CITY OF CENTER CITY:
STORMWATER RETROFIT ASSESSMENT

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With assistance from:

THE METRO CONSERVATION DISTRICTS

For:

THE CITY of CENTER CITY & THE CHISAGO LAKES LAKE IMPROVEMENT DISTRICT

This report details a subwatershed stormwater retrofit assessment resulting in recommended catchments for placement of Best Management Practice (BMP) retrofits that address the goals of the Local Governing Unit (LGU) and stakeholder partners. This document should be considered as *one part* of an overall watershed restoration plan including educational outreach, stream repair, riparian zone management, discharge prevention, upland native plant community restoration, and pollutant source control. The methods and analysis behind this document attempt to provide a sufficient level of detail to rapidly assess sub-watersheds of variable scales and land-uses to identify optimal locations for stormwater treatment. The time commitment required for this methodology is appropriate for *initial assessment* applications. This report is a vital part of overall subwatershed restoration and should be considered in light of forecasting riparian and upland habitat restoration, pollutant hot-spot treatment, agricultural and range land management, good housekeeping outreach and education, and others, within existing or future watershed restoration planning.

The assessment's background information is discussed followed by a summary of the assessment's results, the methods used and catchment profile sheets of selected sites for retrofit consideration. Lastly, the retrofit ranking criteria and results are discussed and source references are provided.

Results of this assessment are based on the development of catchment-specific *conceptual* stormwater treatment best management practices that either supplement existing stormwater infrastructure or provide quality and volume treatment where none currently exists. Relative comparisons are then made between catchments to determine where best to initialize final retrofit design efforts. Final, site-specific design sets (driven by existing limitations of the landscape and its effect on design element selections) will need to be developed to determine a more refined estimate of the reported pollutant removal amounts reported herein. This typically occurs after the procurement of committed partnerships relative to each specific target parcel slated for the placement of BMPs.

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Contents

Executive Summary

The City of Center City (about 600 acres) was broken down into forty-nine catchments, and their existing stormwater management practices, were analyzed for annual pollutant loading. Stormwater practice options were compared, for each catchment, given their specific site constraints and characteristics. A stormwater practice was selected by weighing cost, ease of installation and maintenance and ability to serve multiple functions identified by the City. Twenty-two of the 49 catchments were selected and modeled at various levels of treatment efficiencies. These catchments should be considered the "low-hanging-fruit" for stormwater retrofit opportunities within Center City. Most of the catchments are relatively small due to the topography and geography of Center City.

The following table summarizes the assessment results. Some catchments are not included in the report due to treatment levels (percent removal rates) for retrofit projects that resulted in a prohibitive BMP size, or number, or were too expensive to justify installation. Reported treatment levels are dependent upon optimal siting and sizing. The recommended treatment levels/amounts summarized here are based on a subjective assessment of what can realistically be expected to be installed considering expected public participation and site constraints. As needed, this document will be modified to address new products or updates in the assessment process to make the document more accurate.

Catchment ID	Retrofit Type	Qty of 100 ft+^{3} BMPs	TP Reduction (%)	TP Reduction (lb/yr)	Volume Reduction (ac/ft/yr)	Overall Cost Est [1]	O&M Term (years)	Total Est. Term Cost/lb-TP/yr [2]
CENTER CITY – 2	B	4	30	1.0	0.8	$9,255	30	$480
CENTER CITY – 3	B	2	30	0.6	0.4	$5,948	30	$405
CENTER CITY – 4	B	2	30	0.6	0.4	$6,185	30	$445
CENTER CITY – 5	B	3	30	0.6	0.5	$6,342	30	$449
CENTER CITY – 7	PS	2	50	0.4	0.2	$4,110	30	$379
CENTER CITY – 9	B, PS	3	30	0.8	0.6	$8,530	30	$484
CENTER CITY – 10	B, PS	5	30	1.3	1.0	$12,446	30	$521
CENTER CITY – 11	B, PS	5	31	1.3	1.0	$12,550	30	$515
CENTER CITY – 22	B, PS	15	30	3.6	2.8	$31,508	30	$567
CENTER CITY – 23	B, PS	8	30	1.9	1.5	$15,622	30	$511
CENTER CITY – 26	B, PS, VS	9	49	1.7	1.3	$15,181	30	$541
CENTER CITY – 29	B, PS	5	20	2.2	1.1	$11,330	30	$482
CENTER CITY – 31	B, PS	6	30	1.6	1.2	$12,889	30	$486
CENTER CITY – 32	B	9	20	2.3	1.6	$18,548	30	$514
CENTER CITY – 35	B	5	50	1.0	0.8	$11,196	30	$503
CENTER CITY – 38	B	5	30	1.2	1..0	$9,437	30	$463
CENTER CITY – 41	B	4	30	0.8	0.6	$6,058	30	$433

B = Bioretention (infiltration and/or filtration)
F = Filtration (sand curtain, surface sand filter, sump, etc)
PM = Pond Modification (increased area/depth, additional cells, forebay, and/or outlet modification)
PS = Permeable Surface (infiltration and/or filtration)
VS = Vegetated Swale (wet or dry)

[1]Estimated "Overall Cost" includes design, contracted soil core sampling, materials, contracted labor, promotion and administrative costs (including outreach, education, contracts, grants, etc), pre-construction meetings, installation oversight and 1 year of operation and maintenance costs. [2]"Total Est. Term Cost" includes Overall Cost plus 30 years of maintenance and is divided by 30 years of TP treatment.

About this Document

Document Overview

This Subwatershed 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.

This document is organized into four major sections that describe the general methods used, individual catchment profiles, a resulting retrofit ranking for the subwatershed and references used in this assessment protocol. In some cases, and Appendices section provides additional information relevant to the assessment.

Under each section and subsection, project-specific information relevant to that portion of the assessment is provided with an ***Italicized Heading***.

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. Project-specific details of each process are defined if different from the general, standard procedures.

NOTE: the financial, technical, current landscape/stormwater system, and timeframe limits and needs are highly variable from subwatershed to subwatershed. This assessment uses some, or all, of the methods described herein.

Retrofit Profiles

When applicable, each retrofit profile is labeled with a unique ID to coincide with the subwatershed name (e.g., CENTER CITY-01 for City of Center City catchment 01). This ID is referenced when comparing projects across the subwatershed. Information found in each catchment profile is described below.

Catchment Summary/Description

Within the catchment profiles is a table that summarizes basic catchment information including acres, land cover, parcels, and estimated annual pollutant load (and other pollutants and volumes as specified by the LGU). Also, a table of the principal modeling parameters and values is reported. A brief description of the land cover, stormwater infrastructure and any other important general information is also described here.

Retrofit Recommendation

The recommendation section describes the conceptual BMP retrofit(s) selected for the catchment area and provides a description of why the specific retrofit(s) was chosen.

Cost/Treatment Analysis

A summary table provides for the direct comparison of the expected amount of treatment, within a catchment, that can be expected per invested dollar. In addition, the results of each catchment can be cross-referenced to optimize available capitol budgets vs. load reduction goals.

Site Selection

A rendered aerial photograph highlights properties/areas suitable for retrofit projects. Additional field inspections will be required to verify project feasibility, but the most ideal locations for retrofits are identified here.

Retrofit Ranking

Retrofit ranking takes into account all of the information gathered during the assessment process to create a prioritized project list. The list is sorted by cost per pound of phosphorus treated for each project for the duration of one maintenance term (conservative estimate of BMP effective life). The final cost per pound treatment value includes installation and maintenance costs. There are many possible ways to prioritize projects, and the list provided is merely a starting point. Final project ranking for installation may include:

- Non-target pollutant reductions
- Project visibility
- Availability of funding
- Total project costs
- Educational value
- Others

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 at various points along the assessment protocol.

Methods

Selection of Subwatershed

Before the subwatershed stormwater assessment begins, a process of identifying a high priority water body as a target takes place. Many factors are considered when choosing which subwatershed to assess 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. Assessments supported by a Local Government Unit with sufficient capacity (staff, funding, available GIS data, etc.) to greater facilitate the assessment also rank highly.

In areas without clearly defined studies, such as TMDL or officially listed water bodies of concern, or where little or no monitoring data exist, metrics are used to score subwatersheds against each other. In large subwatersheds (e.g., greater than 2,500 acres), a similar metric scoring is used to identify areas of concern, or focus areas, for a more detailed assessment. This methodology was slightly modified from Manual 2 of the *Urban Stormwater Retrofit Practices* series.

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 included 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 district staff 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.

Center City Scoping

Pollutants of concern for this subwatershed were identified as Total Phosphorus (TP), Total Suspended Solids (TSS), and Volume. Center City has projects identified that they feel are high priority projects. This assessment will be used to reassure or change their priority list to help meet water quality goals.

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). The following table highlights some important features to look for and the associated potential retrofit project.

Subwatershed Metrics and Potential Retrofit Project Site/Catchment	
Screening Metric	**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 or curb-cut raingardens or filtering systems to treat stormwater before it enters storm drain network.**

Step 3: Retrofit Reconnaissance Investigation

After identifying potential retrofit sites through this desktop search, a field investigation was conducted to evaluate each site. 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 also revealed additional retrofit opportunities that could have gone unnoticed during the desktop search.

The following stormwater BMPs were considered for each catchment/site:

Stormwater Treated 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 soil, 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, peat, compost and iron.**
	Infiltration	**A rock-filled trench or sump 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 raingardens, rain barrels, green roofs, cisterns, stormwater planters, dry wells or permeable pavements.**

Step 4: Treatment Analysis/Cost Estimates

Treatment analysis

Sites most likely to be conducive to addressing the LGU goals and appear to be simple-to-moderate in design/install/maintenance considerations are chosen for a cost/benefit analysis in order to relatively compare catchments/sites. Treatment concepts are developed taking into account site constraints and the subwatershed treatment objectives. Projects involving complex stormwater treatment interactions or that pose a risk for upstream flooding require the assistance of a certified engineer. Conceptual designs, at this phase of the design process, include a cost estimate and estimate of pollution reduction. Reported treatment levels are dependent upon optimal site selection and sizing.

Modeling of the site is done by one or more methods such as with P8, WINSLAMM or simple spreadsheet methods using the Rational Method. Event mean concentrations or sediment loading files (depending on data availability and model selection) are used for each catchment/site to estimate relative pollution loading of the existing conditions. The site's conceptual BMP design is modeled to then estimate varying levels of treatment by sizing and design element. This treatment model can also be used to properly size BMPs to meet LGU restoration objectives.

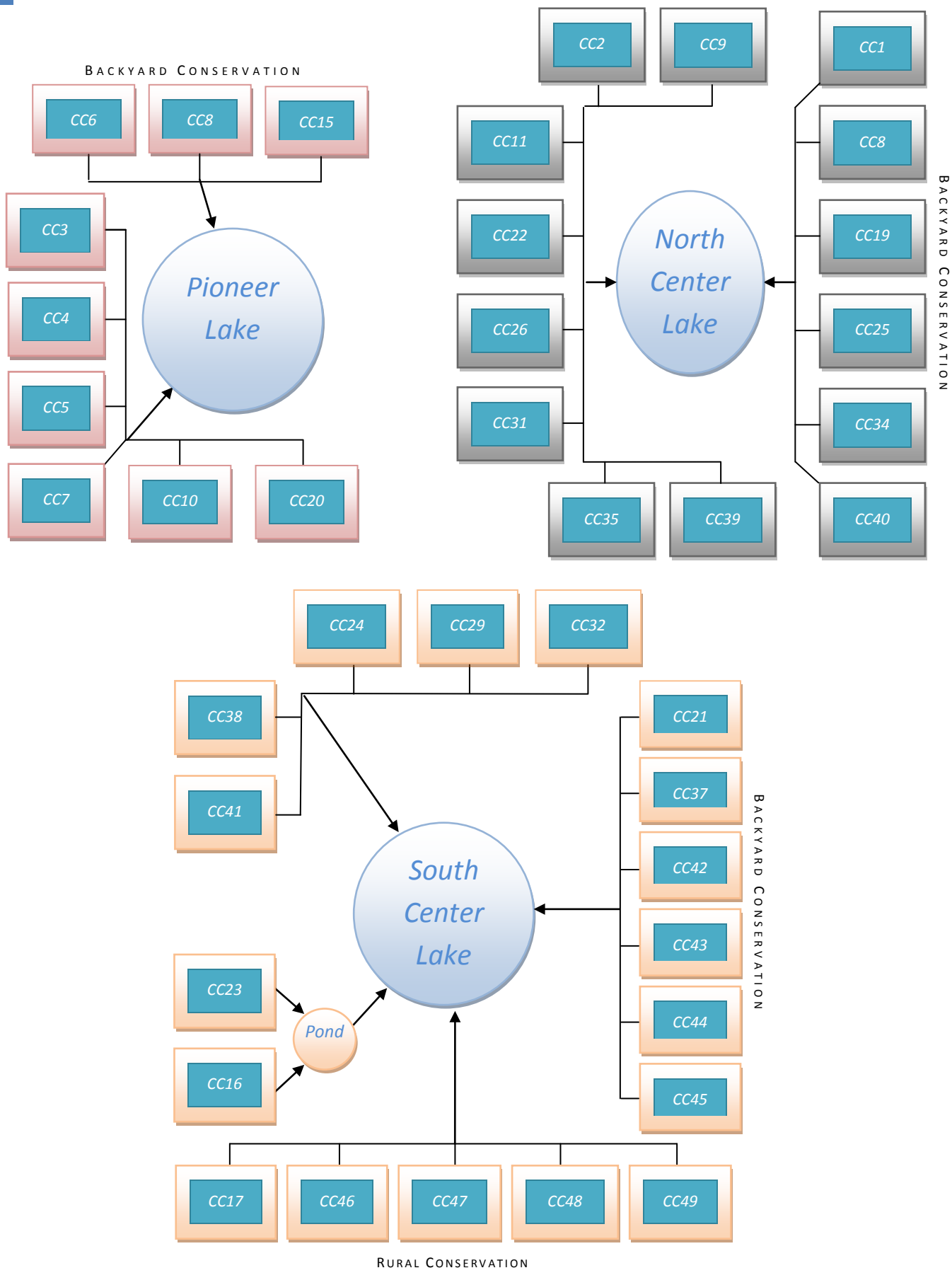
General P8 Model Inputs	
Parameter	Method for Determining Value
Total Area	Source/Criteria
Pervious Area Curve Number	Values from the USDA Urban Hydrology for Small Watersheds TR-55 (1986). A composite curve number was found based on proportion of hydrologic soil group and associated curve numbers for open space in fair condition (grass cover 50%-75%).
Directly Connected Impervious Fraction	Calculated using GIS to measure the amount of rooftop, driveway and street area directly connected to the storm system. Estimates calculated from one area can be used in other areas with similar land cover.
Indirectly Connected Impervious Fraction	Wisconsin urban watershed data (Panuska, 1998) provided in the P8 manual is used as a basis for this number. It is adjusted slightly based on the difference between the table value and calculated value of the directly connected impervious fraction.
Precipitation/Temperature Data	Rainfall and temperature recordings from 1959 were used as a representation of an average year.
Hydraulic Conductivity	A composite hydraulic conductivity rate is developed for each catchment area based on the average conductivity rate of the low and high bulk density rates by USDA soil texture class (Rawls et. al, 1998). Wet soils where practices will not be installed are omitted from composite calculations.
Particle/Pollutant	The default NURP50 particle file was used.
Sweeping Efficiency	Unless otherwise noted, street sweeping was not accounted for.

City of Center City Treatment Analysis

For the City of Center City treatment analysis, each catchment, and each parcel within them, was first assessed for BMP "family" type applicability given specific site constraints and soil types. Pedestrian and car traffic flow, parking needs, snow storage areas, obvious utility locations, existing landscaping, surface water runoff flow, project visibility, "cues of care" in relation to existing landscape maintenance, available space and several other factors dictated the selection of one or more potential BMPs for each site.

P8 was used to model catchments and a hypothetical BMP located at its outfall. The BMP was sized from the Minimum Acceptable to Maximum Feasible treatment size and results were tabulated in the Catchment Profile section of this document.

The existing stormwater network was modeled in P8 as illustrated in the following diagram:


BACKYARD CONSERVATION
CC6
CC8
CC15
CC3
CC4
CC5
CC7
CC10
CC20
Pioneer Lake
CC2
CC9
CC11
CC22
CC26
CC31
CC35
CC39
North Center Lake
CC1
CC8
CC19
CC25
CC34
CC40
BACKYARD CONSERVATION
CC24
CC29
CC32
CC38
CC41
CC23
CC16
Pond
South Center Lake
CC21
CC37
CC42
CC43
CC44
CC45
BACKYARD CONSERVATION
CC17
CC46
CC47
CC48
CC49
RURAL CONSERVATION

Cost Estimates

Each resulting BMP (by percent TP-removal dictated sizing) was then assigned estimated design, installation and first-year establishment-related maintenance costs given its ft^3 of treatment. In cases where live storage was 1-ft, this number roughly related to ft^2 of coverage. An annual cost/TP-removed for each treatment level was then calculated for the life-cycle of said BMP which included promotional, administrative and life-cycle operations and maintenance costs.

The following table provides the BMP cost estimates used to assist in cost-analysis:

Average BMP Cost Estimates

BMP	Median Inst. Cost ($/sq ft)	Marginal Annual Maintenance Cost (contracted)	O & M Term	Design Cost ($70/hr)	Installation Oversight Cost ($70/hr)	Total Installation Cost (Incl. design & 1-yr maint.)
Pond Retrofits	$3.00	$500/acre	30	[1]40% above construction	$210 (3 visits)	**$4.21/sq ft**
Extended Detention	$5.00	$1000/acre	30	[3]$2800/acre	$210 (3 visits)	**$5.09/sq ft**
Wet Pond	$5.00	$1000/acre	30	[3]$2800/acre	$210 (3 visits)	**$5.09/sq ft**
Stormwater Wetland	$5.00	$1000/acre	30	[3]$2800/acre	$210 (3 visits)	**$5.09/sq ft**
Water Quality Swale[6]	$12.00	$250/100 ln ft	30	$1120/100 ln ft	$210 (3 visits)	**$12.91/sq ft**
Cisterns	$15.00	[5]$100	30	NA	$210 (3 visits)	**$15.00/sq ft**
French Drain/Dry Well	$12.00	[5]$100	30	20% above construction	$210 (3 visits)	**$14.40/sq ft**
Infiltration Basin	$15.00	$500/acre	30	$1120/acre	$210 (3 visits)	**$15.04/sq ft**
Rain Barrels	$25.00	[5]$25	30	NA	$210 (3 visits)	**$25.00/sq ft**
Structural Sand Filter (including peat, compost, iron amendments, etc.) [6]	$20.00	$250/25 ln ft	30	$300/25 ln ft	$210 (3 visits)	**$21.47/sq ft**
Impervious Cover Conversion	$20.00	$500/acre	30	$1120/acre	$210 (3 visits)	**$20.04/sq ft**
Stormwater Planter	$27.00	$50/100 sq ft	30	20% above construction	$210 (3 visits)	**$32.90/sq ft**
Rain Leader Disconnect Raingardens	$4.00	[2]$25/150 sq ft	30	$280/100 sq ft	$210 (3 visits)	**$6.97/sq ft**

Simple Bioretention (no eng. soils or under-drains, but w/curb cuts and forebays)	$10.00	$0.75/sq ft	30	$840/1000 sq ft	$210 (3 visits)	**$11.59/sq ft**
Moderate Bioretention (incl. engineered soils, under-drains, curb cuts, no retaining walls)	$12.00	$0.75/sq ft	30	$1120/1000 sq ft	$210 (3 visits)	**$13.87/sq ft**
Moderately Complex Bioretention (incl. eng. soils, under-drains, curb cuts, forebays , 2-3 ft retaining walls)	$14.00	$0.75/sq ft	30	$1250/1000 sq ft	$210 (3 visits)	**$16.00/sq ft**
Highly Complex Bioretention (incl. eng. soils, under-drains, curb cuts, forebays, 3-5 ft retaining walls)	$16.00	$0.75/sq ft	30	[4]$1400/1000 sq ft	$210 (3 visits)	**$18.15/sq ft**
Underground Sand Filter	$65.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$91.75/sq ft**
Stormwater Tree Pits	$70.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$98.75/sq ft**
Grass/Gravel Permeable Pavement (sand base)	$12.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$17.55/sq ft**
Permeable Asphalt (granite base)	$10.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$14.00/sq ft**
Permeable Concrete (granite base)	$12.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$17.55/sq ft**
Permeable Pavers (granite base)	$25.00	$0.75/sq ft	30	[1]40% above construction	$210 (3 visits)	**$35.75/sq ft**
Extensive Green Roof	$225.00	$500/1000 sq ft	30	[1]40% above construction	$210 (3 visits)	**$315.50/sq ft**
Intensive Green Roof	$360.00	$750/1000 sq ft	30	[1]40% above construction	$210 (3 visits)	**$504.75/sq ft**

[1]Likely going to require a licensed, contacted engineer.

[2]Assumed landowner, not contractor, will maintain.

[3]LRP would only design off-line systems not requiring an engineer. For all projects requiring an engineer, assume engineering costs to be 40% above construction costs.

[4]If multiple projects are slated, such as in a neighborhood retrofit, a design packet with templates and standard layouts, element elevations and components, planting plans and cross sections can be generalized, design costs can be reduced.

[5]Not included in total installation cost (minimal).

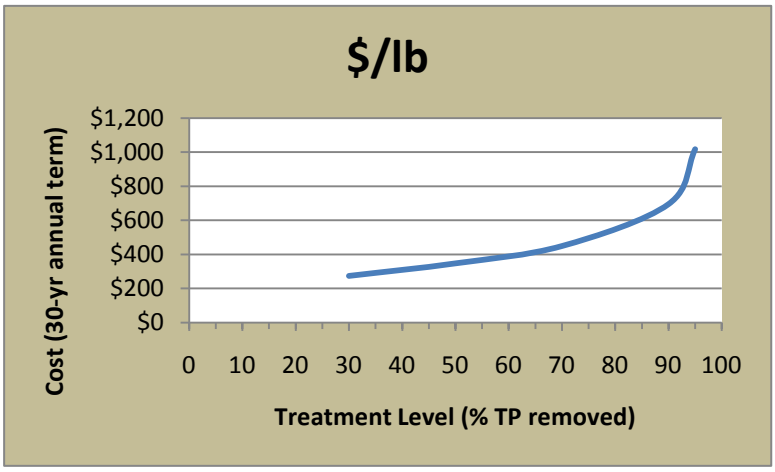
[6]Assumed to be 15 feet in width.

City of Center City Cost Analysis

For the City of Center City cost analysis, promotion and administration for each commercial/public property was estimated using a non-linear formula dependent on total number of 100 ft^3 treatment cells (BMPs), as the labor associated with outreach, education and administrative tasks typically see savings with scale. Annual O & M referred to the ft^2 estimates provided in the preceding table. In cases where multiple BMP types were prescribed for an individual site, both the estimated installation and maintenance-weighted means by ft^2 of BMP were used to produce cost/benefit estimates.

Step 5: Evaluation and Ranking

The results of each site were analyzed for cost/treatment to prescribe the most cost-efficient level of treatment.



City of Center City Evaluation and Ranking

In the City of Center City evaluation and ranking, the recommended level of treatment for each catchment, as reported in the Executive Summary table, was chosen by selecting the level of treatment expected to get considering public buy-in and above a minimal amount needed to justify crew mobilization and outreach efforts to the area. Should the cumulative expected load reduction of the recommended catchment treatment levels not meet LGU goals, moving up one level of treatment (as described in the Catchment Profile tables) should then be selected.

Catchment Profiles

The following pages provide catchment-specific information that was analyzed for stormwater BMP retrofit treatment at various levels. The recommended level of treatment reported in the Ranking Table is determined by weighing the cost-efficiency vs. site specific limitations about what is truly practical in terms of likelihood of being granted access to optimal BMP site locations, expected public buy-in (partnership) and crew mobilization in relation to BMP spatial grouping.

City of Center City Catchment Profiles

For development of the City of Center City catchment profile section, 16 out of 52 catchments were selected as the first-tier areas for stormwater retrofit efforts. Those catchments receiving modern stormwater pond treatment, or in some cases 2 levels of treatment, were not modeled or further analyzed in this assessment. It is recommended that after these initial catchments are built out past the recommended reduction levels that catchments 8, 37-39, 46 and their pond networks be modeled. Analyzing pond modification first, then secondary uphill distributed retrofits are recommended. Newer developments with "water quality" stormwater ponds may still be modeled to achieve even more treatment (Catchments 1-3, 10, 12, 47, 52 and 53) after the other catchment projects are completed or deemed impractical. All other catchments not previously identified were either adequately treated with little opportunity for more treatment, or were in need of backyard conservation (i.e. lakeshore restorations, rain leader disconnect rain gardens, rain barrels, etc.).

The catchments that were modeled for treatment possibilities were modeled at many levels of treatment. The first level was sized for the maximum allowed space for bioretention or the estimated highest level of participation, then levels of treatment below the maximum were modeled. Most of the time the Minimum and Middle treatment level ended up being between 20-50% Total Phosphorus removal.

A cost benefit analysis like this example table is included for each catchment:

	Cost/Benefit Analysis	***Annual Marginal Treatment Enhancement***					
		Min		**Mid**		**Max**	
Treatment	**TP (lb/yr)**	1.3	20%	1.9	30%	3.1	50%
	TSS (lb/yr)	931	48%	1,137	58%	1,460	75%
	Volume (ac-feet/yr)	0.6	11%	1.8	19%	1.9	35%
	Live Storage Volume (cubic feet)	511		1,089		2,367	
Costs	**Materials/Labor/Design**	$8,022		$14,288		$31,056	
	Promotion & Admin Costs	$488		$320		$182	
	Total Project Cost	$8,509		$14,608		$31,238	
	Annual O&M	$459		$817		$1,775	
	Term Cost/lb/yr (30 yr)	$594		$705		$909	

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CENTER CITY – 2

Catchment Summary	
Acres	6.16
Dominant Land Cover	Residential
Parcels	12
Volume (acre-feet/yr)	2.8
TP (lb/yr)	3.3
TSS (lb/yr)	1,027

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.22
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of primarily medium density, single family residential development. There are existing road ditches that are connected under driveways with culverts. These ditches are planted with blue grass and are currently mowed. Water from the back of the houses is directed into the back yards and makes its way to the road ditches on the north end of the catchment.

RETROFIT RECOMMENDATION

The current road ditches can be planted to native grasses and forbs to slow water down and increase infiltration rates. Two options exist for the back yards in the catchment. The swale that currently exists to convey water can be planted and left as a swale, or a small berm can be created to slow water down and allowed to infiltrate.

Combining Catchments 2, 3, 4 and 5 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.7	20%	1.0	30%	1.6	50%
	TSS (lb/yr)	473	46%	580	56%	756	74%
	Volume (acre-feet/yr)	0.5	18%	0.8	29%	1.3	46%
	Live Storage Volume (cubic feet)	253		423		858	
Costs	Materials/Labor/Design	$3,922		$6,557		$13,299	
	Promotion & Admin Costs	$2,348		$2,699		$3,269	
	Total Project Cost	$6,270		$9,255		$16,568	
	Annual O&M	$190		$317		$644	
	Term Cost/lb/yr (30 yr)	$464		$480		$560	

CENTER CITY – 3

Catchment Summary	
Acres	3.64
Dominant Land Cover	Residential
Parcels	8
Volume (acre-feet/yr)	1.6
TP (lb/yr)	1.8
TSS (lb/yr)	575

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.21
Hydraulic Conductivity (in/hr)	0.51

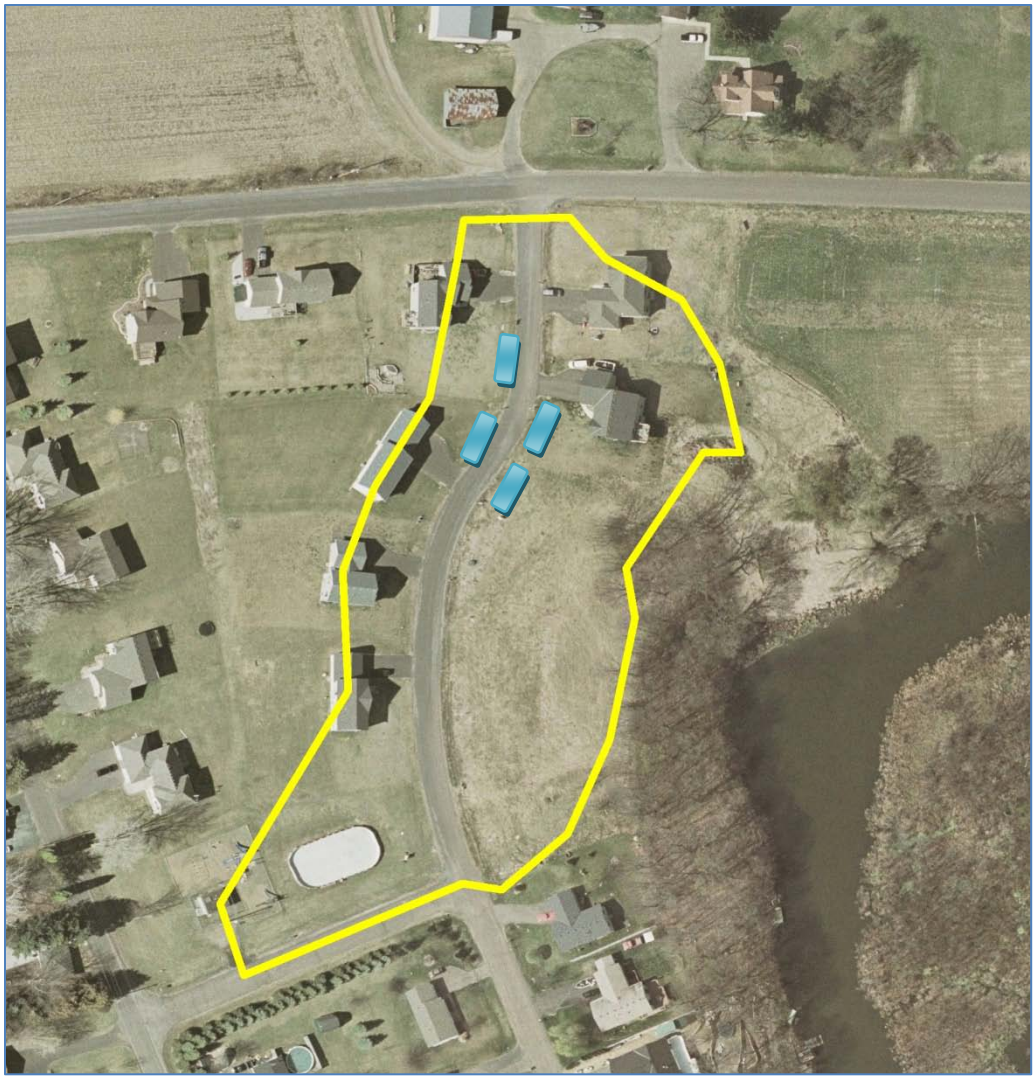
DESCRIPTION

This catchment is comprised of primarily medium density, single family residential development. There are existing road ditches that are connected under driveways with culverts. These ditches are planted with blue grass and are currently mowed. Water from the back of the houses is directed into the back yards and makes its way to the road ditches on the north end of the catchment. There is a small pond at the bottom of the catchment.

RETROFIT RECOMMENDATION

The current road ditches can be planted to native grasses and forbs to slow water down and increase infiltration rates. The best locations for this will be immediately adjacent to the culvert that goes under the road and the area before water heads down the swale to the pond.

Combining Catchments 2, 3, 4 and 5 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.



Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	20%	0.6	30%	0.9	50%
	TSS (lb/yr)	264	46%	325	56%	423	74%
	Volume (acre-feet/yr)	0.3	18%	0.4	29%	0.7	46%
	Live Storage Volume (cubic feet)	139		235		484	
Costs	Materials/Labor/Design	$2,161		$3,646		$7,494	
	Promotion & Admin Costs	$1,998		$2,302		$2,798	
	Total Project Cost	$4,158		$5,948		$10,293	
	Annual O&M	$105		$176		$363	
	Term Cost/lb/yr (30 yr)	$426		$405		$508	

CENTER CITY – 4

Catchment Summary	
Acres	3.93
Dominant Land Cover	Residential
Parcels	11
Volume (acre-feet/yr)	1.7
TP (lb/yr)	1.9
TSS (lb/yr)	600

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.20
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This small catchment is comprised of medium density residential. Water is conveyed through road ditches and under-driveway culverts to a pipe that is at the top of a gully. It is not known if the gully is actively eroding or if it has a stable outlet.

RETROFIT RECOMMENDATION

The current road ditches can be planted to native grasses and forbs to slow water down and increase infiltration rates to reduce the amount of water that reaches the gully. If actively eroding, the gully will need to be stabilized to ensure a reduction in the amount of sediment and phosphorus reaching Pioneer Lake. If the gully is actively eroding, we suggest stabilization to reduce pollutant loading (these pollutant reduction amounts and cost estimates are not included in the assessment – a gully of this size could be stabilized for less than $10,000).

Combining Catchments 2, 3, 4 and 5 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.

Proposed Bioretention Areas Proposed Gully Stabilization

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	20%	0.6	30%	1.0	50%
	TSS (lb/yr)	276	46%	339	56%	441	74%
	Volume (acre-feet/yr)	0.28	17%	0.4	26%	0.8	45%
	Live Storage Volume (cubic feet)	148		248		505	
Costs	Materials/Labor/Design	$2,296		$3,849		$7,828	
	Promotion & Admin Costs	$2,031		$2,336		$2,832	
	Total Project Cost	$4,326		$6,185		$10,659	
	Annual O&M	$111		$186		$379	
	Term Cost/lb/yr (30 yr)	$442		$445		$503	

CENTER CITY - 5

Catchment Summary	
Acres	2.11
Dominant Land Cover	Residential
Parcels	7
Volume (acre-feet/yr)	1.7
TP (lb/yr)	2.0
TSS (lb/yr)	626

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.39
Hydraulic Conductivity (in/hr)	0.51

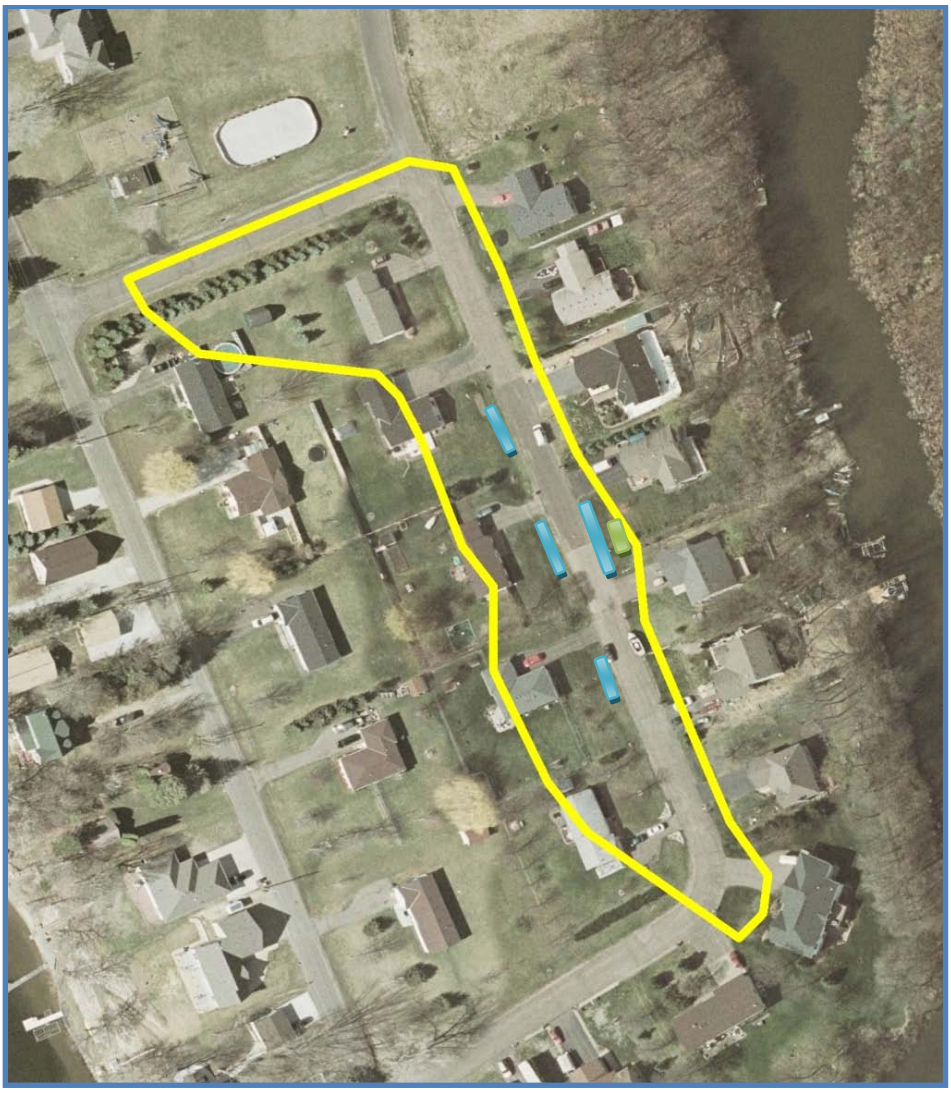
DESCRIPTION

This small catchment is comprised of medium density residential. Water is conveyed through road ditches and under-driveway culverts to a pipe that is at the top of a gully. It is not known if the gully is actively eroding or if it has a stable outlet.

RETROFIT RECOMMENDATION

The current road ditches can be planted to native grasses and forbs to slow water down and increase infiltration rates to reduce the amount of water that reaches the gully. If actively eroding, the gully will need to be stabilized to ensure a reduction in the amount of sediment and phosphorus reaching Pioneer Lake. If the gully is actively eroding, we suggest stabilization to reduce pollutant loading (these pollutant reduction amounts and cost estimates are not included in the assessment – a gully of this size could be stabilized for less than $10,000).

Combining Catchments 2, 3, 4 and 5 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.



Proposed Bioretention Areas Proposed Gully Stabilization

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	20%	0.6	30%	1.0	50%
	TSS (lb/yr)	288	46%	354	56%	461	74%
	Volume (acre-feet/yr)	0.3	17%	0.5	27%	0.8	46%
	Live Storage Volume (cubic feet)	153		257		523	
Costs	Materials/Labor/Design	$2,364		$3,984		$8,102	
	Promotion & Admin Costs	$2,047		$2,358		$2,858	
	Total Project Cost	$4,411		$6,342		$10,960	
	Annual O&M	$114		$193		$392	
	Term Cost/lb/yr (30 yr)	$436		$449		$505	

CENTER CITY – 7

Catchment Summary	
Acres	0.53
Dominant Land Cover	Road
Parcels	-
Volume (acre-feet/yr)	0.6
TP (lb/yr)	0.7
TSS (lb/yr)	223

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.55
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment consists of mostly the very narrow end of Nelson Court. A few yards have a small amount of drainage to the roadway.

RETROFIT RECOMMENDATION

The best opportunity for treatment in this catchment is bioretention in the form of a pervious roadway. Pervious pavers, concrete, or asphalt could be used. Our recommendation is pervious concrete or asphalt due to the cost of pavers. The very end of the road will be transformed to pervious when it is necessary for the road to be replaced. More treatment could be achieved by transforming more area.

Proposed Permeable Pavement

	Cost/Benefit Analysis	Pervious Road					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.1	20%	0.2	30%	0.4	50%
	TSS (lb/yr)	102	46%	125	56%	163	73%
	Volume (acre-feet/yr)	0.1	17%	0.2	27%	0.3	47%
	Live Storage Volume (cubic feet)	52		92		183	
Costs	Materials/Labor/Design	$918		$1,606		$3,210	
	Promotion & Admin Costs	$900		$900		$900	
	Total Project Cost	$1,818		$2,506		$4,110	
	Annual O&M	$52		$92		$183	
	Term Cost/lb/yr (30 yr)	$296		$346		$379	

CENTER CITY - 9

Catchment Summary	
Acres	1.47
Dominant Land Cover	Parking Lot
Parcels	1
Volume (acre-feet/yr)	2.2
TP (lb/yr)	2.6
TSS (lb/yr)	823

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.73
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

The main land uses in this small catchment are parking lots, roads and the Chisago County Government Center. This catchment is highly impervious and has very few "easy" locations for bioretention retrofits. There is currently one small rain garden that collects some runoff from the "Sherriff's Parking Lot", but it is undersized for the whole catchment due to the lack of acceptable space.

RETROFIT RECOMMENDATION

Adding bioretention in the form of infiltration basins will reduce the runoff from the Chisago County Government Center is recommended. Infiltration can be increased along the side of the building to reduce the amount of water and pollutants entering the storm drain. Cost was estimated by combining practices to get an average price. Permeable pavement should be added in prime locations as the current pavement is upgraded. Adding permeable pavement when the current pavement has to be replaced will increase the treatment levels (costs not included due to the recommended treatment level being achieved by bioretention).

Proposed Bioretention Areas Proposed Permeable Pavement Existing Rain Garden

	Cost/Benefit Analysis	Government Center Retrofit *Annual Marginal Treatment Enhancement*					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	20%	0.8	30%	1.3	50%
	TSS (lb/yr)	377	46%	463	56%	603	73%
	Volume (acre-feet/yr)	0.4	18%	0.6	27%	1.0	45%
	Live Storage Volume (cubic feet)	196		335		675	
Costs	Materials/Labor/Design	$3,508		$5,997		$12,083	
	Promotion & Admin Costs	$2,191		$2,534		$3,063	
	Total Project Cost	$5,699		$8,530		$14,146	
	Annual O&M	$147		$251		$506	
	Term Cost/lb/yr (30 yr)	$468		$484		$562	

CENTER CITY – 10

Catchment Summary	
Acres	2.0
Dominant Land Cover	Parking Lot/Road
Parcels	2
Volume (acre-feet/yr)	3.6
TP (lb/yr)	4.3
TSS (lb/yr)	1,341

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.87
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This highly impervious catchment contains parking lots, roads and sidewalks. Within this area there 3 separate outfalls to Pioneer Lake but since the 3 catchments would have been small and they are similar they were combined. Behind the curb, the land is steeply sloped toward Pioneer Lake.

RETROFIT RECOMMENDATION

Space is limited for retrofit opportunities. The best options are potentially high priced. Converting the majority of the parking lot at the northern most part of this catchment is one of the best options given the tight space. There is some room at the top of the slope behind the curb to collect stormwater runoff for bioretention in the form of water quality swales or rain gardens. The cost estimate is a marriage of two BMP types.

Proposed Bioretention Area Proposed Permeable Pavement

	Cost/Benefit Analysis	Impervious Cover Retrofit — Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.9	20%	1.3	30%	2.1	50%
	TSS (lb/yr)	614	46%	754	56%	983	73%
	Volume (acre-feet/yr)	0.6	17%	1.0	27%	1.7	46%
	Live Storage Volume (cubic feet)	322		545		1,106	
Costs	Materials/Labor/Design	$5,656		$9,556		$19,410	
	Promotion & Admin Costs	$2,507		$2,890		$3,502	
	Total Project Cost	$8,164		$12,446		$22,912	
	Annual O&M	$242		$408		$830	
	Term Cost/lb/yr (30 yr)	$490		$521		$606	

CENTER CITY - 11

Catchment Summary	
Acres	2.8
Dominant Land Cover	Parking Lot
Parcels	5
Volume (acre-feet/yr)	3.6
TP (lb/yr)	4.2
TSS (lb/yr)	1,336

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.62
Hydraulic Conductivity (in/hr)	0.10

DESCRIPTION

There is a large amount of impervious in this catchment and the topography change from the large Government Center parking lot to North Lake Street. The parking lot makes up about one-half of the area of the catchment. Some of the runoff along North Lake Street currently travels through a water quality swale to allow for some infiltration.

RETROFIT RECOMMENDATION

As the parking lot needs to be resurfaced or repaired options of permeable asphalt, concrete or pavers should be considered. Reducing the amount of runoff from the large parking lot before it gets to the storm sewer in the center or the edge of the parking lot is necessary. Adding additional water quality swales along North Lake Street would be beneficial as well. A marriage of BMP costs was used for a cost estimate.

Proposed Bioretention Areas Proposed Permeable Pavement Existing Bioretention

	Government Center Parking Lot Retrofit					
	Cost/Benefit Analysis	***Annual Marginal Treatment Enhancement***					
		Min		**Mid**		**Max**	
Treatment	**TP (lb/yr)**	0.8	20%	1.3	31%	2.1	50%
	TSS (lb/yr)	613	46%	752	56%	980	73%
	Volume (acre-feet/yr)	0.6	17%	1.0	28%	1.7	46%
	Live Storage Volume (cubic feet)	322		540		1,089	
Costs	**Materials/Labor/Design**	$5,764		$9,666		$19,493	
	Promotion & Admin Costs	$2,507		$2,884		$3,487	
	Total Project Cost	$8,270		$12,550		$22,980	
	Annual O&M	$242		$405		$817	
	Term Cost/lb/yr (30 yr)	$522		$515		$603	

CENTER CITY – 22

Catchment Summary	
Acres	13.14
Dominant Land Cover	Res/ Commercial
Parcels	31
Volume (acre-feet/yr)	10.4
TP (lb/yr)	12.1
TSS (lb/yr)	3,793

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.38
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

Land uses in this catchment include residential, transportation and commercial business. The catchment has very steep slopes near the roads. There are current plans to reconstruct County Road 9 in the summer of 2011.

RETROFIT RECOMMENDATION

Bioretention projects will be fit into the landscape where the sites are appropriate. We will achieve the most treatment at the bottom of the catchment where the topography is less steep. One lot in the upper part of the catchment is conducive to bioretention, while there are more opportunities further south. One location in the downtown area could be modified to have a terraced rain garden that is designed to slow water and increase bioretention on a steep slope. There is a large City owned lot with great bioretention potential and one area where a paved area could be reduced and utilized for bioretention. As part of the County Road 9 reconstruction, the County will build a stormwater pond to collect a large amount of runoff from the road and allow it to settle and infiltrate before entering the lake.

Proposed Bioretention Areas Proposed Permeable Pavement

	Cost/Benefit Analysis	Bioretention Retrofit — Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	2.4	20%	3.6	30%	6.1	50%
	TSS (lb/yr)	1,743	46%	2,138	56%	2,788	74%
	Volume (acre-feet/yr)	1.8	17%	2.8	27%	4.7	45%
	Live Storage Volume (cubic feet)	919		1,546		3,149	
Costs	Materials/Labor/Design	$16,450		$27,673		$53,367	
	Promotion & Admin Costs	$3,331		$3,835		$4,650	
	Total Project Cost	$19,781		$31,508		$61,017	
	Annual O&M	$689		$1,160		$2,362	
	Term Cost/lb/yr (30 yr)	$519		$567		$666	

CENTER CITY – 23

Catchment Summary	
Acres	4.27
Dominant Land Cover	Church/ Parking
Parcels	6
Volume (acre-feet/yr)	5.4
TP (lb/yr)	6.3
TSS (lb/yr)	1,986

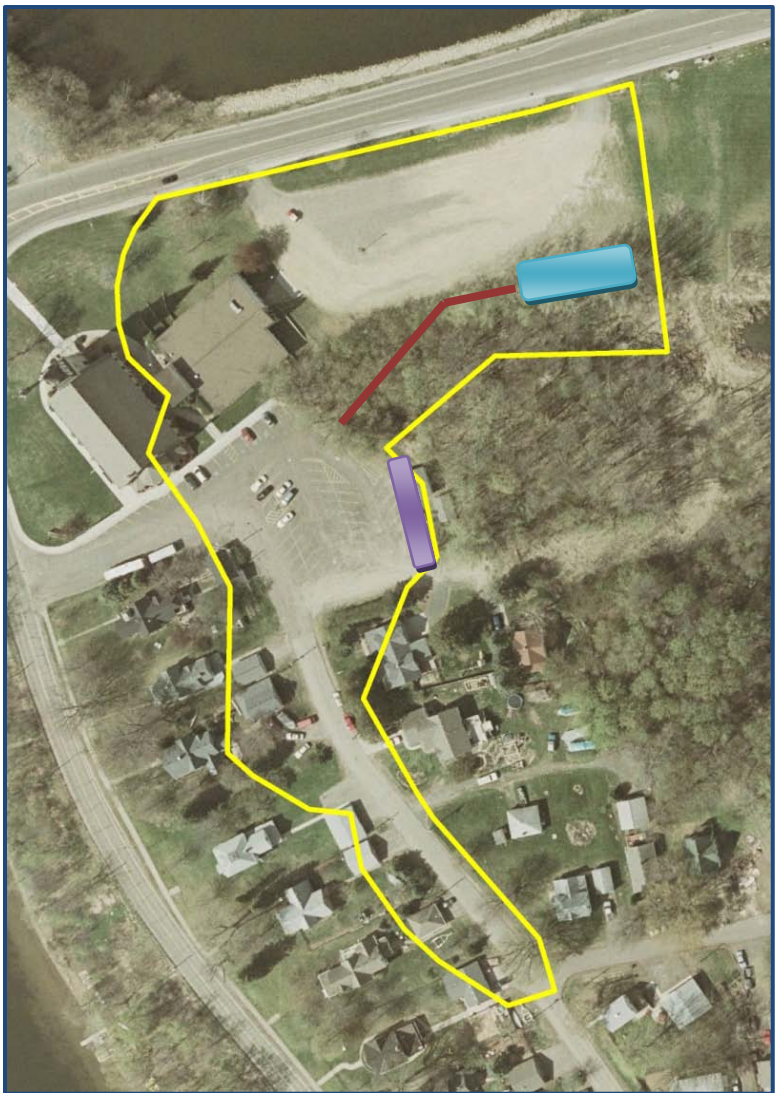
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.61
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

The Chisago Lake Lutheran Church and their parking lots make up the majority of this catchment along with a few residential homes. The Church has 2 large parking lots of which the runoff is mostly untreated. Some of the water from the upper parking lot is directed through a pipe and may get to the County owned stormwater pond in certain situations. The Church is interested in modifying their current parking lots to increase parking and reduce the amount of gravel parking.

RETROFIT RECOMMENDATION

The areas proposed for increased parking should be permeable asphalt or concrete as to not increase runoff to the system. The current pipe that conveys stormwater from the upper parking lot should be lengthened and directed to a bioretention cell that will collect runoff from the upper parking lot and the newly paved lower parking lot. The cost estimate is a marriage of cost estimates for all the practices.



Proposed Bioretention Proposed Pipe Modification Proposed Pervious Pavement

	Cost/Benefit Analysis	Bioretention Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.3	20%	1.9	30%	3.2	50%
	TSS (lb/yr)	911	46%	1,118	57%	1,4547	74%
	Volume (acre-feet/yr)	0.9	17%	1.5	27%	2.5	46%
	Live Storage Volume (cubic feet)	479		806		1,634	
Costs	Materials/Labor/Design	$8,578		$14,422		$29,240	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$9,778		$15,622		$30,440	
	Annual O&M	$359		$604		$1,225	
	Term Cost/lb/yr (30 yr)	$470		$511		$614	

CENTER CITY – 26

Catchment Summary	
Acres	1.81
Dominant Land Cover	Parking Lot/ Commercial
Parcels	2
Volume (acre-feet/yr)	3.0
TP (lb/yr)	3.5
TSS (lb/yr)	1,097

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.79
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

Limited locations for retrofits exist due to the large amount of impervious surface and the high water table in this catchment. Parking lots for the bank and Swedish Village Mall take up the majority of this catchment. This catchment is also very flat, which allows water to move slowly across the landscape. The small number of parcels involved will reduce the cost of promotion and administration.

RETROFIT RECOMMENDATION

Due to the limited space and other constraints, utilizing innovative ideas is a great possibility.

Bioretention should be added in the non-permeable areas of the catchment. Water from the north east part of the catchment should be directed to the current grass areas – these areas will be modified to increase bioretention. The majority of the pollutants from this catchment can be caught with rain gardens and vegetated swales. Adding permeable pavement when the current pavement has to be replaced will increase the treatment levels (costs not included due to the recommended treatment level being achieved by bioretention).

Proposed Bioretention Proposed Vegetated Swale

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.7	20%	1.1	31%	1.7	49%
	TSS (lb/yr)	503	46%	618	56%	805	73%
	Volume (acre-feet/yr)	0.5	17%	0.8	27%	1.3	43%
	Live Storage Volume (cubic feet)	266		444		902	
Costs	Materials/Labor/Design	$4,123		$6,882		$13,981	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$5,323		$8,082		$15,181	
	Annual O&M	$200		$333		$677	
	Term Cost/lb/yr (30 yr)	$419		$426		$541	

CENTER CITY – 29

Catchment Summary	
Acres	8.1
Dominant Land Cover	Residential
Parcels	20
Volume (acre-feet/yr)	6.2
TP (lb/yr)	7.2
TSS (lb/yr)	2,249

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.36
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of medium density residential homes, a City park and a senior apartment complex. Some of the runoff from the apartment complex is treated by a small pond on the East side of the building. Very few catch basins and storm sewer pipes exist in this catchment.

RETROFIT RECOMMENDATION

A combination of bioretention and permeable pavement will be used in this catchment. Bioretention basins can be placed strategically throughout the watershed to maximize treatment. There is a good potential for bioretention along the road at Water Tower Park. Adding permeable pavement when the current pavement has to be replaced will increase the treatment levels (costs not included due to the recommended treatment level being achieved by bioretention).

Proposed Bioretention Areas Proposed Future Permeable Pavement

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.4	20%	2.2	30%	3.6	50%
	TSS (lb/yr)	1,033	46%	1,269	56%	1,652	73%
	Volume (acre-feet/yr)	1.1	17%	1.7	27%	2.8	45%
	Live Storage Volume (cubic feet)	545		919		1,864	
Costs	Materials/Labor/Design	$8,440		$14,246		$28,898	
	Promotion & Admin Costs	$2,890		$3,331		$4,034	
	Total Project Cost *	$11,330		$17,577		$32,933	
	Annual O&M	$408		$689		$1,398	
	Term Cost/lb/yr (30 yr)	$482		$520		$612	

* Does not include the cost or the pollution reduction of permeable pavement due to the timeframe of potential replacement.

CENTER CITY – 31

Catchment Summary	
Acres	3.2
Dominant Land Cover	Parking Lot
Parcels	3
Volume (acre-feet/yr)	4.6
TP (lb/yr)	5.5
TSS (lb/yr)	1,716

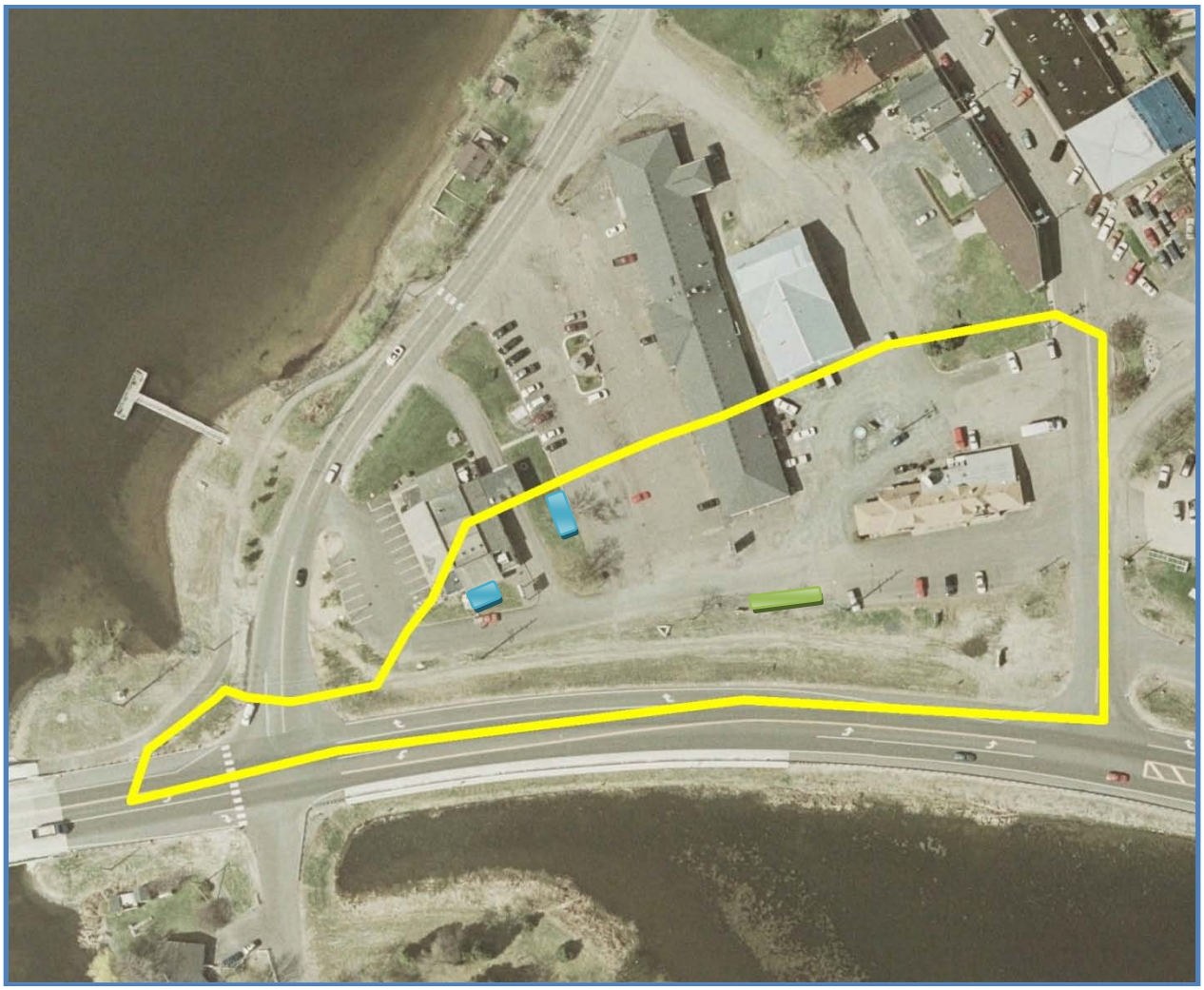
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.69
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of three businesses and city parking. Currently the water flows to a culvert on the west end of the catchment and directly into North Center Lake. There are some landscaping features but no bioretention. The small number of parcels involved will reduce the cost of promotion and administration.

RETROFIT RECOMMENDATION

A combination of bioretention practices is recommended for this catchment. Filtration rain gardens and vegetated swales will increase runoff treatment. Reducing the amount of impervious parking areas and changing it to pervious pavement is also recommended as the current pavement needs replacing. It appears that there is a large amount of parking for a small City – reducing the impervious fraction in the downtown area is necessary to improve water quality. Adding permeable pavement when the current pavement has to be replaced will increase the treatment levels (costs not included due to the recommended treatment level being achieved by bioretention).



Proposed Bioretention Proposed Vegetated Swale

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.1	20%	1.6	30%	2.7	50%
	TSS (lb/yr)	787	46%	964	56%	1,257	73%
	Volume (acre-feet/yr)	0.8	17%	1.2	26%	2.1	45%
	Live Storage Volume (cubic feet)	414		653		1,407	
Costs	Materials/Labor/Design	$7,411		$11,689		$25,185	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$8,611		$12,889		$26,385	
	Annual O&M	$311		$490		$1,055	
	Term Cost/lb/yr (30 yr)	$463		$486		$601	

CENTER CITY – 32

Catchment Summary	
Acres	9.1
Dominant Land Cover	Commercial
Parcels	12
Volume (acre-feet/yr)	9.6
TP (lb/yr)	11.3
TSS (lb/yr)	3,542

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.51
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of a steep part of downtown Center City and large lot commercial. There is a lot of privately owned open space at the bottom of this catchment. Portions of this open space are used for various things such as overflow parking, storage and the seasonal Farmer's Market. A large gravel parking/storage lot takes up a lot of this catchment. Runoff from the upper portion of the catchment is diverted to lower ground near Marine Dock and Lift.

RETROFIT RECOMMENDATION

A combination of bioretention practices is recommended for this catchment. Filtration rain gardens and vegetated swales will increase runoff treatment. Reducing the amount of impervious parking areas and changing it to pervious pavement is also recommended when the current pavement needs replacing. Defining parking areas, driving lanes and open space will help determine the best locations for bioretention.

Proposed Bioretention Areas Proposed Pipe Modification

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	2.3	20%	3.4	30%	5.6	50%
	TSS (lb/yr)	1,626	46%	1,995	56%	2,599	73%
	Volume (acre-feet/yr)	1.6	17%	2.59	27%	4.37	45%
	Live Storage Volume (cubic feet)	854		1,442		2,919	
Costs	Materials/Labor/Design	$15,283		$25,808		$52,241	
	Promotion & Admin Costs	$3,265		$3,763		$4,555	
	Total Project Cost	$18,548		$29,571		$56,796	
	Annual O&M	$640		$1,081		$2,189	
	Term Cost/lb/yr (30 yr)	$514		$562		$666	

CENTER CITY – 35

Catchment Summary	
Acres	2.5
Dominant Land Cover	Residential
Parcels	12
Volume (acre-feet/yr)	1.8
TP (lb/yr)	2.1
TSS (lb/yr)	652

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.34
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

Calendar Isle is a small island that has thirteen large homes and large amounts of impervious surface on it. The lakeside of all the homes drains directly to the lake. The portions of the front of the homes and the driveways drain toward the middle of the island and are conveyed to the lake through a few storm sewer pipes and via the road itself. The homeowners association owns a lot at the point where the storm sewer daylights.

RETROFIT RECOMMENDATION

Bioretention practices will fit nicely into this neatly manicured development. Utilizing the center island of the road with bioretention would keep some water on the top of the hill. Other practices can be installed along the entrance road and on the homeowner's association land where the stormwater pipes outlet. We recommend treating at a high percentage because space is available for treatment.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	20%	0.6	30%	1.0	50%
	TSS (lb/yr)	300	46%	369	56%	480	73%
	Volume (acre-feet/yr)	0.3	17%	0.5	28%	0.8	45%
	Live Storage Volume (cubic feet)	157		266		536	
Costs	Materials/Labor/Design	$2,434		$4,123		$8,308	
	Promotion & Admin Costs	$2,063		$2,380		$2,878	
	Total Project Cost	$4,497		$6,503		$11,186	
	Annual O&M	$118		$200		$402	
	Term Cost/lb/yr (30 yr)	$430		$453		$503	

CENTER CITY – 38

Catchment Summary	
Acres	3.2
Dominant Land Cover	Residential
Parcels	31
Volume (acre-feet/yr)	3.5
TP (lb/yr)	4.1
TSS (lb/yr)	1,304

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.53
Hydraulic Conductivity (in/hr)	0.50

DESCRIPTION

Dew Drop Bay is a small peninsula that has 30 townhomes and one single family home on it. The lakeside of all the homes drains directly to the lake. The front of the homes and the driveways drain toward the street and are conveyed to the lake through a few storm sewer pipes. The homeowners association owns all the land that is not the immediate footprint of the homes (outside the single family home).

RETROFIT RECOMMENDATION

Bioretention practices will fit nicely into this neatly manicured development. Utilizing association owned land will allow for the maximum potential treatment. Bioretention in the form of classic rain gardens will be implemented in this catchment.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.8	20%	1.2	30%	2.1	50%
	TSS (lb/yr)	599	46%	734	56%	957	73%
	Volume (acre-feet/yr)	0.6	17%	1.0	27%	1.6	45%
	Live Storage Volume (cubic feet)	318		531		1,189	
Costs	Materials/Labor/Design	$4,929		$8,237		$18,433	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$6,129		$9,437		$19,633	
	Annual O&M	$239		$399		$892	
	Term Cost/lb/yr (30 yr)	$430		$463		$602	

CENTER CITY – 41

Catchment Summary	
Acres	3.0
Dominant Land Cover	Residential
Parcels	3
Volume (acre-feet/yr)	2.3
TP (lb/yr)	2.7
TSS (lb/yr)	853

Model Inputs	
Parameter	**Input**
Pervious Curve Number	64.3
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.35
Hydraulic Conductivity (in/hr)	0.37

DESCRIPTION

This catchment is very small and has only three parcels along with road easements. The slopes on the east end of the catchment are steep and it levels off toward the west end. One beehive exists to collect the majority of the runoff from this catchment and directs it directly to South Center Lake.

RETROFIT RECOMMENDATION

Bioretention will be achieved in this catchment by raising the beehive at the bottom of the catchment and making the surrounding area conducive to infiltration.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	20%	0.8	30%	1.4	50%
	TSS (lb/yr)	397	46%	484	57%	629	74%
	Volume (acre-feet/yr)	0.4	16%	0.6	25%	1.0	44%
	Live Storage Volume (cubic feet)	222		370		758	
Costs	Materials/Labor/Design	$2,915		$4,858		$9,944	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$4,115		$6,058		$11,144	
	Annual O&M	$167		$278		$568	
	Term Cost/lb/yr (30 yr)	$411		$433		$505	

Retrofit Ranking

Catchment ID	Retrofit Type	Qty of 100 ft+^{3} BMPs	TP Reduction (%)	TP Reduction (lb/yr)	Volume Reduction (ac/ft/yr)	Overall Cost Est [1]	O&M Term (years)	Total Est. Term Cost/lb-TP/yr
CENTER CITY – 2	B	4	30	1.0	0.8	$9,255	30	$480
CENTER CITY – 3	B	2	30	0.6	0.4	$5,948	30	$405
CENTER CITY – 4	B	2	30	0.6	0.4	$6,185	30	$445
CENTER CITY – 5	B	3	30	0.6	0.5	$6,342	30	$449
CENTER CITY – 7	PS	2	50	0.4	0.2	$4,110	30	$379
CENTER CITY – 9	B, PS	3	30	0.8	0.6	$8,530	30	$484
CENTER CITY – 10	B, PS	5	30	1.3	1.0	$12,446	30	$521
CENTER CITY – 11	B, PS	5	31	1.3	1.0	$12,550	30	$515
CENTER CITY – 22	B, PS	15	30	3.6	2.8	$31,508	30	$567
CENTER CITY – 23	B, PS	8	30	1.9	1.5	$15,622	30	$511
CENTER CITY – 26	B, PS, VS	9	49	1.7	1.3	$15,181	30	$541
CENTER CITY – 29	B, PS	5	20	2.2	1.1	$11,330	30	$482
CENTER CITY – 31	B, VS	6	30	1.6	1.2	$12,889	30	$486
CENTER CITY – 32	B	9	20	2.3	1.6	$18,548	30	$514
CENTER CITY – 35	B	5	50	1.0	0.8	$11,186	30	$503
CENTER CITY – 38	B	5	30	1.2	1.0	$9,437	30	$463
CENTER CITY - 41	B	4	30	0.8	0.6	$6,058	30	$433

B = Bioretention (infiltration and/or filtration)
F = Filtration (sand curtain, surface sand filter, sump, etc)
PM = Pond Modification (increased area/depth, additional cells, forebay, and/or outlet modification)
PS = Permeable Surface (infiltration and/or filtration)
VS = Vegetated Swale (wet or dry)

[1]Estimated "Overall Cost" includes design, contracted soil core sampling, materials, contracted labor, promotion and administrative costs (including outreach, education, contracts, grants, etc), pre-construction meetings, installation oversight and 1 year of operation and maintenance costs.

[2]"Total Est. Term Cost" includes Overall Cost plus 30 years of maintenance and is divided by 30 years of TP treatment.

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Appendices

Appendix 1—Catchments not included in Ranking Table

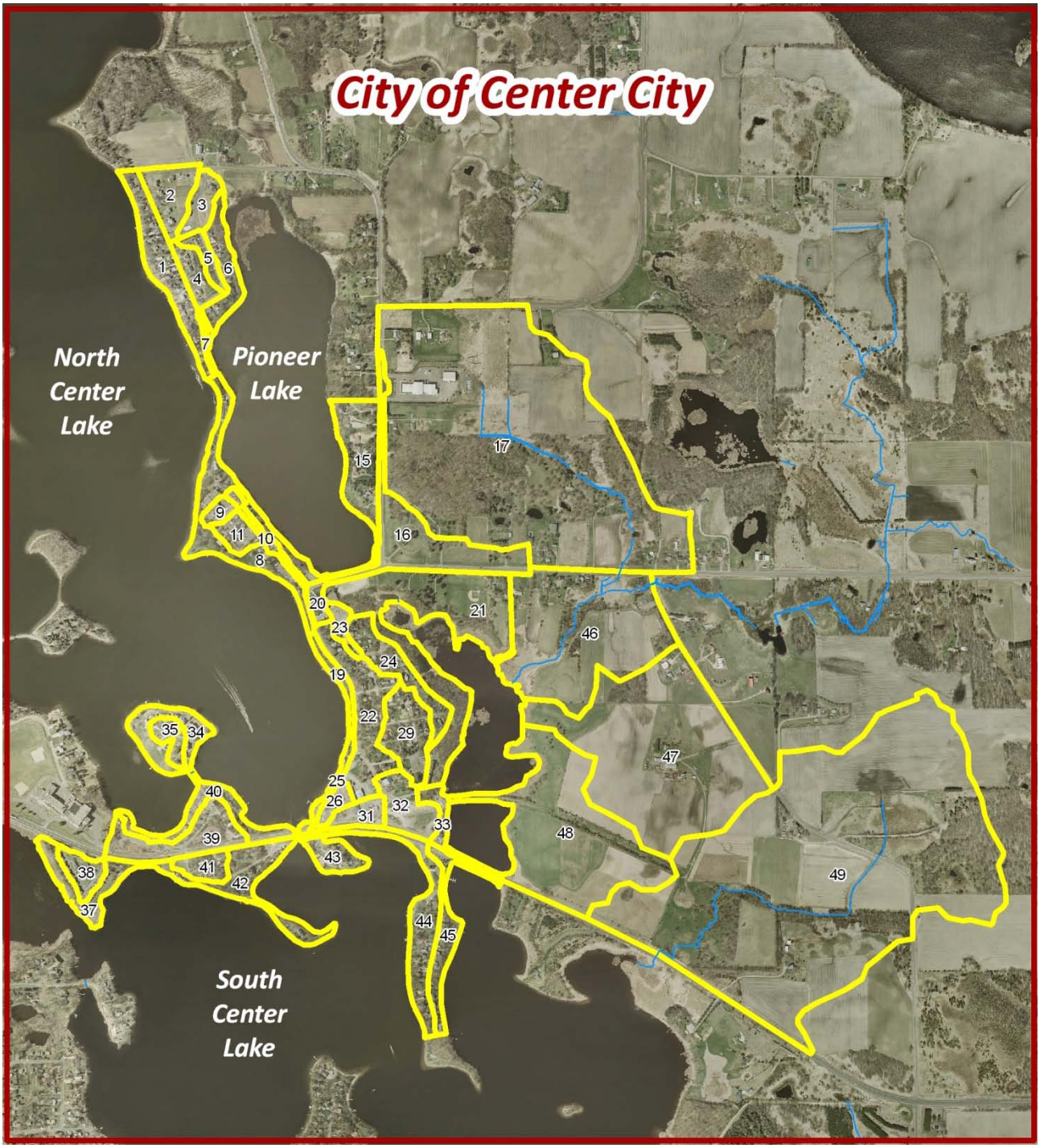
Catchments not included in ranking table were excluded for a number of reasons, mainly involving connectivity to the receiving water. After BMPs are installed within the priority catchments, it is recommended that the City revisit the entire subwatershed to determine other catchments that, while they may be conducive to retrofitting, were not considered a high priority for this report.

Summary of Protocol

This protocol attempts to provide a sufficient level of detail to rapidly assess sub-watersheds or catchments of variable scales and land-uses. It provides the assessor defined project goals that aid in quickly narrowing down multiple potential sites to a point where he/she can look a little more closely at site-specific driven design options that affect, sometimes dramatically, BMP selection. We feel that the time commitment required for this methodology is appropriate for most initial assessment applications and has worked well thus far for the City of Center City Assessment.

Overall Catchment Map

See the following map showing the entire City of Center City and Catchments: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Pioneer Lake
South Center Lake
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