Technical Memo

To: Margaret Johnson, Middle Fork Crow River Watershed District

From: Lucius Jonett, Wenck Associates, Inc.

Copy: Jon Morales, Middle Fork Crow River Watershed District

Date: March 10, 2017

Subject: MFCRWD Water Quality Subwatershed Assessment - Stormwater Modeling

Introduction

Middle Fork Crow River Watershed District received an Accelerated Implementation Grant to complete a two part public stormwater assessment project to identify and prioritize stormwater BMP projects within the watershed. A watershed wide, stormwater water quality analysis was completed to identify areas where runoff pollution is the worst within the city limits of New London and Spicer, MN where the impervious areas were evaluated with P8 (Program for Predicting Polluting Particle Passage thru Pits, Puddles, & Ponds – an urban catchment analysis model) to determine where poor water quality "hotspots" exist within each municipality.

With the hotspots identified, stormwater Best Management Practice (BMP) projects were evaluated, conceptually located and sized to model water quality improvements. Construction estimates and a cost benefit analysis of project costs and water quality improvements will help the District prioritize future implementation of the recommended BMPs to make significant and efficient improvements to the watershed water quality. This memo summarizes the project watershed models & results, the process of locating stormwater BMP conceptual designs, the final prioritized list of recommendations and how the hotspot map is and will change with the implementation of projects.

Deliverables:

- Watershed model & results – including a "hotspot" map
- Stormwater BMP Conceptual Designs and Recommendations
- Prioritization list of the recommended projects based on a cost benefit analysis of estimated project costs and water quality improvements.

Study Areas

The two most urbanized areas within the Middle Fork Crow *River* watershed are the cities of Spicer and New London. These cities both reside within Kandiyohi county. *All figures and details created by Wenck unless otherwise noted.*

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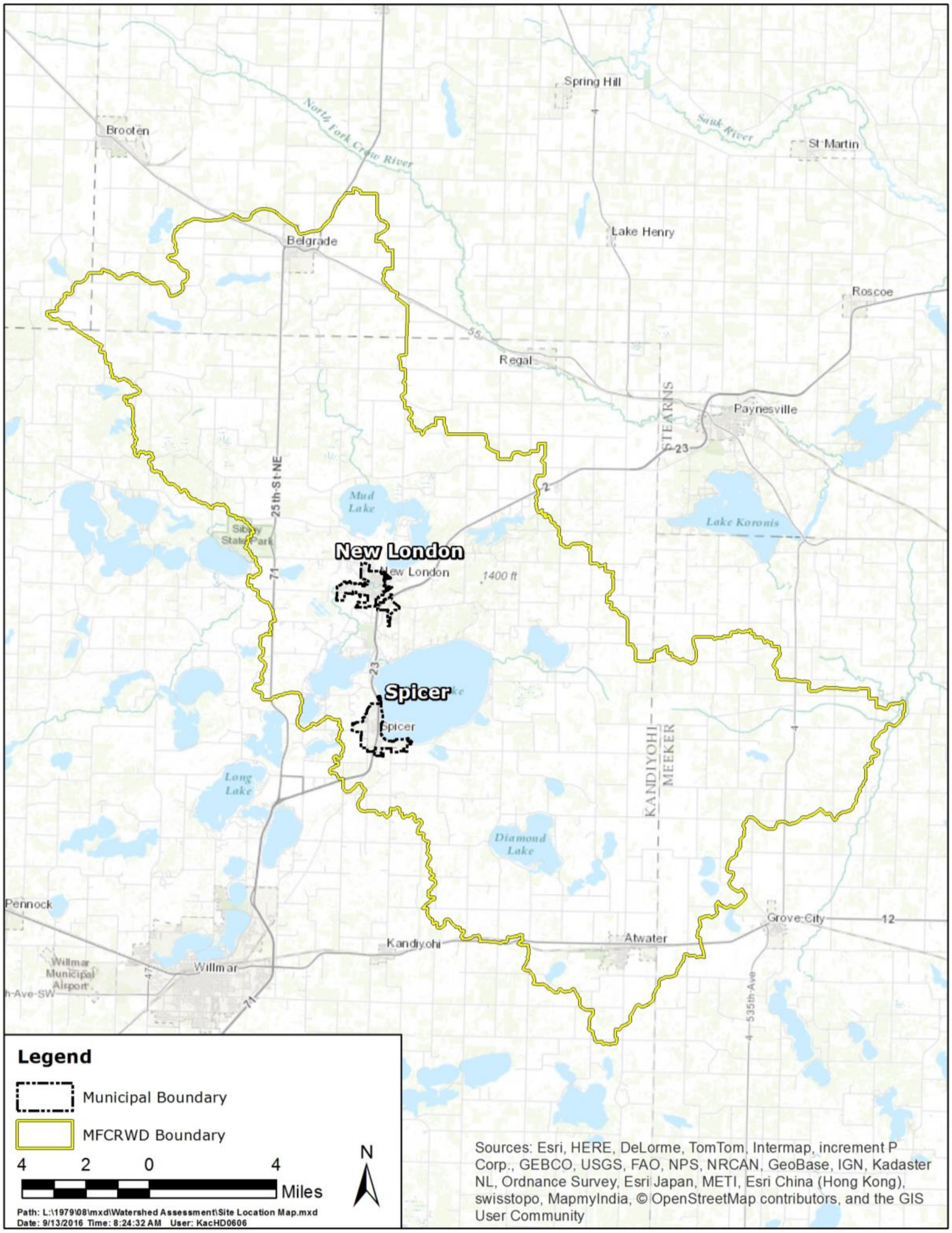

MFCRWD	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	SEPT 2016
Site Location Map		Figure 1

Stormwater Modeling

Two modeling tools were used to complete the stormwater assessment. Modeling was completed using P8 for determining loading in each subwatershed and HydroCad to find the appropriate sizing of BMPs. Both models are necessary to find the relationship between water quality and hydrologic/hydraulic processes. Below is a description of each models uses.

To quantify nutrient loading and flow, P8 was used for both New London and Spicer. Inputs into the model included landuse, hydrologic soil group and impervious percentage. Each city was divided into reasonably sized subwatersheds based on surface topography and subsurface (storm sewer) drainage. The designated landuses are summarized in Table 1.1. Each subwatershed was overlaid with the landuse layer provided by the City and Natural Resources Conservation Service (NRCS) Soil Survey Geographic database (SSURGO) soil type layers. Table 1.2 identifies the inferred impervious percentage curve number from landuse and soil type. Assumptions were made in this step. Not all landuses were defined by this table. Therefore, undefined landuses were modified to fit one of the most accurate impervious percentages. Occasionally subwatershed boundaries extended beyond the municipal boundary due to drainage pattern.

Table 1.1

Landuse Designation	Acres within New London	Acres within Spicer
Agricultural	26.3	47.4
Industrial and Utility	27.1	-
Institutional	84.1	-
Major Highway	81.7	113.1
Mixed Use Commercial	46.1	31.9
Mixed Use Residential	0.2	59.9
Multifamily	12.4	-
Office	-	12.2
Open Water	36.3	-
Park, Recreational, or Preserve	67.7	35.6
Retail and Other Commercial	-	74.4
Single Family Attached	-	25.3
Single Family Detached	260.6	141.1
Undeveloped	94.6	263.9
Total	737.3	804.6

Landuse files provided by the City of Spice and City of New London; area calculations from GIS.

Table 1.2

SCS Curve Number								
		Soil Type						
Landuse Type	**Percent Impervious**	**A**	**A/D**	**B**	**B/D**	**C**	**C/D**	**D**
Agricultural	5	49	66.5	69	76.5	79	81.5	84
Airport	30	68	78.5	79	84.0	86	87.5	89
Farmstead	10	49	59.5	69	76.5	79	81.5	84
Golf Course	10	39	66.5	61	70.5	74	77.0	80
Industrial and Utility	50	68	66.5	79	84.0	86	87.5	89
Institutional	32	39	78.5	61	70.5	74	77.0	80
Major Highway	50	49	59.5	69	76.5	79	81.5	84
Mixed Use Commercial	67	49	59.5	69	76.5	79	81.5	84
Mixed Use Industrial	50	68	85.0	79	84.0	86	87.5	89
Mixed Use Residential	60	39	59.5	61	70.5	74	77.0	80
Multifamily	60	39	59.5	61	70.5	74	77.0	80
Open Water	0	85	78.5	85	85.0	85	85.0	85
Office	32	39	66.5	61	70.5	74	77.0	80
Park, Recreational, or Preserve	10	39	59.5	61	70.5	74	77.0	80
Railway	20	68	59.5	79	84.0	86	87.5	89
Retail and Other Commercial	67	49	78.5	69	76.5	79	81.5	84
Single Family Attached	30	39	59.5	61	70.5	74	77.0	80
Single Family Detached	20	39	59.5	61	70.5	74	77.0	80
Undeveloped	5	39	59.5	61	70.5	74	77.0	80

Curve Number and impervious fraction.

Best management practice (BMP) placement within subwatersheds utilized HydroCAD to size the stage storage using a customized stage void information. The sizing of BMPs were determined based on availability of space. Therefore, some BMPs will be able to hold more than 1 inch of runoff from impervious surfaces and some will hold less than 0.5 inch of runoff. The stage storage from HydroCAD was entered as general device parameters in P8 to model BMP impact. The results used for removal efficiency calculations were water inflow, infiltration, and nutrient loading removed by BMPs.

The results from the P8 modeling are below in the figures for total phosphorous (TP) and total suspended solids (TSS) removal. In the City of New London, subwatersheds with an existing high TP loadings corresponded with high TSS loadings. Within the City of New London, subwatersheds NL-35, NL-36, and NL-34 received the highest loadings. Following BMP placement, loadings in the subwatersheds were reduced significantly. In the City of Spicer similar trends were observed between phosphorus loading and TSS. High phosphorus and TSS loadings were observed in the watersheds directly contributing to Green Lake and in the southern part of the City along Minnesota Highway 23. Table 1.3 and Table 1.4 show the P8 results of TP and TSS for existing conditions and BMP placement. See Appendix A for the complete list of figures showing existing loadings, reduced loadings, and net change in loadings.

Rain barrels were also analyzed to determine TSS and TP loads reaching waterbodies. In the City of Spicer, rain barrels were placed at dwellings adjacent to Green Lake; water quality was minimally improved.

Table 1.3

City of New London P8 Modeling Results						
Watershed	**Existing TP (lbs/yr)**	**BMP Placement TP (lbs/yr)**	**Reduction TP (lbs/yr)**	**Existing TSS (lbs/yr)**	**BMP Placement TSS (lbs/yr)**	**Reduction in TSS (lb/yr)**
NL 1	1.8	0.7	1.1	237.2	205.1	32.1
NL 2	17.5	14.3	3.2	5182.8	4005.5	1177.3
NL 3	12.3	9.0	3.3	3664.5	1987.8	1676.7
NL 4	7.4	6.6	0.8	2147.8	1820.5	327.3
NL 5	12.7	11.4	1.3	3750.1	3297.4	452.7
NL 6	7.5	5.2	2.3	2212.8	1631.5	581.3
NL 7	17.9	17.0	0.9	5309.5	4927.6	381.9
NL 8	2.0	0.0	2.0	192.5	3.8	188.7
NL 9	1.8	5.4	3.6	141.5	141.5	0.0
NL 10	9.9	7.4	2.5	2940.7	2143.3	797.4
NL 11	29.8	29.6	0.2	8796.6	8635.0	161.6
NL 12	6.7	6.4	0.3	1959.5	1832.2	127.3
NL 13	7.3	7.3	0.0	2129.8	2129.8	0.0
NL 14	11.1	11.1	0.0	3204.9	3204.9	0.0
NL 15	11.6	6.1	5.6	3196.6	1347.4	1849.2
NL 16	22.2	19.4	2.8	6585.9	5397.6	1188.3
NL 17	14.0	6.8	7.2	4161.4	1314.2	2847.2
NL 18	0.3	0.0	0.3	9.3	1.9	7.4
NL 19	31.5	29.3	2.2	9368.5	8501.9	866.6
NL 20	17.5	17.4	0.1	5180.3	5120.8	59.5
NL 21	6.8	6.8	0.0	2006.7	2006.7	0.0
NL 22	6.4	6.4	0.0	1815.5	1815.5	0.0
NL 23	9.2	7.3	1.9	2699.3	2043.6	655.7
NL 24	4.0	1.9	2.1	1174.1	523.7	650.4
NL 25	1.9	1.5	0.4	549.7	404.3	145.4
NL 26	9.5	8.4	1.1	2792.4	2405.4	387.0
NL 27	4.5	4.0	0.5	1145.1	1145.1	0.0
NL 28	8.1	7.9	0.2	2342.6	2228.4	114.2
NL 29	2.9	2.7	0.2	863.4	720.5	142.9
NL 30	0.1	0.1	0.0	2.5	2.5	0.0
NL 31	11.2	8.1	3.1	3319.9	1980.2	1339.7
NL 32	15.4	14.0	1.4	4185.3	4151.7	33.6
NL 33	3.8	3.4	0.5	1013.5	965.8	47.7
NL 34	3.9	3.2	0.7	1166.0	881.9	284.1
NL 35	4.2	3.9	0.4	1147.4	1147.4	0.0
NL 36	2.5	2.3	0.2	685.8	684.3	1.6
NL 37	5.6	3.3	2.3	1530.4	627.1	903.3
NL 38	14.5	14.5	0.0	4316.3	4316.3	0.0

P8 results for the City of New London

Table 1.4

City of Spicer P8 Modeling Results						
Watershed	**Existing TP(lbs/yr)**	**BMP Placement TP (lbs/yr)**	**Reduciton in TP (lb/yr)**	**Existing TSS (lbs/yr)**	**BMP Placement TSS (lbs/yr)**	**Reduction TSS (lbs/yr)**
S 1	10.4	0.0	10.4	3101.0	0.0	3101.0
S 2	7.0	3.2	3.8	2097.6	668.1	1429.5
S 3	2.2	0.0	2.2	223.4	0.0	223.4
S 4	2.0	1.1	0.9	606.0	255.4	350.6
S 5	5.1	0.0	5.1	211.0	0.0	211.0
S 6	19.5	13.1	6.4	5796.1	3793.3	2002.8
S 7	5.3	5.0	0.3	1555.8	1151.0	404.8
S 8	1.8	1.8	0.0	531.4	531.4	0.0
S 9	3.6	0.0	3.6	355.3	0.0	355.3
S 10	9.9	6.8	3.1	2952.0	1683.5	1268.5
S 11	18.5	2.3	16.2	3377.5	0.0	3377.5
S 12	7.0	0.0	7.0	975.8	0.0	975.8
S 13	1.8	1.8	0.0	529.8	529.8	0.0
S 14	2.1	0.0	2.1	98.4	0.0	98.4
S 15	7.4	2.1	5.3	2208.7	-962.5	3171.2
S 16	3.8	0.0	3.8	242.0	0.0	242.0
S 17	9.0	0.5	8.5	2669.3	243.6	2425.7
S 18	5.3	4.5	0.8	1571.3	1135.4	435.9
S 19	8.5	7.3	1.2	2519.8	1915.1	604.7
S 20	5.9	0.0	5.9	438.4	0.0	438.4
S 21	0.7	0.0	0.7	69.5	0.0	69.5
S 22	2.3	0.0	2.3	199.7	0.0	199.7
S 23	5.6	1.7	3.9	792.2	0.0	792.2
S 24	12.5	0.0	12.5	1052.2	0.0	1052.2
S 25	13.1	13.0	0.1	3855.0	3778.4	76.6
S 26	6.1	2.6	3.5	1017.6	0.0	1017.6
S 27	42.3	36.6	5.7	12375.7	10797.3	1578.4
S 28	9.3	0.0	9.3	948.8	0.0	948.8
S 29	1.9	0.0	1.9	218.5	0.0	218.5
S 30	1.1	0.0	1.1	21.0	0.0	21.0
S 31	7.8	0.0	7.8	499.9	0.0	499.9
S 32	8.5	3.4	5.1	2520.5	928.3	1592.2
S 33	17.6	17.6	0.0	4903.5	4903.5	0.0
S 34	2.3	2.1	0.2	655.7	616.4	39.3
S 35	5.8	4.1	1.7	1032.7	0.0	1032.7
S 36	1.4	1.4	0.0	381.8	381.8	0.0
S 37	8.3	7.4	0.9	2478.8	2157.5	321.3
S 38	5.8	2.7	3.1	1663.9	680.4	983.5
S 39	15.4	13.1	2.3	4574.9	3811.4	763.5
S 40	13.9	0.0	13.9	2343.7	0.0	2343.7
S 41	4.1	2.0	2.1	1082.6	451.8	630.8
S 42	8.9	7.3	1.6	2623.9	1660.5	963.4
S 43	17.5	0.0	17.5	5156.5	0.0	5156.5
S 44	3.3	0.0	3.3	947.0	0.0	947.0
S 45	2.0	0.0	2.0	242.7	0.0	242.7
S 46	11.5	5.4	6.1	3425.0	1375.2	2049.8

P8 results for the City of Spicer

Stormwater Best Management Practices (BMPs)

P8 utilizes a variety of stormwater best management practices. Below are brief descriptions and a visualization of the BMPs used in the model.

Raingarden

Raingardens are small depression areas adjacent to sidewalks, curb cuts or in the road verge or boulevard. Raingardens can also be placed near buildings where downspouts concentrate roof runoff. These areas receive direct surface runoff or roof runoff and can quickly infiltrate water in engineer soils.

Many different types of vegetation can be used in the raingardens. The vegetation will have the ability to adapt to the fluctuating moisture conditions. After the raingarden has been filled with stormwater runoff, the excess volume will be routed to the storm sewer via an over flow.

Pretreatment for raingardens, sometimes called stormwater planters, is required by the Minnesota Pollution Control Agency (MPCA) to filter large debris and particles from runoff prior to entering the planter. Pretreatment options for stormwater planters include sump catchbasins, forebays, or proprietary devices (i.e. Rain Guardian or Stauner sediment trap).

Photo Credit (yale.edu)

Underground Infiltration

Underground Infiltration is used in high urban areas with limited green or pervious spaces such as parking lots. Runoff is directed into perforated pipes or cisterns placed below the surface. Pretreatment of runoff is provided by a filter, manhole sump, or hydrodynamic device before entering the storage area. In large storm events, runoff is routed through an overflow to the storm sewer. The system is designed to infiltrate within 48 hours.

Photo Credit (waterworld.com)

Tree Trench
A tree trench is green infrastructure that provides underground storage for runoff that is then infiltrated or taken up by tree roots and transpired. They are aesthetically pleasing and particularly useful in highly impervious areas. Sidewalks, boulevards, or parking lot islands are great locations for tree trenches.

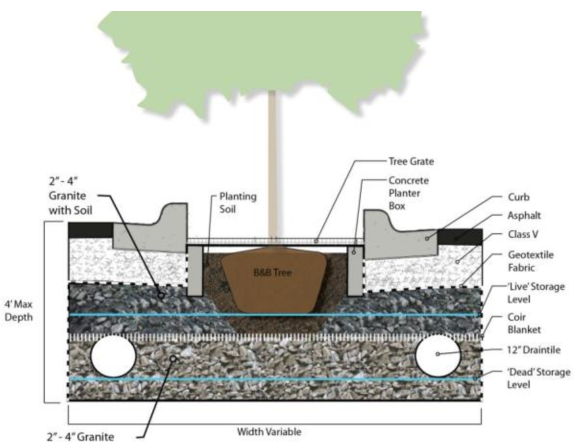

Photo Credit (mnerosion.org)

Permeable Paving
Pervious pavement has several different designs that follow the same general structure and result in reduced runoff volumes. Impervious pavement (concrete or asphalt) increases the void space in the material allowing water to pass through to the sub-base. The subbase consists of an angular rock with large void spaces to temporarily store and infiltrate/filtrate water that passes through the pervious pavement above. This method of pavement construction provides a means of infiltrating runoff from paved surfaces as well as any other contributing surface areas.

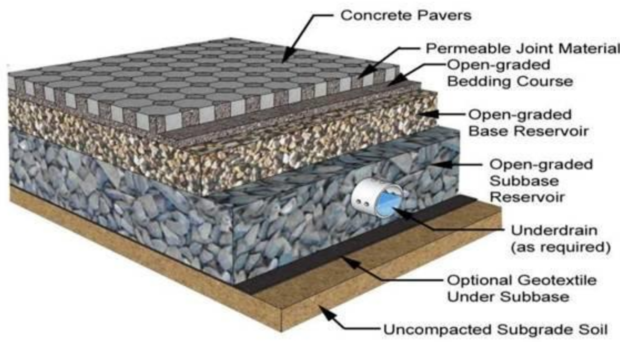

Photo Credit (vt.edu)

Detention Basin
Stormwater detention basins are designed to meet National Urban Runoff Program (NURP) standards for controlling stormwater volume and pollutant removal. Detention basins can be wet or dry and are designed to hold the 100-year storm event in the dead pool (below the outlet).
Detention ponds primarily treat runoff through the settling of solids. Sediments settle out on the bottom of the pond that have nutrients bound to the particles. In addition to settling sediments, NURP ponds improve water quality through chemical plant uptake.

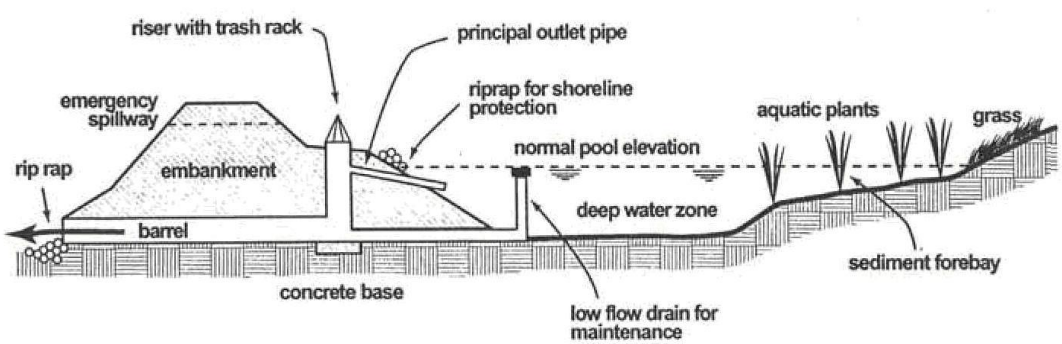

Photo Credit (clemson.edu)

Iron Enhanced Sand Filter
The iron enhanced sand filter or Minnesota filter combines iron filings with sand to target the removal of dissolved phosphorous, organic material, and other contaminants. The engineered media in the Minnesota filter contains oxidized iron filings which bind strongly with dissolved phosphorus and organics. As runoff passes through the filter media, those pollutants in the runoff bind to the iron thus removing the target contaminants. The removal efficiency of the filter varies with age. However, Minnesota filters remove an average of 60 percent of the total phosphorus in stormwater runoff. They are expected to have a lifespan of 35 years under regular maintenance, at which point the filter media would need to be replaced.

Typical stormwater ponds are effective at removing particulate phosphorus and total suspended solids. One way to increase the dissolved phosphorus removal within a stormwater pond is to retrofit the basin with a Minnesota filter. In the treatment train system, runoff is collected in the pond, which acts as pretreatment. Suspended solids and debris settle out of the water while in the pond. As the pond fills, water is filtered through the media and exits the system through an underdrain. A secondary outlet above the filter provides rate control and prevents flooding.

Bioreactor

The bioreactor redirects runoff into an underground or above ground system where biological and chemical processes remove excess nutrients. Bioreactors have been used in agricultural settings to help with denitrification of runoff from drain tiles. In an urban setting, bioreactors can help reduce phosphorus loading in lakes and streams.

In a denitrification bioreactor, runoff passes through a charcoal medium such as wood chips or corn cobs. In the event of large storm events, runoff is routed into the storm sewer as to not overload the system. Bioreactors have a 50% to 80% load reduction with an approximate lifespan of 20 years.

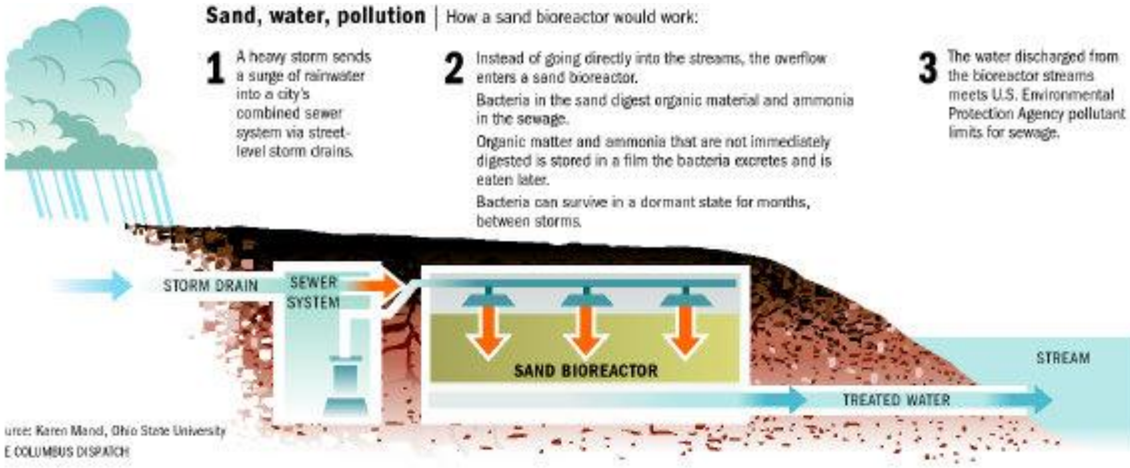

Photo Credit (bioreactor)

Infiltration Trench/Ditch

An infiltration trench is installed on the surface to intercept overland flow and store the runoff in a porous medium. The trench usually has a layer of filter fabric overlain the porous medium where the runoff percolates through the upper horizon. The water stored in the medium infiltrates through the sides or bottom of the excavation. Infiltration trenches require pretreatment of runoff to remove sediments that would inhibit percolation to the underground reservoir.
Infiltration trenches have limitations for controlling peak discharges. The trench should be used in tandem with other BMPs to control the peak runoff, such as a detention basin downstream.

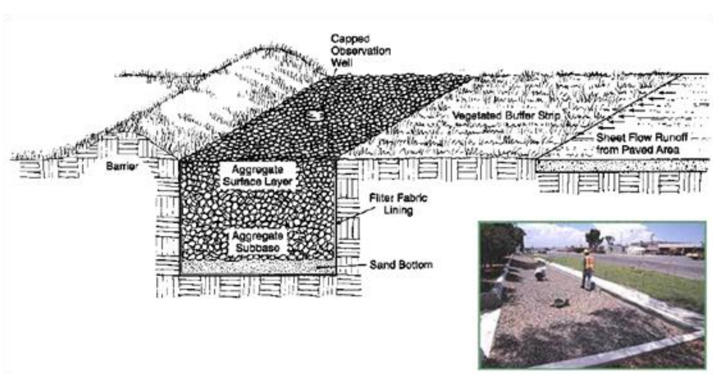

Photo Credit (esf.edu)

Infiltration Catch Basin
An infiltration catch basin allows stormwater runoff to collect in a manhole sump with a porous medium. The bottom of the catch basin contains a rock media where water can infiltrate through the bottom of the structure. The catch basin contains an emergency outflow to route large storm events.

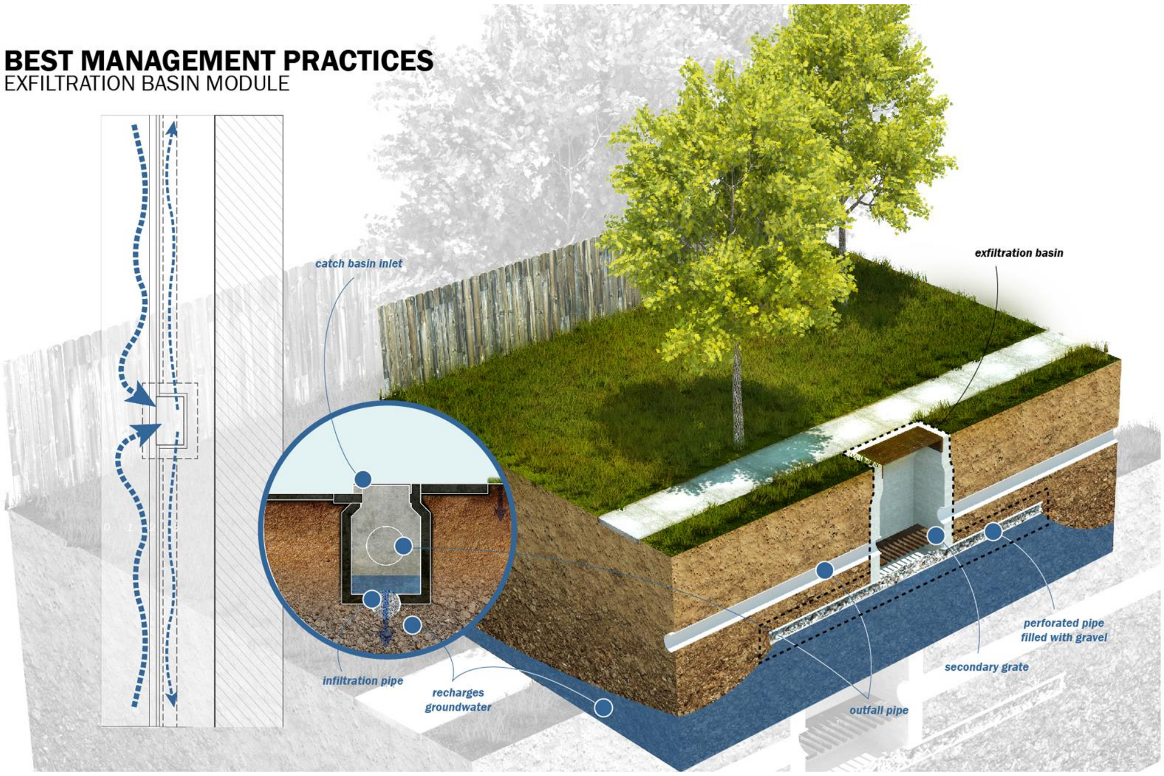

Photo Credit (livingwithwater.com)

Table 1.5

BMP	Estimated Construction Cost Per Unit	Units
Raingarden	\$20 - \$30	SQ FT
Underground infiltration	\$10 - \$20	CU FT
Tree Trench	\$350 - \$450	LIN FT
Permeable Paving	\$30	SQ FT
Detention Basin	\$250 - \$300	CU FT Wetted volume
Iron Enhanced Sand Filter	\$280 - \$380	LIN FT
Bioreactor	\$25 - \$75	CU YD
Infiltration Trench/Ditch	\$35 - \$45	SQ FT
Infiltration Catch Basin	\$10,000 - \$20,000	EACH

Construction cost estimates for the stormwater BMPs

Construction Cost Estimates

Tables 1.6 and 1.7 contain cost estimates for the actual sizing of BMPS. In some instances, BMPs sizes were reduced to fit within the project constraints.

Table 1.6 – Spicer BMPs

Watershed	BMP	Watershed Area (ac)	Sizing (WLH, ft)	Layers	Cost Estimate (Range)	Cost per	UNIT
S 1	Infiltration ditch 1	3.09	3*213*2	0.67 soil 10/1.33 gravel 40	$22,365 - $28,755	$35 - $45	SQ FT
S 1	Infiltration ditch 2	7.54	12*350*2	0.67 soil 10/1.33 gravel 40	$147,000 - $189,000	$35 - $45	SQ FT
S 1	Infiltration ditch 3	4.60	12*350*2	0.67 soil 10/1.33 gravel 40	$147,000 - $189,000	$35 - $45	SQ FT
S 2	Infiltration trench	6.11	20*107*4	0.5 soil 10/3.5 gravel 60	$74,900 - $96,300	$35 - $45	SQ FT
S 4	Filter bench	7.08	6*103*2	0.67 sand 25/1.33 gravel 40	$21,60 - $27,810	$35 - $45	SQ FT
S 5	Filter bench	24.18	12*323*2	0.67 sand 25/1.33 gravel 40	$135,660 - $174420	$35 - $45	SQ FT
S 6	Infiltration catch basin	9.83			$10,000 - $20,000	$10,000 - $20,000	EACH
S 6	Raingarden	3.30	20*20*1.5	0.5 soil 10/1 gravel 40	$8,000 - $12,000	$20 - $30	SQ FT
S 6	Raingarden	2.50	20*20*1.5	0.5 soil 10/1 gravel 40	$8,000 - $12,000	$20 - $30	SQ FT
S 6	Infiltration trench	2.60	20*85*4	0.5 soil 10/3.5 gravel 60	$59,500 - $76,500	$35 - $45	SQ FT
S 7	Bioreactor	20.39			$15,000 - $20,000	$25 - $75	CU YD
S 10	Infiltration basin	8.93	40*20*1.5	0.5 soil 10/3.5 gravel 60	$28,000 - $36,000	$35 - $45	SQ FT
S 10	Infiltration catch basin	1.60			$10,000 - $20,000	$10,000 - $20,000	EACH
S 11	Filter bench	21.60	6*102*2	0.67 sand 25/1.33 gravel 40	$21,420 - $27,540	$35 - $45	SQ FT
S 12	Filter bench	17.23	6*90*2	0.67 sand 25/1.33 gravel 40	$18,900 - $24,300	$35 - $45	SQ FT
S 15	Detention pond	13.77	110*110*2	100% void space	$6,050,000 - $7,260,000	$250 - $300	CU FT Wetted Vol
S 17	Infiltration basin	5.86	20*45*4	0.5 soil 10/3.5 gravel 60	$31,500 - $40,500	$35 - $45	SQ FT
S 18	Raingarden	5.07	20*20*1.5	0.5 soil 10/1 gravel 40	$8,000 - $12,000	$20 - $30	SQ FT
S 18	Infiltration catch basin	8.46			$10,000 - $20,000	$10,000 - $20,000	EACH
S 19	Permeable pavement	0.29	6*30*4	40% void space	$4,500 - $6,300	$25 - $35	SQ FT
S 19	Infiltration catch basin	2.72			$10,000 - $20,000	$10,000 - $20,000	EACH
S 19	Tree trench	0.86	5*55*2	0.5 open 100/1 soil 10/0.5 gravel 40	$22,000	$400	LIN FT
S 20	Infiltration ditch	9.51	3*345*2	0.67 soil 10/1.33 gravel 40	$36,225 - $46,575	$35 - $45	SQ FT
S 20	Infiltration trench	3.30	20*35*4	0.5 soil 10/3.5 gravel 60	$24,500 - $31,500	$35 - $45	SQ FT
S 24	Permeable pavement	0.95	6*50*4	40% void space	$7,500 - $10,500	$25 - $35	SQ FT
S 25	Detention pond	1.22	20*20*2	100% void space	$200,000 - $240,000	$250 - $300	CU FT Wetted Vol
S 26	Infiltration ditch	0.75	9*130*2	0.67 soil 10/1.33 gravel 40	$40,950 - $52,650	$35 - $45	SQ FT
S 17	Detention pond/IEF	11.95	45*45*2	100% void space		$250 - $300	CU FT Wetted Vol
S 27	Infiltration basin		40*60*4		$84,000 - $108,000	$35 - $45	SQ FT

Watershed	BMP	Watershed Area (ac)	Sizing (WLH, ft)	Layers	Cost Estimate (Range)	Cost per	UNIT
S 27	Detention pond		67*67*2		$2,244,500 - $2,693,400	$250 - $300	CU FT Wetted Vol
S 28	Infiltration basin	2.51	37*90*4	0.5 soil 10/3.5 gravel 60	$116,550 - $149,850	$35 - $45	SQ FT
S 28	Underground storage	7.51	10*177*6	60% void space	$17,700 - $35,400	$10 - $20	CU FT Vol
S 28	Permeable pavement	1.37	6*54*4	40% void space	$8,100 - $11,340	$25 - $35	SQ FT
S 29	Filter bench	3.58	6*100*2	0.67 sand 25/1.33 gravel 40	$21,000 - $27,000	$35 - $45	SQ FT
S 30	Filter bench	7.53	6*171*2	0.67 sand 25/1.33 gravel 40	$35,910 - $46,170	$35 - $45	SQ FT
S 32	Raingarden	1.35	12*20*1.5	0.5 soil 10/1 gravel 40	$4,800 - $7,200	$20 - $30	SQ FT
S 32	Infiltration trench	6.90	15*70*4	0.5 soil 10/3.5 gravel 60	$35,750 - $47,250	$35 - $45	SQ FT
S 32	Detention pond	1.53	18*18*2	100% void space	$168,000 - $194,400	$250 - $300	CU FT Wetted Vol
S 32	Infiltration catch basin	2.58			$10,000 - $20,000	$10,000 - $20,000	EACH
S 34	Tree trench	0.57	10*50*4	0.5 soil 10/3.5 gravel 40	$20,000	$400	LIN FT
S 37	Infiltration catch basin	5.12			$10,000 - $20,000	$10,000 - $20,000	EACH
S 37	Tree trench	1.19	12*20*4	0.5 soil 10/3.5 gravel 40	$8,000	$400	LIN FT
S 38	Filter bench	16.13	6*203*2	0.67 sand 25/1.33 gravel 40	$42,630 - $54,810	$35 - $45	SQ FT
S 39	Infiltration catch basin	4.02			$10,000 - $20,000	$10,000 - $20,000	EACH
S 39	Raingarden	4.81	32*32*1.5	0.5 soil 10/1 gravel 40	$20,480 - $30,720	$20 - $30	SQ FT
S 40	Infiltration ditch	15.72	24*500*2	0.67 soil 10/1.33 gravel 40	$420,000 - $540,000	$35 - $45	SQ FT
S 40	Infiltration trench	12.04	15*140*4	0.5 soil 10/3.5 gravel 60	$73,500 - $94,500	$35 - $45	SQ FT
S 41	Filter bench	29.06	6*151*2	0.67 sand 25/1.33 gravel 40	$31,710 - $40,770	$35 - $45	SQ FT
S 42	Detention pond	6.15	30*30*2	100% void space	$450,000 - $540,000	$250 - $300	CU FT Wetted Vol
S 43	Underground storage	7.13	55*55*2	60% void space	$36,300 - $72,600	$10 - $20	CU FT Vol
S 43	Infiltration ditch	10.22	6*600*2	0.67 soil 10/1.33 gravel 40	$126,000 - $162,000	$35 - $45	SQ FT
S 43	Permeable pavement	12.95	12*300*4	40% void space	$90,000 - $126,000	$25 - $35	SQ FT
S 44	Infiltration basin	8.16	40*120*4	0.5 soil 10/3.5 gravel 60	$168,000 - $216,000	$35 - $45	SQ FT
S 45	Filter bench	2.59	6*100*2	0.67 sand 25/1.33 gravel 40	$21,000 - $27,000	$35 - $45	SQ FT
S 46	Detention pond	2.75	76*76*2	100% void space	$2,888,000 - $3,465,600	$250 - $300	CU FT Wetted Vol
S 46	Infiltration ditch 1	1.65	10*125*2	0.67 soil 10/1.33 gravel 40	$43,750 - $56,250	$35 - $45	SQ FT
S 46	Infiltration ditch 2	1.91	10*95*2	0.67 soil 10/1.33 gravel 40	$33,250 - $42,750	$35 - $45	SQ FT

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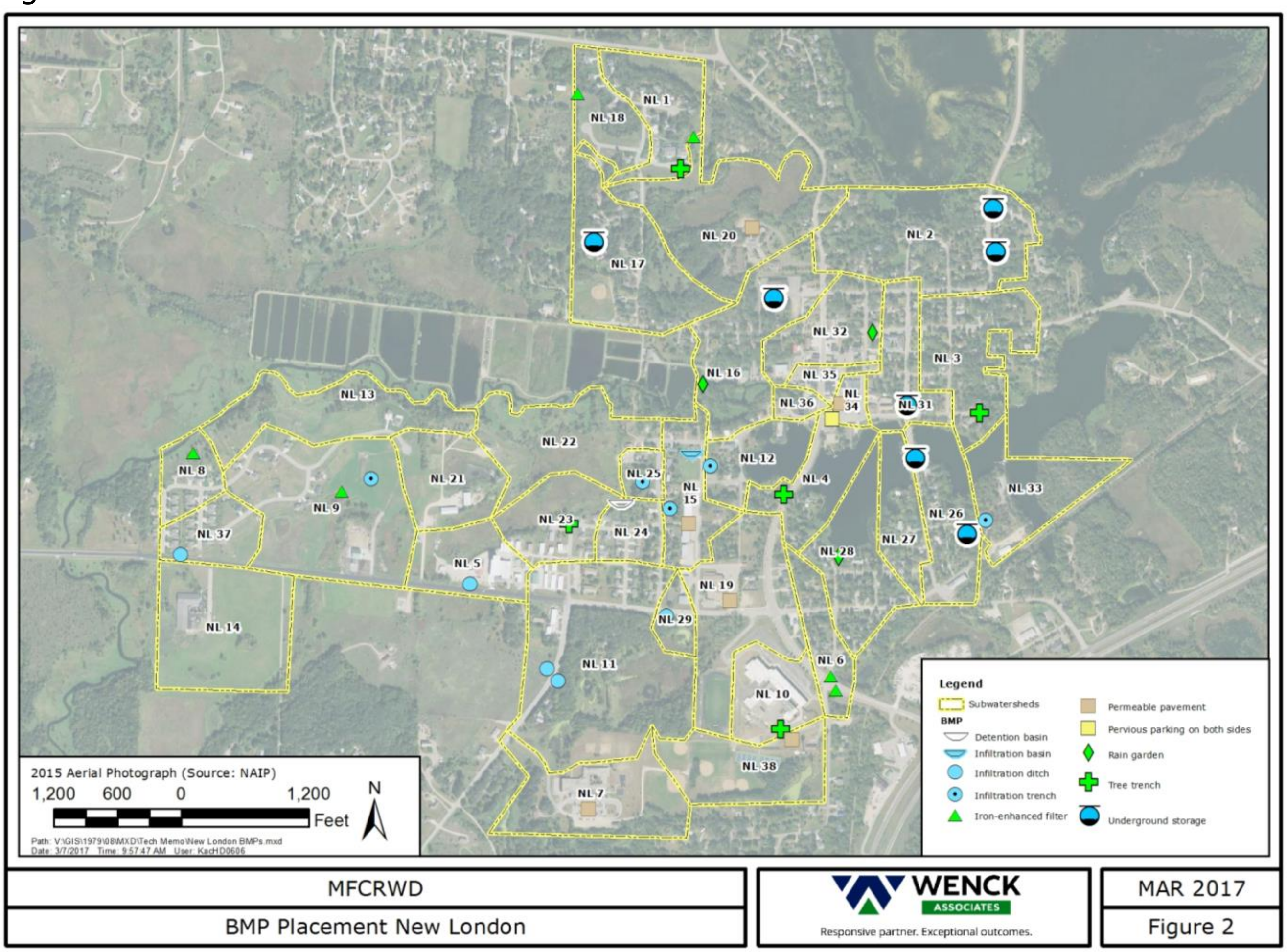
Table 1.7 – New London BMPs

Watershed	BMP	Area (ac)	Sizing (WLH, ft)	Layers	Cost Estimate (Range)	Cost per	UNIT
NL 1	Iron-enhanced filter	6.55	10*100*2	0.64 sand 25/ 1.36 gravel 40	$28,000 - $38,000	$280 - $380	LIN FT
NL 1	Tree trench	3.27	10*40*4	0.5 soil 10/3.5 gravel 40	$16,000.00	$400.00	LIN FT
NL 11	Infiltration ditch 1	1.09	3*50*2	0.64 soil 10/1.36 gravel 40	$5,250 - $6,750	$35 - $45	SQ FT
NL 11	Infiltration ditch 2	1.49	3*50*2	0.64 soil 10/1.36 gravel 40	$5,250 - $6,750	$35 - $45	SQ FT
NL 12	Infiltration trench	1.47	10*30*4	0.5 soil 10/3.5 gravel 60	$10,500 - $13,500	$35 - $45	SQ FT
NL 4	Tree trench	2.36	10*30*4	0.5 soil 10/3.5 gravel 40	$12,000.00	$400.00	LIN FT
NL 15	Infiltration basin	5.21	20*65*4	0.5 soil 10/3.5 gravel 60	$45,500 - $58,500	$35 - $45	SQ FT
NL 15	Infiltration trench	3.32	40*21*4	0.5 soil 10/3.5 gravel 60	$29,400 - $37,800	$35 - $45	SQ FT
NL 15	Permeable pavement	2.13	15*35*4	40% void space	$13,125 - $18,375	$25 - $35	SQ FT
NL 16	Underground storage	3.97	12*80*6	60% void space	$34,560 - $69,120	$10 - $20	CU FT Vol
NL 16	Rain garden	2.67	20*30*1.5	0.5 soil 10/1 gravel 40	$30,000 - $45,000	$20 - $30	SQ FT
NL 18	Iron-enhanced filter	2.39	10*150*2	0.64 sand 25/ 1.36 gravel 40	$42,000 - $57,000	$280 - $380	LIN FT
NL 19	Permeable pavement	4.19	15*100*4	40% void space	$37,500 - $52,500	$25 - $35	SQ FT
NL 2	Underground storage 1	8.56	12*95*6	60% void space	$41,040 - $82,080	$10 - $20	CU FT Vol
NL 2	Underground storage 2	2.63	12*30*6	60% void space	$12,960 - $25,920	$10 - $20	CU FT Vol
NL 20	Permeable pavement	0.73	5*20*4	40% void space	$2,500 - 3,500	$25 - $35	SQ FT
NL 24	Detention basin	4.53	38.5*38.5*2	100% void space	$741,250 - $889,500	$250 - $300	CU FT Wetted Vol
NL 25	Infiltration trench	0.65	10*20*4	0.5 soil 10/3.5 gravel 60	$7,000 - $9,000	$35 - $45	SQ FT
NL 26	Underground storage 2	0.89	12*20*6	60% void space	$8,640 - $17,280	$10 - $20	CU FT Vol
NL 26	Underground storage 1	2.34	12*45*6	60% void space	$19,440 - $38,800	$10 - $20	CU FT Vol
NL 28	Rain garden	2.74	10*20*1.5	0.5 soil 10/1 gravel 40	$4,000 - $6,000	$20 - $30	SQ FT
NL 29	Infiltration ditch	2.27	10*22*2	0.64 soil 10/1.36 gravel 40	$7,700 - $9,900	$35 - $45	SQ FT
NL 31	Underground storage	10.93	12*80*6	60% void space	$34,560 - $69,120	$10 - $20	CU FT Vol
NL 32	Rain garden	0.23	7*10*1.5	0.5 soil 10/1 gravel 40	$1,400 - $2,100	$20 - $30	SQ FT
NL 33	Infiltration trench	0.89	10*30*4	0.5 soil 10/3.5 gravel 60	$10,500 - $13,500	$35 - $45	SQ FT
NL 34	Permeable pavement	1.21	10*45*4	40% void space	$11,250 - $15,750	$25 - $35	SQ FT
NL 37	Infiltration ditch	11.38	10*200*2	0.64 soil 10/1.36 gravel 40	$70,000 - $90,000	$35 - $45	SQ FT
NL 4	Pervious parking on both sides	1.07	5*150*4*2	40% void space	$37,500 - $52,500	$25 - $35	SQ FT
NL 5	Infiltration ditch	2.26	10*200*2	0.64 soil 10/1.36 gravel 40	$70,000 - $90,000	$35 - $45	SQ FT
NL 6	Iron-enhanced filter 1	2.77	10*150*2	0.64 sand 25/ 1.36 gravel 40	$42,000 - $57,000	$280 - $380	LIN FT
NL 6	Iron-enhanced filter 2	2.97	10*150*2	0.64 sand 25/ 1.36 gravel 40	$42,000 - $57,000	$280 - $380	LIN FT

Watershed	BMP	Area (ac)	Sizing (WLH, ft)	Layers	Cost Estimate (Range)	Cost per	UNIT
NL 8	Iron-enhanced filter	8.84	10*130*2	0.64 sand 25/ 1.36 gravel 40	$37,000 - $50,000	$280 - $380	LIN FT
NL 9	Iron-enhanced filter	22.07	10*200*2	0.64 sand 25/ 1.36 gravel 40	$56,000 - $76,000	$280 - $380	LIN FT
NL 9	Infiltration trench	2.60	10*25*4	0.5 soil 10/3.5 gravel 60	$8,750 - $11,250	$35 - $45	SQ FT
NL 23	Tree trench	4.45	20*85*4	0.5 soil 10/3.5 gravel 40	$68,000.00	$400.00	LIN FT
NL 7	Permeable pavement	2.96	10*59*4	40% void space	$14,750 - $20,650	$25 - $35	SQ FT
NL 3	Tree trench	24.45	10*200*4	0.5 soil 10/3.5 gravel 40	$80,000.00	$400.00	LIN FT
NL 17	Underground storage	30.76	12*200*6	60% void space	$86,400 - $172,800	$10 - $20	CU FT Vol

Figure 1.2



New London BMP locations

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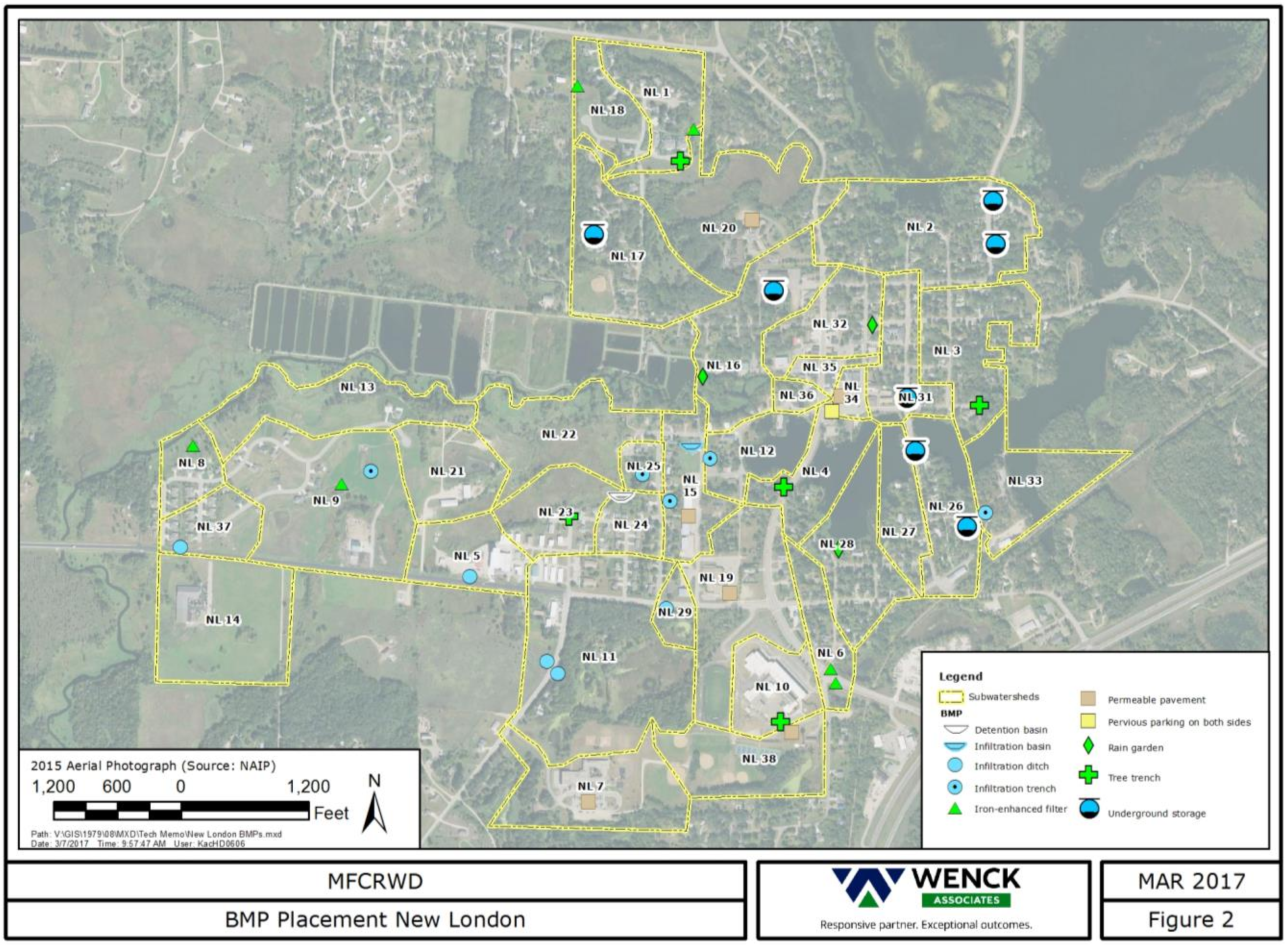
Figure 1.3



Spicer BMP locations

Cost Benefit Analysis

All of the proposed projects are effective at reducing total suspended solids and phosphorous contributions from the Spicer and New London watersheds. If all projects were built, 31 tons of sediment and 249 lbs. of phosphorous would be reduced, but the project cost would be $ 41,820, 080.

To help prioritize the order in which projects should be pursued, the following table summarizes each project and ranks them from lowest to highest in dollars per pound of phosphorous.

A weighted ranking system was developed to categorically rank factors in selecting priority BMP placement. The ranking factored the cost to remove a pound of sediment (30%), the landuse where the BMP will be implemented (20%), watershed contributing area (10%), and the high-end cost of the project (40%). The BMPs with the lowest score received a best ranking, in ascending order. Project cost was assumed to be the most critical factor for placing BMPs and existing landuse the second most important for implementing the project.

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Landuse was ranked in descending order with 5 being the most willing and 1 being unknown or unwilling, below are the full rankings of landuse.

Table 1.8

Rank	Landuse Type
Private Land/Owner – Unwilling or Unknown Participant	1
Private Land/Owner –Willing	2
Commercial/Institutional Land/Owner	3
Public Land/Owner	4
Within Existing Easement	5

Below are the tables associated from the cost-benefit analysis for the City of New London and City of Spicer.

Table 1.9

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted)
NL 1	Iron-enhanced filter	6.55	2,152.50	$ 28,000.00	$ 38,000.00	$ 17.65	1
NL 8	Iron-enhanced filter	8.84	1,507.10	$ 37,000.00	$ 50,000.00	$ 33.18	2
NL 28	Rain garden	2.74	121.80	$ 4,000.00	$ 6,000.00	$ 49.26	3
NL 9	Infiltration trench	2.60	203.10	$ 8,750.00	$ 11,250.00	$ 55.39	4
NL 1	Tree trench	3.27	280.30	$ 16,000.00	$ 16,000.00	$ 57.08	5
NL 9	Iron-enhanced filter	22.07	4,517.80	$ 56,000.00	$ 76,000.00	$ 16.82	6
NL 15	Infiltration trench	3.32	706.80	$ 29,400.00	$ 37,800.00	$ 53.48	7
NL 18	Iron-enhanced filter	2.39	1,831.60	$ 42,000.00	$ 57,000.00	$ 31.12	8
NL 7	Permeable pavement	2.96	438.80	$ 14,750.00	$ 20,650.00	$ 47.06	9
NL 25	Infiltration trench	0.65	168.30	$ 7,000.00	$ 9,000.00	$ 53.48	10
NL 31	Underground storage	10.93	1,522.80	$ 34,560.00	$ 69,120.00	$ 45.39	11
NL 19	Permeable pavement	4.19	1,003.20	$ 37,500.00	$ 52,500.00	$ 52.33	12
NL 4	Tree trench	2.36	214.70	$ 12,000.00	$ 12,000.00	$ 55.89	13
NL 3	Tree trench	24.45	1,854.80	$ 80,000.00	$ 80,000.00	$ 43.13	14
NL 29	Infiltration ditch	2.27	153.10	$ 7,700.00	$ 9,900.00	$ 64.66	15
NL 34	Permeable pavement	1.21	325.80	$ 11,250.00	$ 15,750.00	$ 48.34	16
NL 15	Infiltration basin	5.21	1,050.40	$ 45,500.00	$ 58,500.00	$ 55.69	17
NL 20	Permeable pavement	0.73	67.40	$ 2,500.00	$ 3,500.00	$ 51.93	18

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted)
NL 15	Permeable pavement	2.13	386.20	$ 13,125.00	$ 18,375.00	$ 47.58	19
NL 11	Infiltration ditch 2	1.49	94.70	$ 5,250.00	$ 6,750.00	$ 71.28	20
NL 17	Underground storage	30.76	3,297.70	$ 86,400.00	$ 172,800.00	$ 52.40	21
NL 11	Infiltration ditch 1	1.09	80.50	$ 5,250.00	$ 6,750.00	$ 83.85	22
NL 2	Underground storage 2	2.63	255.90	$ 12,960.00	$ 25,920.00	$ 101.29	23
NL 32	Rain garden	0.23	37.00	$ 1,400.00	$ 2,100.00	$ 56.76	24
NL 16	Rain garden	2.67	409.90	$ 30,000.00	$ 45,000.00	$ 109.78	25
NL 12	Infiltration trench	1.47	143.40	$ 10,500.00	$ 13,500.00	$ 94.14	26
NL 2	Underground storage 1	8.56	1,131.00	$ 41,040.00	$ 82,080.00	$ 72.57	27
NL 16	Underground storage	3.97	951.00	$ 34,560.00	$ 69,120.00	$ 72.68	28
NL 23	Tree trench	4.45	772.20	$ 68,000.00	$ 68,000.00	$ 88.06	29
NL 6	Iron-enhanced filter 1	2.77	497.20	$ 42,000.00	$ 57,000.00	$ 114.64	30
NL 37	Infiltration ditch	11.38	1,003.30	$ 70,000.00	$ 90,000.00	$ 89.70	31
NL 26	Underground storage 1	2.34	307.20	$ 19,440.00	$ 38,800.00	$ 126.30	32
NL 26	Underground storage 2	0.89	147.50	$ 8,640.00	$ 17,280.00	$ 117.15	33
NL 33	Infiltration trench	0.89	55.10	$ 10,500.00	$ 13,500.00	$ 245.01	34
NL 24	Detention basin	4.53	774.70	$ 741,250.00	$ 889,500.00	$ 1,148.19	35
NL 6	Iron-enhanced filter 2	2.97	158.00	$ 42,000.00	$ 57,000.00	$ 360.76	36
NL 4	Pervious parking on both sides	1.07	163.10	$ 37,500.00	$ 52,500.00	$ 321.89	37
NL 5	Infiltration ditch	2.26	525.30	$ 70,000.00	$ 90,000.00	$ 171.33	38

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Table 1.10

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted)
S 7	Bioreactor	20.39	404.80	$ 15,000.00	$ 20,000.00	$ 49.41	1
S 12	Infiltration Bench	17.23	3,966.90	$ 18,900.00	$ 24,300.00	$ 6.13	2
S 11	Infiltration Bench	21.60	5,080.90	$ 21,420.00	$ 27,540.00	$ 5.42	3
S 41	Infiltration Bench	29.06	630.80	$ 31,710.00	$ 40,770.00	$ 64.63	4
S 29	Infiltration Bench	3.58	1,302.80	$ 21,000.00	$ 27,000.00	$ 20.72	5
S 18	Raingarden	5.07	319.80	$ 8,000.00	$ 12,000.00	$ 37.52	6
S 38	Infiltration Bench	16.13	983.50	$ 42,630.00	$ 54,810.00	$ 55.73	7
S 30	Infiltration Bench	7.53	1,222.30	$ 35,910.00	$ 46,170.00	$ 37.77	8
S 6	Infiltration Catchbasin	9.83	262.40	$ 10,000.00	$ 20,000.00	$ 76.22	9
S 40	Infiltration Trench	12.04	3,640.50	$ 73,500.00	$ 94,500.00	$ 25.96	10
S 10	Infiltration Basin	8.93	1,158.90	$ 28,000.00	$ 36,000.00	$ 31.06	11
S 28	Underground Storage	7.51	1,318.00	$ 17,700.00	$ 35,400.00	$ 26.86	12
S 43	Underground Storage	7.13	1,932.70	$ 36,300.00	$ 72,600.00	$ 37.56	13
S 32	Infiltration Trench	6.90	1,184.00	$ 35,750.00	$ 47,250.00	$ 39.91	14
S 43	Permeable pavement	12.95	1,560.50	$ 90,000.00	$ 126,000.00	$ 80.74	15
S 20	Infiltration Trench	9.51	589.80	$ 36,225.00	$ 46,575.00	$ 78.97	16
S 43	Infiltration Ditch	10.22	1,918.20	$ 126,000.00	$ 162,000.00	$ 84.45	17
S 45	Infiltration Bench	2.59	1,286.90	$ 21,000.00	$ 27,000.00	$ 20.98	18
S 1	Infiltration Ditch 2	7.54	1,731.40	$ 147,000.00	$ 189,000.00	$ 109.16	19
S 40	Infiltration Ditch	15.72	1,721.90	$ 420,000.00	$ 540,000.00	$ 313.61	20
S 20	Infiltration Ditch	9.51	757.70	$ 36,225.00	$ 46,575.00	$ 61.47	21
S 2	Infiltration Trench	6.11	1,409.90	$ 74,900.00	$ 96,300.00	$ 68.30	22
S 4	Infiltration Bench	7.08	350.60	$ 21,600.00	$ 27,810.00	$ 79.32	23
S 15	Stormwater Pond	13.77	3,171.20	$ 6,050,000.00	$ 7,260,000.00	$ 2,289.35	24
S 18	Infiltration Catchbasin	8.46	116.10	$ 10,000.00	$ 20,000.00	$ 172.27	25
S 1	Infiltration Ditch 1	3.09	340.20	$ 22,365.00	$ 28,755.00	$ 84.52	26
S 6	Infiltration Trench	2.60	970.60	$ 59,500.00	$ 76,500.00	$ 78.82	27

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted)
S 28	Permeable pavement	1.37	230.00	$ 8,100.00	$ 11,340.00	$ 49.30	28
S 42	Stormwater Pond	6.15	963.40	$ 450,000.00	$ 540,000.00	$ 560.51	29
S 37	Tree Trench	1.19	188.60	$ 8,000.00	$ 8,000.00	$ 42.42	30
S 24	Permeable pavement	0.95	213.80	$ 7,500.00	$ 10,500.00	$ 49.11	31
S 46	Infiltration Ditch 2	1.91	559.40	$ 33,250.00	$ 42,750.00	$ 76.42	32
S 39	Raingarden	4.81	635.40	$ 20,480.00	$ 30,720.00	$ 48.35	33
S 6	Raingarden 1	3.30	400.70	$ 8,000.00	$ 12,000.00	$ 29.95	34
S 44	Infiltration Basin	8.16	1,009.60	$ 168,000.00	$ 216,000.00	$ 213.95	35
S 17	Infiltration Basin	5.86	759.30	$ 31,500.00	$ 40,500.00	$ 53.34	36
S 46	Infiltration Ditch 1	1.65	586.10	$ 43,750.00	$ 56,250.00	$ 95.97	37
S 27	Infiltration Basin	-	1,239.70	$ 84,000.00	$ 108,000.00	$ 87.12	38
S 46	Stormwater Pond	2.75	904.30	$ 2,888,000.00	$ 3,465,600.00	$ 3,832.36	39
S 1	Infiltration Ditch 3	4.60	1,061.80	$ 147,000.00	$ 189,000.00	$ 178.00	40
S 37	Infiltration Catchbasin	5.12	132.70	$ 10,000.00	$ 20,000.00	$ 150.72	41
S 6	Raingarden 2	2.50	353.90	$ 8,000.00	$ 12,000.00	$ 33.91	42
S 28	Infiltration Basin	2.51	698.50	$ 116,550.00	$ 149,850.00	$ 214.53	43
S 39	Infiltration Catchbasin	4.02	128.10	$ 10,000.00	$ 20,000.00	$ 156.13	44
S 19	Planter	2.72	165.00	$ 10,000.00	$ 20,000.00	$ 121.21	45
S 32	Stormwater Pond	1.53	143.20	$ 168,000.00	$ 194,400.00	$ 1,357.54	46
S 27	Stormwater Pond	-	338.70	$ 2,244,500.00	$ 2,693,400.00	$ 7,952.17	47
S 19	Infiltration Catchbasin	2.72	130.30	$ 10,000.00	$ 20,000.00	$ 153.49	48
S 26	Infiltration Ditch	0.75	349.80	$ 40,950.00	$ 52,650.00	$ 150.51	49
S 19	Pervious Pavement	0.29	309.40	$ 4,500.00	$ 6,300.00	$ 20.36	50
S 32	Infiltration Catchbasin	2.58	108.10	$ 10,000.00	$ 20,000.00	$ 185.01	51
S 34	Tree Trench	0.57	39.30	$ 20,000.00	$ 20,000.00	$ 508.91	52
S 10	Infiltration Catchbasin	1.60	101.50	$ 10,000.00	$ 20,000.00	$ 197.04	53
S 32	Raingarden	1.35	156.90	$ 4,800.00	$ 7,200.00	$ 45.89	54
S 25	Stormwater Pond	1.22	76.60	$ 200,000.00	$ 240,000.00	$ 3,133.16	55

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Conclusion

The Cities of New London and Spicer will have the opportunity to implement stormwater improvements that reduce the loadings reaching the Districts water resources. For the City of Spicer, the top projects to focus on are infiltration. In the City of New London, the top projects for improving water quality are iron-enhanced filters and infiltration trenches. See the table below for an aggerated list of the top then projects for the City of New London and the City of Spicer.

Table 1.11 – City of New London Top Then Projects

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted: Cost, Removal, Treatment Area, Project Implementation)
NL 1	Iron-enhanced filter	6.55	2,152.50	$ 28,000.00	$ 38,000.00	$ 17.65	1
NL 8	Iron-enhanced filter	8.84	1,507.10	$ 37,000.00	$ 50,000.00	$ 33.18	2
NL 28	Rain garden	2.74	121.80	$ 4,000.00	$ 6,000.00	$ 49.26	3
NL 9	Infiltration trench	2.60	203.10	$ 8,750.00	$ 11,250.00	$ 55.39	4
NL 1	Tree trench	3.27	280.30	$ 16,000.00	$ 16,000.00	$ 57.08	5
NL 9	Iron-enhanced filter	22.07	4,517.80	$ 56,000.00	$ 76,000.00	$ 16.82	6
NL 15	Infiltration trench	3.32	706.80	$ 29,400.00	$ 37,800.00	$ 53.48	7
NL 18	Iron-enhanced filter	2.39	1,831.60	$ 42,000.00	$ 57,000.00	$ 31.12	8
NL 7	Permeable pavement	2.96	438.80	$ 14,750.00	$ 20,650.00	$ 47.06	9
NL 25	Infiltration trench	0.65	168.30	$ 7,000.00	$ 9,000.00	$ 53.48	10

Table 1.12

Watershed	BMP Type	Treatment Area (ac)	Load Reduction (lbs/yr)	Low Cost	High Cost	Cost per lb of Pollutant Removed	Ranking (Weighted: Cost, Removal, Treatment Area, Project Implementation)
S 7	Bioreactor	20.39	404.80	$ 15,000.00	$ 20,000.00	$ 49.41	1
S 12	Infiltration Bench	17.23	3,966.90	$ 18,900.00	$ 24,300.00	$ 6.13	2
S 11	Infiltration Bench	21.60	5,080.90	$ 21,420.00	$ 27,540.00	$ 5.42	3
S 41	Infiltration Bench	29.06	630.80	$ 31,710.00	$ 40,770.00	$ 64.63	4
S 29	Infiltration Bench	3.58	1,302.80	$ 21,000.00	$ 27,000.00	$ 20.72	5
S 18	Raingarden	5.07	319.80	$ 8,000.00	$ 12,000.00	$ 37.52	6
S 38	Infiltration Bench	16.13	983.50	$ 42,630.00	$ 54,810.00	$ 55.73	7
S 30	Infiltration Bench	7.53	1,222.30	$ 35,910.00	$ 46,170.00	$ 37.77	8
S 6	Infiltration Catchbasin	9.83	262.40	$ 10,000.00	$ 20,000.00	$ 76.22	9
S 40	Infiltration Trench	12.04	3,640.50	$ 73,500.00	$ 94,500.00	$ 25.96	10

To achieve the best water quality outcomes, the top ten projects should be explored first. The weighted rankings consider several factors; however, the projects are dependent upon cost and if the landowner is willing to be involved in the project. Partnering with landowners and sharing the cost between the District, municipalities and applying for implementation grant money will distribute the cost burden. The implementation of the projects should be phased as a long-term solution to water quality issues and be suggested during development or redevelopment projects.