Coleraine Stormwater Retrofit Assessment

Technical Memorandum

HRG Project 170503

6/19/2018

PREPARED FOR

North Central Minnesota Joint Powers Board
Itasca Soil and Water Conservation District
City of Coleraine, MN

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SUMMARY

The North Central Minnesota Joint Powers Board (NCMJPB) commissioned an analysis of the City of Coleraine, MN to investigate the potential for the retrofit of new stormwater best management practices focused on improving water quality for Trout Lake. The NCMJPB partnered with the Itasca Soil and Water Conservation District and the City of Coleraine for this analysis.

Locations for several forms of stormwater best management practices (BMPs) were identified and modeled for water quality treatment capacity, and then compared to installation and life-cycle costs to generate an index of potential value (expressed in dollars per pound of pollutants removed in an average year). Potential locations were identified through review of aerial photography, readily available geographical data sets, city data and field review of select locations. Recommended strategies were sorted by economic return on investment to provide the City with information useful in generating an implementation plan towards the protection of Trout Lake (Table 1). In many cases, additional benefits should be considered that address social and additional economic and environmental values.

This report describes the process, results and recommended strategies for treating urban runoff to Trout Lake but does not provide a full feasibility assessment of the more complicated projects it identifies as possibilities. In some cases, notes on additional information and analysis are identified as a requirement before any implementation can be considered. Additionally, the study did not model the entirety of the urbanized portion of the city or its more rural, natural areas. The study focused on the more directly-connected, urbanized lands within the city's boundary.

Table 1. Recommended Implementation Strategies Ranked by Economic Return on Investment (TP = Total Phosphorus)

Subwatershed	BMP	Install Cost	TP lb/yr	30-yr TP value	Values Addressed			
					Manage Stormwater	Surface WQ	Enhance Public Space	Infrastr. Integration
7	Infiltration Trench	$2,500	1.3	$1,923	Y	Y	N	N
6	Extended Detention	$105,000	46	$2,299	Y	Y	Y	Y
10	Raingardens	$24,000	5.8	$4,181	Y	Y	Y	Y
13	Raingardens	$9,000	2.1	$4,406	Y	Y	Y	Y
7	Raingardens	$15,000	2.8	$5,446	Y	Y	Y	Y
11	Stormwater Planters	$14,000	1.8	$7,917	Y	Y	Y	Y
7	H169 Detention	$63,000	7.5	$8,500	Y	Y	Y	Y
1	Stormwater Planters	$45,745	4.8	$9,582	Y	Y	Y	Y
12	Stormwater Planters	$7,000	0.7	$10,360	Y	Y	Y	Y
3	Stormwater Planters	$49,000	4.6	$10,707	Y	Y	Y	Y
1	Permeable Paving	$140,400	9.8	$14,347	Y	Y	N	Y
7	Stormwater Planters	$42,000	2.3	$18,370	Y	Y	Y	Y
1	Sub-Sidewalk Storage	$195,000	4.4	$44,375	Y	Y	N	Y

Section 1. Methods

Desktop Analysis

Issues and Goals Identification

To assist in driving the analysis of the City of Coleraine, MN stormwater infrastructure, and to identify potential opportunities to retrofit stormwater water quality best management practices (BMPs), meetings were held with city staff and the Itasca Soil and Water Conservation District. Information from these meetings was supplemented with additional conversations throughout the analysis to clarify stormwater conveyance and treatment issues and opportunities.

Subwatershed Delineation

The city's stormwater pipes were digitized in Geographic Information Systems (GIS) software to then delineate Subwatersheds. Stormwater outfalls to the lake and confluences of major pipe systems were used as spill points to facilitate this effort. The resulting pipesheds allow the City to account for watershed pollutant loading to Trout Lake as well as for planning for its treatment.

Initial Retrofit Review

A review of areas suitable for retrofitting BMPs was performed via desktop using GIS and aerial imagery (Google Earth and Street View). The process involved scrutinizing various land uses and existing ponds and outfalls for indicators suggesting retrofit opportunities. Areas potentially conducive to retrofitting were recorded within a GIS Shapefile along with their potential BMPs.

The areas reviewed were as follows, in order of importance;

1. Outfalls
2. Existing ponds
3. Public lands
4. Residential lands
5. Commercial and Industrial lands

Field Reconnaissance

A review of potential retrofit opportunities within the city was performed by visiting neighborhoods, commercial and industrial land. A mapbook of subwatersheds, stormwater infrastructure, flow paths and aerial imagery was referenced for this work. Field review of the downtown area, its parks, Highway 169 and select neighborhoods was performed to validate land use, site suitability and initial BMP selection.

Modeling

Each subwatershed's stormwater effluent water quality was modeled within P8 Urban Catchment Model (version 3.5; Walker, 2015). Land use classifications were defined through review of aerial imagery and field observations. Modeling parameters from Pitt, Voorhees, Burger and Joachim (WINSLAMM 2012) were correlated to land uses to assist in estimating pollutant build up and delivery to the Lake (e.g., pervious/impervious surface ratios, surface pitting). NRCS soils data, obtained from the NRCS Web Soil Survey, were used for classification of hydrologic soil groups. The base and treatment models ran several decades of hourly precipitation data to generate average annual loading and potential treatment estimates.

Section 2. Results

Setting the Stage

Issues and Goals Identification

It is important to understand local stakeholder values and goals when considering water resource management actions. Sustainability of natural resources is greatly enhanced when management actions address local values related to natural resources, quality of life, local economies and the potential risks to them. To understand the city's concerns and values, a meeting was held with the City Council explaining the study scope and intent, and a request was made for input regarding their objectives. A questionnaire was presented to the council to help define preferred strategies and related objectives. Descriptions of each level of management effort and strategy objectives is presented in the Appendix (Appendix – Stormwater Retrofit Questionnaire).

Table 2. City Council value summary results for chosen level of retrofit implementation and future development goals.

	GOALS				
Value	Improved	Enhanced	Superior	Conserving	Restorative
Manage stormwater	**Increased treatment capacity.** The target water storage capacity for a project is a 30% improvement in water storage capacity. The target water quality treatment for phosphorus is 30% and 50% for sediments.				
Protect wetlands and surface water quality	**Avoidance of risk.** Avoid development and establish at least a 50-foot buffer.				
Enhance public space	**No adverse effects.** Project team works with the community, property owner and required regulatory and resource agencies to identify public space resources and develop possible solutions. Feasibility analysis done for incorporating preservation, enhancement, or the creation of new spaces into the project. Project is designed such that it results in no long-term adverse effects and may include mitigation. Project may result in minor temporary impacts. **No Impact to resources.** Project team works with the community, property owner and required regulatory and resource agencies to develop avoidance solutions. Focus is on no impact to resource. The project has no significant permanent impact to the resource. Temporary impacts are minimized. Consideration is given to the creation of new public space.				
Improve infrastructure integration	**Narrow optimization focus.** Project performance improvements in the triple bottom line, including resource conservation and use of renewable resources. Protection of environmental, economic, and social systems are substantive, but are confined to individual components. Individual gains are present, but are suboptimal because of the lack of component integration. Little or no exploration of synergies among components.				

Table 3. City Council comments by strategy.

Strategy	Notes
Manage stormwater	N/A
Protect wetlands and surface water quality	Concern about possible increase in water temperature that may exacerbate algae growth. If Hollywood location project is not done correctly, water quality of lake may deteriorate.
Enhance public space	Longyear Park – consider an aeration pump?
Improve infrastructure	Vital to improve community support/assistance.

Table 4. City Council comments relating to management history and resources.

<table>
<tr><th>Question</th><th>Response</th></tr>
<tr><td>What potential partners does the City have to implement projects related to stormwater, waste water, water supply, parks and roadways? E.g., County, State. Federal agencies, local non-government organizations.</td><td>Local, non-government organization; IRRRB</td></tr>
<tr><td>Does the City, and can you provide, technical resources such as GIS or CAD databases, as-builts and technical staff time (for field visits)?</td><td>Is this an area we should consider when hiring a new street department employee?</td></tr>
<tr><td>What existing stormwater infrastructure problems does the City face? (e.g., undersized pipes, aging infrastructure, infiltration/inflow, interior flooding, etc.)?</td><td>Infiltration/inflow (I and I) because of old, clay pipes.</td></tr>
<tr><td>What stormwater water quality, rate or volume control controls does the City currently employ?</td><td>A constant concern/effort (I and I)</td></tr>
<tr><td>Is the City open to using Green Infrastructure (raingardens, stormwater wetlands, stormwater planters, pervious pavements, water quality swales, etc.) to supplement its Grey Infrastructure (pipes and below ground structures)?</td><td>Yes</td></tr>
<tr><td>Are buried utilities mapped in the City?</td><td>Unknown</td></tr>
<tr><td>Does the City have a pavement management plan?</td><td>No</td></tr>
<tr><td>Does the City plan on refurbishing/renovating its boulevards and pedestrian corridors?</td><td>Gradually</td></tr>
<tr><td>What level of coordination between City offices has there been in the past in implementation of projects?</td><td>Lack of awareness of the problem of concern.</td></tr>
<tr><td>Who are the key staff we should know about?</td><td><table>
<tr><td>Person/Title</td><td>Phone</td><td>Email</td></tr>
<tr><td>Harry Bertram</td><td>218.259.4255</td><td>harryb@cityofcoleraine</td></tr>
<tr><td>Todd Marlette</td><td>612.804.8982</td><td>Toddm@cityofcoleraine</td></tr>
</table></td></tr>
</table>

Subwatershed Delineation and Land Use Classification

A total of 15 urban subwatersheds were delineated (Figure 1). Digitized land uses (Figure 2) were clipped by subwatershed with 14 separate classifications identified (Table 2). This combined subwatershed-land use information was used to build the existing conditions stormwater water quality model.

Table 5. Land use summary for urbanized areas of Coleraine.

	ACRES OF LAND USE WITHIN SUBWATERSHEDS														
Sub-Shed	**CDT**	**FREE**	**INST**	**LDR**	**LI**	**MDRNA**	**MDRWA**	**MFRNA**	**MI**	**OSUD**	**PARK**	**SCH**	**SCOM**	**SUB**	**W**	**Sum**
1	2	12		14	12		13		9	108	7	1	3			**181**
2		1					2					2				**5**
3	1	2					9					5				**18**
4		1					5									**5**
5		2					4									**5**
6		1	1						2		3					**6**
7		6	1	11	1	34			6	25				21		**105**
8		4	4		3											**12**
9		8		22		2		2		107	98			78	3	**319**
10				1		34		1			2					**38**
11						8										**8**
12						4										**4**
13						5				9						**14**
14										21	12			17		**50**
15										112						**112**
Sum	**3**	**35**	**6**	**48**	**16**	**88**	**33**	**2**	**17**	**382**	**123**	**8**	**3**	**116**	**3**	**885**

CODE	DESCRIPTION
CDT	Commercial Downtown
FREE	Freeway/Highway
INST	Institutional
LDR	Low Density Residential
LI	Light Industrial
MDRNA	Medium Density Residential, no alleys
MDRWA	Medium Density Residential, with alleys
MFRNA	Multi-family Residential, no alleys
MI	Medium Industrial
OSUD	Open Space, Urban
PARK	Parks
SCH	Schools
SCOM	Strip Commercial
SUB	Suburban
W	Water

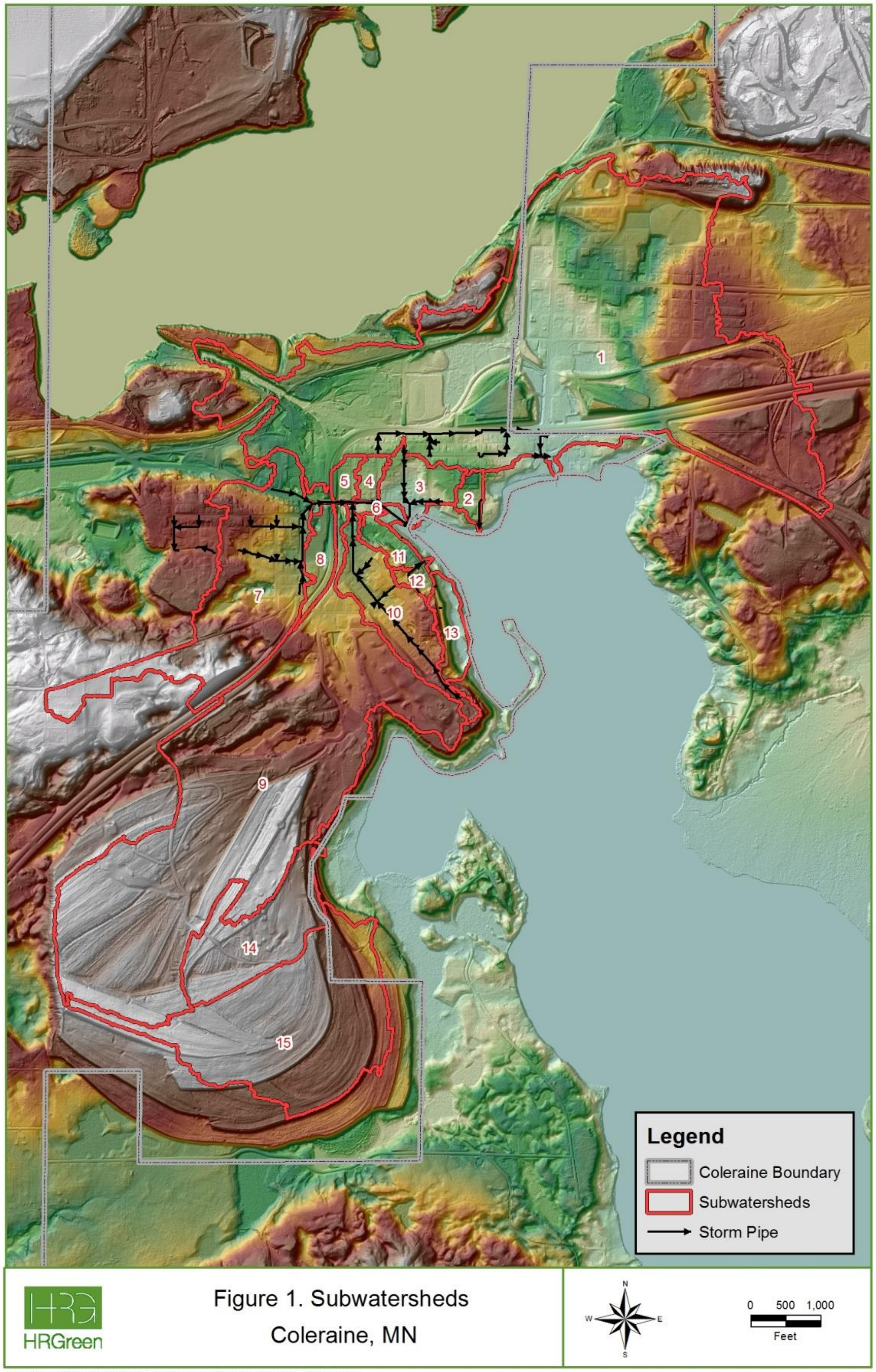


Figure 1. Urbanized Subwatersheds within the city of Coleraine

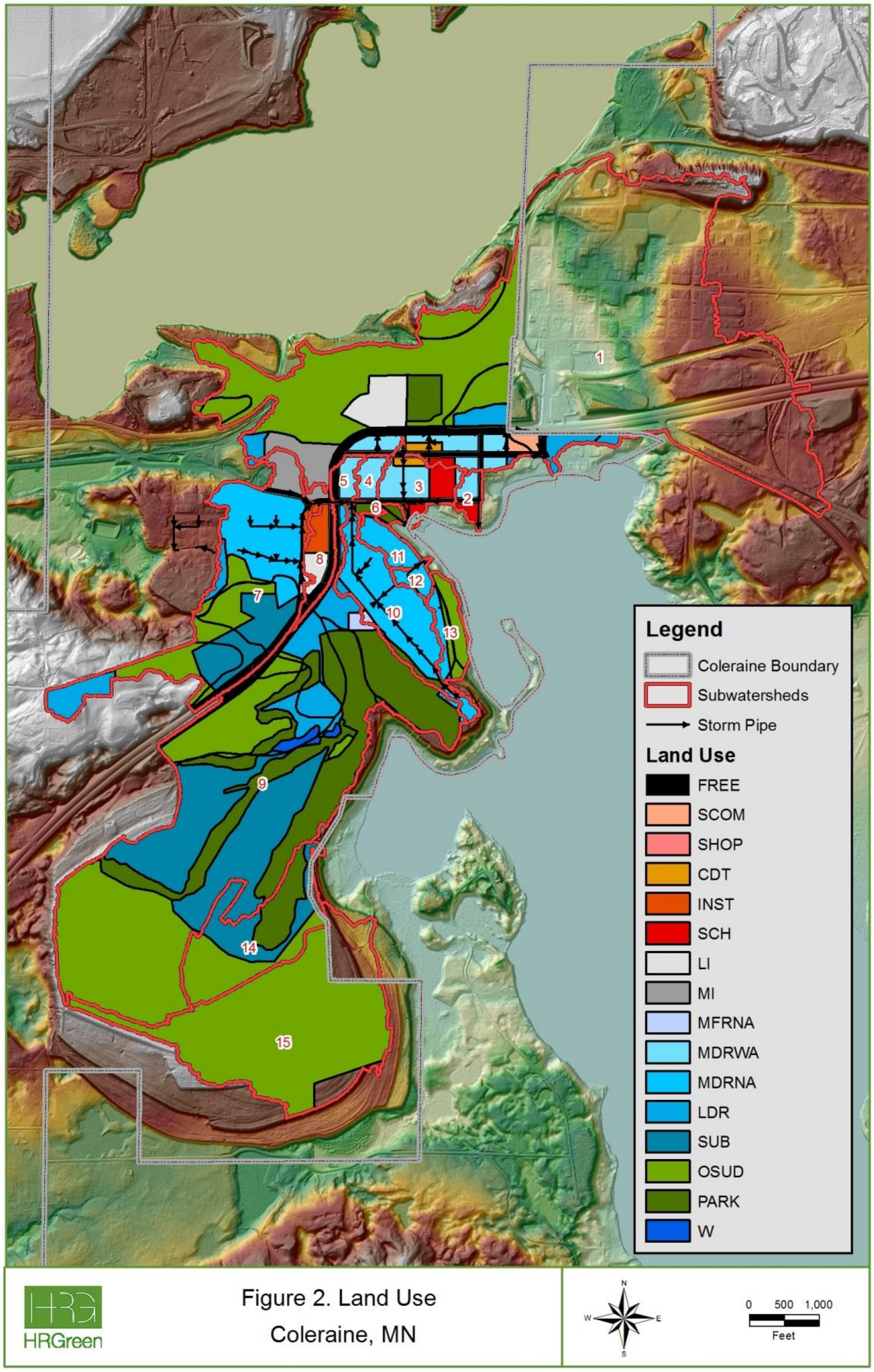


Figure 2. Urban land uses within the city of Coleraine.

SUBWATERSHED WATER QUALITY MODELING AND TREATMENT VALUE RESULTS

Eleven of the 15 subwatersheds were selected for the proposed strategy's (Figure 3) treatment capacity and all were modeled for potential existing pollutant loading to Trout Lake. Only lands within the City of Coleraine were modeled for this analysis. A cost-benefit estimation was then made for each treatment strategy. The following sections describe each of the 10 subwatershed's opportunities, performance and cost-benefit.

The following subwatersheds were not selected for treatment modeling analysis within this study.

Subwatershed 2

Subwatershed 2 has recently been redeveloped with new roadway and parking lot surfaces with little to no room for retrofitting of BMPs near its outfall. In addition, curb cut types of BMP locations only occur high in its drainage area and would yield minimal treatment value. Modeling results suggest that 4.9 lbs of phosphorus and 1,509 lbs of sediment are transported annually to Trout Lake on an average year.

Subwatershed 8

Subwatershed 8's runoff is likely effectively treated by the presence of a very large, highly vegetated depression located along Highway 169, on its eastern boundary. No further treatment is recommended at this time. An estimated 18.5 lbs of phosphorus and 5,752 lbs of sediment is generated and transported to the depression and is likely highly treated.

Subwatersheds 14 and 15

Subwatersheds 14 and 15 are comprised of suburban and open space with highly limited opportunities for retrofitting water quality BMPs. Subwatershed 14 may contribute 10.5 lbs of phosphorus and 2,702 lbs of sediment annually to Trout Lake on an average year; while Subwatershed 15 may contribute 15.0 lbs of phosphorus and 3,808 lbs of sediment annually, though this depends largely on the extent of surface flow connection between large natural areas and the roadway/storm sewer conveyance connection.

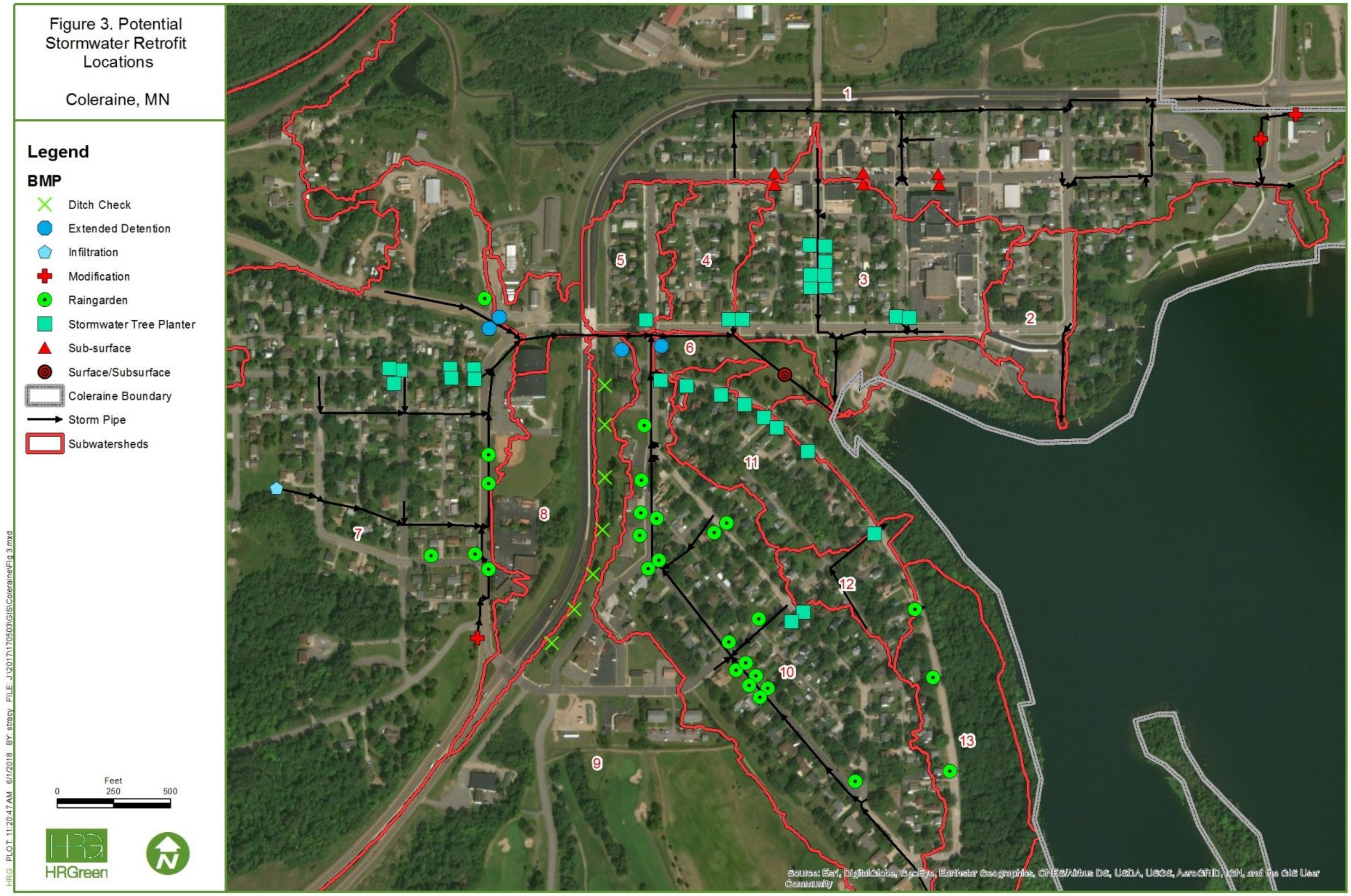


Figure 3. Potential locations and types of stormwater best management practices (BMPs).

Subwatershed 1

Estimated total subwatershed loading

Subwatershed 1 was modeled to estimate its average annual generation and transport of phosphorus and sediment to Trout Lake. Subwatershed 1 drains to a combined system, with Bovey, to a very small stormwater pond before entering Trout Lake. The Church pond and the City of Bovey's stormwater modeling were beyond the scope of this analysis, though the pond's size relative to its drainage area would suggest it currently has very limited treatment capacity. For the sake of this analysis, this pond was considered to have no treatment capacity. Therefore, the results of subwatershed transport of pollutants equals that of its modeled annual supply.

Figure 4. Subwatershed 1 modeled annual loading of phosphorus and sediment to Trout Lake.

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 1	82.2	2.47	25,350	12,675

Potential Strategy

Two forms of stormwater BMP opportunities were identified in Subwatershed 1. Parking-lane or sidewalk underground storage, filtration or infiltration and modification to existing stormwater features.

<u>Parking Lane/Sidewalk options</u>

Opportunity for either stormwater filtration, infiltration or sedimentation processes occur along the parking lanes and adjacent sidewalks within Roosevelt St between Olcot and Clemsen Avenues. Soils in this area are classified as highly permeable, potentially lending themselves to infiltration of stormwater, though impacts to infiltration likely exist in the form of compaction and fill. Any proposed infiltration BMP will need further soils investigation to identify design strategies.

Option	Function	Benefits	Notes
Permeable parking lanes	Filtration or infiltration	Retain parking spaces while treating stormwater.	Requires periodic vacuuming of surface to retain surface pore spaces for infiltration to storage layer. Recommended increase in street sweeping and regulated sand application in winter.
Stormwater planter boxes	Filtration or infiltration	Adds aesthetic enhancements, rain interception and shade as well as treats stormwater.	Removes a portion of the sidewalk area. Requires forebay sediment capture for ease of sediment removal.
Sub-sidewalk storage	Sedimentation	Retains sidewalk space while treating stormwater.	Requires annual vacuuming sediment from access ports

<u>Modification to existing stormwater features</u>

Opportunity exists for the expansion of stormwater runoff storage from Highway 169 and 2nd Avenue. An existing linear pond is located within the Mary Immaculate Church property with plenty of room for the expansion of the pond area to include extended detention of larger amounts of runoff and for improvement on water quality treatment. The entirety of the city's storm sewer within Subwatershed 1 drains to this point as well as stormwater from Bovey (not quantified within this study). The Church pond and the City of Bovey's stormwater modeling were beyond the scope of this analysis.

Cost-Benefit

Table 6. Subwatershed 1 30-year Cost-Benefit Results for Recommended Strategy - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)[2]	TP Removed (%/YR)[2]	TP Removed (LB/YR)[2]	30-Year Treatment Value ($/LB/YR)[2]
Permeable Parking[3]	$140,400	$200	10.6	78	9.8	$14,347
Stormwater Planters[4]	$45,745	$250	10.6	45	4.8	$9,582
Sub-sidewalk Storage[5]	$195,000	$250	10.6	42	4.4	$44,375

Table 7. Subwatershed 1 30-year Cost-Benefit Results for Recommended Strategy - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)[2]	TSS Removed (%/YR)[2]	TSS Removed (LB/YR)[2]	30-Year Treatment Value ($/LB/YR)[2]
Permeable Parking[3]	3275	89	3,467	$41
Stormwater Planters[4]	3275	65	2,130	$22
Sub-sidewalk Storage[5]	3275	73	2,395	$82

[1]D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.
[2]Results reflect export and treatment associated with Coleraine's subwatersheds exported to the Mary Immaculate Church property's linear pond. No modeling of this pond or Bovey's loading was performed.
[3]2600-ft2 total of permeable asphalt lanes, no sub-infiltration, drain at bottom.
[4]Several planters totaling 1,307 ft^2, 3 feet of media with drain tile and no sub-infiltration. Openings between planters are expected to allow for pedestrian traffic from the parking lane to the sidewalk.
[5]3-ft deep storage with 0.5-ft outlet 1-foot from the bottom invert; total of 2,600 ft^2.

It is recommended that the Bovey stormwater infrastructure be obtained for additional modeling to estimate watershed loading and the effects of modifications to the Mary Immaculate Church pond. Pond expansion and possible inclusion of a surface enhanced sand filter bench (iron-enhanced sand filter) to treat both City's stormwater would likely yield a very high return on investment. A feasibility study and 30% design would effectively supplement a Clean Water Fund Grant application and likely be very competitive given the total drainage area size it would possibly treat.

Subwatersheds 3, 4 and 5

Estimated total subwatershed loading

Subwatersheds 3, 4, and 5 are comprised of similar land uses with similar potential BMP treatment type. All three subwatersheds drain directly to the Lake with no water quality treatment currently in place.

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 3	16.4	4.9	5,085	2,543
Subwatershed 4	3.2	1.0	980	490
Subwatershed 5	4.5	1.4	1,368	684

Potential Strategy

Stormwater planter boxes were the primary form of stormwater treatment opportunity identified within these Subwatersheds. Given the tight spaces between the roadways and sidewalks in this mixed land use setting, it is recommended that stormwater tree planter boxes be considered to new stormwater water quality treatment. Though a few locations for opportunities were noted in subwatersheds 4 and 5 (Figure 3), their estimated annual loading was far less than the subwatershed 3 and the expected return on investment was lower. Therefore, only subwatershed 3 was modeled for potential treatment. However, the addition of 1 to 2 of these BMPs in both remaining subwatersheds would achieve the prioritized water quality treatment levels by the city for this phase of retrofitting.

Cost-Benefit

Table 8. Subwatershed 3, 30-year Cost-Benefit Results for Recommended Strategy - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)	TP Removed (%/YR)	TP Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
SW-3 Stormwater Planters[2]	$49,000	$250	9.4	49	4.6	$10,707

Table 9. Subwatershed 3, 30-year Cost-Benefit Results for Recommended Strategy - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)	TSS Removed (%/YR)	TSS Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
SW-3 Stormwater Planters[2]	2,935	68	1,990	$25

[1]D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.
[2]SW-3 Stormwater Planters - 7 planter boxes (200 ft2 each)

Subwatersheds 6 (4-7, 9, 10, 11)

Estimated total subwatershed loading

Subwatershed 6 drains it surface water runoff, combined with Subwatersheds 4, 5, 6, 7, 9, 10 and 11. Subwatershed 6 likely has limited pollutant export on its own, while the total load moving through the storm sewer system from the upland subwatersheds is significantly greater. This report summarizes results for Subwatershed 6 as defined by the combination of these subwatersheds with only the portions of Subwatershed 9 from the buildings on the north end of the Golf Course to the headwaters of Subwatershed 6 and without Subwatershed 8 (*see*, Subwatershed 9 summary). The decision to not include Subwatershed 8 was made given the expansive storage capacity present within its drainage area.

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatersheds (4, 5, 6, 7, 9, 10, 11)	80	24	24,439	12,200

Potential Strategy

The creation of an extended detention wetland located on the western portion of the existing park could capture significant runoff from a large portion of the City's watershed. Conceptual layout of the system would include a 1-acre pond planted with native upland species as a buffer surrounding the wetland and emergent, native vegetation in the shallow portions of the open water areas. This concept assumes that a split from the main sewer line can be made to transfer a significant portion of flows to the wetland by gravity, though an assessment of this needs to be made. Though loss of turf area within the park would be necessary, additional benefits beyond water quality improvements include:

1. Pollinator and bird habitat diversity.
2. A single best management practice to maintain in lieu of the more distributed options identified within the subwatersheds draining to it.
3. Location on public land, whereas the majority of other options upstream of the site would necessitate home owner buy in and possibly maintenance agreements.
4. Rate control to the downstream pipe leading to the existing forebay to Trout Lake.
5. More cost effective than a sub-surface treatment chamber system and easier to maintain.

Cost-Benefit

Table 10. Subwatershed 3, 30-year Cost-Benefit Results for Recommended Strategy - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)	TP Removed (%/YR)	TP Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Extended Detention[2]	$225,000	$750	67	46	31	$2,299

Table 11. Subwatershed 3, 30-year Cost-Benefit Results for Recommended Strategy - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)	TSS Removed (%/YR)	TSS Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Extended Detention[2]	20,531	77	15,782	$7

[1]D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.

[2]1-acre stormwater wetland, 3 foot permanent pool (dead storage minimum; actual design may vary), 2 feet of storage pool.

Subwatershed 7

Estimated total subwatershed loading

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 7	46.9	14.1	14,311	7,156

Potential Strategy

Subwatershed 7 provides several forms of stormwater treatment opportunities. Select strategies were modeled independently from each other, not as a treatment train, given the uncertainty of private BMP buy-in.

1. Two open spaces exist at the intersection of Cole and Gunn Streets where potential Extended Detention Ponds or an Infiltration Basin may be considered. The entirety of the Subwatershed's storm sewer system drains to this point and consideration of retrofitting a flow splitter from the confluence of the two tributary pipe systems (under Cole street) or from each tributary is recommended. No parcel ownership identifier was provided within County Parcel data for either location. Limitations on the ability to route stormwater from the pipes to these locations will be controlled by the storm sewer pipe invert elevations, tight project boundaries and topography (likely retaining wall needed on southwest corner of intersection) and further investigation will be required to fully determine the recommendation's feasibility.
2. Several locations suitable for raingardens that could receive runoff via a new curb opening and sediment forebay were noted. Four of these are located on road right of way, while two are located on private road front property.
3. Seven locations were identified for potential Stormwater Tree Planter Boxes, located between the roadway and sidewalk along Mitchel Avenue.
4. A potential small infiltration trench location within city easement Hearding and Hawkins Avenues was identified. Potentially rapidly-infiltrating soils at this location may be conducive to infiltration of backyard and street runoff before entering the city's storm sewer network via a surface inlet.
5. An open space bound by Curley Avenue and Highway 169 has potential for the creation of an extended detention basin. Runoff from Highway 169, rural development and forest, contribute water to this location before entering the city stormwater sewer. Soils at this location are likely not conducive to infiltration and any design should be focused on ponding for at least 48 hours, include a sediment forebay for ease of maintenance and include wetland and upland native plant communities to aid in treatment. Additional treatment may also be achieved through integration of an Iron-enhanced sand filter bench as its primary outlet, though was not modeled in this analysis.
6. An additional option of routing stormwater via a new, ~400 linear foot pipe from Curley Avenue immediately south of the Hedgens Berado Arena to the deep, vegetated depression along the west side of Highway 169 is possible. This option would route the entire upper half to two-thirds of the Subwatershed out of its storm sewer. This depression, however, requires additional

investigation into contributing drainage area and its hydrology, topography and hydraulics to further determine the feasibility of this option.

Cost-Benefit

Table 12. Subwatershed 7 30-year Cost-Benefit Results for Recommended Independent Strategies - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)	TP Removed (%/YR)	TP Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Raingardens[2]	$15,000	$250	8.3	34	2.8	$5,446
Stormwater Planter Boxes[3]	$42,000	$250	4.2	56	2.3	$18,370
Infiltration Trench[4]	$2,500	$0	2.1	79	1.3	$1,923
H169 Detention[5]	$135,000	$750	13.4	59	7.5	$8,500

Table 13.Subwatershed 7 30-year Cost-Benefit Results for Recommended Independent Strategies - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)	TSS Removed (%/YR)	TSS Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Raingardens[2]	2,503	57	1422	$11
Stormwater Planter Boxes[3]	1,286	75	958	$44
Infiltration Trench[4]	643	90	581	$4
H169 Detention[5]	4,024	90	3,492	$18

[1]D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.
[2]5 raingardens (200 ft2 each)
[3]6 planter boxes (200 ft2 each)
[4]500 ft2
[5] 0.6-acres, 3 foot permanent pool (dead storage minimum; actual design may vary), 2 feet of storage pool

Subwatershed 9

Estimated total subwatershed loading

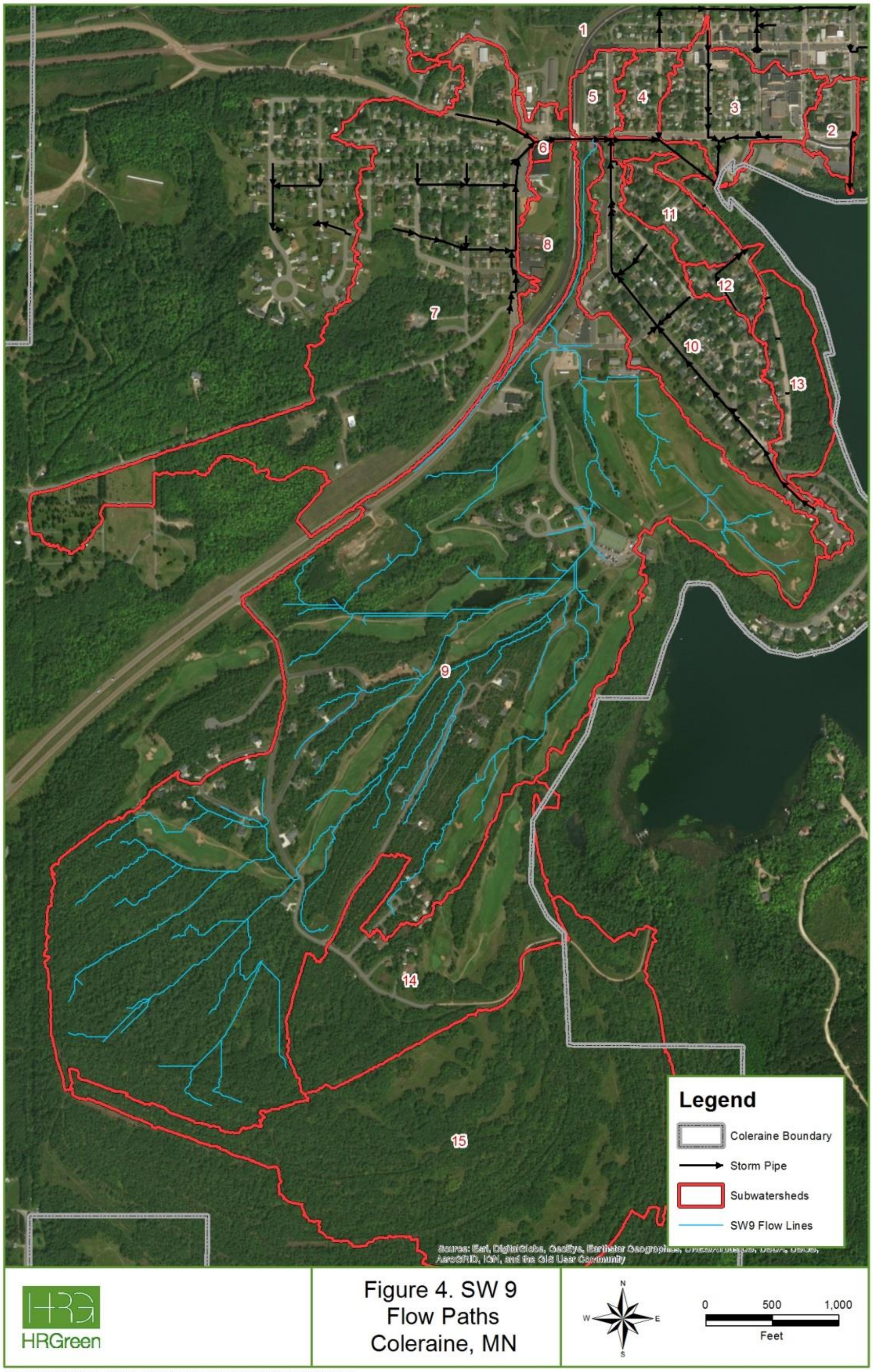
Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 9[1]	87.8	26	24,642	12,321

[1]Subwatershed loading to Trout Lake assumes golf course property discharges stormwater runoff, though this analysis suggests this would occur only periodically (more in-depth analysis is required for validation and subsequent treatment efficiencies).

Potential Strategy

Subwatershed 9 is largely comprised of the city golf course and lower density residential development. A review of surface water flow paths (**Error! Reference source not found.**) and surface depressional storage and ponding suggests the majority of annual precipitation is retained within the extent of the golf course. Further investigation is required to ascertain the extent to which the golf course discharges water to the Highway 169 ditch. In addition, the golf course itself likely generates substantial phosphorus given typical turf management activities. In the event of larger storm events that may lead to runoff from the golf course, runoff is routed along the eastern ditch of Highway 169, combining with roadway and residential runoff, to potential locations for ditch checks and regional treatment BMPs. This water is combined with a portion of Highway 169's runoff and sediment/phosphorus sourcing. Consideration of storage/treatment at the golf course's outlet and ditch checks within the Highway 169 eastern ditch line is recommended once more detailed evaluation of the subwatershed occurs. Both water quality and flow effects on downstream pipe capacity and potential surcharging would be addressed by these potential projects. Ditch checks within the steep flow lines of the H169 drainage are likely to yield minimal water quality benefits unless the design incorporates sub-surface flows through media (wood chip/sand mix or leaf compost/sand mix). Consideration of this design should be made as secondary in preference to those items called out for other watersheds in this analysis.

An existing parking lot (lot PIN 88-031-4102) and adjacent green space could be used for installation of a below ground stormwater storage and settling chamber. However, this is privately owned land, and the complexity and cost of installing such a system does not lend itself to being recommended for consideration at this time.



HRG PLOT: 11:52:28 AM 6/1/2018 BY: stracy FILE: J:\2017\170503\GIS\Coleraine\Fig 4.mxd

Figure 5. Subwatershed 9 surface flow lines.

Subwatershed 10

Estimated total subwatershed loading

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 10	18.8	5.6	5777	2889

Potential Strategy

Subwatershed 10 presents opportunities for raingardens and stormwater tree planter boxes within its predominantly residential land uses. Where space was limited, tree planter box locations were noted between the roadway and sidewalks, while raingardens were noted for locations with no sidewalks, trees or other spatial limitations were observed in aerial photography. Given the proximity of raingardens to surface stormwater catch basins and lower relative costs than stormwater tree planter boxes, raingardens were prioritized for modeling.

Cost-Benefit

Table 14. Subwatershed 10 30-year Cost-Benefit Results for Recommended Strategy - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)	TP Removed (%/YR)	TP Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Raingardens[2]	$24,000	$250	18.8	31	5.8	$4,181

Table 15.Subwatershed 10 30-year Cost-Benefit Results for Recommended Strategy - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)	TSS Removed (%/YR)	TSS Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Raingardens[2]	5777	53	3,084	$8

[1] D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.

[2] 8 raingardens (200 ft^2 each)

Subwatersheds 11, 12 and 13

Estimated total subwatershed loading

Subwatershed

Subwatershed	Annual TP Load (LB/YR)	Target TP Load Reduction (30%)	Annual TSS Load (LB/YR)	Target TSS Load Reduction (50%)
Subwatershed 11	4.1	1.2	1246	623
Subwatershed 12	2.1	0.6	639	319
Subwatershed 13	3.2	1.0	965	484

Potential Strategy

A combination for installation of raingardens and stormwater tree planted boxes is recommended for consideration along Lakeview Boulevard within these subwatersheds. Tree planter box locations were noted where space was limited between the roadway and sidewalks, while raingardens were noted for locations with no sidewalks, trees or other spatial limitations were observed in aerial photography and were proximal to catch basins that drain directly to the Lake.

Cost-Benefit

Table 16. Subwatershed 11, 12, 13 30-year Cost-Benefit Results for Recommended Strategy - Phosphorus

Alternative	Install Cost	Annual O&M	D.A. Load[1] (TP-LB/YR)	TP Removed (%/YR)	TP Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Stormwater Planter Boxes (SW 11)[2]	$14,000	$250	4.1	44	1.8	$7,917
Stormwater Planter Boxes (SW 12)[3]	$7,000	$250	2.1	34	0.7	$10,360
Raingardens (SW 13)[4]	$9,000	$250	3.2	67	2.1	$4,406

Table 17.Subwatershed 11, 12, 13 30-year Cost-Benefit Results for Recommended Strategy - Total Sediment

Alternative	D.A. Load[1] (TSS-LB/YR)	TSS Removed (%/YR)	TSS Removed (LB/YR)	30-Year Treatment Value ($/LB/YR)
Stormwater Planter Boxes (SW11)[2]	1,246	65	804	$18
Stormwater Planter Boxes (SW 12)[3]	639	56	357	$20
Raingardens (SW 13)[4]	965	83	799	$12

[1]D.A. Load = The load of pollutant draining to the potential Best Management Practice as a portion of the entire subwatershed.

[2]2 Stormwater tree planters (200 ft^2 each)

[3]1 Stormwater tree planters (200 ft^2)

[4]3 Raingardens (200 ft^2 each)

Appendix – Stormwater Retrofit Questionnaire

MANAGE STORMWATER

Intent

Minimize the impact of infrastructure on stormwater runoff quantity and quality.

Description

Development causes a change to the natural flow of runoff on a site. Increasing the quantity of impervious surfaces reduces the amount of stormwater that infiltrates to the ground, decreases the amount absorbed and expired by plants, and increases the amount of surface runoff.

Increased surface runoff typically leads to increases in the erosion of land surfaces, increased water temperatures, and an increase in pollutants reaching surface waters. It can deposit sediment and pollutants into waterways and warm historically cold-water streams. It also increases the quantity of water that drains into water bodies, which can cause channel erosion in streams and downstream flooding. Changes in flow, increased sedimentation, pollutants, water temperatures, and loss of groundwater input can negatively impact aquatic life as native species are replaced with more pollutant-tolerant warm-water species.

Green infrastructure measures can be incorporated into stormwater design to reduce the negative impacts associated with increased runoff. Designs attempt to restore the water handling ability of a site through infiltration, filtration, detention, evaporation, water harvesting, and cistern storage. These may include rain gardens and bioretention, boulevard open space storage, vegetated swales, ponds and wetlands, buffer strips, tree preservation, roof leader disconnection, underground or in storm sewer system storage, permeable pavements, soil amendments, impervious surface reduction and disconnection, and pollution prevention. These features provide some level of flow retention as well as water quality treatment of the runoff, filtering pollutants and cooling runoff water before reaching the receiving waterway and maintaining or restoring groundwater input to the waterway.

Objectives

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
N/A	**Increased treatment capacity.** The target water storage capacity for a project is a 30% improvement in water storage capacity. The target water quality treatment for phosphorus is 30% and 50% for sediments.	**Extended treatment capacity.** The target water storage capacity for a project is a 50% improvement in water storage capacity. The target water quality treatment for phosphorus is 50% and 70% for sediments.	**Sustainable stormwater management.** The target water storage capacity for a project is 90% improvement in water storage capacity. The target water quality treatment for phosphorus is 70% and 90% for sediments.	**Enhanced stormwater management.** Runoff is maintained on site and/or restores the hydrologic conditions of the undeveloped regional ecosystem. Stormwater management programs and stormwater handling structures are designed to capture and repurpose more than 100% of stormwater on site as part of overall water management regime.

PROTECT WETLANDS AND SURFACE WATER QUALITY

Intent

Protect, buffer, enhance, and restore areas designated as wetlands, shorelines, and waterbodies by providing natural buffer zones, vegetation, and soil-protection zones.

Description

Wetlands, shorelines, and waterbodies provide a number of important ecological services, including mitigating flooding, improving water quality, and providing wildlife habitat. Maintaining the integrity of these important elements requires more than simply protecting the elements themselves from adverse impacts of infrastructure and related development. Buffer zones around wetlands, shorelines, and waterbodies play particularly important roles in the following:

- Protecting wildlife habitats, providing connected habitat corridors, and maintaining biodiversity—Many wetland and aquatic-dependent species also require access to riparian or upland habitats for feeding, nesting, breeding, and hibernation;
- Regulating water temperature—Receiving water infiltrated from surface sources to the ground in buffer areas and shade from vegetation in buffer areas maintains water temperatures. Increased water temperatures can harm aquatic life;
- Maintaining water quality—Buffer areas provide erosion control and filter excess nutrients, such as nitrogen and phosphorus, and pollutants from runoff through groundwater infiltration;
- Protecting hydrology—Buffer areas regulate the flow of stormwater runoff and help preserve surface water and groundwater levels and flows;
- Protecting against human disturbance—Providing a buffer helps protect wetlands and surface waters from impacts in nearby areas, including destroying vegetation, compacting soils, debris, noise, and light.

Objectives

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
Avoid development and establish at least a 50-foot buffer. **Avoid development on sites that contain or are located within 50 feet of wetlands, shorelines, or waterbodies. Additionally, if applicable, establish vegetation and soil protection zones (VSPZ) for an area within 50 feet of any waterbody or within setback distances from wetlands prescribed in state or local laws and/or regulations.**	**At least a 100-foot buffer.** Establish a VSPZ for an area within 100 feet of any wetland areas, shoreline, or waterbody or within setback distances from wetlands prescribed in state or local laws and/or regulations, whichever is more stringent.	**At least a 200-foot buffer.** Establish a VSPZ for an area within 200 feet of any wetland areas, shoreline, or waterbody or within setback distances from wetlands prescribed in state or local laws and/or regulations, whichever is more stringent.	**At least a 300-foot buffer.** Establish a VSPZ for an area within 300 feet of any wetland areas, shoreline, or waterbody or within setback distances from wetlands prescribed in state or local laws and/or regulations, whichever is more stringent.	**Aquatic and wetland restoration.** In addition to establishing a VSPZ with a 300-foot buffer, the project restores previously degraded buffer zones to a natural state, making them elements of the VSPZ.

ENHANCE PUBLIC SPACE

Intent

Improve public spaces including parks, plazas, recreational facilities, or wildlife refuges to enhance community livability.

Description

Opening or enhancing space whenever possible is helpful in educating the public about sustainable infrastructure, and encouraging healthy and vibrant neighborhoods. Public spaces include parks and recreation areas, schools, public building parcels and possibly road right of ways, where there is significant and formalized public access. Stormwater management practices are regularly sited within open spaces, particularly parks and boulevards, and designed with water quality, aesthetic and public education values in mind.

Any infrastructure action is a net benefit if it results in the overall enhancement of the significant activities, features, and attributes of an open space.

Objectives

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
No adverse effects. Project team works with the community, property owner and required regulatory and resource agencies to identify public space resources and develop possible solutions. Feasibility analysis done for incorporating preservation, enhancement, or the creation of new spaces into the project. Project is designed such that it results in no long-term adverse effects and may include mitigation. Project may result in minor temporary impacts.	**No Impact to resources.** Project team works with the community, property owner and required regulatory and resource agencies to develop avoidance solutions. Focus is on no impact to resource. The project has no significant permanent impact to the resource. Temporary impacts are minimized. Consideration is given to the creation of new public space.	**Improvement and enhancement.** The project team identifies and implements meaningful enhancement or the creation of new public space. The project team works with stakeholders (users, regulatory agencies, and the resource owner) to develop a sensitive design. Official with jurisdiction over the resource must concur in writing with impact assessment, both for temporary and permanent impacts.	**Overall net benefit.** Examples include creating new space or facilities, addition of recreational facilities to an existing resource, and/or significantly improving access for current and future users. Stakeholder satisfaction with planned efforts and outcomes. Official with jurisdiction over the resource must concur in writing with impact assessment, both for temporary and permanent impacts.	**Substantial restoration.** Restoration of existing plazas, parks, recreational areas, or wildlife refuges is delivered. Examples may include restoring hiking trails, pavilions, or athletic fields. Urban contexts may include opening previously private space to public access or restoring existing public space. Stakeholder satisfaction with efforts and results. Official(s) with jurisdiction over that resource must concur in writing with impact assessment, both for temporary and permanent impacts.

IMPROVE INFRASTRUCTURE INTEGRATION

Intent

Design the project to take into account operational relationships among other elements of community infrastructure that result in an overall improvement in infrastructure efficiency and effectiveness.

Description

Optimal infrastructure performance integrates all infrastructure elements at the community level. Therefore, each new or renovated element of infrastructure is ideally designed and constructed to take into account how that element of infrastructure will link with other existing and planned infrastructure elements.

Priority is given to the repair and replacement of existing infrastructure that is currently in poor condition because continuing degradation could be harmful, cause additional inefficiencies, and increase repair or replacement costs disproportionately. Project planning efforts assess opportunities for improving linkages and compatibilities with other infrastructure elements to improve overall efficiencies and effectiveness. Strong consideration is given to restoring existing community infrastructure assets. Preservation and use of natural system functions and resources is also factored into project plans and designs.

Objectives

IMPROVED	ENHANCED	SUPERIOR	CONSERVING	RESTORATIVE
Narrow optimization focus. **Project performance improvements in the triple bottom line, including resource conservation and use of renewable resources. Protection of environmental, economic, and social systems are substantive, but are confined to individual components. Individual gains are present, but are suboptimal because of the lack of component integration. Little or no exploration of synergies among components.**	**Internal systems focus.** Project owner and designer look at the project and its delivered works as a system. Triple bottom line project performance improvements are significant because of efforts to optimize performance across the entire project and its delivered works. Efforts are made to integrate the design, to eliminate design conflicts, and to find system synergies that enhance overall performance.	**Infrastructure bundling and synergies.** Project is planned and designed with other related community infrastructure taken into account (i.e., how its design and operation will work in harmony with other infrastructure elements external to the project). Additional investments are planned to create linkages and improve synergies and, by doing so, improve overall performance. Infrastructure deficit (i.e., need to repair and refurbish existing infrastructure) is factored in.	**Full infrastructure integration.** The project owner and designer place the project in a community context and participate in multisectoral regional strategic planning for integrated community sustainability plans. They assess the existing community's physical infrastructure as well as its nonphysical assets. Project is planned and designed to take into account not only physical infrastructure, but also related community infrastructure. The project incorporates and takes advantage of valuable community assets (e.g., knowledge and social capital). The project integrates with the community's asset management program.	**High performance through restorative actions.** Early in project development, the project owner and project team work with the community to identify existing community assets in the natural or built environment that, when restored, would improve the economic growth and development capacity of the community. The project incorporates restoration of those assets. The project takes into account other related community infrastructure as well as sustaining and/or restoring community assets to enhance overall community efficiencies and effectiveness. There is integration with, and restoration of, natural systems, resources, community knowledge, and social capital assets.

Summary tables

Please note which level of objective you would like to pursue for each strategy described in this section.

Strategy	Improved	Enhanced	Superior	Conserving	Restorative
Manage stormwater					
Protect wetlands and surface water quality					
Enhance public space					
Improve infrastructure integration					

If you would like to revise any of the four strategy's objectives, please provide them here.

Strategy	Revised Objective
Manage stormwater	
Protect wetlands and surface water quality	
Enhance public space	
Improve infrastructure integration	

Instructions

Step 1. Please review each of the following questions ahead of a working group session and record your responses as applicable. This information is broad-level and some language or content may not apply to your city.

Step 2. In a working group session, discuss and come to an agreement on the collective responses. Record your response in the provided table.

Questions

<table>
<tr><td>1. What potential partners does the City have to implement projects related to stormwater, waste water, water supply, parks and roadways? E.g., County, State. Federal agencies, local non-government organizations.</td><td colspan="3"></td></tr>
<tr><td>2. Does the City, and can you provide, technical resources such as GIS or CAD databases, as-builts and technical staff time (for field visits)?</td><td colspan="3"></td></tr>
<tr><td>3. What existing stormwater infrastructure problems does the City face? (e.g., undersized pipes, aging infrastructure, infiltration/inflow, interior flooding, etc.)?</td><td colspan="3"></td></tr>
<tr><td>4. What stormwater water quality, rate or volume control controls does the City currently employ?</td><td colspan="3"></td></tr>
<tr><td>5. Is the City open to using Green Infrastructure (raingardens, stormwater wetlands, stormwater planters, pervious pavements, water quality swales, etc.) to supplement its Grey Infrastructure (pipes and below ground structures)?</td><td colspan="3"></td></tr>
<tr><td>6. Are buried utilities mapped in the City?</td><td colspan="3"></td></tr>
<tr><td>7. Does the City have a pavement management plan?</td><td colspan="3"></td></tr>
<tr><td>8. Does the City plan on refurbishing/renovating its boulevards and pedestrian corridors?</td><td colspan="3"></td></tr>
<tr><td>9. What level of coordination between City offices has there been in the past in implementation of projects?</td><td colspan="3"></td></tr>
<tr><td rowspan="6">10. Who are the key staff we should know about?</td><td>Person/Title</td><td>Phone</td><td>Email</td></tr>
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