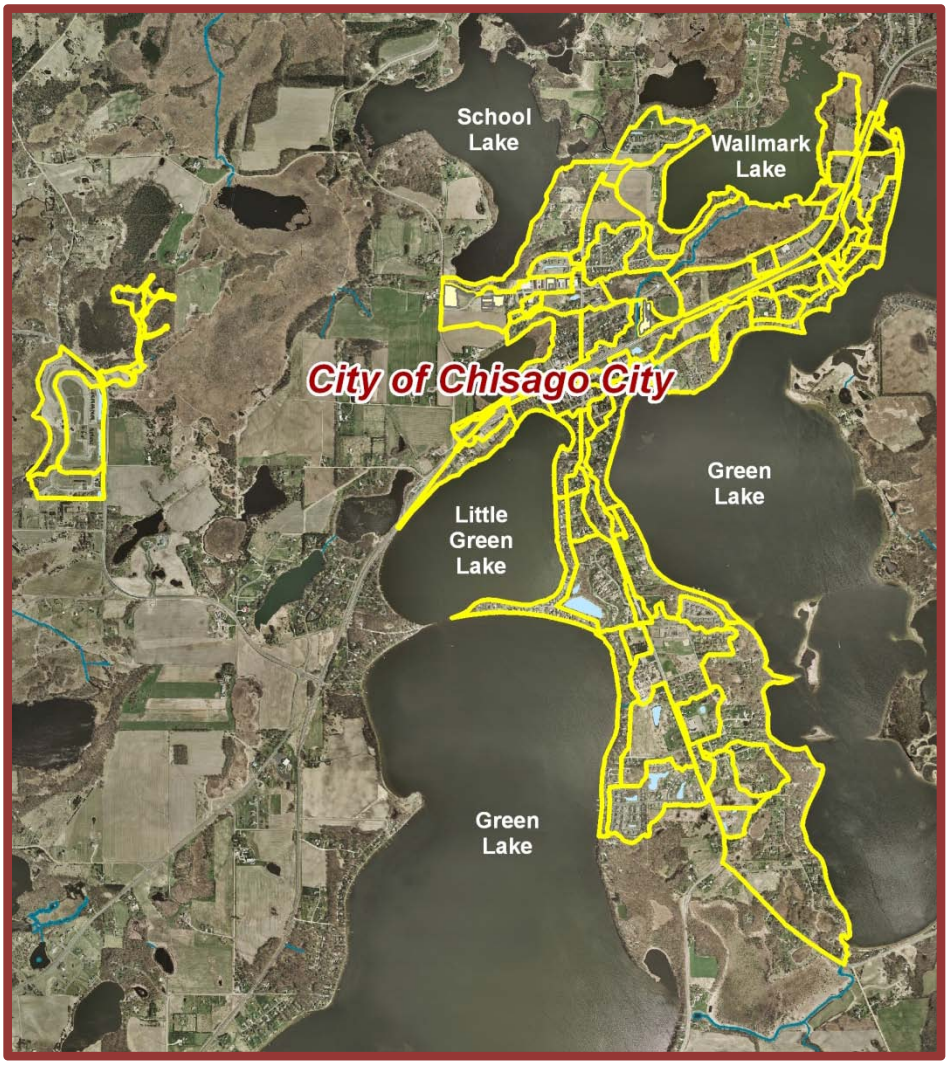
CITY OF CHISAGO CITY:
STORMWATER RETROFIT ASSESSMENT



Prepared by:

CHISAGO SOIL & WATER CONSERVATION DISTRICT

With assistance from:

THE METRO CONSERVATION DISTRICTS

For:

THE CITY of CHISAGO 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.

Funding in part for the Stormwater Retrofit Assessment was provided by the Clean Water Fund from the Clean Water, Land and Legacy Amendment.

Contents

Executive Summary

The City of Chisago City (about 1,200 acres) was broken down into seventy-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-seven of the 79 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 Chisago 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]
CHISAGO CITY –2	B, PS, VS	17	30	4.1	3.1	$31,765	30	$538
CHISAGO CITY – 3	B, PS, VS	7	30	1.8	1.4	$15,157	30	$509
CHISAGO CITY – 5	B	4	32	0.8	0.4	$10,176	30	$584
CHISAGO CITY – 9	B	7	30	1.2	0.7	$16,181	30	$706
CHISAGO CITY – 10	B, PS, VS	6	30	1.1	0.6	$11,697	30	$623
CHISAGO CITY – 12	B	5	30	1.0	0.6	$12,637	30	$638
CHISAGO CITY – 15	B	15	30	2.9	1.6	$31,839	30	$707
CHISAGO CITY – 19	B, VS	11	50	1.8	1.3	$23,389	30	$701
CHISAGO CITY – 27	B, VS	3	50	0.8	0.6	$10,364	30	$510
CHISAGO CITY – 31	B, VS	10	30	1.8	1.0	$19,134	30	$658
CHISAGO CITY – 32	B, VS	18	20	3.8	1.9	$36,601	30	$647
CHISAGO CITY – 34	B, PS	20	20	4.7	2.8	$40,705	30	$590
CHISAGO CITY – 35	VS	6	30	1.6	1.2	$13,364	30	$505
CHISAGO CITY – 37	B	2	40	0.6	0.5	$6,494	30	$425
CHISAGO CITY – 38	B, VS	7	20	2.0	1.5	$16,645	30	$509
CHISAGO CITY – 43	B	2	40	0.6	0.4	$7,215	30	$457
CHISAGO CITY – 45	B	7	20	2.0	1.4	$16,529	30	$512
CHISAGO CITY – 46	B, VS	6	20	1.8	1.3	$13,130	30	$478
CHISAGO CITY – 49	B	21	30	5.2	4.0	$43,034	30	$561
CHISAGO CITY – 51	B	15	20	4.0	3.0	$31,272	30	$517
CHISAGO CITY – 52	B	4	20	1.1	0.8	$9,782	30	$500
CHISAGO CITY – 54	B	3	30	0.9	0.7	$9,196	30	$503
CHISAGO CITY – 56	B	8	30	1.9	1.5	$17,879	30	$545
CHISAGO CITY – 57	B	3	30	0.8	0.6	$8,530	30	$491
CHISAGO CITY – 61	B, VS	2	40	0.5	0.4	$5,785	30	$417
CHISAGO CITY – 62	G							
CHISAGO CITY – 69	G							

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)
G = Gully Stabilization

[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., CHISAGO CITY-01 for City of Chisago 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.

Chisago City Scoping

Pollutants of concern for this subwatershed were identified as Total Phosphorus (TP), Total Suspended Solids (TSS), and Volume.

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.

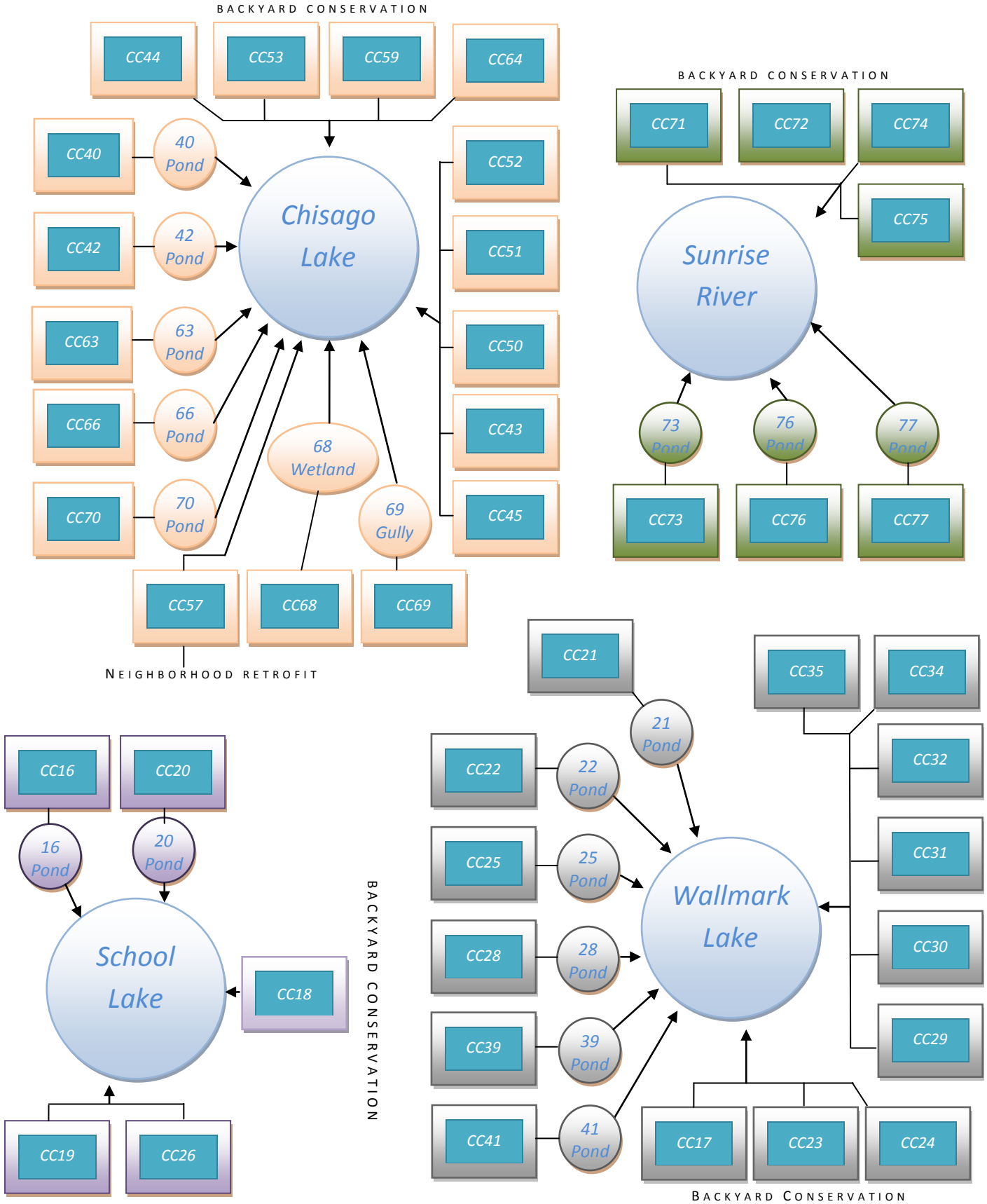
Modeling of the site is done by one or more methods such as with P8, WINSLAMM or simple spreadsheet methods using the Rational Method. Event mean concentrations or sediment loading files (depending on data availability and model selection) are used for each catchment/site to estimate relative pollution 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 Chisago City Treatment Analysis

For the City of Chisago 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: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CC44
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CC59
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40 Pond
CC42
42 Pond
CC63
63 Pond
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66 Pond
CC70
70 Pond
Chisago Lake
CC52
CC51
CC50
CC43
CC45
68 Wetland
69 Gully
CC57
CC68
CC69
NEIGHBORHOOD RETROFIT
BACKYARD CONSERVATION
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CC72
CC74
CC75
Sunrise River
73 Pond
76 Pond
77 Pond
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16 Pond
20 Pond
School Lake
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BACKYARD CONSERVATION
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39 Pond
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Wallmark Lake
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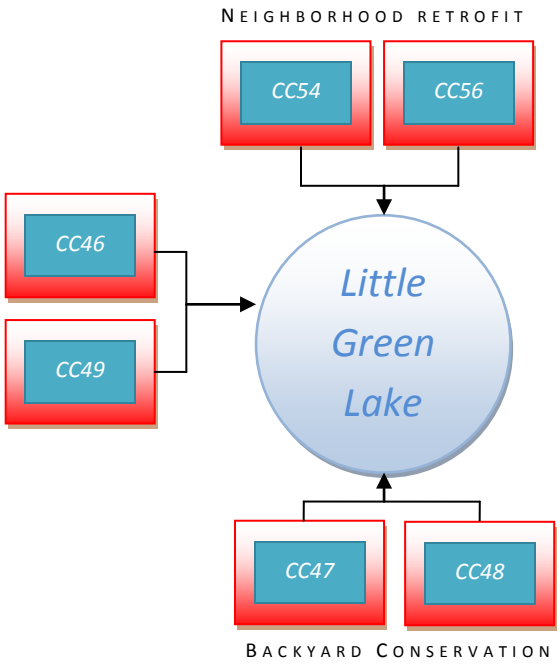
BACKYARD CONSERVATION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Little Green Lake
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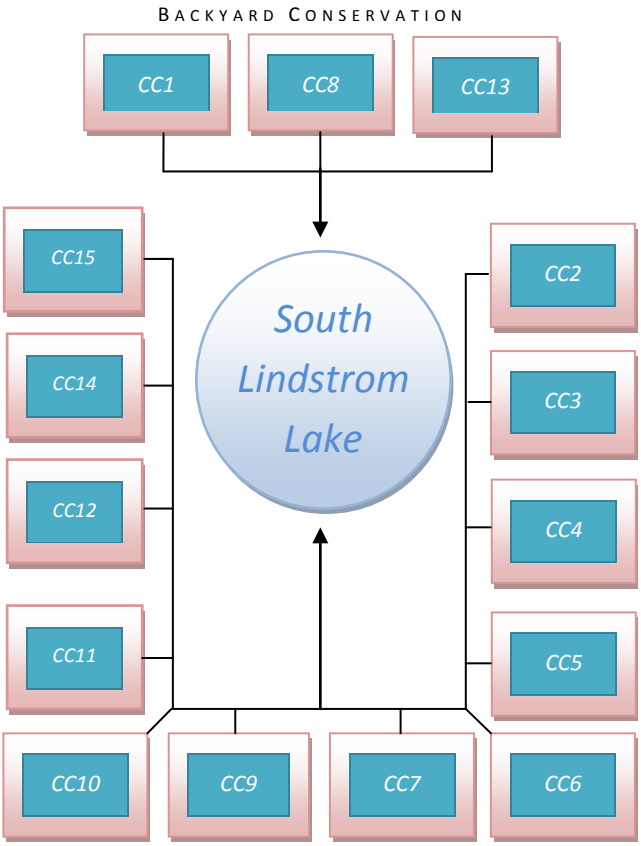
BACKYARD CONSERVATION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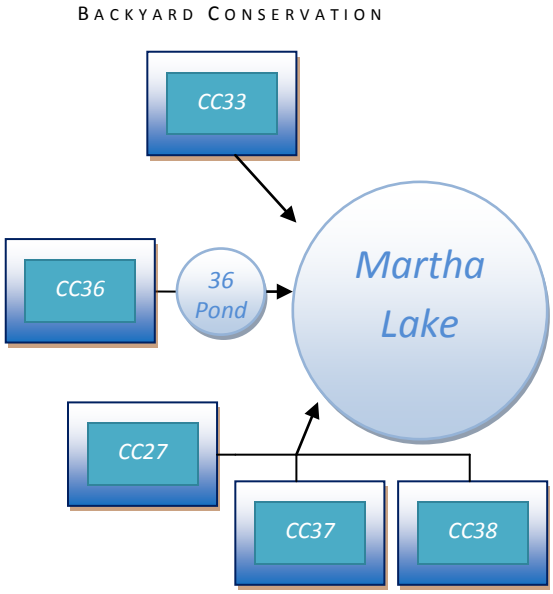
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CC36
36 Pond
Martha Lake
CC27
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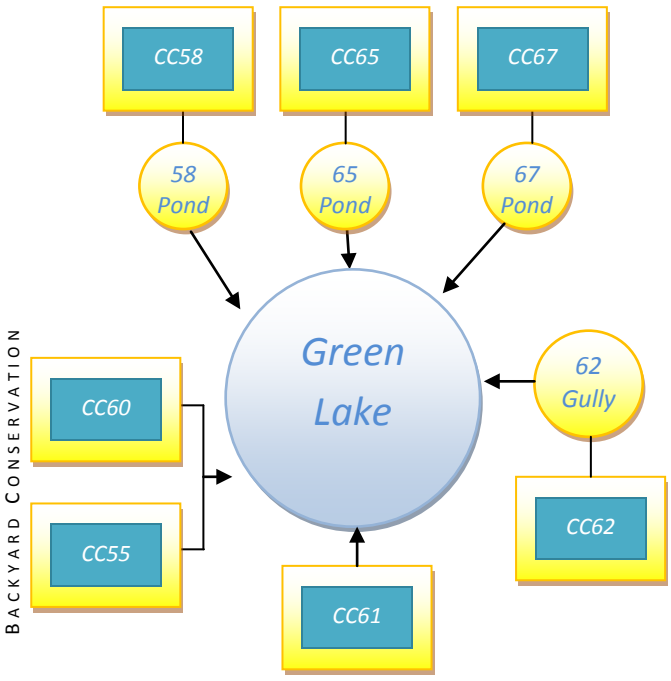
CC38


CC58
CC65
CC67
58 Pond
65 Pond
67 Pond
Green Lake
62 Gully
CC62
BACKYARD CONSERVATION
CC60
CC55
CC61

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).

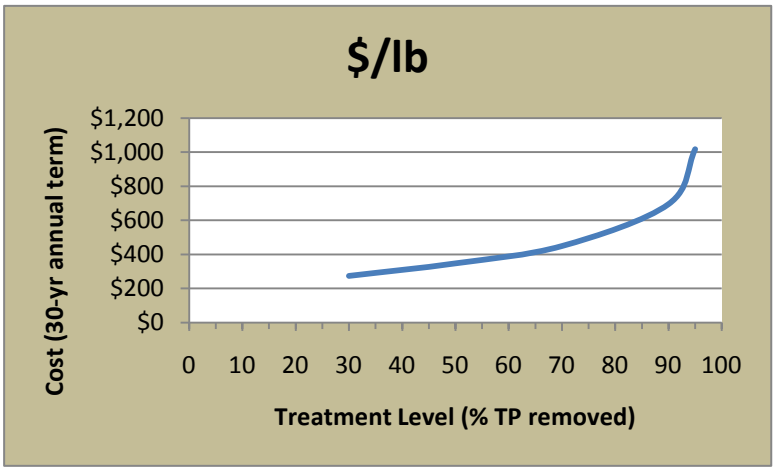
[6]Assumed to be 15 feet in width.

City of Chisago City Cost Analysis

For the City of Chisago 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 Chisago City Evaluation and Ranking

In the City of Chisago 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 Chisago City Catchment Profiles

For development of the City of Chisago City catchment profile section, 27 out of 77 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 with ponds 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 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 (acre-feet/yr)	0.6	11%	1.0	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	

CHISAGO CITY – 2

Catchment Summary	
Acres	15.8
Dominant Land Cover	Parking lot/ Building
Parcels	3
Volume (acre-feet/yr)	11.6
TP (lb/yr)	13.5
TSS (lb/yr)	4,230

Model Inputs	
Parameter	**Input**
Pervious Curve Number	70.4
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.35
Hydraulic Conductivity (in/hr)	0.54

DESCRIPTION

This catchment is comprised of the building and parking lots of the Fairview Health Services hospital and Chisago Lakes Area Library. The hospital parking lots are in poor condition and need to be resurfaced in the near future. The library's western parking lot was recently paved and has storm drains that capture all of the runoff, which goes to a pond to the north of the library building. A second pond at the eastern edge of the catchment captures road and parking lot runoff and drains directly to South Lindstrom Lake.

RETROFIT RECOMMENDATION

Working with the hospital when the parking lots are resurfaced will be important. Rain gardens can be added into the design for the parking lot. Additional bioretention areas can be added in the green space around the building and parking lots to treat runoff. If possible, the parking lot or parking spaces should be resurfaced in a pervious pavement. Combining Catchments 2 and 3 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Highly Impervious Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	2.7	20%	4.1	30%	6.8	50%
	TSS (lb/yr)	1,935	46%	2,378	56%	3,106	73%
	Volume (acre-feet/yr)	2.0	17%	3.10	27%	5.3	46%
	Live Storage Volume (cubic feet)	1,015		1,708		3,520	
Costs	Materials/Labor/Design	$18,168		$30,565		$63,002	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$19,368		$31,765		$64,202	
	Annual O&M	$761		$1,281		$2,640	
	Term Cost/lb/yr (30 yr)	$485		$538		$659	

CHISAGO CITY – 3

Catchment Summary	
Acres	5.3
Dominant Land Cover	Building/ Parking lot
Parcels	1
Volume (acre-feet/yr)	5.2
TP (lb/yr)	6.1
TSS (lb/yr)	1,922

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.47
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised primarily of parking lot for the Fairview Health Services hospital building and Stinson Avenue. The lower parking lot of the clinic is in better condition and will not need to be resurfaced in the near future. There are two catch basins along Stinson Avenue at the north end of the catchment.

RETROFIT RECOMMENDATION

Rain gardens can be added into the design to capture parking lot runoff. Additional bioretention areas can be added in the green space around the building and parking lots to treat runoff. In the future, if possible, the parking lot or parking spaces should be resurfaced in a pervious pavement. Combining Catchments 2 and 3 into one project may drastically reduce costs. Mobilization, promotion and administration costs could be considerably less.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Highly Impervious Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.2	20%	1.8	30%	3.1	50%
	TSS (lb/yr)	880	46%	1,081	56%	1410	73%
	Volume (acre-feet/yr)	0.9	17%	1.4	27%	2.4	46%
	Live Storage Volume (cubic feet)	462		780		1,597	
Costs	Materials/Labor/Design	$8,265		$13,957		$28,585	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$9,465		$15,157		$29,785	
	Annual O&M	$346		$585		$1,198	
	Term Cost/lb/yr (30 yr)	$466		$509		$615	

CHISAGO CITY – 5

Catchment Summary	
Acres	3.1
Dominant Land Cover	Residential
Parcels	4
Volume (acre-feet/yr)	2.2
TP (lb/yr)	2.5
TSS (lb/yr)	786

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.33
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This small catchment is comprised of medium density residential with storm sewer. The area is relatively flat. The catchment is only two blocks from the channel between South Lindstrom and Chisago Lakes.

RETROFIT RECOMMENDATION

Multiple bioretention cells with curb cuts would work well where appropriate. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit — Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	20%	0.8	32%	1.3	50%
	TSS (lb/yr)	375	48%	457	58%	588	75%
	Volume (acre-feet/yr)	0.3	14%	0.4	19%	0.8	37%
	Live Storage Volume (cubic feet)	240		418		897	
Costs	Materials/Labor/Design	$4,288		$7,485		$16,062	
	Promotion & Admin Costs	$2,314		$2,691		$3,309	
	Total Project Cost	$6,602		$10,176		$19,371	
	Annual O&M	$180		$314		$673	
	Term Cost/lb/yr (30 yr)	$572		$584		$754	

CHISAGO CITY – 9

Catchment Summary	
Acres	4.4
Dominant Land Cover	Residential
Parcels	11
Volume (acre-feet/yr)	3.66
TP (lb/yr)	4.1
TSS (lb/yr)	1,285

Model Inputs	
Parameter	**Input**
Pervious Curve Number	79
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.38
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This small catchment consists of medium density residential lots. The development is well established with large trees. There are two catch basins at the end of Oak Street that drain directly into South Lindstrom Lake.

RETROFIT RECOMMENDATION

A neighborhood retrofit of bioretention cells with curb cuts would work well where appropriate. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.8	20%	1.2	30%	2.1	50%
	TSS (lb/yr)	618	48%	754	59%	968	75%
	Volume (acre-feet/yr)	0.4	11%	0.7	19%	1.3	36%
	Live Storage Volume (cubic feet)	413		729		1,594	
Costs	Materials/Labor/Design	$7,384		$13,053		$28,538	
	Promotion & Admin Costs	$2,681		$3,128		$3,867	
	Total Project Cost	$10,065		$16,181		$32,405	
	Annual O&M	$309		$547		$1,196	
	Term Cost/lb/yr (30 yr)	$626		$706		$886	

CHISAGO CITY - 10

Catchment Summary	
Acres	2.5
Dominant Land Cover	Parking Lot
Parcels	1
Volume (acre-feet/yr)	3.08
TP (lb/yr)	3.6
TSS (lb/yr)	1,135

Model Inputs	
Parameter	**Input**
Pervious Curve Number	67.2
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.6
Hydraulic Conductivity (in/hr)	0.59

DESCRIPTION

The main land use of this catchment is a paved parking lot for the DNR public boat access to South Lindstrom and Chisago Lakes. The entire parking lot slopes down to the lake with very little treatment for the runoff water. There are small curbed islands located on both ends of the lot.

RETROFIT RECOMMENDATION

Modifying the current raised islands in the parking lot to accept runoff will decrease the amount of water reaching the lake. Also, cleaning up the current treatment areas will increase their treatment capabilities. Restoring possible shoreline erosion is also recommended if work is being completed on site.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Boat Launch Retrofit *Annual Marginal Treatment Enhancement*					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.7	20%	1.1	30%	1.8	50%
	TSS (lb/yr)	524	46%	681	58%	850	75%
	Volume (acre-feet/yr)	0.3	11%	0.6	19%	1.1	36%
	Live Storage Volume (cubic feet)	354		626		1,365	
Costs	Materials/Labor/Design	$6,331		$11,197		$24,429	
	Promotion & Admin Costs	$500		$500		$500	
	Total Project Cost	$6,831		$11,697		$24,929	
	Annual O&M	$265		$469		$1,024	
	Term Cost/lb/yr (30 yr)	$536		$623		$807	

CHISAGO CITY – 12

Catchment Summary	
Acres	4.5
Dominant Land Cover	Residential
Parcels	9
Volume (acre-feet/yr)	2.9
TP (lb/yr)	3.3
TSS (lb/yr)	1,039

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.3
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of medium density residential lots and portions of two roads. The lots drain towards the road and have a decent slope behind the curb. There are two catch basins located along the road that drain directly to South Lindstrom Lake.

RETROFIT RECOMMENDATION

A neighborhood retrofit of bioretention cells with curb cuts would work well where appropriate. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Area

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.7	20%	1.0	30%	1.7	50%
	TSS (lb/yr)	495	48%	603	58%	776	75%
	Volume (acre-feet/yr)	0.3	12%	0.6	20%	1.1	38%
	Live Storage Volume (cubic feet)	314		545		1,163	
Costs	Materials/Labor/Design	$5,614		$9,747		$20,819	
	Promotion & Admin Costs	$2,489		$2,890		$3,550	
	Total Project Cost	$8,103		$12,637		$24,369	
	Annual O&M	$235		$408		$872	
	Term Cost/lb/yr (30 yr)	$588		$638		$780	

CHISAGO CITY - 15

Catchment Summary	
Acres	11.8
Dominant Land Cover	Residential/ Park
Parcels	30
Volume (acre-feet/yr)	8.2
TP (lb/yr)	9.5
TSS (lb/yr)	2,986

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.33
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is mainly medium density residential, but also includes Surfland Park. The park has a playground, but is mostly made up of a large green area used as a baseball field. Runoff from this area is captured in two catch basins located north of the park along Lakeview Road or two catch basins at the end of the cul-de-sac on Interlachen Road and drains directly into South Lindstrom Lake.

RETROFIT RECOMMENDATION

A neighborhood retrofit of bioretention cells with curb cuts would work well where appropriate. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit — Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.9	20%	2.9	30%	4.8	50%
	TSS (lb/yr)	1,421	48%	1733	58%	2,230	75%
	Volume (acre-feet/yr)	1.0	12%	1.60	20%	3.1	38%
	Live Storage Volume (cubic feet)	902		1,564		3,332	
Costs	Materials/Labor/Design	$16,140		$27,992		$59,649	
	Promotion & Admin Costs	$3,313		$3,847		$4,722	
	Total Project Cost	$19,454		$31,839		$64,371	
	Annual O&M	$676		$1,173		$2,499	
	Term Cost/lb/yr (30 yr)	$631		$707		$876	

CHISAGO CITY – 19

Catchment Summary	
Acres	20.2
Dominant Land Cover	Res/ Agricultural
Parcels	20
Volume (acre-feet/yr)	3.1
TP (lb/yr)	3.6
TSS (lb/yr)	1,132

Model Inputs	
Parameter	**Input**
Pervious Curve Number	70.4
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.15
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

About half of this catchment is used as agricultural field, while the other half is a newer medium density residential development. The catchment also includes a portion of County Road 77 (Lofton Avenue). The agricultural land drains into the road ditch along CR 77. There is a backyard swale that runs between the homes to drain the backyard of the lots. The swale drains into the CR 77 ditch. The front side of the lots along CR 77 drain into the street, where the water runs into catch basins.

RETROFIT RECOMMENDATION

Several small curb cut rain gardens would be beneficial along Lofton Avenue. The water that does not get captured in these rain gardens should be slowed in the road ditch with planted vegetation and some ditch checks. In the back yards of the development, bioretention can be achieved.

Proposed Bioretention Areas Proposed Vegetated Swale

		Bioretention Retrofit					
	Cost/Benefit Analysis	*Annual Marginal Treatment Enhancement*					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.7	20%	1.1	30%	1.8	50%
	TSS (lb/yr)	532	47%	649	57%	838	74%
	Volume (acre-feet/yr)	0.4	14%	0.7	23%	1.3	42%
	Live Storage Volume (cubic feet)	313		534		1,111	
Costs	Materials/Labor/Design	$5,602		$9,567		$19,883	
	Promotion & Admin Costs	$2,487		$2,876		$3,506	
	Total Project Cost	$8,090		$12,443		$23,389	
	Annual O&M	$235		$401		$833	
	Term Cost/lb/yr (30 yr)	$548		$591		$701	

CHISAGO CITY – 27

Catchment Summary	
Acres	2.5
Dominant Land Cover	Residential/ Industrial
Parcels	3
Volume (acre-feet/yr)	1.4
TP (lb/yr)	1.6
TSS (lb/yr)	509

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.27
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This small catchment is made up of the portion of a building, its parking lot, and some wooded residential lots. Runoff from the building and parking lots drains to the south via a swale and culvert into Martha Lake.

RETROFIT RECOMMENDATION

Bioretention is possible in this catchment however, due to the size, the site achieve a high percentage of pollutant removal or it could be combined with nearby retrofit opportunities. Parking lot upgrades could also be made to trap pollutants as they are leaving the impervious areas.

Proposed Bioretention Proposed Vegetated Swale

	Cost/Benefit Analysis	Bioretention Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	30%	0.7	40%	0.8	50%
	TSS (lb/yr)	287	56%	333	65%	374	73%
	Volume (acre-feet/yr)	0.4	27%	0.51	36%	0.64	46%
	Live Storage Volume (cubic feet)	209		308		428	
Costs	Materials/Labor/Design	$3,735		$5,520		$7,657	
	Promotion & Admin Costs	$2,229		$2,477		$2,707	
	Total Project Cost	$5,963		$7,998		$10,364	
	Annual O&M	$156		$231		$321	
	Term Cost/lb/yr (30 yr)	$449		$475		$510	

CHISAGO CITY – 31

Catchment Summary	
Acres	4.7
Dominant Land Cover	Commercial
Parcels	2
Volume (acre-feet/yr)	5.1
TP (lb/yr)	6.0
TSS (lb/yr)	1,896

Model Inputs	
Parameter	**Input**
Pervious Curve Number	73.2
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.53
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This is a small catchment with two commercial buildings included. It is highly impervious and portions of the area have a dramatic slope. The runoff from the buildings and parking lots drains to a culvert in the ditch along North Avenue. The culvert outlets on the north side of the road to a wetland connected to Wallmark Lake.

RETROFIT RECOMMENDATION

Correcting erosion problems at the corner of the Meredee's Bistro parking lot is necessary. The water from the parking lot needs to be slowed down as it comes off the parking lot and then spill into a vegetated area. There is limited space available for bioretention on site, so innovative approaches will be looked into.

Proposed Bioretention Areas Proposed Vegetated Swale

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.2	20%	1.8	30%	3.0	50%
	TSS (lb/yr)	902	48%	1,100	58%	1,415	75%
	Volume (acre-feet/yr)	0.6	12%	1.0	19%	2.0	38%
	Live Storage Volume (cubic feet)	575		1,002		2,147	
Costs	Materials/Labor/Design	$10,292		$17,934		$38,431	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost *	$11,492		$19,134		$39,631	
	Annual O&M	$431		$751		$1,610	
	Term Cost/lb/yr (30 yr)	$582		$658		$835	

CHISAGO CITY – 32

Catchment Summary	
Acres	12.5
Dominant Land Cover	Commercial
Parcels	4
Volume (acre-feet/yr)	16.3
TP (lb/yr)	19.1
TSS (lb/yr)	6,008

Model Inputs	
Parameter	**Input**
Pervious Curve Number	71.1
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.63
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is highly impervious and consists of commercial buildings and their parking lots. Water is currently captured, transported to the ditches, and piped under the road to outlet into a wetland connected to Wallmark Lake. There is one small pond that captures water from one parking lot area and overflows into the ditch/culvert system.

RETROFIT RECOMMENDATION

A combination of bioretention practices is recommended for this catchment. Filtration rain gardens and vegetated swales will increase runoff treatment. The lowest treatment level is recommended due to future maintenance and total cost. 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)	3.8	20%	5.7	30%	9.6	50%
	TSS (lb/yr)	2,858	48%	3,486	58%	4,484	75%
	Volume (acre-feet/yr)	1.9	12%	3.2	20%	6.7	38%
	Live Storage Volume (cubic feet)	1,821		3,184		6,808	
Costs	Materials/Labor/Design	$32,592		$56,998		$121,871	
	Promotion & Admin Costs	$4,009		$4,664		$5,731	
	Total Project Cost	$36,601		$61,662		$127,602	
	Annual O&M	$1,366		$2,388		$5,106	
	Term Cost/lb/yr (30 yr)	$647		$737		$931	

CHISAGO CITY – 34

Catchment Summary	
Acres	17.0
Dominant Land Cover	Residential
Parcels	23
Volume (acre-feet/yr)	20.0
TP (lb/yr)	23.5
TSS (lb/yr)	7,412

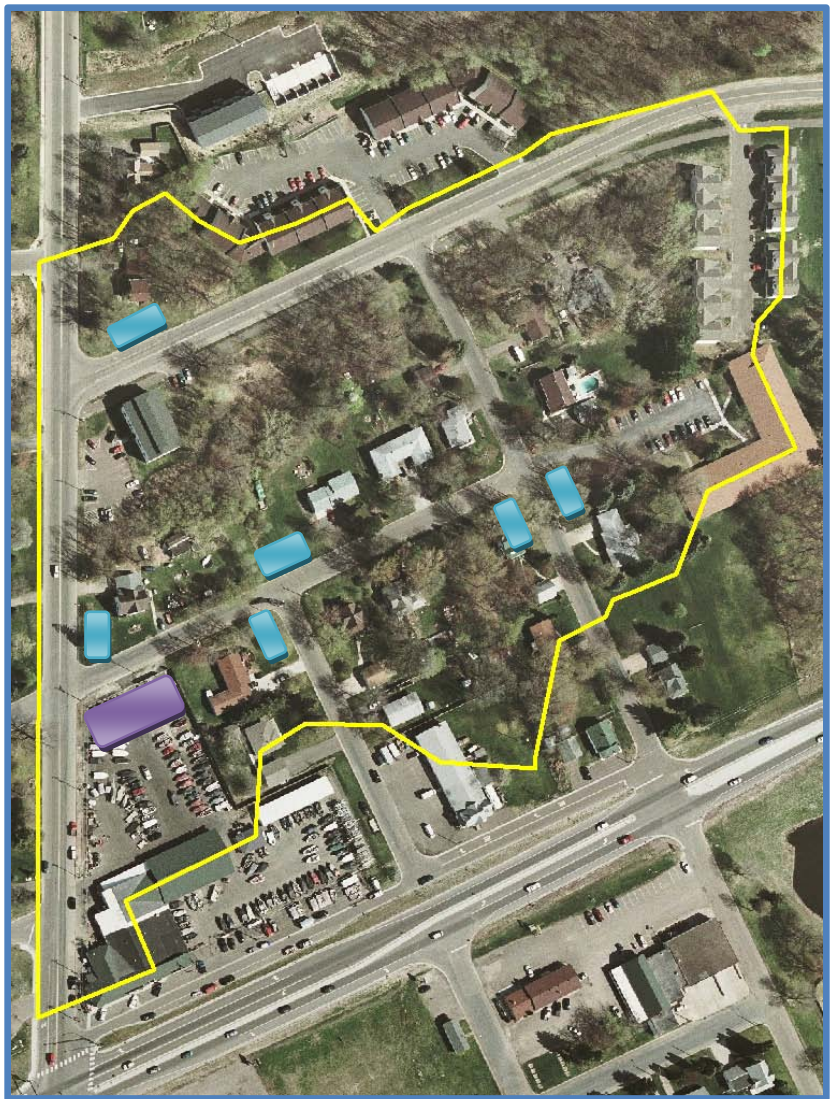
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.1
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.57
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of a medium density residential neighborhood that includes several high density buildings. There is also a large retail building and lot included in the catchment. The roads and lots are drained via catch basins into a wetland area in the catchment. This wetland connects to a stream that eventually enters Wallmark Lake.

RETROFIT RECOMMENDATION

A combination of bioretention practices is recommended for this catchment. Curb cut rain gardens could fit nicely into this neighborhood where appropriate. Reducing the amount of impervious parking areas and changing it to pervious pavement is also recommended when the current pavement needs replacing. The lowest treatment level is recommended due to future maintenance and total cost. 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 Pervious Pavement

	Cost/Benefit Analysis	Bioretention – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	4.7	20%	7.1	30%	11.8	50%
	TSS (lb/yr)	3,475	47%	4,241	57%	5,486	74%
	Volume (acre-feet/yr)	2.8	14%	4.5	23%	8.3	42%
	Live Storage Volume (cubic feet)	2,043		3,485		7,263	
Costs	Materials/Labor/Design	$36,569		$62,378		$130,004	
	Promotion & Admin Costs	$4,136		$4,780		$5,832	
	Total Project Cost	$40,705		$67,157		$135,836	
	Annual O&M	$1,532		$2,614		$5,447	
	Term Cost/lb/yr (30 yr)	$590		$660		$811	

CHISAGO CITY – 36

Catchment Summary	
Acres	3.6
Dominant Land Cover	Commercial/ Road
Parcels	1
Volume (acre-feet/yr)	4.5
TP (lb/yr)	5.3
TSS (lb/yr)	1,668

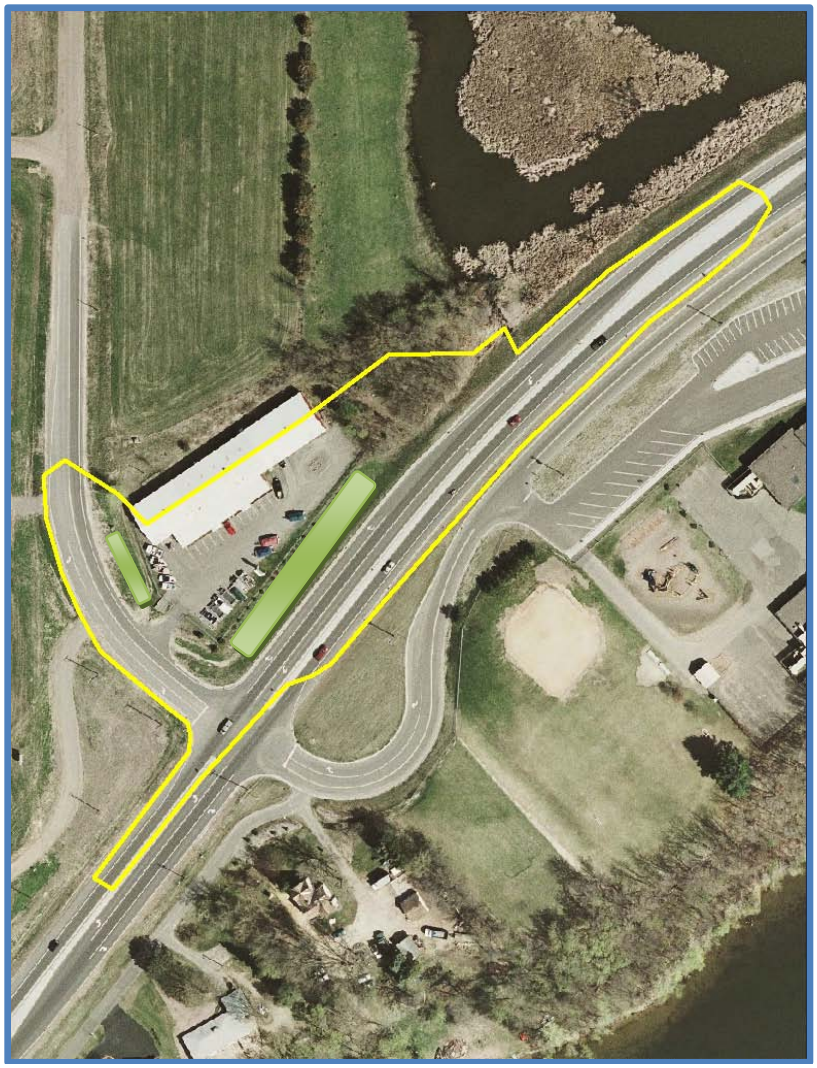
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.6
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment consists mostly of impervious roadway, parking lot, or building. Highway 8 (Lake Blvd) and County Road 80 intersect within this catchment. There are numerous catch basins along Hwy 8, as well as the roadside ditches, that drain into Lake Martha.

RETROFIT RECOMMENDATION

Vegetated swales or bioretention can be utilized in the road ditches and at the edge of the parking lot. Properly placed BMPs will be able to trap large amounts of sediment from the parking lot and slow water from the roof and parking lot before directly discharging to Lake Martha.



Proposed Vegetated Swales

	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)	763	46%	937	56%	1,222	73%
	Volume (acre-feet/yr)	0.8	17%	1.2	27%	2.1	46%
	Live Storage Volume (cubic feet)	402		680		1,385	
Costs	Materials/Labor/Design	$7,189		$12,164		$24,795	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$8,389		$13,364		$25,995	
	Annual O&M	$301		$510		$1,039	
	Term Cost/lb/yr (30 yr)	$461		$505		$605	

CHISAGO CITY – 37

Catchment Summary	
Acres	1.0
Dominant Land Cover	Commercial/ Road
Parcels	2
Volume (acre-feet/yr)	1.3
TP (lb/yr)	1.6
TSS (lb/yr)	495

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.64
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is very small and is mostly impervious. Trapper's Restaurant and parking lot and South Avenue make up the majority of the catchment. The parking lot and the catch basins on the road drain to a grassy area between the parking lot and neighboring parcel. This catchment is right on the edge of Lake Martha.

RETROFIT RECOMMENDATION

Bioretention can be added to the grassy areas at the edge of the parking lot. If the parking areas need to be resurfaced, permeable pavement should be looked at as an option.

Proposed Bioretention Area

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	30%	0.6	40%	0.8	50%
	TSS (lb/yr)	278	56%	326	66%	363	73%
	Volume (acre-feet/yr)	0.4	27%	0.5	37%	0.6	46%
	Live Storage Volume (cubic feet)	201		296		412	
Costs	Materials/Labor/Design	$3,598		$5,294		$7,376	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$4,798		$6,494		$8,576	
	Annual O&M	$151		$222		$309	
	Term Cost/lb/yr (30 yr)	$404		$425		$460	

CHISAGO CITY – 38

Catchment Summary	
Acres	7.3
Dominant Land Cover	Road/ Commercial
Parcels	5
Volume (acre-feet/yr)	8.5
TP (lb/yr)	9.9
TSS (lb/yr)	3,123

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.56
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

Highway 8 makes up the majority of this catchment, along with portions of some roadside commercial lots and most of Vilhelm Moberg Park. The catchment is highly impervious and has many catch basins, which drain directly to Lake Martha.

RETROFIT RECOMMENDATION

Due to the large amount of this catchment being Highway, we will have to fit BMPs in where appropriate. A vegetated swale can be added near the front of the Community Center and the Fire Department to capture runoff from these buildings and parking areas.

Proposed Bioretention Areas Proposed Vegetated Swales

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	2.0	20%	3.0	30%	5.0	50%
	TSS (lb/yr)	1,428	46%	1,755	56%	1,755	73%
	Volume (acre-feet/yr)	1.5	17%	2.3	27%	3.9	46%
	Live Storage Volume (cubic feet)	754		1,268		2,596	
Costs	Materials/Labor/Design	$13,489		$22,690		$46,472	
	Promotion & Admin Costs	$3,156		$3,634		$4,413	
	Total Project Cost	$16,645		$26,324		$50,885	
	Annual O&M	$565		$951		$1,947	
	Term Cost/lb/yr (30 yr)	$509		$557		$667	

CHISAGO CITY – 43

Catchment Summary	
Acres	1.1
Dominant Land Cover	Residential
Parcels	5
Volume (acre-feet/yr)	1.2
TP (lb/yr)	1.4
TSS (lb/yr)	450

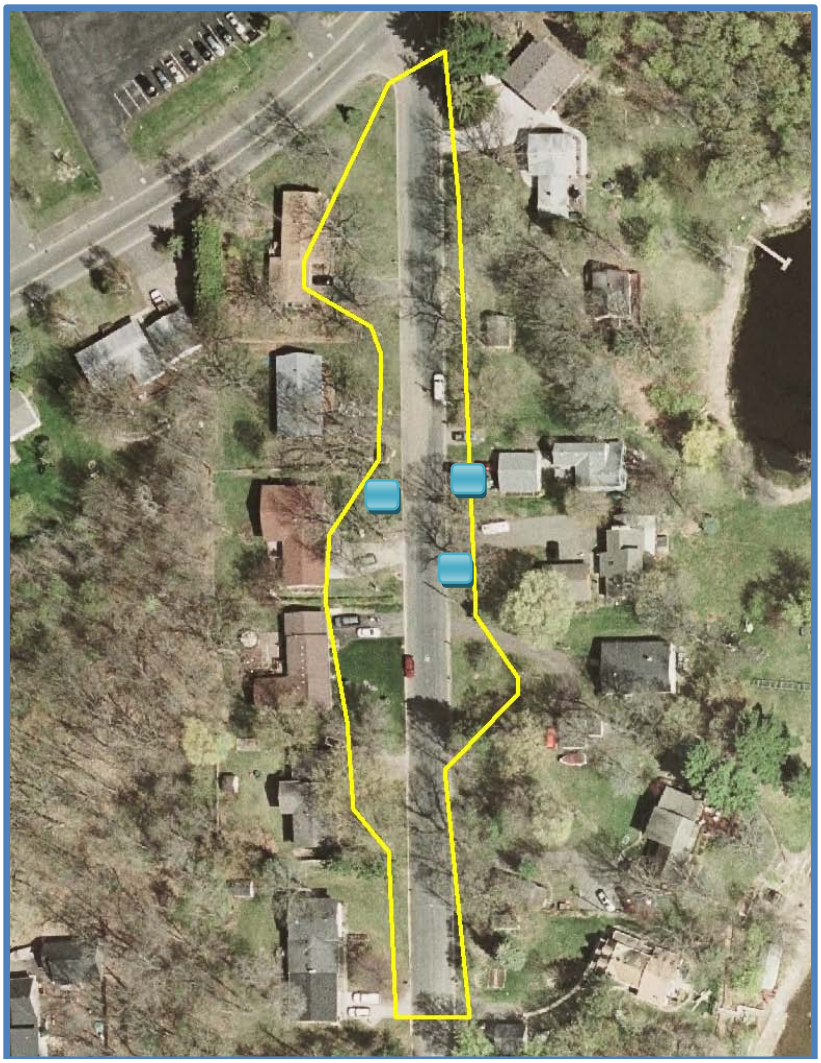
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.52
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is very small and consists only of the front portion of residential lots and a road (Kings Bluff). The road has two catch basins that drain directly into Chisago Lake. The yards behind the curb are gently sloped.

RETROFIT RECOMMENDATION

Bioretention near the catch basins will be achieved through curb cut rain gardens or beehive modifications. Slowing the water down as it enters the storm sewer will also reduce the erosion problem at the end of the storm sewer pipe into Chisago Lake.



Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	30%	0.6	40%	0.7	50%
	TSS (lb/yr)	253	56%	293	65%	330	73%
	Volume (acre-feet/yr)	0.3	27%	0.4	36%	0.6	46%
	Live Storage Volume (cubic feet)	183		270		375	
Costs	Materials/Labor/Design	$3,275		$4,826		$6,713	
	Promotion & Admin Costs	$2,151		$2,389		$2,612	
	Total Project Cost	$5,425		$7,215		$9,326	
	Annual O&M	$137		$202		$281	
	Term Cost/lb/yr (30 yr)	$435		$457		$484	

CHISAGO CITY – 45

Catchment Summary	
Acres	6.9
Dominant Land Cover	Residential/ Commercial
Parcels	11
Volume (acre-feet/yr)	8.4
TP (lb/yr)	9.9
TSS (lb/yr)	3,105

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.59
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is a mixture of medium density residential lots and commercial buildings with parking lots. The commercial areas are highly impervious. The residential lots slope towards the streets. There are several catch basins along Railroad Avenue, which drain to the wetland area in Chuckie Lindquist Park.

RETROFIT RECOMMENDATION

A neighborhood retrofit of bioretention cells with curb cuts would work well where appropriate. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	2.0	20%	3.0	30%	4.9	50%
	TSS (lb/yr)	1,420	46%	1,745	56%	2,275	73%
	Volume (acre-feet/yr)	1.4	17%	2.3	27%	3.9	46%
	Live Storage Volume (cubic feet)	747		1,261		2,579	
Costs	Materials/Labor/Design	$13,380		$22,573		$46,160	
	Promotion & Admin Costs	$3,149		$3,629		$4,405	
	Total Project Cost	$16,529		$26,202		$50,565	
	Annual O&M	$561		$946		$1,934	
	Term Cost/lb/yr (30 yr)	$512		$558		$667	

CHISAGO CITY – 46

Catchment Summary	
Acres	6.6
Dominant Land Cover	School/ Road
Parcels	1
Volume (acre-feet/yr)	7.5
TP (lb/yr)	8.8
TSS (lb/yr)	2,772

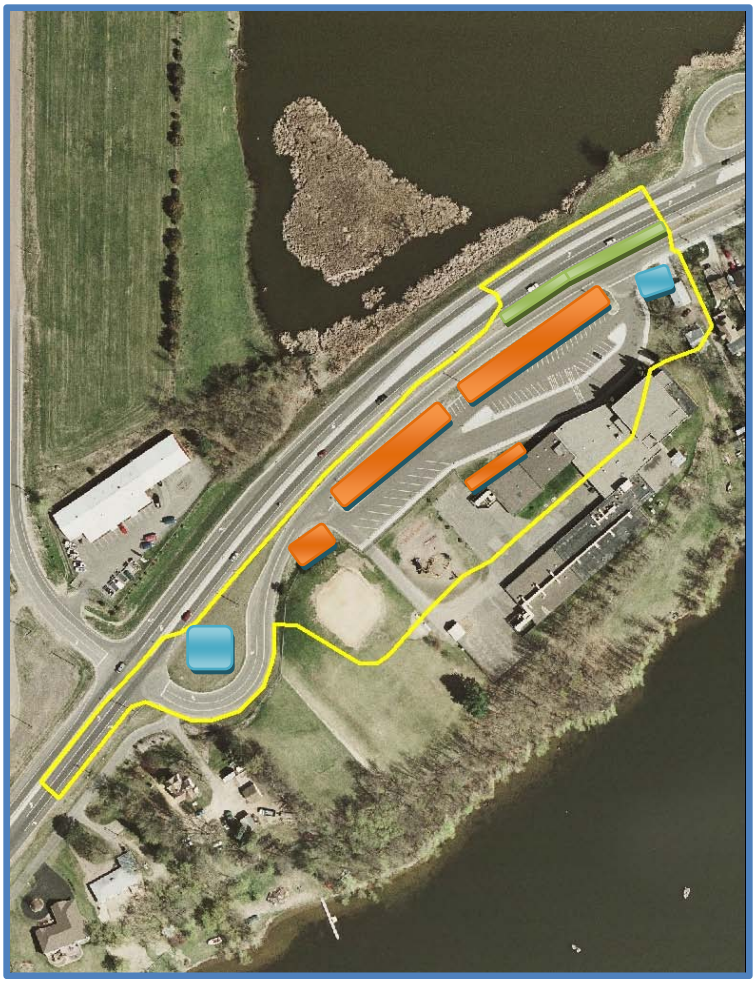
Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.55
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

The Lakeside Elementary School is included in this catchment, along with a parking lot and portions of Highway 8 and Wyoming Avenue. The catchment has a lot of impervious area, some of which is already treated with existing rain gardens. However, there are other areas that remain untreated.

RETROFIT RECOMMENDATION

Adding bioretention in the remaining green space along Wyoming Avenue would complete the stormwater management on the Lakeside School property. Working with the school has been successful in the past; continuing the relationship with them will benefit not only the lakes, but also the students and faculty.



Proposed Bioretention Areas Proposed Vegetated Swale Existing Bioretention Areas

	Cost/Benefit Analysis	Bioretention – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.8	20%	2.7	30%	4.4	50%
	TSS (lb/yr)	1,268	46%	1,558	56%	2,033	73%
	Volume (acre-feet/yr)	1.3	17%	2.0	27%	3.5	46%
	Live Storage Volume (cubic feet)	665		1,128		2,309	
Costs	Materials/Labor/Design	$11,930		$20,195		$41,325	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$13,130		$21,395		$42,525	
	Annual O&M	$500		$846		$1,732	
	Term Cost/lb/yr (30 yr)	$478		$529		$641	

CHISAGO CITY – 49

Catchment Summary	
Acres	12.6
Dominant Land Cover	Residential/ Commercial
Parcels	24
Volume (acre-feet/yr)	14.7
TP (lb/yr)	17.2
TSS (lb/yr)	5,400

Model Inputs	
Parameter	**Input**
Pervious Curve Number	68.2
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.56
Hydraulic Conductivity (in/hr)	0.54

DESCRIPTION

This catchment includes both residential and commercial lots. There are many catch basins located along the streets, which drain into Little Green Lake. In the commercial areas, there is very little green space to work with.

RETROFIT RECOMMENDATION

Capturing runoff near the catchbasins may be difficult in the commercial areas, but if possible, it is a good option. Curb cut rain gardens or tree pit bioretention areas are the best options for catchment 49. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or tree pits.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	3.4	20%	5.2	30%	8.6	50%
	TSS (lb/yr)	2,465	46%	3,030	56%	3,953	73%
	Volume (acre-feet/yr)	2.5	17%	4.0	27%	6.7	46%
	Live Storage Volume (cubic feet)	1,286		2,169		79,376	
Costs	Materials/Labor/Design	$23,025		$38,830		$5,102	
	Promotion & Admin Costs	$3,648		$4,203		$84,476	
	Total Project Cost	$26,674		$43,034		$3,326	
	Annual O&M	$965		$1,627		$3,326	
	Term Cost/lb/yr (30 yr)	$511		$561		$676	

CHISAGO CITY – 51

Catchment Summary	
Acres	20.0
Dominant Land Cover	Residential
Parcels	60
Volume (acre-feet/yr)	7.9
TP (lb/yr)	10.1
TSS (lb/yr)	4,648

Model Inputs	
Parameter	**Input**
Pervious Curve Number	70.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.41
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This is a long catchment that centers around Old Towne Road (County Highway 24). Along both sides of this road are medium residential lots, which are partially included in the catchment. There are catch basins located along the road that drain to both Little Green Lake and Chisago Lake.

RETROFIT RECOMMENDATION

Many curb cut rain gardens or tree pits could be placed appropriately along Old Towne Road. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. At the southern end of the catchment there is some City owned property that could be conducive to a large scale project.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	4.0	20%	6.1	30%	10.1	50%
	TSS (lb/yr)	2,903	46%	3,566	46%	4,648	73%
	Volume (acre-feet/yr)	3.0	17%	4.7	27%	7.9	45%
	Live Storage Volume (cubic feet)	1,533		2,587		5,286	
Costs	Materials/Labor/Design	$27,446		$46,316		$94,620	
	Promotion & Admin Costs	$3,826		$4,409		$5,351	
	Total Project Cost	$31,272		$50,725		$99,970	
	Annual O&M	$1,150		$1,941		$3,965	
	Term Cost/lb/yr (30 yr)	$517		$570		$689	

CHISAGO CITY – 52

Catchment Summary	
Acres	5.5
Dominant Land Cover	Residential
Parcels	16
Volume (acre-feet/yr)	4.5
TP (lb/yr)	5.2
TSS (lb/yr)	1,646

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.39
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is comprised of medium density housing. The area is relatively flat, although there are some areas directly behind that curb that have a considerable slope. There are two catch basins that drain this catchment directly to Chisago Lake.

RETROFIT RECOMMENDATION

Curb cut rain gardens should be added to this catchment. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size and lack of suitable locations, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.1	20%	1.6	30%	2.6	50%
	TSS (lb/yr)	754	46%	926	56%	1,209	73%
	Volume (acre-feet/yr)	0.8	17%	1.2	27%	2.1	46%
	Live Storage Volume (cubic feet)	398		671		1,376	
Costs	Materials/Labor/Design	$7,127		$12,008		$24,639	
	Promotion & Admin Costs	$2,655		$3,058		$3,716	
	Total Project Cost	$9,782		$15,066		$28,355	
	Annual O&M	$299		$503		$1,032	
	Term Cost/lb/yr (30 yr)	$500		$534		$631	

CHISAGO CITY – 54

Catchment Summary	
Acres	3.8
Dominant Land Cover	Residential
Parcels	10
Volume (acre-feet/yr)	2.4
TP (lb/yr)	2.9
TSS (lb/yr)	900

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.31
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is small and is made up of medium density residential lots. Hayes Street and Green Lake Avenue intersect in this catchment. There are catch basins along both roads that drain directly into Little Green Lake. A portion of the backyards of several lots drain together into a swale that also drains to Little Green Lake.

RETROFIT RECOMMENDATION

Curb cut rain gardens should be added to this catchment. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing Catchment 56 at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.6	20%	0.9	30%	1.4	50%
	TSS (lb/yr)	413	46%	507	56%	661	73%
	Volume (acre-feet/yr)	0.4	17%	0.7	27%	1.5	61%
	Live Storage Volume (cubic feet)	218		369		754	
Costs	Materials/Labor/Design	$3,910		$6,596		$13,489	
	Promotion & Admin Costs	$2,256		$2,600		$3,156	
	Total Project Cost	$6,166		$9,196		$16,645	
	Annual O&M	$164		$276		$565	
	Term Cost/lb/yr (30 yr)	$491		$503		$577	

CHISAGO CITY – 56

Catchment Summary	
Acres	8.4
Dominant Land Cover	Residential
Parcels	16
Volume (acre-feet/yr)	5.5
TP (lb/yr)	6.4
TSS (lb/yr)	2,000

Model Inputs	
Parameter	**Input**
Pervious Curve Number	69.0
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.31
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment is made up of medium residential lots. The whole catchment drains to three catch basins in the southwestern corner of the catchment. These catch basins drain directly into Little Green Lake. The lots are relatively flat behind the curb.

RETROFIT RECOMMENDATION

Curb cut rain gardens should be added to this catchment. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing Catchment 54 at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	1.3	20%	1.9	30%	3.2	50%
	TSS (lb/yr)	917	46%	1,126	56%	1,469	73%
	Volume (acre-feet/yr)	0.9	17%	1.5	27%	2.5	45%
	Live Storage Volume (cubic feet)	485		818		1,677	
Costs	Materials/Labor/Design	$8,686		$14,651		$30,012	
	Promotion & Admin Costs	$2,801		$3,228		$3,920	
	Total Project Cost	$11,487		$17,879		$33,931	
	Annual O&M	$364		$614		$1,257	
	Term Cost/lb/yr (30 yr)	$504		$545		$647	

CHISAGO CITY – 57

Catchment Summary	
Acres	2.2
Dominant Land Cover	Residential
Parcels	7
Volume (acre-feet/yr)	2.3
TP (lb/yr)	2.6
TSS (lb/yr)	821

Model Inputs	
Parameter	**Input**
Pervious Curve Number	72.4
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.48
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This small catchment is mostly medium residential but also includes a portion of a road (Park Place) that has a small dead-end portion. At the end of this dead-end are two catch basins that drain to Chisago Lake.

RETROFIT RECOMMENDATION

Curb cut rain gardens should be added to this catchment. Curb cuts should be placed on the up-hill side of catch basins to divert water into rain gardens or vegetated swales. Due to the small catchment size, completing more than one other nearby catchment at the same time would likely lower total costs and cost per pound of pollutant removal.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Neighborhood Retrofit – Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.5	20%	0.8	30%	1.5	50%
	TSS (lb/yr)	376	46%	462	56%	602	73%
	Volume (acre-feet/yr)	0.4	17%	0.6	27%	1.0	45%
	Live Storage Volume (cubic feet)	199		335		687	
Costs	Materials/Labor/Design	$3,556		$5,996		$12,288	
	Promotion & Admin Costs	$2,199		$2,534		$3,077	
	Total Project Cost	$5,755		$8,530		$15,366	
	Annual O&M	$146		$251		$515	
	Term Cost/lb/yr (30 yr)	$474		$491		$567	

CHISAGO CITY – 61

Catchment Summary	
Acres	6.9
Dominant Land Cover	Ball Field/ Wetland
Parcels	1
Volume (acre-feet/yr)	1.3
TP (lb/yr)	1.3
TSS (lb/yr)	378

Model Inputs	
Parameter	**Input**
Pervious Curve Number	75.1
Indirectly connected Impervious Fraction	0
Directly Connected Impervious Fraction	0.07
Hydraulic Conductivity (in/hr)	0.51

DESCRIPTION

This catchment has little impervious area. It includes a baseball field, a wetland area, and a tree plantation. There is a small portion of a road (Maple Ridge) with several catch basins that drain to Green Lake.

RETROFIT RECOMMENDATION

Capturing runoff in the form of curb cut rain garden from Lofton Avenue and 284th Street can add some beauty while treating some runoff. The parcel itself is already quite pervious. Utilizing the open space to capture road runoff is ideal. Combining this retrofit with nearby catchments could improve the cost per pound.

Proposed Bioretention Areas

	Cost/Benefit Analysis	Bioretention					
		Annual Marginal Treatment Enhancement					
		Min		Mid		Max	
Treatment	TP (lb/yr)	0.4	30%	0.5	40%	0.6	50%
	TSS (lb/yr)	219	58%	255	67%	286	76%
	Volume (acre-feet/yr)	0.3	23%	0.4	32%	0.5	40%
	Live Storage Volume (cubic feet)	173		256		361	
Costs	Materials/Labor/Design	$3,100		$4,585		$6,470	
	Promotion & Admin Costs	$1,200		$1,200		$1,200	
	Total Project Cost	$4,300		$5,785		$7,670	
	Annual O&M	$130		$192		$271	
	Term Cost/lb/yr (30 yr)	$405		$417		$464	

CHISAGO CITY – 62 & 69

DESCRIPTION

62 - This is a large, complex catchment that includes residential areas, the Chisago Lakes Elementary School, and the Parmly Campus. Most of this area is treated in stormwater ponds scattered across the landscape. There is one gully that is eroding into Green Lake.

69 - This catchment is a mixture of residential lots and a wetland complex. There is little impervious in this catchment. There is a gully that drains from the wetland to Chisago Lake.

RETROFIT RECOMMENDATION

Gully stabilizations are recommended for these catchments. Upstream infiltration is also recommended where possible. The cost to fix each of these gullies could be close to $30,000 each. Depending on the Severity of the erosion, they could remove 4-10 pounds of Phosphorus and 3,000-6,000 pounds of Sediment.

Proposed Gully Stabilizations

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[2]
CHISAGO CITY –2	B, PS, VS	17	30	4.1	3.1	$31,765	30	$538
CHISAGO CITY – 3	B, PS, VS	7	30	1.8	1.4	$15,157	30	$509
CHISAGO CITY – 5	B	4	32	0.8	0.4	$10,176	30	$584
CHISAGO CITY – 9	B	7	30	1.2	0.7	$16,181	30	$706
CHISAGO CITY – 10	B, PS, VS	6	30	1.1	0.6	$11,697	30	$623
CHISAGO CITY – 12	B	5	30	1.0	0.6	$12,637	30	$638
CHISAGO CITY – 15	B	15	30	2.9	1.6	$31,839	30	$707
CHISAGO CITY – 19	B, VS	11	50	1.8	1.3	$23,389	30	$701
CHISAGO CITY – 27	B, VS	3	50	0.8	0.6	$10,364	30	$510
CHISAGO CITY – 31	B, VS	10	30	1.8	1.0	$19,134	30	$658
CHISAGO CITY – 32	B, VS	18	20	3.8	1.9	$36,601	30	$647
CHISAGO CITY – 34	B, PS	20	20	4.7	2.8	$40,705	30	$590
CHISAGO CITY – 35	VS	6	30	1.6	1.2	$13,364	30	$505
CHISAGO CITY – 37	B	2	40	0.6	0.5	$6,494	30	$425
CHISAGO CITY – 38	B, VS	7	20	2.0	1.5	$16,645	30	$509
CHISAGO CITY – 43	B	2	40	0.6	0.4	$7,215	30	$457
CHISAGO CITY – 45	B	7	20	2.0	1.4	$16,529	30	$512
CHISAGO CITY – 46	B, VS	6	20	1.8	1.3	$13,130	30	$478
CHISAGO CITY – 49	B	21	30	5.2	4.0	$43,034	30	$561
CHISAGO CITY – 51	B	15	20	4.0	3.0	$31,272	30	$517
CHISAGO CITY – 52	B	4	20	1.1	0.8	$9,782	30	$500
CHISAGO CITY – 54	B	3	30	0.9	0.7	$9,196	30	$503
CHISAGO CITY – 56	B	8	30	1.9	1.5	$17,879	30	$545
CHISAGO CITY – 57	B	3	30	0.8	0.6	$8,530	30	$491
CHISAGO CITY – 61	B, VS	2	40	0.5	0.4	$5,785	30	$417
CHISAGO CITY – 62	G							
CHISAGO CITY – 69	G							

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)
G = Gully stabilization

[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

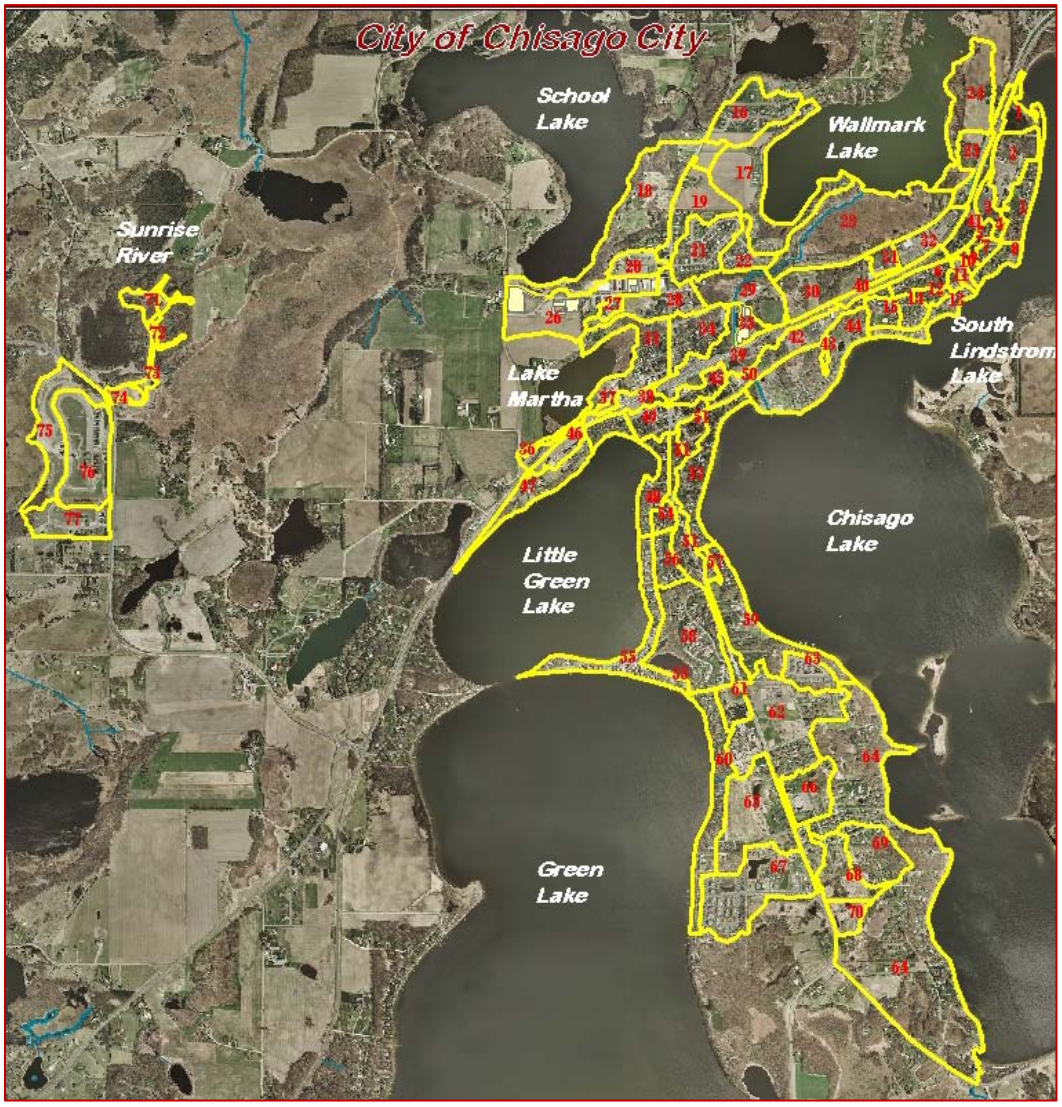
Catchments not included in ranking table were excluded for a number of reasons, mainly involving connectivity to the receiving water. After BMPs are installed within the priority catchments, it is recommended that the City revisit the entire subwatershed to determine other catchments that, while they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

Overall Catchment Map

See the following map showing the entire City of Chisago City and Catchments:



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