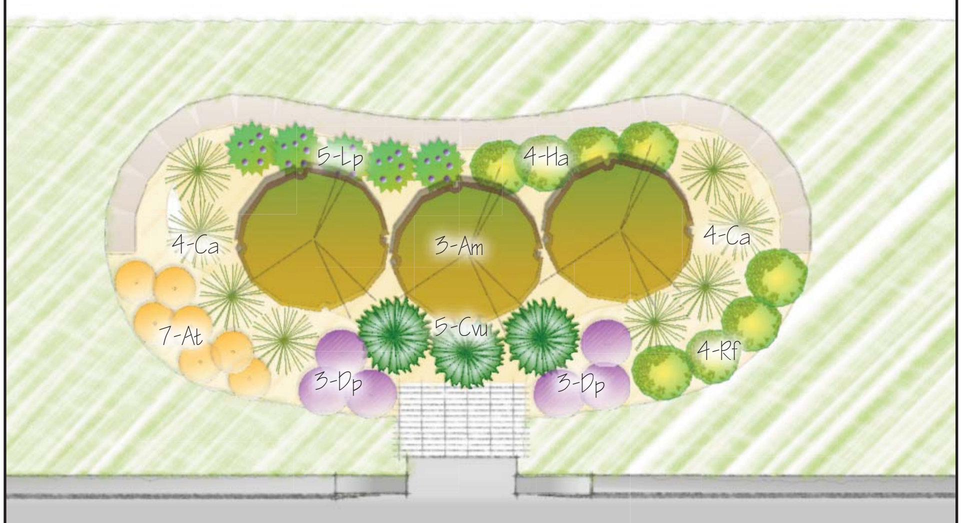
IX. Curvilinear Garden - Sunny Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden



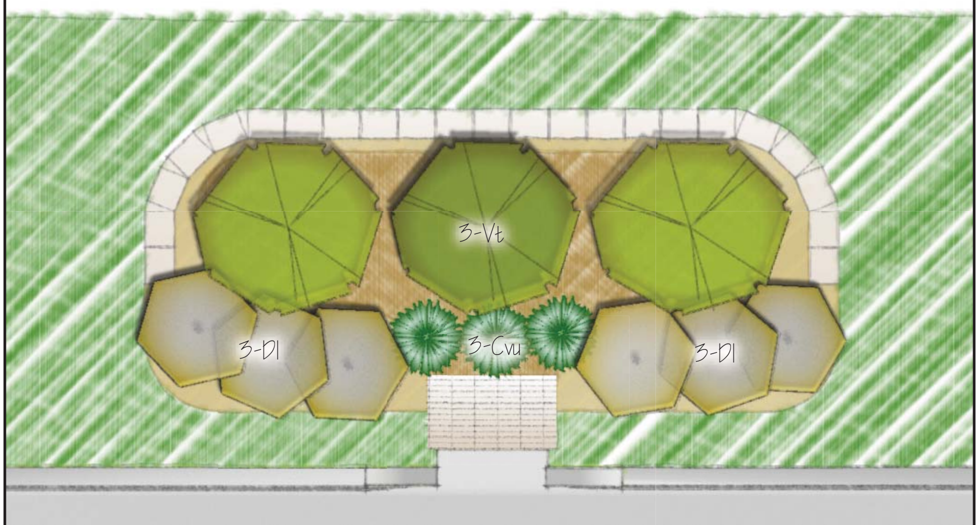
Mixed Shrub/Flower Garden

Plant Key

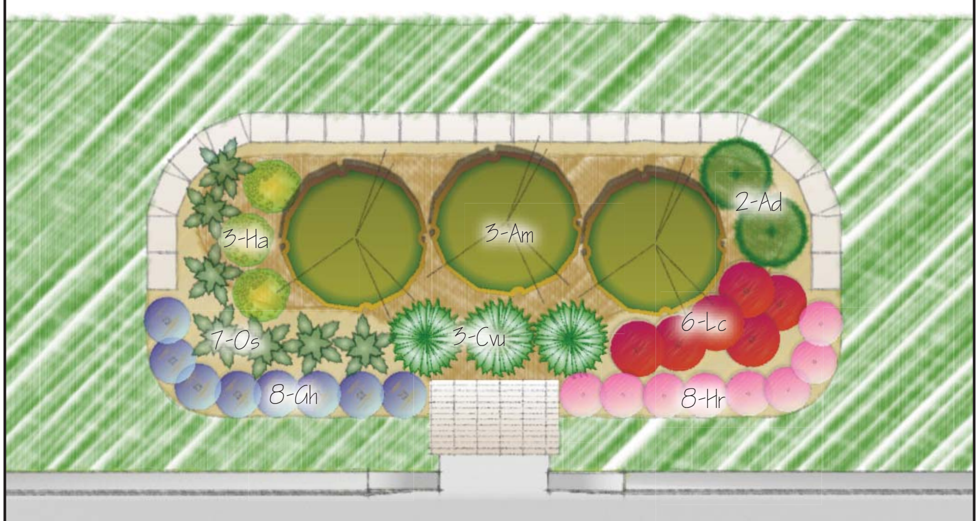
Am	BLACK CHOKEBERRY *Aronia melonocarpa*
At	BUTTERFLY MILKWEED *Asclepias tuberosa*
An	ASTER 'PURPLE DOME' *Aster novae-angliae 'Purple Dome'*
Ca	KARL FORESTER GRASS *Calamagrostis acutifolia*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Ha	SNEEZEWEED *Helenium autumnale*
Lp	PRAIRIE BLAZING STAR *Liatris pycnostachya*
Rf	GOLDSTRUM BLACK-EYED SUSAN *Rudbeckia fulgida*
Sh	PRAIRIE DROPSEED *Sporobolis heterolepsis*
Vv	CULVERS ROOT *Vronicastrum virginicum*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

X. Rectangle Garden - Shady Site - Retaining Wall

Flowering Perennial Garden



Shrub Garden

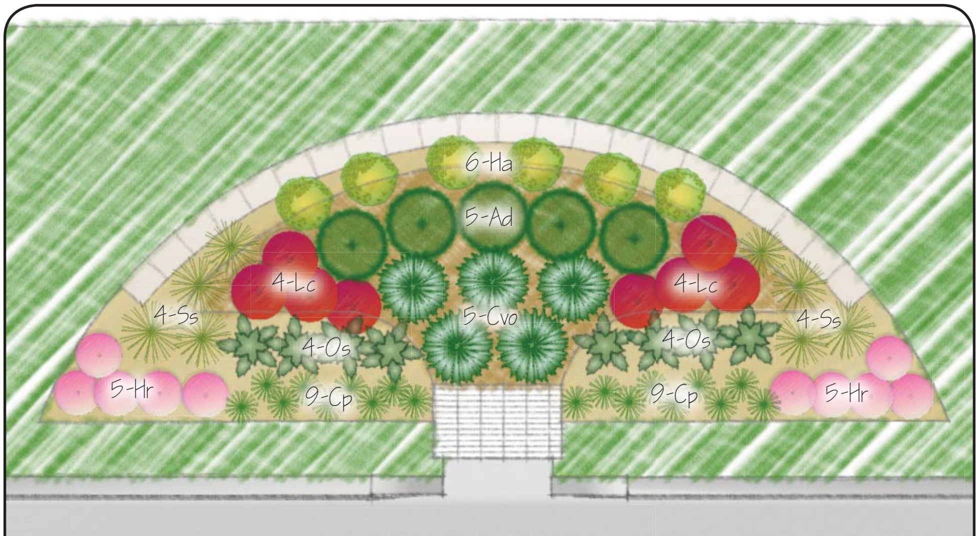


Mixed Shrub/Flower Garden

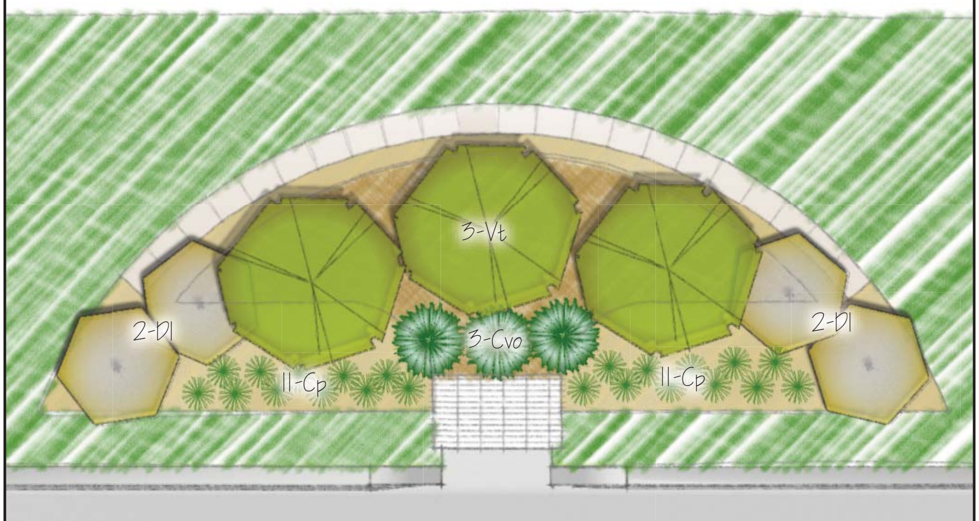
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvu	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

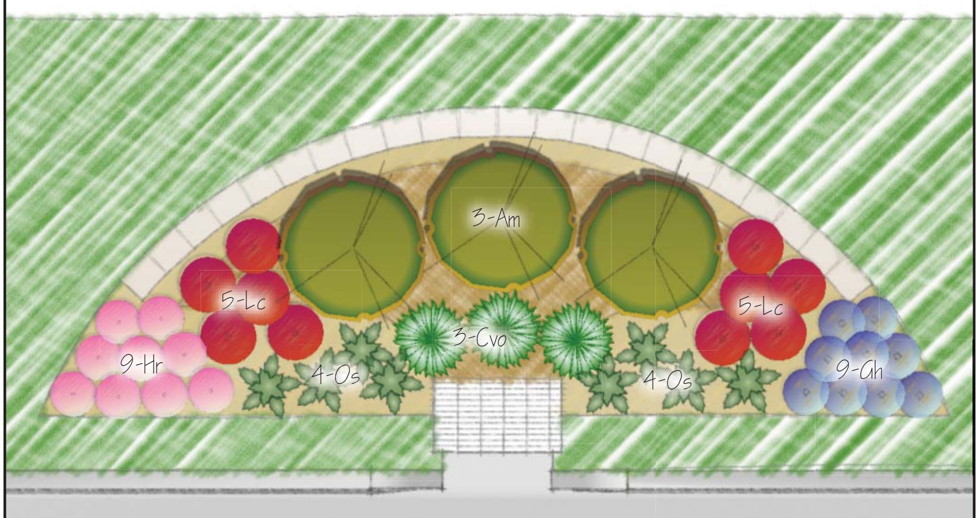
XI. Arc Garden - Shady Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden

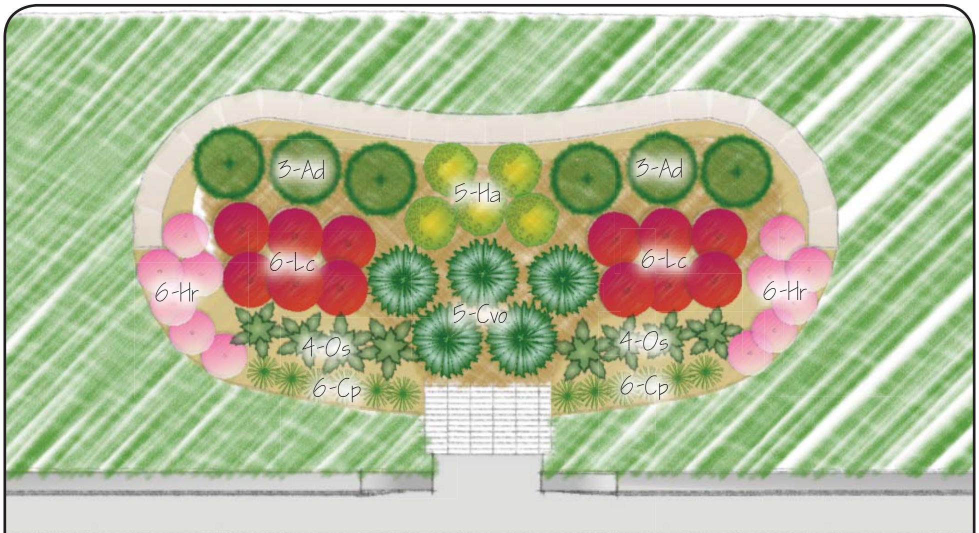


Mixed Shrub/Flower Garden

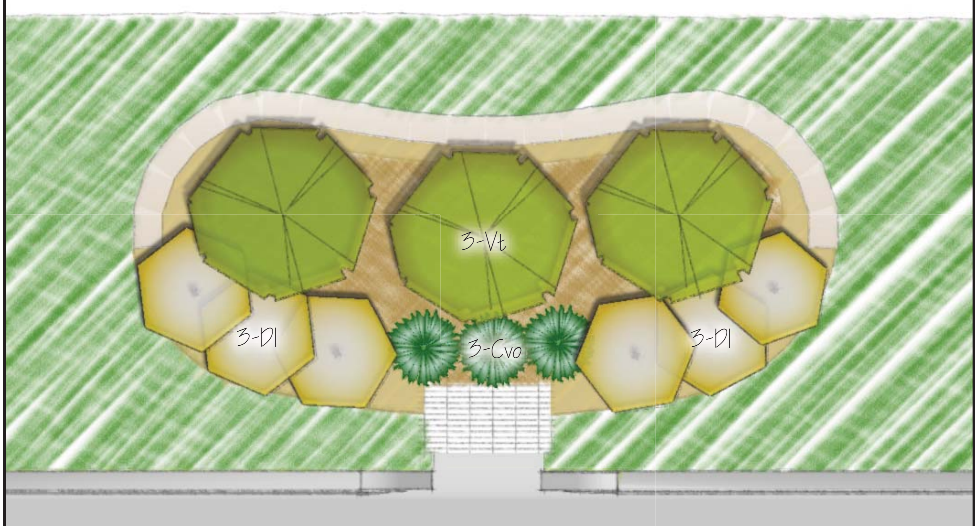
Plant Key

Am	BLACK CHOKEBERRY *Aronia melonocarpa*
Ad	GOAT'S BEARD *Aruncus diocius*
Cp	PENNSYLVANIA SEDGE *Carex pennsylvanica*
Cvo	FOX SEDGE *Carex vulpinoidea*
Dl	DWARF BUSH HONEYSUCKLE *Diervilla lonicera*
Gh	GERANIUM 'JOHNSON BLUE' *Geranium himalayense x pratense*
Ha	SNEEZEWEED *Helenium autumnale*
Hr	ALUMROOT *Heuchera richardsonii*
Lc	CARDINAL FLOWER *Lobelia cardinalis*
Os	SENSITIVE FERN *Onoclea sensibilis*
Ss	LITTLE BLUESTEM *Schizachyrium scoparium*
Vt	CRANBERRYBUSH VIBURNUM *Viburnum trilobum 'compactum'*

XII. Curvilinear Garden - Shady Site - Retaining Wall



Flowering Perennial Garden



Shrub Garden

Mixed Shrub/Flower Garden

Plant Key

- **Am** — BLACK CHOKEBERRY, *Aronia melonocarpa*
- **Ad** — GOAT'S BEARD, *Aruncus diocius*
- **Cp** — PENNSYLVANIA SEDGE, *Carex pennsylvanica*
- **Cvo** — FOX SEDGE, *Carex vulpinoidea*
- **Dl** — DWARF BUSH HONEYSUCKLE, *Diervilla lonicera*
- **Gh** — GERANIUM 'JOHNSON BLUE', *Geranium himalayense x pratense*
- **Ha** — SNEEZEWEED, *Helenium autumnale*
- **Hr** — ALUMROOT, *Heuchera richardsonii*
- **Lc** — CARDINAL FLOWER, *Lobelia cardinalis*
- **Os** — SENSITIVE FERN, *Onoclea sensibilis*
- **Vt** — CRANBERRYBUSH VIBURNUM, *Viburnum trilobum 'compactum'*

FLOWERING PERENNIAL
Plant pallette

CANADA ANEMONE
Anemone canadensis

GOAT'S BEARD
Aruncus diocius

BUTTERFLY MILKWEED
Asclepias tuberosa

ASTER 'PURPLE DOME'
Aster novae-angliae 'Purple Dome'

COREOPSIS 'MOONBEAM'
Coreopsis verticillata 'Moonbeam'

PURPLE PRARIE CLOVER
Dalea purpurea

PURPLE CONEFLOWER
Echinacea purpurea

GERANIUM 'JOHNSON BLUE'
Geranium himalayense x pratense

PRAIRIE SMOKE
Geum trifolium

SNEEZEWEED
Helenium autumnale

ALUMROOT
Heuchera richardsonii

PRAIRIE BLAZING STAR
Liatris pycnostachya

CARDINAL FLOWER
Lobelia cardinalis

SENSITIVE FERN
Onoclea sensibilis

GOLDSTRUM BLACK-EYED SUSAN
Rudbeckia fulgida

CULVERS ROOT
Veronicastrum virginicum

SHRUB
Plant pallette

BLACK CHOKEBERRY
Aronia melonocarpa

DWARF BUSH HONEYSUCKLE
Diervilla lonicera

DART'S RED SPIRAEA
Spiraea japonica

CRANBERRYBUSH VIBURNUM
Viburnum trilobum 'compactum'

GRASSES
Plant pallette

KARL FORESTER GRASS
Calamagrostis acutifolia

PENNSYLVANIA SEDGE
Carex pennsylvanica

FOX SEDGE
Carex vulpinoidea

JUNE GRASS
Koeleria macrantha

LITTLE BLUESTEM
Schizachyrium scoparium

PRAIRIE DROPSEED
Sporobolis heterolepsis