Grant

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Tamarack River, Horseshoe, Island and Minnewawa Lakes Nine Key Element Plan

Federal Clean Water Act Section 319 Small Watersheds Focus Grant Workplan

MINNESOTA POLLUTION CONTROL AGENCY

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Executive summary

The Subwatershed of Horseshoe, Island, and Minnewawa (SWHIM) Lakes is located in the Mississippi River Grand Rapids Watershed in north central Minnesota. The SWHIM is a subset of the Big Sandy Area Lakes Watershed Management Project (BSALWMP) that has a history of over 30 years of working together to restore water quality that has been impacted by historical forestry and ditching as well as new impacts from agriculture and development. The drainage area of the watershed consists of two hydrological unit code (HUC) 10 watersheds (Tamarack Creek subwatershed 0701010305 and Minnewawa Creek subwatershed 0701010306) containing many lakes and several streams with the watershed outlet being the Prairie River flowing into the Mississippi River. The BSALWMP has selected the SWHIM for the Section 319 Small Watersheds Focus Program (Figure 1 and Figure 2).

There are five lakes and one stream segment that are the focus of this watershed effort (

Table 1). These waterbodies were selected for focus because they contribute excess phosphorous to Big Sandy Lake which is the receiving water of this area. The lakes are impaired waters that are either near meeting the water quality standards, are showing improving water quality trends, or have engaged citizen associations committed to improving these water bodies.

Figure 1. Subwatershed of Horseshoe, Island and Minnewawa Lakes (SWIM)

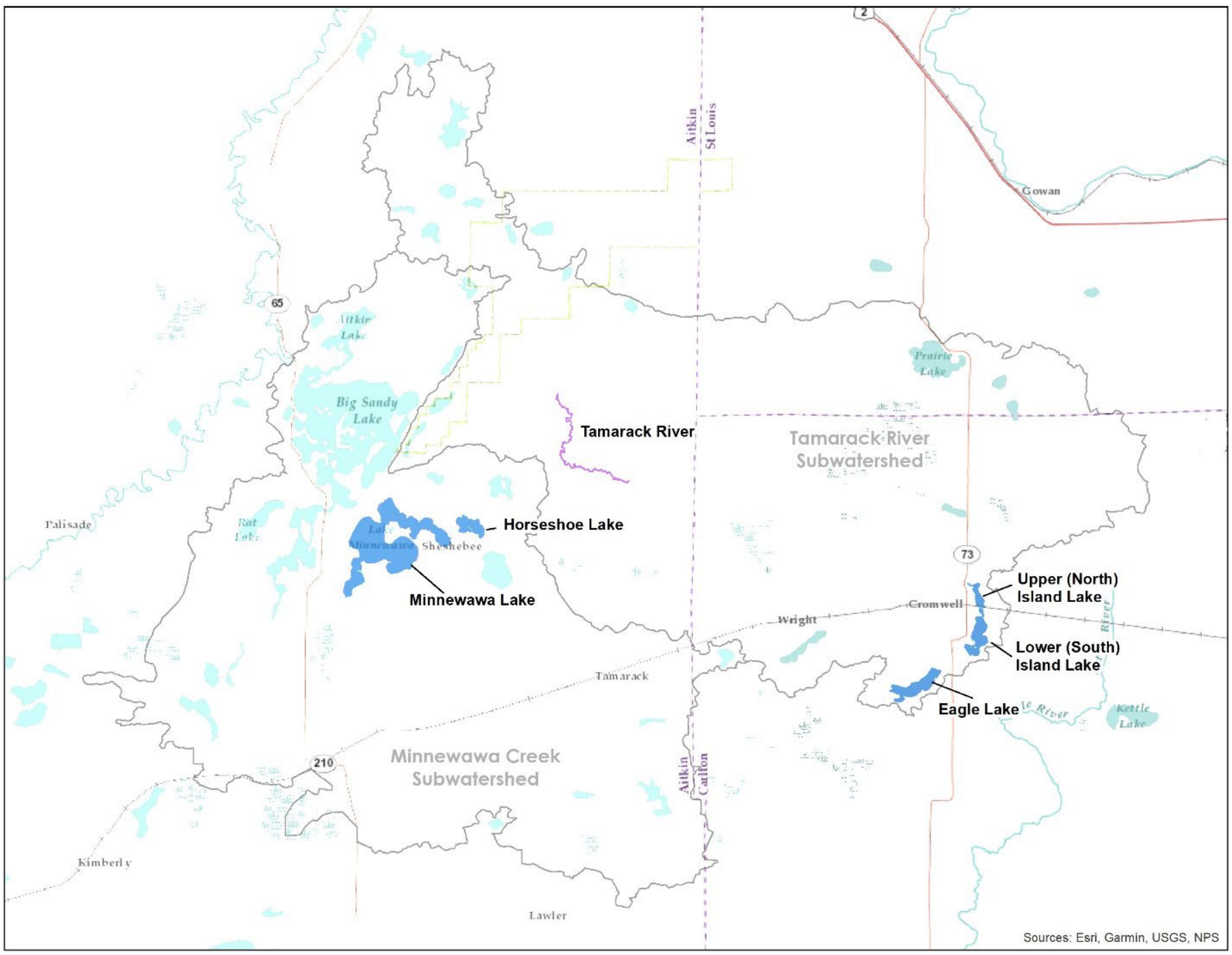


Figure 2. SWHIM location in Minnesota

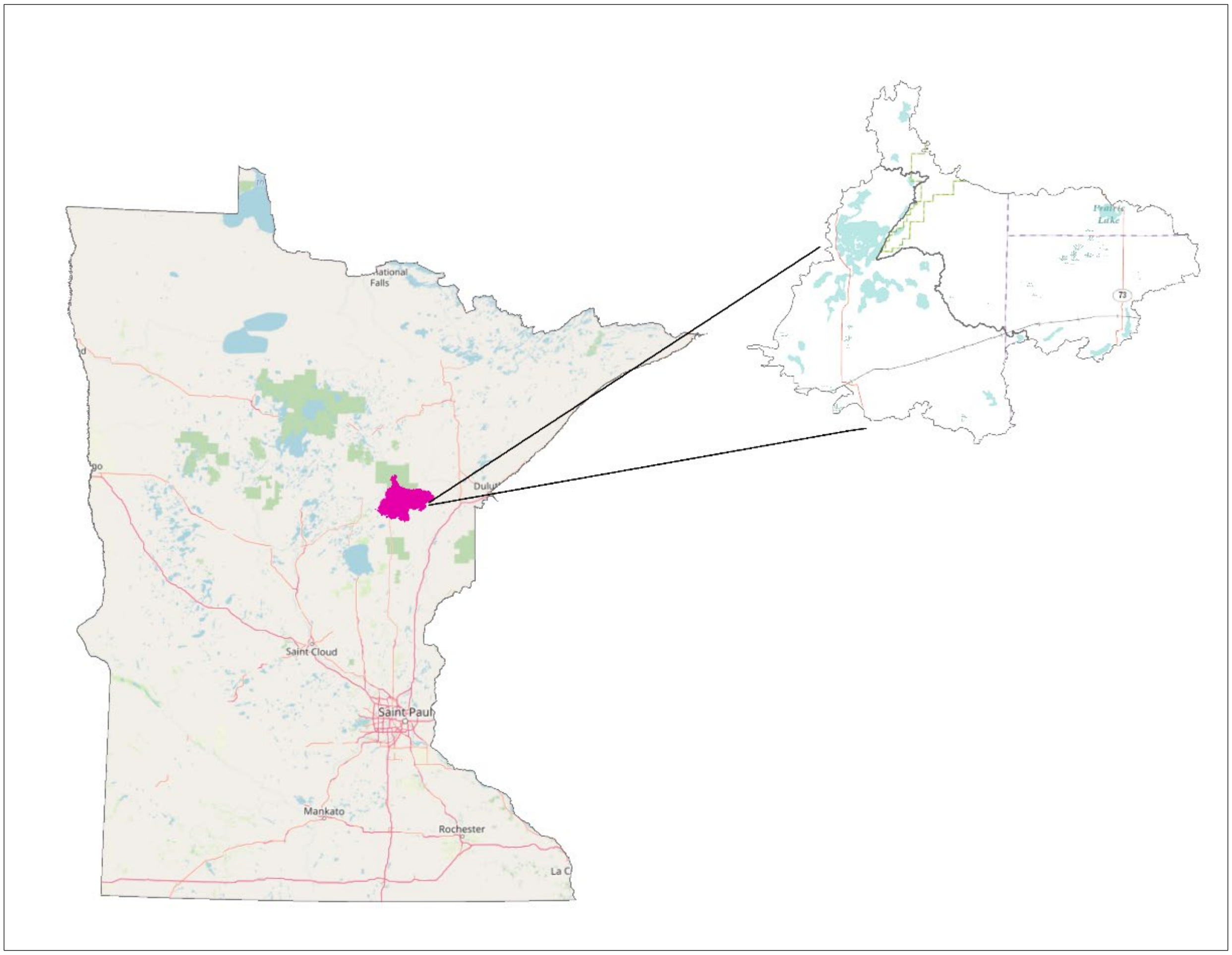


Table 1. SWHIM waterbodies to be addressed in this Nine Element Plan

Name	ID	Impairment Status
Eagle Lake	09-0057-00	Impaired for nutrients
Lower (South) Island Lake	09-0060-02	Impaired for nutrients and fishes bioassessments
Upper (North) Island Lake	09-0060-01	Impaired for nutrients
Tamarack River	07010103-758	Impaired for *E.coli*
Lake Minnewawa	01-0033-00	Impaired for nutrients and mercury
Horseshoe Lake	01-0034-00	Impaired for nutrients

The suite of BMPs and other management activities utilized by the partners over the years are specifically identified to address the critical pollutant sources and biological stressors needed to achieve the water quality standards for the waterbodies in these watersheds. The activities included in this plan include stormwater management practices, shoreland buffers, private forest management plans, pasture management, and septic system upgrades and replacements. The plan presents the practices and activities, estimated load reductions, milestones, assessment criteria, and estimated costs for a ten-year period to achieve water quality standards for the waterbodies in the watershed. This plan meets all nine key elements (NKE) described by the U.S. Environmental Protection Agency (EPA) for the federal Clean Water Act Section 319 program. The implementation of the practices, pollutant load reductions, and achievement of water quality standards in the waterbodies will support the larger efforts of the BSALWMP partners in improving the water quality of the other lakes and streams in the overall HUC10 watersheds.

For the purposes of the Section 319 grant program, only practices and activities eligible for funding under the EPA 2014 Section 319 program guidance and Minnesota's Nonpoint Source Pollution Program Management Plan (NPSPPMP) are eligible for Section 319 funding. All match activities must be eligible for Section 319 funding, except where noted in the NPSPPMP. Other activities will need to seek alternative funding sources, including various state grants and local participation.

Watershed Overview and Condition Summary

An overview of the watershed characteristics of the two watersheds is given in Table 2. Table 3 provides a summary of the water quality conditions of the lakes and streams in these watersheds.

Table 2. Landuse in the SWHIM (WHAF, DNR)

Watershed	Urban	Cropland	Pastureland	Forest	User Defined	Total acres
Eagle Lake	122	12	155	939	1082	2310
Lower South Island	258	48	328	844	828	2306
Upper North Island	138	10	248	1042	3368	4806
Tamarack River	1529	11	5799	17883	40711	65933
Lake Minnewawa	692	1	443	5083	9,148	15,367
Horseshoe Lake	318	69	237	2778	1825	5227

Figure 3. Land use map for SWHIM (WHAF, 2023)

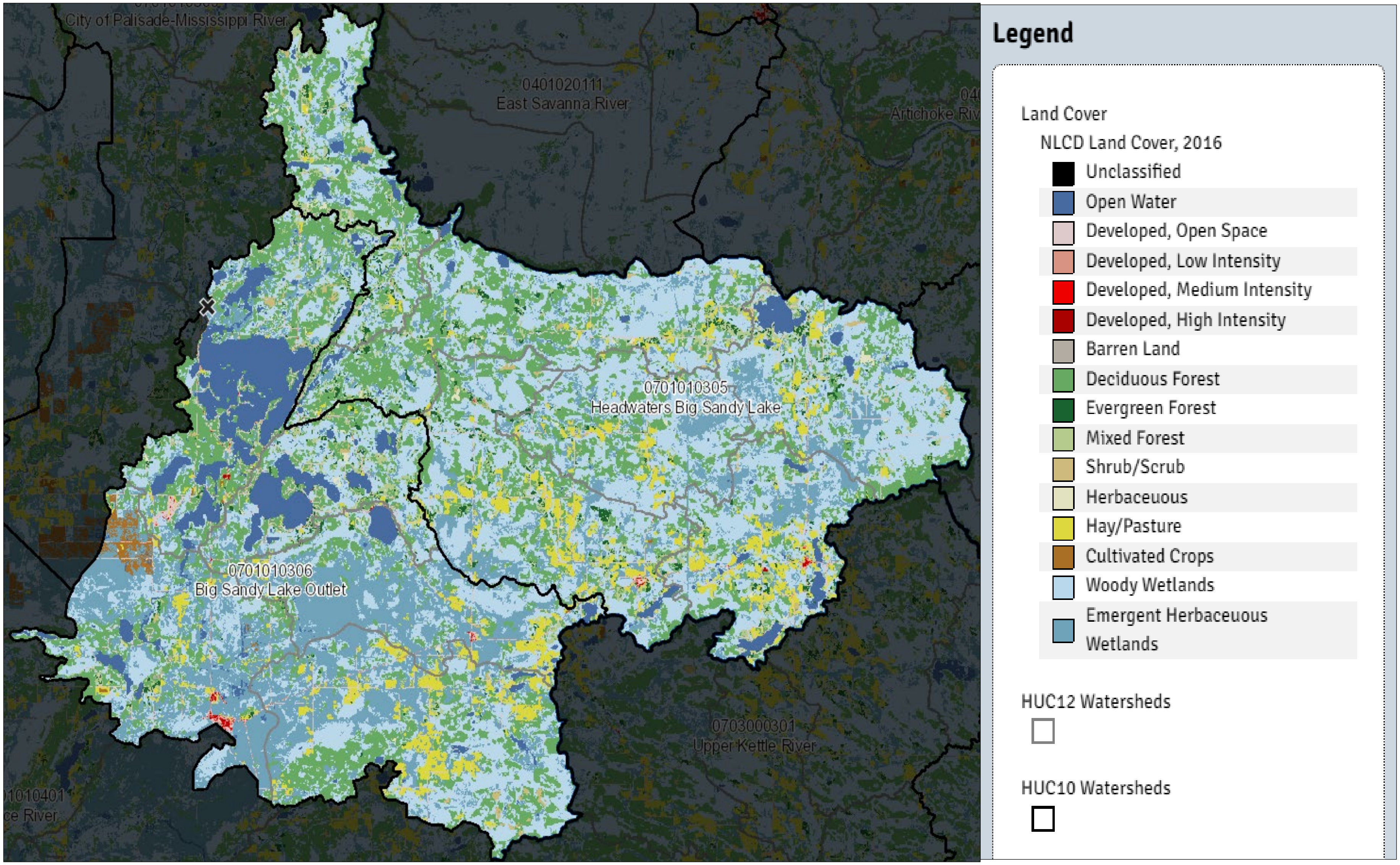


Table 3. Water Quality Summary for selected waterbodies

<table>
<tr><th>Lake Name/ID</th><th>Lake (Ac)</th><th>Lake Depth Max (ft)</th><th>Lake Watershed (Ac)</th><th>TP (µg/L)</th><th>Chl-a (µg/L)</th><th>Secchi (m)</th></tr>
<tr><td>Eagle Lake 09-0057-00</td><td>389</td><td>35</td><td>2,304</td><td>28</td><td>11</td><td>2.3</td></tr>
<tr><td colspan="7">Eagle Lake was listed as impaired in 2002. The current 10-year (2007 through 2016) growing season average TP concentration is 28 µg/L with a WQS goal of <30 µg/L, however the standard error is large enough to suggest that the true mean still doesn't meet the standard. The TMDL reduction goal was based on achieving a 10-year growing season average TP concentration of 25.6 µg/L.</td></tr>
<tr><td>Lower (South) Island Lake 09-0060-02</td><td>324</td><td>22</td><td>4,028</td><td>29</td><td>10</td><td>1.8</td></tr>
<tr><td colspan="7">South Island Lake was listed as impaired for nutrients in 2008. The current 10-year (2007 through 2016) growing season average TP concentration is 29 µg/L with a WQS goal of <30 µg/L. The standard error of the current data set is inconclusive as to whether the lake is meeting standards. The TMDL reduction goal was based on achieving a 10-year growing season average TP concentration of 26.9 µg/L.</td></tr>
<tr><td>Upper (North) Island Lake 09-0060-01</td><td>114</td><td>25</td><td>4,798</td><td>27</td><td>8</td><td>1.7</td></tr>
<tr><td colspan="7">North Island Lake was listed as impaired for nutrients in 2010. The current 10-year (2007 through 2016) growing season average TP concentration is 27 µg/L with a WQS goal of <30 µg/L. However, the data set have a standard error large enough to suggest that the true mean may still exceed the standard. The TMDL reduction goal was based on achieving a 10-year growing season average TP concentration of 24.6 µg/L.</td></tr>
<tr><th>Stream Name/WID</th><th>Stream Length</th><th>Direct Drainage Area (Ac)</th><th>Month</th><th># Samples</th><th>Geo Mean</th><th>Min-Max</th></tr>
<tr><td rowspan="3">Tamarack River 07010103-758</td><td rowspan="3">7.52 mi</td><td rowspan="3">6,208</td><td>June</td><td>5</td><td>163</td><td>82-435</td></tr>
<tr><td>July</td><td>6</td><td>98</td><td>22-816</td></tr>
<tr><td>August</td><td>5</td><td>57</td><td>18-144</td></tr>
<tr><td colspan="7">Aquatic life indicators for streams and rivers of the Tamarack River subwatershed (0701010305-02) generally reflect excellent water quality. FIBI and MIBI scores are high, and streams are characterized by low levels of sediment. One stream (Tamarack River; from the Little Tamarack River to Prairie River) meets Exceptional Use biocriteria based on FIBI and MIBI scores. Although the biology is Exceptional, nutrient concentrations are slightly elevated, and high bacteria concentrations warrant an aquatic recreation impairment. Elevated levels of nutrients and bacteria appear to be localized to the lower portions of the Tamarack River, as conditions greatly improve below the confluence with the Prairie River.</td></tr>
</table>

Implementation strategies

The implementation strategies, schedule, milestones, assessments, and costs are described in the following tables, with each water body addressed by its own table. The implementation strategies summarized in each table are estimated to yield the reductions needed to reach water quality standards in each waterbody, within 10 years.

Table 4. Implementation strategies, schedule, milestones, assessment, and costs for Eagle Lake

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
26 failing SSTS upgraded	6 SSTS replaced/upgraded	5 SSTS replaced/ upgraded	5 SSTS replaced/ upgraded	5 SSTS replaced/ upgraded	5 SSTS replaced/ upgraded	# SSTS	$520,000 at $20,000/system
3600 ft. shoreline buffers	720 ft of shoreline	720 ft of shoreline	720 ft of shoreline	720 ft of shoreline	720 ft of shoreline	# ft	$756,000
800 ft. shoreline restoration	160 ft shoreline restoration	160 ft shoreline restoration	160 ft shoreline restoration	160 ft shoreline restoration	160 ft shoreline restoration	# ft	$67,200
1500 sq ft. raingardens (approx. 15 at 100 sq ft)	3 raingardens	3 raingardens	3 raingardens	3 raingardens	3 raingardens	# sq ft	$72,000
Pasture BMPs one 40-acre pasture							
Exclusion fencing		40 acres				# acres	$6,144
Heavy use protection		5 acres				# acres	$11,806
Prescribed grazing	40 acres					# acres	$1,240
Nutrient/manure management on Pasture 100 acres	100 acres					# acres	$800
Staff time for Agricultural BMPs at one farm	Site visit & technical design	Construction inspection	Technical assistance	Technical assistance	Technical assistance	BMPs Designed, Implemented and Maintained	$3,314
SWCD time staff to conduct outreach in Eagle Lake	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	# site visits, mailings	$28,800
Shoreland Survey	Conduct Survey					Survey completed	$17,000
GIS Stormwater Analysis	Complete Analysis					Analysis completed	$8,000

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
BMP Effectiveness Monitoring	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Data collected	$25,000

Table 5. Implementation strategies, schedule, milestones, assessment, and costs for South (Lower) Island Lake

	Milestones						
Treatment type	**2-year (2023)**	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**	**Assessment**	**Cost**
11 failing SSTS upgraded	2 SSTS replaced/upgraded	2 SSTS replaced/ upgraded	2 SSTS replaced/ upgraded	3 SSTS replaced/ upgraded	2 SSTS replaced/ upgraded	# SSTS	$220,000 at $20,000/ system
2400 ft. shoreline buffers	400 ft of shoreline	500 ft of shoreline	500 ft of shoreline	500 ft of shoreline	500 ft of shoreline	# ft	$216,000
1000 ft. shoreline restoration	200 ft shoreline restoration	200 ft shoreline restoration	200 ft shoreline restoration	200 ft shoreline restoration	200 ft shoreline restoration	# ft	$84,000
1500 sq ft. raingardens (approx. 15 at 100 sq ft)	3 raingardens	3 raingardens	3 raingardens	3 raingardens	3 raingardens	# sq ft	$72,000
Pasture BMPs 160 acres of pasture							
Exclusion fencing			160 acres			# acres	$14,167
Heavy use protection			10 acres			# acres	$7,372
Prescribed grazing		160acres				# acres	$8,480
Staff time for Agricultural BMPs at one farm	Site visit & technical design	Construction inspection	Technical assistance	Technical assistance	Technical assistance	BMPs Designed, Implemented and Maintained	$3,314
SWCD staff to conduct outreach to shoreland owners	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	# mailings, site visits	$28,800

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
Shoreland Survey	Conduct Survey					Survey completed	$17,000
GIS Stormwater Analysis	Complete Analysis					Analysis completed	$8,000
BMP Effectiveness Monitoring	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Data collected	$25,000
South Alley Stormwater						#culverts	$14,400
Raingardens 4.5ac						# acres	$12,000
Ditch mod. .9 ac						# acres	$6,000
Bioswales 857ft	Design	Install				#ft	$26,710
Northern Middle Road							
Culvert retrofit 2						# culverts	$14,400
Raingarden						# raingarden	$8,500
Bioswale		Design	Install			#swales	$9,000
Lippo Ln & Recycling Cntr.							
Culvert retrofit	Design	Install				# culverts	$14,400
Bioswale		Design				#Swales	$8,500
Raingarden	Design	Install	Install			#Raingarden	$8,500
Cromwell School						#Swales	
Bioswale						#Raingarden	
Raingarden						# culverts	$25,500
Culvert retrofit							$12,000
Rainwater harvest/reuse			Design	Install		#Rainwater harvest/RU	$14,400 $9,000

Table 6. Implementation strategies, schedule, milestones, assessment, and costs for North (Upper) Island Lake

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
26 failing SSTS upgraded	5 SSTS replaced/upgraded	5 SSTS replaced/ upgraded	5 SSTS replaced/ upgraded	5 SSTS replaced/ upgraded	6 SSTS replaced/ upgraded	# SSTS	$520,000 at $20,000/ system
2400 ft. shoreline buffers	400 ft of shoreline	500 ft of shoreline	500 ft of shoreline	500 ft of shoreline	500 ft of shoreline	# ft	$201,600
1500 ft. shoreline restoration	300 ft shoreline restoration	300 ft shoreline restoration	300 ft shoreline restoration	300 ft shoreline restoration	300 ft shoreline restoration	# ft	$126,000
1500 sq ft. raingardens (approx. 15 at 100 sq ft)	3 raingardens	3 raingardens	3 raingardens	3 raingardens	3 raingardens	# sq ft	$72,000
Pasture BMPs 160 acres of pasture							
Exclusion fencing		80 acres			80 acres	# acres	$28,334
Heavy use protection		10 acres			10 acres	# acres	$14,745
Prescribed grazing		80 acres			80 acres	# acres	$8,480
Staff time for Agricultural BMPs at one farm	Site visit & technical design	Construction inspection	Technical assistance	Technical assistance	Technical assistance	BMPs Designed, Implemented and Maintained	$3,314
SWCD staff to conduct outreach to shoreland owners	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	Mailings, 9 site visits	# Site visits, mailings	$33,200
Shoreland Survey	Conduct Survey					Survey completed	$17,000
GIS Stormwater Analysis	Complete Analysis					Analysis completed	$8,000

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
BMP Effectiveness Monitoring	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Data collected	$25,000
Forest Management Planning & BMPs on 365 acres	Education & Outreach	Education & Outreach	Education & Outreach	Combined Practices 183 acres	Combined Practices 182 acres	# acres	$2,320
North Alley BMPs targeting 10.3 acres							
Raingardens 3			1 garden	1 garden		#raingarden	$15,000
Bioswales 2		1 garden	1 swale	1 swale		#swales	$10,000
Stormwater Demo at City Park							
Raingarden	4 raingardens					# raingarden	
Bioswale	2 swales					#swales	$33,188

Table 7. Implementation strategies, schedule, milestones, assessment, and costs for Tamarack River

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
19 failing SSTS upgraded	3 SSTS replaced/upgraded	4 SSTS replaced/upgraded	4 SSTS replaced/upgraded	4 SSTS replaced/upgraded	4 SSTS replaced/upgraded	# SSTS	$380,000
Heavy use exclusion (19 farms)		3	4	6	6	# Sq Ft	$140,083
Livestock fencing (1,100 acres)		275	275	275	275	# acres	$311,678
Nutrient/manure management (1,100 acres)	220	220	220	220	220	# acres	$20,200
Roof Runoff (19 Farms)		3	4	6	6	Ft	$95,760
Prescribed Grazing (1,100 Acres)	220	220	220	220	220	# acres	$40,920

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
Livestock Pipeline (Ct)		3	4	2	6	Ct	$57,000
Well (Unit)		1	1	1	2	Unit	$66,720
Watering Facility (Unit)		3	4	6	6	Unit	$8,660
Access Control (acres)		3	4	6	6	Acres	$51,300
Staff time for Agricultural BMPs at one farm. BMPs could be any combination of exclusion fencing, grazing management, heavy use protection and nutrient management (see costs above).	Plan BMPs for 5 landowners; Meet with 19 landowners/year	Plan BMPs for 5 landowners; Meet with 19 landowners/year	Plan BMPs for 5 landowners; Meet with 19 landowners/year	Plan BMPs for 5 landowners; Meet with 19 landowners/year	Plan BMPs for 5 landowners; Meet with 19 landowners/year	# site visits/BMPs designed	$169,864
Effectiveness monitoring of E. coli 2 times per month during the growing season	12	12	12	12	12	Data collected	$15,600

Table 8. Implementation strategies, schedule, milestones, assessment, and costs for Horseshoe Lake

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
3 failing SSTS upgraded	1 SSTS	1 SSTS	1 SSTS			# SSTS	$60,000
10,000 ft. shoreline buffers	2,000 ft of shoreline	2,000 ft of shoreline	2,000 ft of shoreline	2,000 ft of shoreline	2,000 ft of shoreline	# ft	$900,000
2500 ft. shoreline restoration	500 ft shoreline restoration	500 ft shoreline restoration	500 ft shoreline restoration	500 ft shoreline restoration	500 ft shoreline restoration	# ft	$210,000
1500 sq ft. raingardens (approx. 15 at 100 sq ft)	3 raingardens	3 raingardens	3 raingardens	3 raingardens	3 raingardens	# sq ft	$72,000

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
Vegetated Filter Strips 4,500 ft	900 ft filter strips installed	900 ft filter strips installed	900 ft filter strips installed	900 ft filter strips installed	900 ft filter strips installed	# ft	$1,080,000
Infiltration Basin 5 acres	1 ac basin	1 ac basin	1 ac basin	1 ac basin	1 ac basin	# acres	$115,200
Nutrient/manure management 237 acres	50 acres	50 acres	50 acres	50 acres	37 acres	# acres	$21,896
Forest Stewardship Plans 1800 acres	360 acres	360 acres	360 acres	360 acres	360 acres	# acres	$10,150
Staff time for Agricultural BMPs at one farm	1 site visit	1 site visit	1 site visit	1 site visit	1 site visit	BMPs Designed, Implemente d and Maintained	$3,000
SWCD staff to conduct outreach to shoreland owners	Mailings	Mailings, site visits	Mailings, site visits	Mailings, site visits	Mailings, site visits	# mailings, site visits	$28,800
Shoreland Survey	Conduct Survey					Survey completed	$6,000
GIS Stormwater Analysis	Complete Analysis					Analysis completed	$8,000
BMP Effectiveness Monitoring	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Data collected	$25,000

Table 9. Implementation strategies, schedule, milestones, assessment, and costs for Lake Minnewawa

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
4 failing SSTS upgraded	1 SSTS	1 SSTS	1 SSTS	1 SSTS		# SSTS	$96,600
25,000 ft. shoreline buffers	5,000 ft	5,000 ft	5,000 ft	5,000 ft	5,000 ft	# ft	$1,750,000
10,000 ft. shoreline restoration	2,000 ft	2,000 ft	2,000 ft	2,000 ft	2,000 ft	# ft	$892,000

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
1500 sq ft. raingardens (approx. 2 at 100 sq ft)	1 raingarden		1 raingarden			# sq ft	$9,600
Vegetated Filter Strips 20,000 ft	4,000 ft	4,000 ft	4,000 ft	4,000 ft	4,000 ft	# ft	$480,000
Infiltration Basin 10 acres	2 acres	2 acres	2 acres	2 acres	2 acres	# acres	192,000
Nutrient/manure management 100 acres	20 acres	20 acres	20 acres	20 acres	20 acres	# acres	$30,800
Forest Stewardship Plans 2000 acres	400 acres	400 acres	400 acres	400 acres	400 acres	# acres	$11,600
Staff time for Agricultural BMPs at one farm	1 site visit	9 site visits	9 site visits	9 site visits	9 site visits	BMPs Designed, Implemente d and Maintained	$3,000
SWCD staff to conduct outreach to shoreland owners	Mailings, site visits	Mailings, site visits	Mailings, site visits	Mailings, site visits	Mailings, site visits	# Site Visits, mailings	$58,083
Shoreland Survey	Conduct Survey					Survey completed	$28,400
GIS Stormwater Analysis	Complete Analysis					Analysis completed	$8,000
BMP Effectiveness Monitoring	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Lake sampled for TP, Chla, Secchi values	Data collected	$50,000

Table 10. Implementation strategies, schedule, milestones, assessment, and costs watershed wide

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessmen t	Cost
outreach to SSTS owners	1 mailing and workshop/bian nually	1 mailing and workshop/bia nnually	1 mailing and workshop/bia nnually	1 mailing and workshop/bia nnually	1 mailing and workshop/bia nnually	# mailings	$18,500

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
Outreach targeted to agricultural owners	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	# mailings, # workshops	$18,500
outreach to forest landowners	1 mailing and workshop/biannually	1 mailing and workshop/biannually	1 mailing and workshop/biannually	1 mailing and workshop/biannually	1 mailing and workshop/biannually	# mailings	$18,500
outreach to lake landowners	Annual Newsletter & Social Media, Biannual watershed tour & workshops,	Annual Newsletter & Social Media, Biannual watershed tour & workshops,	Annual Newsletter & Social Media, Biannual watershed tour & workshops,	Annual Newsletter & Social Media, Biannual watershed tour & workshops,	Annual Newsletter & Social Media, Biannual watershed tour & workshops,	# mailings, # workshops	$95,000
Contractor/Realtor Workshops	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	1 mailing & workshop biannually	# workshops	$10,000
Culvert Inventory	Inventory Culverts near Eagle Lake, Lake Minnewawa	Inventory Culverts near Upper Island/Lower Island	Inventory Culverts Horseshoe Lake, Tamarack River East End	Inventory Culverts Tamarack River Mid River	Inventory Culverts West Tamarack River	Complete culvert inventory to identify potential soil erosion/phosphorous sources	$34,500
Lake Association Support	Support the work of Lake Associations in the watershed by attending and providing resources	12 meetings/year	12 meetings/ year	12 meetings/ year	12 meetings/ year	Meetings Attendance	$28,800

Treatment type	Milestones 2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)	Assessment	Cost
Project Coordinator	Coordinate project	Coordinate project	Coordinate project	Coordinate project	Coordinate project	Grant reporting is up to date	$150,000

Element a. Sources

The causes and sources of pollution are similar for the lakes and streams throughout the watershed. Streams impaired for *E.coli* are the result of improper livestock and nutrient management. Lakes are impaired by failing septic systems, watershed runoff, untreated stormwater, pressure of development, and shoreline erosion. The following describes in greater detail, the sources to the pollution on the lake and streams.

E.coli

The Tamarack River exceeds the *E.coli* standards during low flow conditions. Cromwell WWTP (MN0051101) is located in the watershed and is meeting permit requirements. The Tamarack WWTP is alternative system that releases into the Tamarack River and is meeting permit requirements.

There are approximately 1,967 households in the drainage area and 65 are estimated to be failing or in need of septic upgrades. The main source of the *E.coli* is from livestock/manure management runoff. There are an estimated 121 bovines according to the MPCA feedlot registration database. Many operations do not meet the requirements for registration. The watershed has an estimated 950 cow and calf pairs.

In low flow times, cattle tend to gravitate to the stream for better grazing and sources of drinking water and to cool off during hot summer months. Access to the stream increases *E. coli* and nutrient loading.

Fish Bioassessments

Lower South Island Lake is impaired for Fish Bioassessments (and also nutrients) and does not support aquatic life use based on a fish-based index of biological integrity (FIBI) score that was below the impairment threshold established for similar lakes. The primary candidate stressor contributing to the condition of the lake's fish community, as measured with the FIBI, is eutrophication resulting from excess nutrients. By addressing the nutrient impairment, the FIBI score should improve and ultimately meet standards for aquatic life.

Nutrients/Total Phosphorus

Lake Minnewawa, Horseshoe Lake, Eagle Lake, Lower (South) Island Lake and Upper (North) Island Lake are all impaired for nutrients. Total Phosphorus (TP) is often the limiting factor controlling primary production in freshwater lakes: as in-lake P concentrations increase, algal growth increases resulting in higher chlorophyll-a (Chl-a) concentrations and lower water transparency. In addition to meeting P standards, lakes must also meet Chl-a concentration and Secchi transparency depth standards. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (Heiskary and Wilson, 2005). Clear relationships were established between the causal factor (TP) and the response variables (Chl-a and Secchi transparency). Based on these relationships, it is expected that by meeting the P target in each lake, the Chl-a and Secchi standards will, likewise, be met. These impaired lakes were assessed against the Northern Lakes and Forest water quality standards.

Manure loading from the 950 cow/calf pairings in this watershed is a significant source of TP across the entire SWHIM.

Eagle Lake

The shoreline of the lake is well developed with very small lots that were originally seasonal but are currently converting to year-round homes. There are several agricultural farms and pastures within the watershed that are contributing agricultural runoff to the lake. The majority of the runoff is coming from the urban landscape adjacent to the lakes. The main sources include runoff from lawns and impervious surfaces as well as failing septic systems.

Figure 4. Eagle Lake lakeshore development map (Google Maps, 2023)

Lower South Island Lake

There are several sources of phosphorus to the lake. Eagle Lake is upstream of South Island Lake and contributes about 25% of the load to the lake which is why addressing Eagle Lake will be essential for Lower South Island Lake to achieve its water quality goals. Like Eagle Lake, the shoreline is highly developed with small lots and conversions to year-round homes. Some of these small lots were connected to the Cromwell sewer system in 2007 but there are still potentially eleven lots with failing septic systems that are contributing phosphorus to the lake. Runoff from eroding shorelines as well as runoff from lawns and impervious surfaces also contribute to the loading from these dense residential areas. South Island Lake receives some stormwater runoff from the city of Cromwell. A stormwater analysis was completed and identified approximately four areas where stormwater BMPS can be installed to reduce loading from these sources (Figure 5). The final source of phosphorus to the lake comes from pasture runoff.

Upper North Island Lake

There are several sources of phosphorus to the lake. The lake watershed is 4,798 acres, or 42 times the lake surface area and both Eagle Lake and South Island Lakes are upstream of North Island Lake which will be critical areas to address nutrients. Like both upstream lakes, the shoreline is highly developed with small lots and conversions to year-round homes. Runoff from these developed shorelines (lawns and impervious surfaces) also contribute to the loading from these dense residential areas. The City of Cromwell also contributes stormwater runoff to the lake. According to the recently completed stormwater analysis for the City, significant phosphorus is coming from the North Alley area of Cromwell (Figure 5). There are also two farms within the watershed that contribute nutrients to the lake through improper nutrient and grazing management practices.

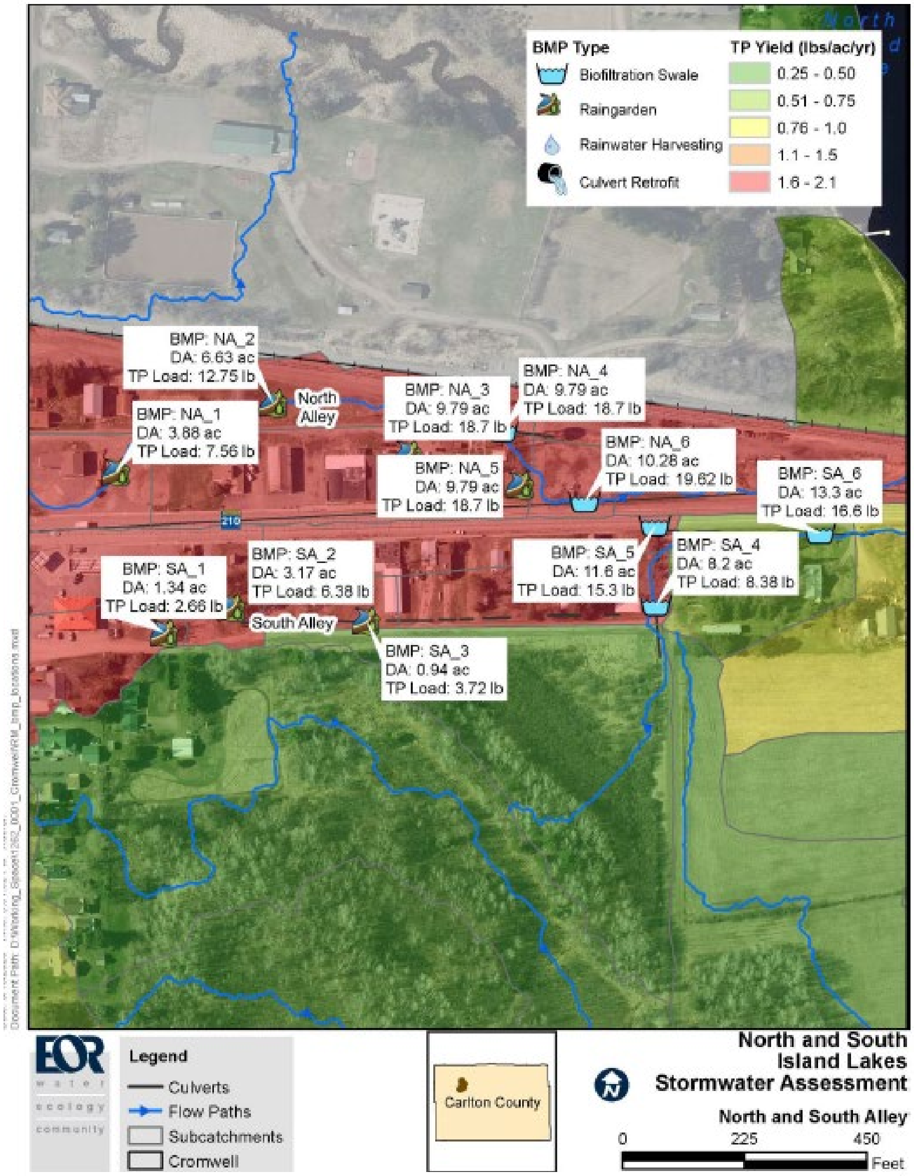


Figure 5. Stormwater BMP placement for North Alley and South Alley critical loading areas

Tamarack River

Although the biology is exceptional, nutrients concentrations are slightly elevated, and high bacteria concentrations warrant an aquatic recreation impairment. Elevated levels of nutrients and bacteria appear to be localized to the lower portions of the Tamarack River, as conditions greatly improve below the confluence with the Prairie River. Sources of these anthropogenic inputs of nutrients and bacteria are from failing septic systems, livestock in streams, and improper nutrient management.

Lake Minnewawa

Significant portions of the shoreline are developed with seasonal and year-round homes and contribute 50% of the loading to the lake. Development is dense in many areas and lot sizes are small. Farms in the lakeshed also contribute nutrients from runoff of improper management practices. There are also significant forested areas that contribute runoff from inadequate harvesting practices

Horseshoe Lake

The lake watershed is 21,622 acres, or 90 times the lake surface area. Due to the large watershed to lake area ratio, there are numerous sources of phosphorus to the lake that need to be addressed. Runoff from nutrients from the near shore high density development around the lake contribute a significant amount of phosphorus directly to the lake including approximately 3 failing septic systems. The larger watershed has some livestock/pasture issues the need to implement nutrient management practices to reduce phosphorus. The extensive forested areas also contribute nutrients and incorporating forest stewardship practices, easements and other BMP tools need to be employed to reduce phosphorus from these sources.

Mercury

Lake Minnewawa is impaired for mercury (and also nutrients). Atmospheric deposition of mercury is uniform across the state and supplies more than 99.5% of the mercury getting into fish. Agency research has demonstrated that 70% of current mercury deposition in Minnesota comes from human sources and 30% from natural sources, such as volcanoes. There are no known natural sources in the state that emit mercury directly to the atmosphere.

Almost all the mercury in Minnesota’s lakes and rivers is delivered by the atmosphere. Mercury can be carried great distances on wind currents before it is brought down to earth in rain and snow. About 90% of the mercury deposited on Minnesota comes from other states and countries. Similarly, the vast majority of Minnesota’s mercury emissions are carried by wind to other states and countries. It's impossible for Minnesota to solve this problem alone; the United States and other countries must greatly reduce mercury releases from all sources.

Element b. Reductions

Phosphorus load reductions for the activities and practices described in Element c were calculated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL) tool.

Eagle Lake

The TP TMDL for Eagle Lake is summarized in Table 11. There is a 45.2 kg/yr, which converted into pounds is 99.6 lbs/yr.

Table 11. Eagle Lake P TMDL

Eagle Lake load component		**Existing**	**Goal**		**Reduction**		
		(kg/yr)	**(kg/yr)**	**(kg/day)**	**(kg/yr)**	**(%)**	**Lbs/yr**
Wasteload allocations	Construction stormwater (MNR100001)	0.010	0.010	0.000027	0.0	0%	0.0
	Industrial stormwater (MNR500000)	0.010	0.010	0.000027	0.0	0%	0.0
	Total WLA	0.020	0.020	0.000054	0.0		0.0
Load allocations	*Watershed runoff*	*75.8*	*69.0*	*0.189*	*6.8*	*9%*	*14.9*
	Failing septics	*7.4*	*0.0*	*0.000*	*7.4*	*100%*	*16.3*
	Internal load	*99.5*	*68.5*	*0.188*	*31.0*	*31%*	*68.3*
	Total Watershed/In-lake	182.7	137.5	0.377	45.2	25%	99.6
	Atmospheric	26.8	26.8	0.073	0.0	0%	0.0
	Total LA	**209.5**	**164.3**	**0.45**	**45.2**	**22%**	**99.6**
MOS			**18.3**	**0.050**			
TOTAL		**209.5**	**182.6**	**0.50**			

The load reductions for the BMPs to be implemented in (Table 4) are shown in Table 12. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The combined watershed runoff and SSTS load reduction of 46.3 pounds/year of phosphorus exceeds the 31.3 pounds/year reduction identified for the two sources in the TMDL.

Table 12. BMP load reductions to be achieved for Eagle Lake with completion of NKE activities.

BMP	**P reduction (lbs/year)**
Lake Shore Restoration	1.8
Shoreland Buffer	5.4
Raingardens	2.0
Combined pasture practices	8.4
Nutrient/manure management in pasture	12.4
Watershed subtotal	30.0
SSTS fixes	16.3
Total reductions	46.3

Given that the current TP concentrations (summer average of 28 µg/L) in Eagle Lake are meeting the water quality standard of 30 µg/L and the target watershed and SSTS load reductions will be achieved, it is expected that the Eagle Lake TP concentrations will remain below the standard and likely decrease further to protect its good water quality condition.

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

South Island Lake

The TP TMDL for South Island Lake is summarized in Table 13. There is a 34.4 kg/yr, which converted into pounds is 75.8 lbs/yr.

Table 13. South Island Lake P TMDL

Island Lake (South Basin) load component		**Existing**	**Goal**		**Reduction**		
		(kg/yr)	**(kg/yr)**	**(kg/day)**	**(kg/yr)**	**(%)**	**(lbs/yr)**
Wasteload allocations	Construction stormwater (MNR100001)	0.004	0.004	0.000011	0.0	0%	0.0
	Industrial stormwater (MNR500000)	0.004	0.004	0.000011	0.0	0%	0.0
	Total WLA	**0.008**	**0.008**	**0.000022**	**0.0**		**0.0**
Load allocations	*Watershed runoff*	*34.9*	*31.6*	*0.086*	*3.3*	*10%*	*7.3*
	Failing septics	*2.8*	*0.0*	*0.000*	*2.8*	*100%*	*6.2*
	Internal load	*78.4*	*54.0*	*0.148*	*24.4*	*31%*	*53.8*
	Total Watershed/In-lake	116.1	85.6	0.234	30.5	26%	67.2
	Eagle Lake	46.3	42.4	0.116	3.9	9%	8.5
	Atmospheric	22.3	22.3	0.061	0.0	0%	
	Total LA	**184.7**	**150.3**	**0.411**	**34.4**	**19%**	**75.8**
MOS			**16.6**	**0.046**			
TOTAL		**184.7**	**166.9**	**0.457**			

The load reductions for the BMPs to be implemented in Table 5 are summarized in Table 14. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The combined watershed runoff, SSTS, and Eagle Lake load reduction of 74.4 pounds/year of phosphorus exceeds the 34.4 pounds/year reduction identified in the TMDL.

Table 14. BMP adjusted load reductions to be achieved for South Island Lake with completion of NKE activities.

BMP	**P reduction (lbs/year)**
Lake Shore Restoration	1.5
Shoreland Buffer	3.6

BMP	P reduction (lbs/year)
Raingardens	2.0
Combined pasture practices	16.4
South Alley Stormwater BMPs	3.1
SA_1 to SA_2 Raingardens	
SA_3 Ditch augmentation	
SA_4 to SA_6 Swales	
Northern Middle Road, Trunk Highway 210, & South Lake Street	
MR_1 - culvert retrofit	7.3
TH210_1 - culvert retrofit	0.5
LS_1 - bioinfiltration swale	0.04
Island Lake Park combined BMPs	**16.5**
ILP_1 culvert retrofit	
ILP_2 raingarden	
ILP_3 swale	
Lippo Lane & Recycle Center	
LL_1 & LL_2 combined BMPs	4.7
RC_1 - rain garden	0.3
Cromwell School	
CS_1-4 combined BMPs	3.1
CS_5 - rainwater harvest and reuse	0.6
Watershed subtotal	**59.6**
SSTS fixes	6.2
Eagle Lake load reductions (upstream)	8.6
Total reductions	**74.4**

A load reduction of 74.4 lbs/yr is expected from the watershed BMPs and the SSTS upgrades in the milestone table greatly exceeding the load reduction targets for watershed sources of P (34.4 lbs/yr). In addition, the reductions would almost result in the total load reduction target of the TMDL including the reductions assigned to internal load being achieved (75.9 lbs/yr). The estimated load reductions for the watershed and SSTS BMPs greatly exceeds the watershed load targets in the TMDL and nearly equals the overall reductions included in the TMDL including that assigned to internal load. With the large load reductions expected and the current TP concentrations (summer average of 27 µg/L) in South Island Lake being lower than the water quality standard of 30 µg/L, it is expected that the South Island Lake TP concentrations will remain below the standard and likely decrease further to protect its good water quality condition and will likely be considered for delisting from the 303(d) list

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

North Island Lake

The TP TMDL for North Island Lake is summarized in Table 15. There is a 45.2 kg/yr, which converted into pounds is 99.6 lbs/yr.

Table 15. North Island Lake P TMDL summary

Island Lake (North Basin) Load Component		Existing	Goal		Reduction		
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)	(lbs/yr)
Wasteload allocations	Construction stormwater (MNR100001)	0.016	0.016	0.000044	0.0	0%	0.0
	Industrial stormwater (MNR500000)	0.016	0.016	0.000044	0.0	0%	0.0
	Total WLA	**0.032**	**0.032**	**0.000088**	**0.0**		**0.0**
Load allocations	*Watershed runoff*	*133.7*	*110.1*	*0.301*	*23.6*	*18%*	*52.0*
	Failing septics	*2.2*	*0.0*	*0.000*	*2.2*	*100%*	*4.9*
	Internal load	*13.4*	*0.0*	*0.000*	*13.4*	*100%*	*29.5*
	Total Watershed/In-lake	149.3	110.1	0.301	39.2	26%	86.4
	Island Lake (South Basin)	83.5	77.5	0.212	6.0	7%	13.22
	Atmospheric	7.8	7.8	0.021	0.0	0%	0.0
	Total LA	**240.6**	**195.4**	**0.534**	**45.2**	**19%**	**99.6**
MOS			21.7	0.059			
TOTAL		**240.6**	**217.1**	**0.593**			

The load reductions for the BMPs to be implemented in Table 6 are shown in Table 16. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The combined watershed runoff, SSTS, and South Island Lake load reduction of 62.2 pounds/year of phosphorus just less than the 70.1 pounds/year reduction identified for the three in the TMDL.

Table 16. Reductions from implementation planned for North Island Lake Watershed by practice

BMP	P reduction (lbs/year)
Lake shore restoration	2.3
Shoreland buffers	3.6
Raingardens	2
North Alley stormwater BMPs	4.7
Raingardens (3)	
Swales (2)	
Combined pasture practices	32.3
Nutrient/manure management (targeted lakeshore farm)	14.7

BMP	P reduction (lbs/year)
Forestry combined BMPs	22.5
Watershed subtotal	**82.1**
SSTS fixes	4.9
South Island Lake load reductions	13.2
Total reductions	**100.2**

Given that the current TP concentrations (summer average of 27 µg/L) in North Island Lake are meeting the water quality standard of 30 µg/L and all of the target watershed and SSTS load reductions will be achieved, it is expected that the North Island Lake TP concentrations will remain below the standard and likely decrease further to protect its good water quality condition. The internal load (29.5 lbs P/yr) reduction identified in the TMDL is not needed to protect the water quality of North Island Lake.

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

Tamarack River

The *E. coli* TMDL for Tamarack River is summarized in Table 17. The TMDL requires a reduction of 28,490 B org/yr in the low flow regime.

Table 17. Tamarack River *E. coli* TMDL summary

Tamarack River 07010103-758 Load Component		**Flow Regime**					
		Very High	**High**	**Mid**	**Low**	**Very Low**	
		***E. coli* (billion organisms per day)**					
Existing Load		*189.1*	*122.3*	*NA*	*129.2*	*5.0*	
Wasteload Allocations	***Cromwell WWTP (MN0051101)***	*2.8*	*2.8*	*2.8*	*2.8*	*2.8*	
	Total WLA	2.8	2.8	2.8	2.8	2.8	
Load Allocations	*Watershed Runoff*	*395.6*	*127.1*	*70.2*	*43.3*	*20.8*	
	Total LA	395.6	127.1	70.2	43.3	20.8	
10% MOS		44.3	14.4	8.1	5.1	2.6	
Total Loading Capacity		442.7	144.3	81.1	51.2	26.2	
Estimated Load Reduction		*NA*	*NA*	*NA*	*78*	*NA*	
		NA	*NA*	*NA*	*60%*	*NA*	

The load reductions for the BMPs to be implemented in Table 7 are shown in Table 18. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The estimated reductions described in Table 18 exceeds the TMDL reduction of 28,490 B orgs/yr *E. coli*.

Table 18. BMP load reductions to be achieved for Tamarack River with completion of NKE activities

BMPs	*E. coli* reduction (lbs/yr)
SSTS fixes	29,084
Heavy use exclusion	249
Livestock fencing	249
Nutrient/manure management	345
Total reductions	**29,927**

The planned implementation for Tamarack River will exceed the TMDL reductions to meet water quality standards in 10 years.

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

Horseshoe Lake

The TP TMDL for Horseshoe Lake is summarized in Table 19. There is a 144.4 kg/yr, which converted into pounds is 318.3 lbs/yr.

Table 19. Horseshoe Lake P TMDL summary

Horseshoe Lake Load Component		**Existing**	**Goal**		**Reduction**		
		(kg/yr)	**(kg/yr)**	**(kg/day)**	**(kg/yr)**	**(%)**	**(lbs/yr)**
Wasteload allocations	Construction stormwater (MNR100001)	0.024	0.024	0.000066	0.0	0%	0.0
	Industrial stormwater (MNR500000)	0.024	0.024	0.000066	0.0	0%	0.0
	Total WLA	**0.048**	**0.048**	**0.000132**	**0.0**		**0.0**
Load allocations	Watershed runoff	242.4	143.8	0.394	98.6	41%	217.4
	Failing septics	0.4	0.0	0.000	0.4	100%	.9
	Wetland anoxic release	4.3	4.3	0.012	0.0	0%	0.0
	Near-shore runoff	79.1	33.7	0.092	45.4	57%	100.1
	Total Watershed/In-lake	326.2	181.8	0.498	144.4	44%	318.3
	Atmospheric	16.5	16.5	0.045	0.0	0%	0.0
	Total LA	**342.7**	**198.3**	**0.543**	**144.4**	**42%**	**318.3**
MOS			**22.0**	**0.060**			
TOTAL		**342.7**	**220.3**	**0.603**			

The load reductions for the BMPs to be implemented in Table 7 are shown in Table 20

Table 20. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The estimated reduction of 318.7 lbs/yr TP exceeds the TMDL reduction of 318.3 lbs/yr TP.

Table 20. BMP load reductions to be achieved for Horseshoe Lake with completion of NKE activities

BMP	**P reduction (lbs/year)**
Lake Shore Restoration	7.3
Shoreland Buffer	29.6
Raingardens	5.3
Vegetated filter strips	1.8
Sand Filter/Infiltration Basin	23.9
Manure/nutrient management on pasture	54.6
Forest management	195.3
Watershed subtotal	**317.8**
SSTS fixes	0.9
Total reductions	**318.7**

The planned implementation for Horseshoe Lake will exceed the TMDL reductions to meet water quality standards in 10 years.

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

Lake Minnewawa

The TP TMDL for Lake Minnewawa is summarized in Table 21. There is a 769 kg/yr, which converted into pounds is 381 lbs/yr.

Table 21. Lake Minnewawa P TMDL

Watershed TP Sources	**Existing TP Load (kg)**	**TMDL Wasteload Allocation**	**Daily TMDL Wasteload Allocation**	**WLA reduction needed**	**Percent Reduction of Existing TP Load (Percent)**
		(WLA) (kg)	**(WLA) (kg/day)**	**WLA(lbs)**	
Permitted Dischargers	0	0	0	0	0
Total Wasteload Sources	0	0	0	0	0
Internal and Nonpoint Sources	**Existing TP Load (kg)**	**TMDL Load Allocation**	**TMDL Load Allocation**	**LA reduction needed**	**Percent Reduction of Existing TP Load (Percent)**
		(LA) (kg)	**(LA) (kg/day)**	**LA (lbs)**	
Internal Sources	0	0	0	0	0

Watershed TP Sources	Existing TP Load (kg)	TMDL Wasteload Allocation	Daily TMDL Wasteload Allocation	WLA reduction needed	Percent Reduction of Existing TP Load (Percent)
		(WLA) (kg)	(WLA) (kg/day)	WLA(lbs)	
Non-point watershed sources					
Agriculture	57	43	0.12	31	25
Forest	214	212	0.58	4	1
Developed	344	187	0.51	346	46
Open Water/Wetlands	149	149	0.41	0	0
Atmospheric Sources	178	178	0.49	0	0
Total Load Sources	**942**	**769**	**2.1**	**381**	**18**
Reserve Capacity (RC)	0	0.7	0.002		0
Margin of Safety (MOS)	0	40	0.11		0
Overall Source Total	942	810	2.2		14

The load reductions for the BMPs to be implemented in Lake Minnewawa are shown in

Table 9. The watershed BMP reductions were estimated using individual practice and combined practice efficiencies in STEPL. The SSTS reduction is assumed to be equal to the SSTS load identified in the TMDL. The combined watershed runoff, SSTS, Horseshoe Lake outlet load reduction of 398 lbs/year of phosphorus exceeds the reduction identified in the TMDL.

Table 22. BMP load reductions to be achieved for Lake Minnewawa with completion of NKE activities.

BMP	P reduction (lbs/year)
Lake Shore Restoration	15.0
Shoreland Buffer	37.6
Raingardens	26.3
Vegetated filter strips	4.2
Sand Filter/Infiltration Basin	47.9
Forest management	122
Nutrient/manure management on hay	9.9
Watershed subtotal	**262.9**
SSTS fixes	1.2
Reductions from Horseshoe Lake	133.8
Total reductions	**398.1**

The planned implementation for Lake Minnewawa will exceed the TMDL reductions to meet water quality standards in 10 years.

Water quality monitoring of the lake will continue to document its status and the internal load estimate made for the TMDL will be reevaluated with additional data.

Element c. BMPs

The BMPs to be implemented to address the *E.coli* impairment in the Tamarack River and the nutrient impairments and protection goals for the lakes listed in the milestone table (Table 7) are described in Table 23. The BMPs encompass a combination of lakeshore, urban stormwater, forestry, agricultural, and SSTS practices.

Table 23. BMP descriptions for SWHIM

BMP	BMP Description	Critical Area
SSTS upgrades	Repairing or installing a new septic system to property treat wastewater.	SSTS upgrades are a requirement for all the lakes and stream within the study area. Imminent public health threats, known failing systems closets to riparian areas and systems with no information within the last 10 years.
Shoreland buffers	An area of native vegetation along the water's edge.	The critical area for shoreland buffers are riparian lots with less than 75% native buffers/shoreline.
Shoreland restoration	Installing plants or other items to prevent shoreline erosion. It may include slope modification, armoring and seeding or other means to revegetate.	The critical area for this BMP are riparian lots with erosion issues.
Raingardens*	A rain garden is a garden of native shrubs, perennials, and flowers planted in a small depression, which is generally formed on a natural slope**.** It is designed to temporarily hold and soak in rain water runoff that flows from roofs, driveways, patios or lawns.	The critical area for raingardens are on lots with more than 15% impervious surface. *Additional raingardens will be located at Cromwell school, Lippo Lane, Norther middle road, south alley, north alley, and a demo site at Cromwell City Park.
Vegetated filter strips	A strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff and wastewater before they reach water bodies or water sources, including wells.	The critical areas where these BMPs will be installed in areas of dense development where native vegetation has been removed from the shoreline. These include Sheshebe Point on Lake Minnewawa and the southern shore of Horseshoe Lake
Infiltration basins	A facility constructed in highly permeable soil that provides temporary storage of runoff during rain events. Over a period of several hours or days, the basin allows the water to discharge primarily by infiltration through the surrounding soil. It might have an outlet for overflow discharge to surface water.	The critical area for infiltration basins are lots with more than 15% impervious surface. Locations with sandy soil are suited for this, including Sheshebe Point on Lake Minnewawa and the northern shore of Horseshoe Lake.
Bioswale*	Elongated depressions in the land surface that are at least seasonally wet, usually heavily vegetated, and normally without flowing water. Swales direct storm water flows into primary drainage channels and allow some of the storm water to infiltrate into	These BMPs will be located at the North Alley, City Park, South Alley, Northern Middle Road, Lippo Lane, and Cromwell School.

BMP	BMP Description	Critical Area
	the ground surface. Swales are vegetated with erosion resistant, and flood tolerant grasses.	
Culvert retrofit*	Modification of existing culverts (size, location, etc.) to properly treat stormwater runoff.	The critical area for this BMP is Northern Middle Road, Lippo Lane, and Cromwell School.
Rainwater harvest/reuse*	Harvest and use can consist of rain barrels, cisterns, or other containers—usually made of either metal, plastic, or concrete—that receive runoff for temporary storage and later use.	This BMP will be located at the Cromwell School.
Ditch modification*	Flow-through ditch checks (ditch checks with underdrains) help slow the water down and/or divert into off-line storage within the right-of-way or on public property.	This BMP will be installed at the South Alley area.
Exclusion fencing	Funds the installation of fencing to exclude livestock from sensitive areas.	Eagle, South (Lower) Island, North (Upper) Island,
Heavy use protection	Heavy Use Area Protection is a way to stabilize a ground surface that is frequently and intensively used by people, animals, or vehicles.	Eagle, South (Lower) Island, North (Upper) Island, Tamarack River
Access control	Access control includes temporary or permanent exclusion of animals, people, vehicles, and equipment from an area. Payments are made to the landowner for the land taken out of production.	Animal Operations within 1000 ft of shoreline areas
Roof runoff	A roof runoff structure is made of various components that will collect, control and convey precipitation runoff from a roof, preventing clean stormwater from running through a feedlot and washing nutrients and bacteria into surface waters.	Animal Operations within 1000 ft of shoreline areas
Prescribed grazing	The controlled harvest of vegetation with grazing or browsing animals, managed with the intent to maintain or improve water quality and quantity.	Animal Operations within 1000 ft of shoreline areas
Livestock pipeline	A livestock pipeline is a pipeline installed to convey water for livestock or wildlife. It is installed to facilitate prescribed grazing systems and provide water sources other than surface waters.	Animal Operations within 1000 ft of shoreline areas
Nutrient/manure Management	Manage rate, source, placement, and timing of plant nutrients and soil amendments while reducing environmental impacts.	Animal Operations within 1000 ft of shoreline areas
Watering facility	A watering facility is a means of providing drinking water to livestock or wildlife and are needed when livestock are excluded from surface waters.	Animal Operations within 1000 ft of shoreline areas
Well	Installation of a well as an alternate water source for livestock instead of fragile lakes, streams, and wetland areas.	Animal Operations within 1000 ft of shoreline areas
Forest stewardship plans	A site-specific plan developed for a landowner to address one or more resource concerns on private forestland where forestry-related conservation activities or practices will be planned and applied	The critical area for this BMP are private landowners who own 20 acres or more on or near riparian areas that drain to Eagle Lake,

BMP	BMP Description	Critical Area
		Horseshoe Lake and Lake Minnewawa.
Forest BMPs	Forest BMPs help maintain forest health and protect sensitive resources. They include Riparian Forest Buffers, Early Successional Habitat Development/Management, Forest Stand Improvement, Forest Trails and Landings, Stream Crossings, Tree/Shrub Site Preparation & Establishment and Woody Residue Treatment	North Island Lake
Shoreland survey	Effectiveness monitoring of shoreline buffer and stabilization practices using drone imagery of priority lakes.	Eagle, Upper& Lower Island Lakes, Lake Minnewawa, Horseshoe Lake
GIS stormwater analysis	Effectiveness monitoring of developed shorelines to assess reductions of impervious surfaces of developed areas.	Eagle, Upper& Lower Island Lakes, Lake Minnewawa, Horseshoe Lake

*specific details of these BMPs and critical areas can be found in the City of Cromwell Stormwater Assessment document.

Mercury emission reduction goals are addressed through the *Implementation Plan for Minnesota's Statewide Mercury TMDL* (MPCA 2009) at state and regional scales, given that atmospheric deposition of mercury from power plant emissions is uniform across the state of Minnesota. Since the vast majority of mercury deposited in Minnesota is from outside the state, mitigation is required at both national and international scales, beyond the scope of this NKE.

Critical loading areas

Eagle Lake

Shoreland farms and developed shoreline were identified as sources of nutrient loading. Pastured animals located within 1,000 feet of the lake shoreland are critical loading sites for Eagle Lake.

Approximately 25% of the developed shoreland of Eagle Lake are considered nonconforming lots, creating a smaller lot footprint with more concentrated impervious areas. Eagle Lane at the northern side and Little Cloquet Road on the southern side are particularly developed. The south side of Eagle Lake is significantly sloped, increasing the likelihood of runoff. These areas contribute a disproportionate amount of nutrient loading. Stormwater BMPs will be targeted to address these areas.

Areas that are identified as having significant amounts of riparian vegetation removed will be targeted to restore vegetation. Shoreland lots with more than 50% traditional grass lawns are the critical loading areas.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for *E. coli*. These systems will be targeted for upgrades and replacements.

Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

South Island Lake

Approximately 20% of the developed shoreland of South Island Lake are considered nonconforming lots, creating a smaller lot footprint with more concentrated impervious areas. A small section near South

Lake Street, Lippo Lane, and Heather Lane are densely developed with small lot sizes. This creates a high loading area due to density. Stormwater BMPs will be targeted to address these lots (Figure 7).

Stormwater from the city of Cromwell loads 1.6 to 2.1 TP lbs/ac/yr (Figure 6).

Figure 6. Critical phosphorus loading area for North and South Island Lakes

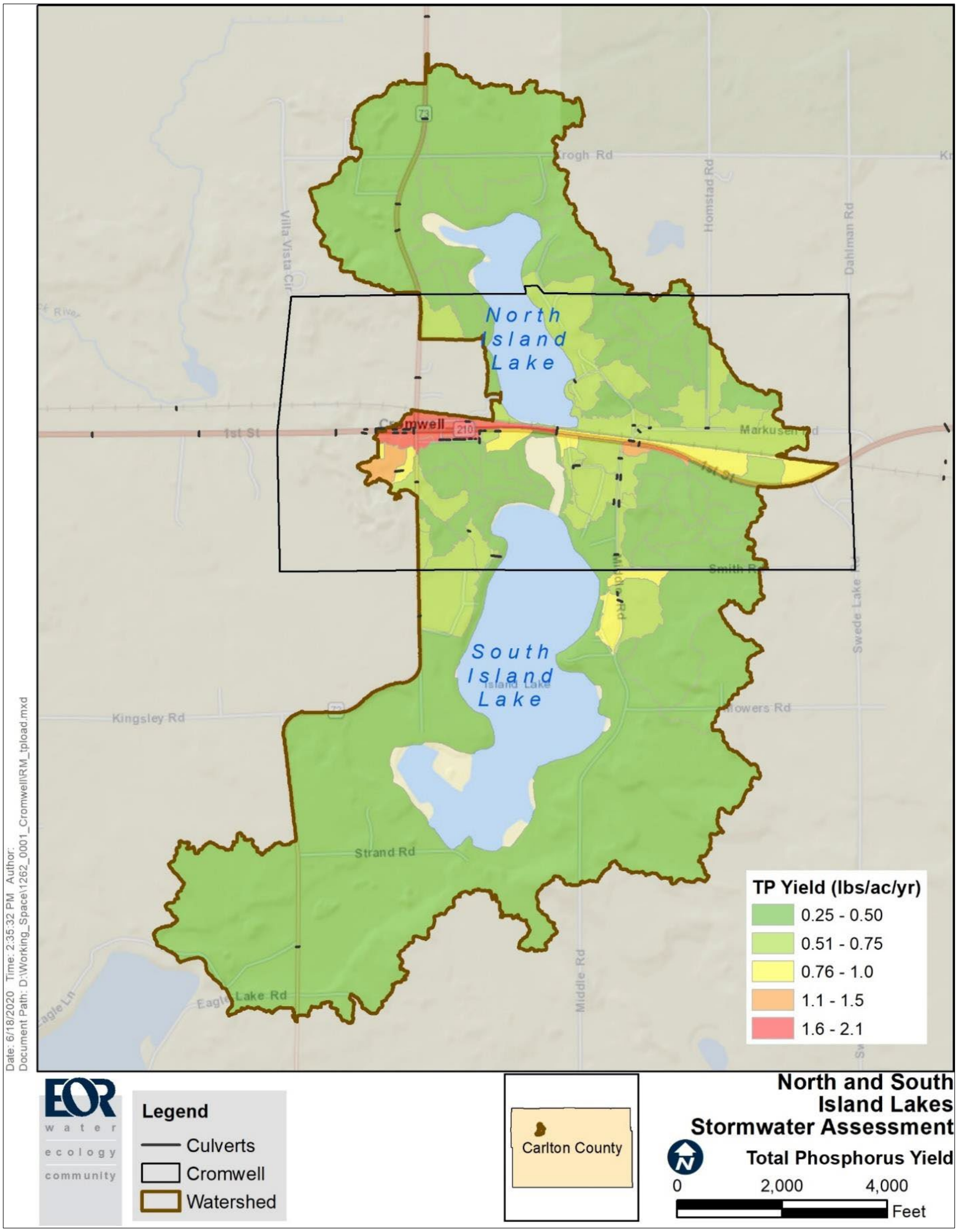
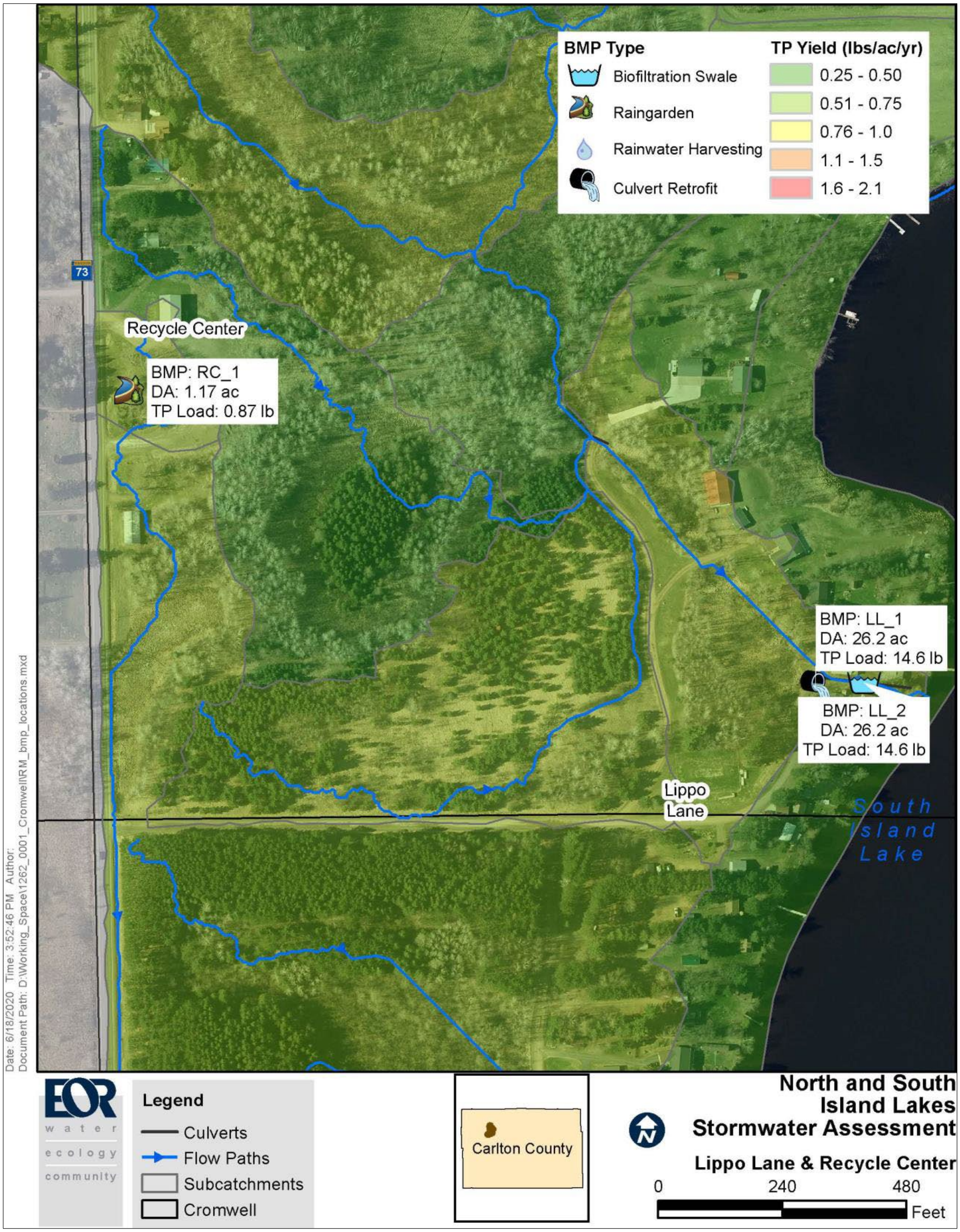


Figure 7. Lippo Lane and Recycle Center potential BMP locations (EOR, 2020).



Larger drainages and phosphorous loading to South Island Lake were identified in the Cromwell Stormwater Assessment. Specific BMPs identified through this planning effort will be targeted.

Figure 8. Northern Middle Road BMPs

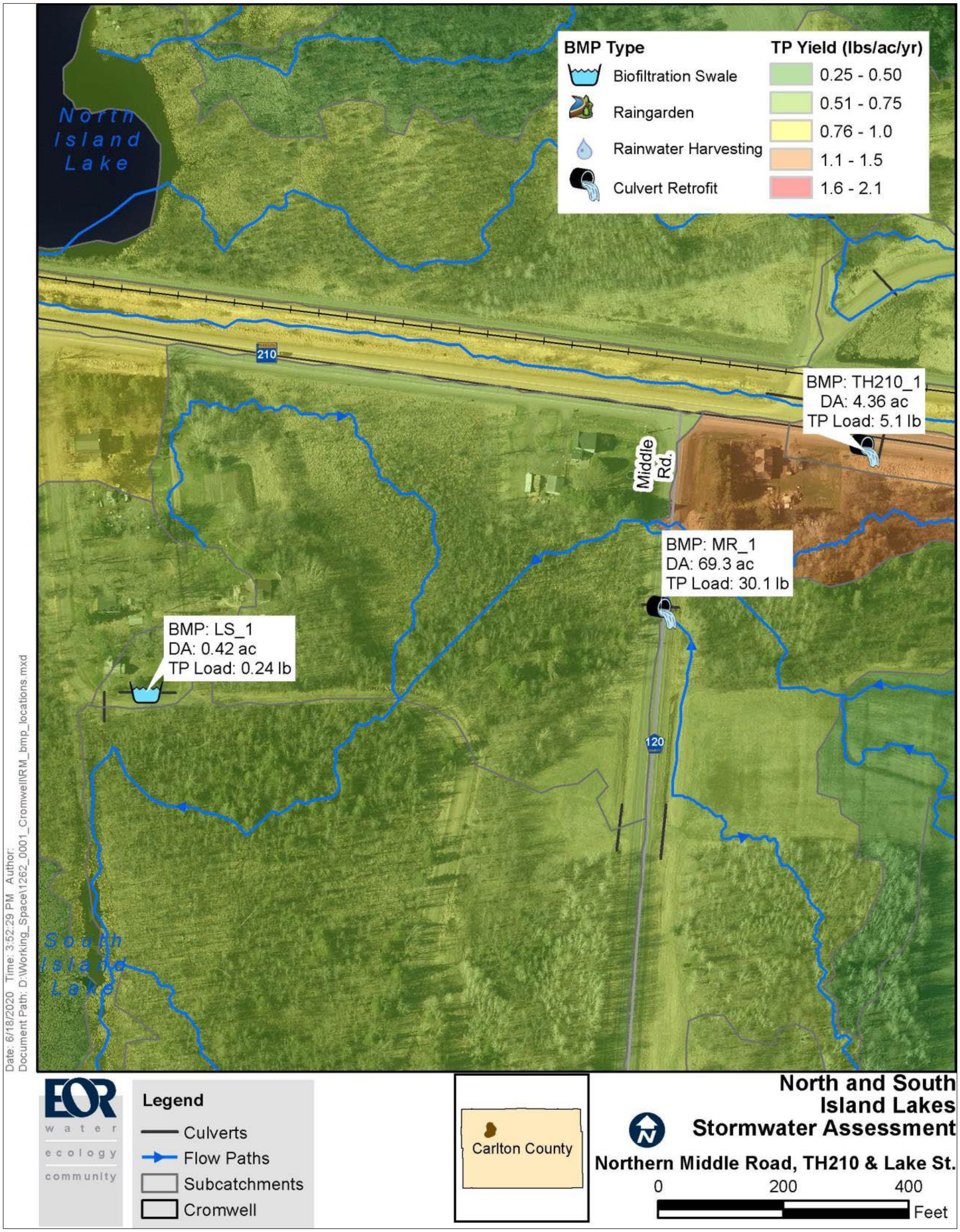
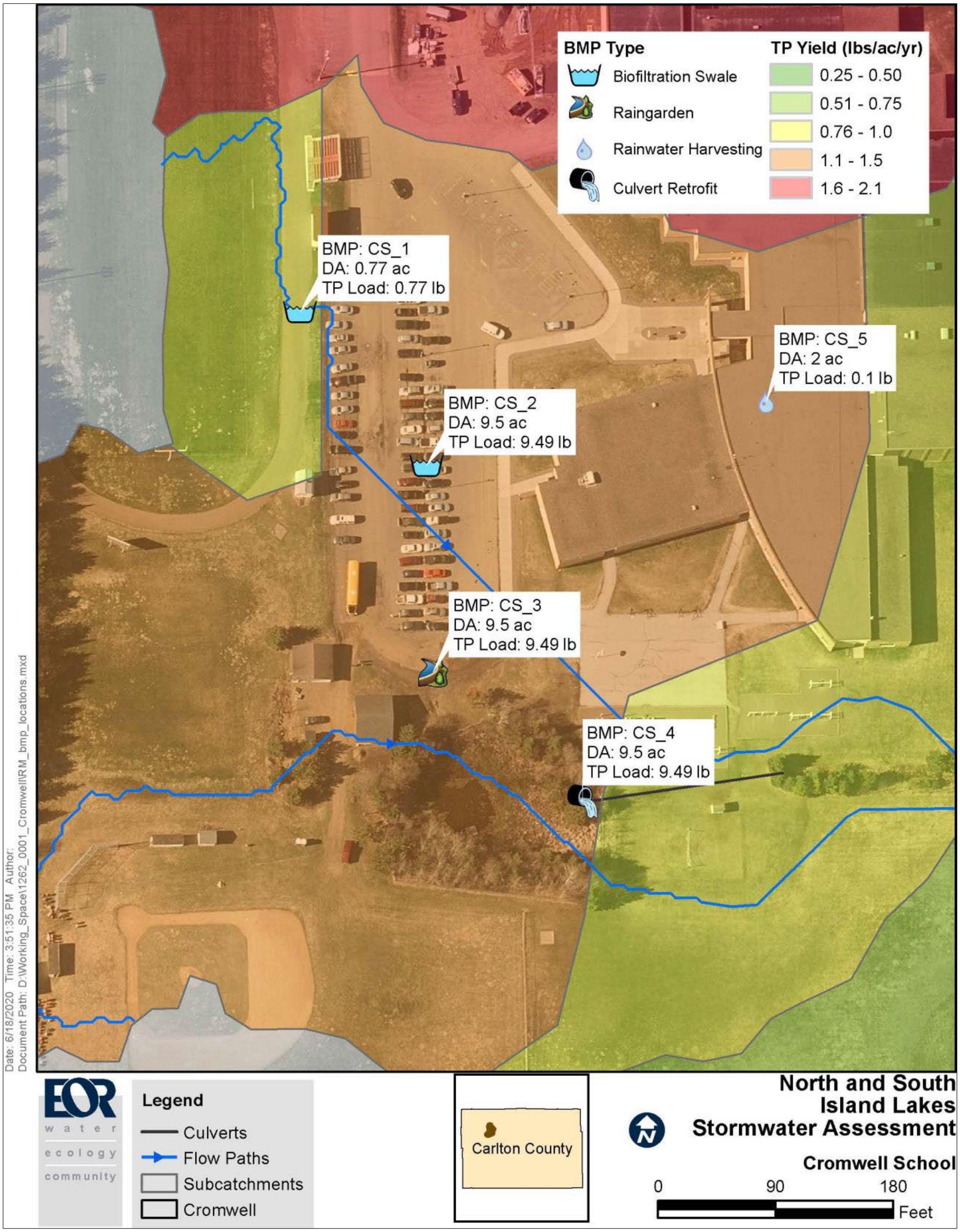


Figure 9. Cromwell School BMPs



Areas that are identified as having significant amounts of riparian vegetation removed will be targeted to restore vegetation. Shoreland lots with more than 50% traditional grass lawns are the critical loading areas.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for E. coli. These systems will be targeted for upgrades and replacements.

Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

North Island Lake

Shoreland farms and developed shoreline were identified as sources of nutrient loading. Pastured animals located within 1,000 feet of the lake shoreland are critical loading sites for North Island Lake.

Concentrated, small lots on the east side of the lake along Belt Lane and Mingus Road (Figure 10) are highly impervious. densely developed with small lot sizes. This creates a high loading area due to density. Stormwater BMPs will be targeted to address these lots (Figure 5).

Figure 10. Map of area Belt Lane and Mingus Road

Areas that are identified as having significant amounts of riparian vegetation removed will be targeted to restore vegetation. Shoreland lots with more than 50% traditional grass lawns are the critical loading areas.

Forest land adjacent to, or containing, riparian lands will be critical to manage to reduce runoff. Forest parcels that are adjacent to subdivided and developed areas will be targeted for forest management to protect them from being converted to other land uses.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for E. coli. These systems will be targeted for upgrades and replacements.

Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

Tamarack River

Animal operations within 1,000 feet off the shoreland are the most critical loading areas for *E. coli*.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for E. coli. These systems will be targeted for upgrades and replacements.

Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

Horseshoe Lake

Concentrated, small lots on the east side of the lake are highly impervious. Development on the north and west sides of the lake has included removal of shoreline vegetation. This, in addition to an increase in impervious surfaces require BMPs to reduce the loading.

Areas that are identified as having significant amounts of riparian vegetation removed will be targeted to restore vegetation. Shoreland lots with more than 50% traditional grass lawns are the critical loading areas.

Forest land adjacent to, or containing, riparian lands are critical to reduce runoff. Forest parcels that are adjacent to subdivided and developed areas will be targeted for forest management to protect them from being converted to other land uses.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for E. coli. These systems will be targeted for upgrades and replacements.

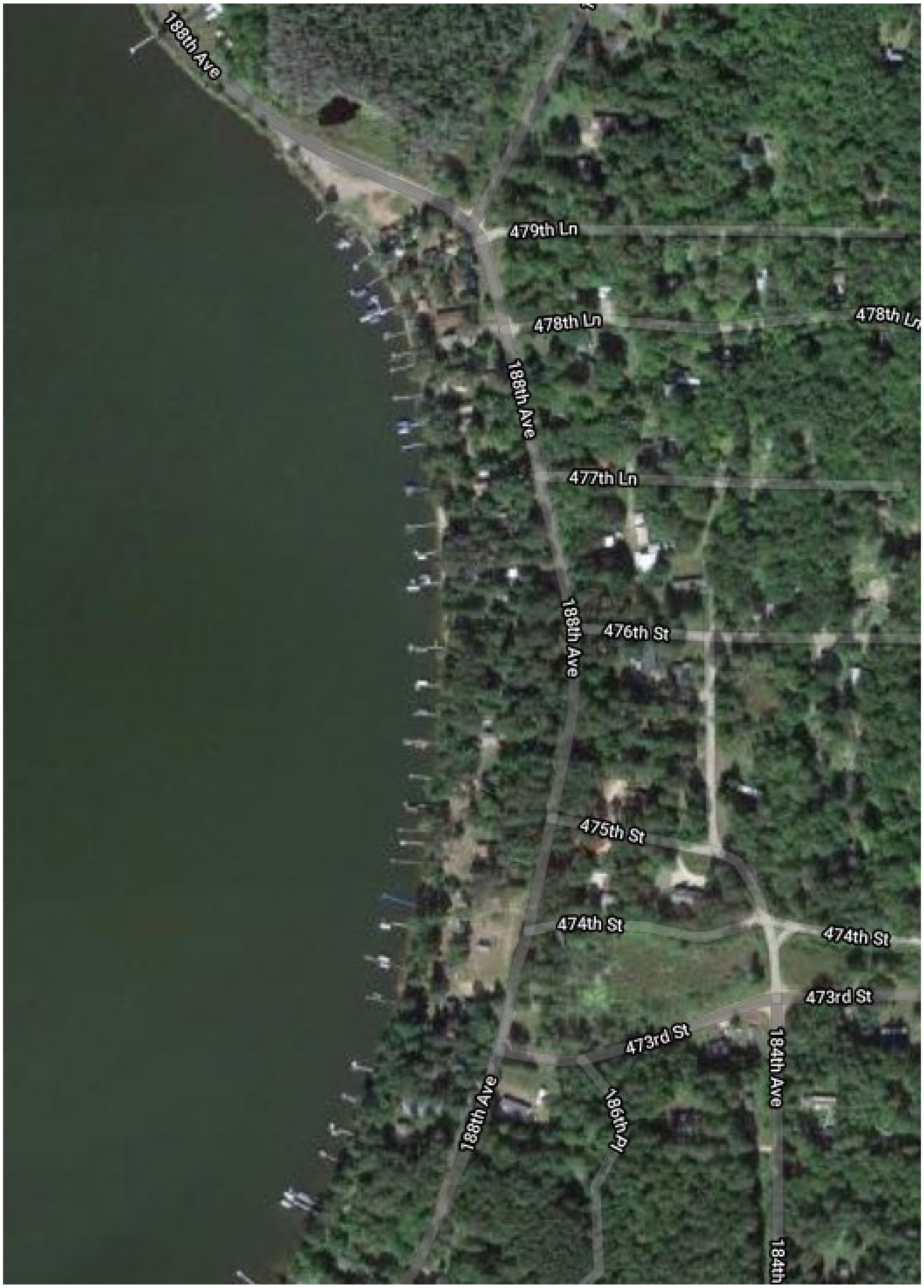
Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

Lake Minnewawa

Shoreland farms and developed shoreline were identified as sources of nutrient loading. Pastured animals located within 1,000 feet of the lake shoreland are critical loading sites for Lake Minnewawa.

Concentrated, small lots in Sheshebe Point are critical loading (Figure 11). The northwest corner of Lake Minnewawa is experiencing a lot of erosion and high loading. The sandy, loose soil in this area is highly erodible.

Figure 11. Sheshebe Point area at Lake Minnewawa



Areas that are identified as having significant amounts of riparian vegetation removed will be targeted to restore vegetation. Shoreland lots with more than 50% traditional grass lawns are the critical loading areas.

Forest land adjacent to, or containing, riparian lands will be critical to manage to reduce runoff. Forest parcels that are adjacent to subdivided and developed areas will be targeted for forest management to protect them from being converted to other land uses.

IPHTs and failing SSTS within the shoreland zone are the most critical loading for P and for E. coli. These systems will be targeted for upgrades and replacements.

Projects in these critical loading areas will be the primary focus of attention and these projects will be prioritized over projects with less impact.

Element d. technical and financial assistance

The cost to implement this plan fully is estimated at approximately $11,400,000. This estimate includes implementation of BMPs, staff time, education and outreach, studies, inventories, and monitoring. The implementation of this plan will be funded by local funding, state and federal grants, and support from private organizations.

Staff time

A Watershed Coordinator is needed to coordinate the technical work of the watershed, be the main contact for citizen involvement, organize outreach campaigns and events, and maintain records and reports for the project. This will be a quarter time position.

Partnerships

Through the discussion of policies and practices, current activities, and ongoing research, project stakeholders have developed and will continue to refine, principles to guide the implementation of the load reduction plan. Strategies will be adjusted to ensure that activities are being focused where the greatest improvement may be made, while utilizing available funding judiciously. Practices will be designed to implement a well-rounded, comprehensive approach to meeting the water quality standards.

Table 24 describes the partnerships and entities that will support the implementation of this NKE.

Table 24. Partnerships in this NKE

Partner	Role
Aitkin County	Outreach, Implementation
Aitkin County Soil and Water Conservation District	Administration, outreach, implementation,
Big Sandy Lake Association	Outreach, Implementation
Carlton County	Outreach, Implementation
Carlton County Soil and Water Conservation District	Administration, outreach, implementation,
City of Cromwell	Outreach, Implementation
Horseshoe Lake Association	Outreach, Implementation
Lake Minnewawa Association	Outreach, Implementation
Minnesota Board of Water and Soil Resources	Outreach, Implementation, Funding
Minnesota Department of Natural Resources	Outreach, Implementation, Technical support, Funding
Minnesota Pollution Control Agency	Technical support, Funding
Minnesota Department of Agriculture	Outreach, Implementation
Natural Resources Conservation Service	Outreach, Implementation
Shamrock Township	Outreach, Implementation
Tamarack River Watershed Committee	Outreach, Implementation

Element e. education and outreach

There are several strategies to provide education and outreach for this project as highlighted in the implementation tables (Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10). This is a critical tool for successful implementation for BMPs. Providing landowners with the information they need to make wise management decisions for their property is key to restoring the quality of these waters.

Agricultural areas

In this area of the state, we have discovered that mailings and workshops are a great way to engage our local farmers. In addition, one-on-one farm visits are very successful outreach strategies. We plan to mail targeted agricultural owners' information and provide workshops biannually for the 10-year project. We also plan site visits with targeted landowners each year. The long-term goal would have agricultural land owners that are informed and reducing impacts to lakes and streams by addressing problem areas.

Forested areas

Forest stewardship plans are a great way to work with private landowners who own forested areas in the watershed. Targeted mailings and workshops biannually, will be the strategy employed to provide information and select landowners to prepare forest stewardship plans for their property. The long-term goal is to have forest landowners informed about the connection of forests and water quality, and of programs to keep their forests healthy and productive.

Shoreland areas

Multiple strategies will be employed to provide information and engage citizens who live on lakes and streams. Annual newsletters, social media, biannual watershed tours and workshops will be conducted over the 10-year project. The long-term goal is to have riparian landowners informed about lakeshore BMPs, as well as technical and financial assistance to install these BMPs.

Lake associations are also a valuable audience to educate and help reach out to other lakeshore owners. One of the best ways to engage with this audience is to support their work in the watershed by attending and supporting their meetings and providing resources. The goal is to attend 12 meeting per year throughout the 10-year project.

Contractors and realtors also play a critical role in making sure shoreland is protected and information is accurate and available to lakeshore owners. This will be accomplished by mailings and workshops help biannually over the 10-year project. The long-term goal is to ensure contractors and realtors are informed about regulations, bioengineering and BMPs.

SSTS owners

Properly functioning septic systems are important to ensure good water quality and are an important strategy outlined in the implementation table. Outreach to septic systems owners will be done biannually through targeted mailings and workshops. The long-term goal is to have SSTS owners informed on the importance of proper septic system maintenance and how to manage the SSTS and keep it functioning properly.

The planned implementation for this watershed will take place over the next ten years (2021-2031). Specific timelines for each activity are captured in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10. It is expected that the activities described in the previous tables will meet the reductions needed to meet water quality standards in 10 years.

Element f. reasonable schedule

The schedule for this watershed plan are designated in 2-year increments described in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10. When implemented as planned, the activities and BMPs described will reach the estimated reductions needed to meet water quality standards in 10 years.

Element g. milestones

The planned milestones for this watershed are designated in 2-year increments and will take place over the next 10 years (2021-2031). Specific milestones for each activity are captured in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10. The accomplishment of these milestones will be used to evaluate the implementation of this plan.

Element h. assessment criteria

The assessment criteria for this watershed are designated in 2-year increments and the unit of measure is described in Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, and Table 10. The assessment criteria will be used in part, to measure the accomplishment of the milestones.

Element i. Monitoring

The water quality of the SWHIM has been monitored in some capacity for the past three decades and will continue to be monitored for the foreseeable future. A watershed program is also in place with different types of ongoing monitoring in different areas of the watershed being conducted. It will also be important to monitor the long-term effectiveness of any water quality improvement projects being constructed in the Big Sandy or Lake Minnewawa watersheds. Various agencies working within the watershed will cooperate to coordinate the ongoing monitoring. Measurements to assess effectiveness of BMPs will be collected once per month from May through September. Parameters include:

- Secchi disc
- Total Phosphorus
- Chlorophyll *a*

Bacteria monitoring on the Tamarack River will also be needed to determine effectiveness. Monitoring will be conducted at one site twice per month from June through August.

1. **Lake Monitoring:** Six lake sites within the Big Sandy Lake Watershed will be monitored each year for BMP/plan effectiveness monitoring: Eagle, Upper Island, Lower Island, Horseshoe and two sites on Lake Minnewawa.

   Implementation Priority: High

   Estimated Cost: $ 16,000/yr x 20 yrs = $ 320,000

   Responsible Parties: Lake Assns., SWCDs

   Timeline: Yearly May through September

2. **Bacteria Monitoring:** One site will be tested for BMP/plan effectiveness. Baseline water quality data will continue to be collected at these sites. (Figure 12)

   Implementation Priority: High

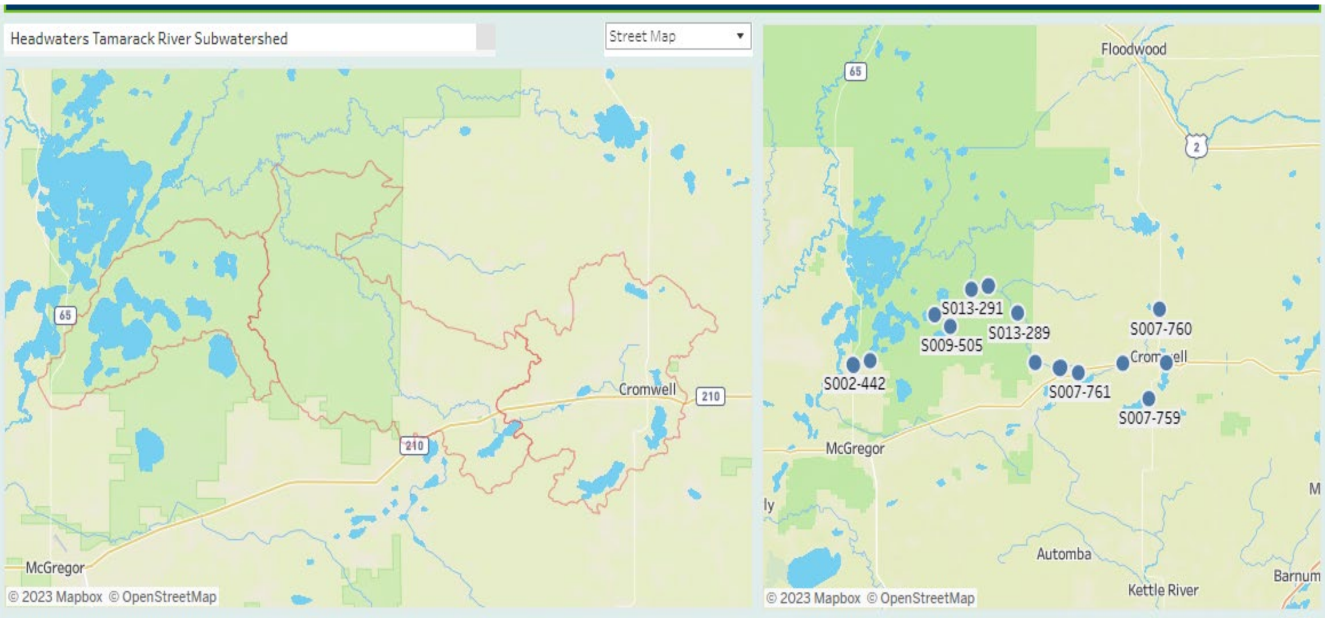
   Estimated Cost: $ 1,500/yr x 20 yrs = $ 30,000

   Responsible Parties: Aitkin SWCD, Carlton SWCD

   Timeline: Ongoing

In addition, effectiveness monitoring of BMPs will be conducted by drone surveys of Eagle, Lower & Upper Island, Horseshoe lakes and Lake Minnewawa. GIS Impervious Surface analysis will also be conducted to determine effectiveness of stormwater BMPs.

Figure 12. Stream monitoring sites in the NKE Watershed (MPCA, 2023).



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Appendix A STEPL practices and assumptions

The STEPL was used to estimate P and *E. coli* loads and reductions for the watershed. The loads estimated in STEPL were comparable with the loading that was estimated using HSPF-SAM for the development of the draft TMDLs in the watershed.

The reductions for BMPs identified in the ten-year milestone table were summed and entered as combined efficiency practices in STEPL. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the "BMPList" worksheet in STEPL. The practices and assumed reduction efficiencies are shown in Table 25. The Combined Efficiencies of the BMPs with area of subwatershed treated is described in Table 26. The treatment efficiencies for the BMPs that are not in the original list of BMPs and reduction efficiencies (BMPList) in STEPL were assigned based on the similarity of the treatment processes with selected BMPList practices.

Table 25. STEPL BMP efficiencies

Landuse	BMP & Efficiency	N	P	BOD	TSS	*E. coli*
Cropland						
Cropland	0 No BMP	0	0	0	0	0
Cropland	Bioreactor	0.453	ND	ND	ND	ND
Cropland	Buffer - Forest (100ft wide)	0.478	0.465	ND	0.586	ND
Cropland	Buffer - Grass (35ft wide)	0.338	0.435	ND	0.533	ND
Cropland	Combined BMPs-Calculated	0	0	0	0	0
Cropland	Conservation Tillage 1 (30-59% Residue)	0.15	0.356	ND	0.403	ND
Cropland	Conservation Tillage 2 (equal or more than 60% Residue)	0.25	0.687	ND	0.77	ND
Cropland	Contour Farming	0.279	0.398	ND	0.341	ND
Cropland	Controlled Drainage	0.388	0.35	ND	ND	ND
Cropland	Cover Crop 1 (Group A Commodity) (High Till only for Sediment)	0.008	ND	ND	ND	ND
Cropland	Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)	0.196	0.07	ND	0.1	ND
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.204	0.15	ND	0.2	ND
Cropland	Land Retirement	0.898	0.808	ND	0.95	ND
Cropland	Manure/Nutrient Management	0.247	0.56	ND	ND	0.9
Cropland	Nutrient Management 1 (Determined Rate)	0.154	0.45	ND	ND	0.9
Cropland	Nutrient Management 2 (Determined Rate Plus Additional Considerations)	0.247	0.56	ND	ND	0.9
Cropland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	ND
Cropland	Terrace	0.253	0.308	ND	0.4	ND
Cropland	Two-Stage Ditch	0.12	0.28	ND	ND	ND
Pastureland						
Pastureland	0 No BMP	0	0	0	0	0

Landuse	BMP & Efficiency	N	P	BOD	TSS	*E. coli*
Pastureland	30m Buffer with Optimal Grazing	0.364	0.653	ND	ND	ND
Pastureland	Alternative Water Supply	0.133	0.115	ND	0.187	ND
Pastureland	Combined BMPs-Calculated	0	0	0	0	0
Pastureland	Critical Area Planting	0.175	0.2	ND	0.42	ND
Pastureland	Forest Buffer (minimum 35 feet wide)	0.452	0.4	ND	0.533	ND
Pastureland	Grass Buffer (minimum 35 feet wide)	0.868	0.766	ND	0.648	ND
Pastureland	Grazing Land Management (rotational grazing with fenced areas)	0.43	0.263	ND	0.333	0.65
Pastureland	Heavy Use Area Protection	0.183	0.193	ND	0.333	0.65
Pastureland	Litter Storage and Management	0.14	0.14	ND	0	ND
Pastureland	Livestock Exclusion Fencing	0.203	0.304	ND	0.62	0.65
Pastureland	Manure/Nutrient Management	0.154	0.45	ND	ND	0.9
Pastureland	Multiple Practices	0.246	0.205	ND	0.221	ND
Pastureland	Pasture and Hayland Planting (also called Forage Planting)	0.181	0.15	ND	ND	ND
Pastureland	Prescribed Grazing	0.408	0.227	ND	0.333	ND
Pastureland	Streambank Protection w/o Fencing	0.15	0.22	ND	0.575	ND
Pastureland	Streambank Stabilization and Fencing	0.75	0.75	ND	0.75	ND
Pastureland	Use Exclusion	0.39	0.04	ND	0.589	ND
Pastureland	Winter Feeding Facility	0.35	0.4	ND	0.4	ND
Forest						
Forest	0 No BMP	0	0	0	0	0
Forest	Combined BMPs-Calculated	0.7	0.85	0	0.75	0
Forest	Road dry seeding	ND	ND	ND	0.41	ND
Forest	Road grass and legume seeding	ND	ND	ND	0.71	ND
Forest	Road hydro mulch	ND	ND	ND	0.41	ND
Forest	Road straw mulch	ND	ND	ND	0.41	ND
Forest	Road tree planting	ND	ND	ND	0.5	ND
Forest	Site preparation/hydro mulch/seed/fertilizer	ND	ND	ND	0.71	ND
Forest	Site preparation/hydro mulch/seed/fertilizer/transplants	ND	ND	ND	0.69	ND
Forest	Site preparation/steep slope seeder/transplant	ND	ND	ND	0.81	ND
Forest	Site preparation/straw/crimp seed/fertilizer/transplant	ND	ND	ND	0.95	ND
Forest	Site preparation/straw/crimp/net	ND	ND	ND	0.93	ND
Forest	Site preparation/straw/net/seed/fertilizer/transplant	ND	ND	ND	0.83	ND
Forest	Site preparation/straw/polymer/seed/fertilizer/transplant	ND	ND	ND	0.86	ND
Feedlots						
Feedlots	0 No BMP	0	0	0	0	0

Landuse	BMP & Efficiency	N	P	BOD	TSS	*E. coli*
Feedlots	Diversion	0.45	0.7	ND	ND	ND
Feedlots	Filter strip	ND	0.85	ND	ND	ND
Feedlots	Runoff Mgmt System	ND	0.825	ND	ND	ND
Feedlots	Solids Separation Basin	0.35	0.31	ND	ND	ND
Feedlots	Solids Separation Basin w/Infilt Bed	ND	0.8	0.85	ND	ND
Feedlots	Terrace	0.55	0.85	ND	ND	ND
Feedlots	Waste Mgmt System	0.8	0.9	ND	ND	ND
Feedlots	Waste Storage Facility	0.65	0.6	ND	ND	ND
Urban						
Urban	0 No BMP	0	0	0	0	0
Urban	Alum Treatment	0.6	0.9	0.6	0.95	ND
Urban	Bioretention facility	0.63	0.8	ND	ND	ND
Urban	Combined BMPs-Calculated	0	0	0	0	0
Urban	Concrete Grid Pavement	0.9	0.9	ND	0.9	ND
Urban	Dry Detention	0.3	0.26	0.27	0.575	ND
Urban	Extended Wet Detention	0.55	0.685	0.72	0.86	ND
Urban	Filter Strip-Agricultural	0.5325	0.6125	ND	0.65	ND
Urban	Grass Swales	0.1	0.25	0.3	0.65	ND
Urban	Infiltration Basin	0.6	0.65	ND	0.75	ND
Urban	Infiltration Devices	ND	0.83	0.83	0.94	ND
Urban	Infiltration Trench	0.55	0.6	ND	0.75	ND
Urban	Lake Shore Restoration	0.43	0.81	ND	0.73	0.3
Urban	LID*/Cistern	0	0	0	0	0
Urban	LID*/Cistern+Rain Barrel	0	0	0	0	0
Urban	LID*/Rain Barrel	0	0	0	0	0
Urban	LID/Bioretention	0.43	0.81	ND	ND	ND
Urban	LID/Dry Well	0.5	0.5	0.7	0.9	ND
Urban	LID/Filter/Buffer Strip	0.3	0.3	0.4	0.6	ND
Urban	LID/Infiltration Swale	0.5	0.65	ND	0.9	ND
Urban	LID/Infiltration Trench	0.5	0.5	0.7	0.9	ND
Urban	LID/Vegetated Swale	0.075	0.175	ND	0.475	ND
Urban	LID/Wet Swale	0.4	0.2	ND	0.8	ND
Urban	Oil/Grit Separator	0.05	0.05	ND	0.15	ND
Urban	Porous Pavement	0.85	0.65	ND	0.9	ND
Urban	Raingarden	0.6	0.65	ND	0.75	0.9
Urban	Sand Filter/Infiltration Basin	0.35	0.5	ND	0.8	ND
Urban	Sand Filters	ND	0.375	0.4	0.825	ND
Urban	Settling Basin	ND	0.515	0.56	0.815	ND
Urban	Shoreland Buffer	0.4	0.81	0.505	0.73	0.3
Urban	Vegetated Filter Strips	0.4	0.4525	0.505	0.73	ND
Urban	Weekly Street Sweeping	ND	0.06	0.06	0.16	ND
Urban	Wet Pond	0.35	0.45	ND	0.6	ND
Urban	Wetland Detention	0.2	0.44	0.63	0.775	ND

Landuse	BMP & Efficiency	N	P	BOD	TSS	*E. coli*
Urban	WQ Inlet w/Sand Filter	0.35	ND	ND	0.8	ND
Urban	WQ Inlets	0.2	0.09	0.13	0.37	ND

Combined efficiencies calculations

The following combined efficiencies were conducted for the subwatersheds.

Table 26. Combined efficiencies of pasture management BMPs (grazing management, heavy use protection, and exclusion fencing)

BMP	P efficiency	*E. coli* efficiency
Combined pasture BMPs	.568	.947
Combined North Alley stormwater BMPs	.923	.945
Combined Middle Road stormwater BMPs	.484	.277
Combined Island Lake Park stormwater BMPs	.806	.900
Combined Lippo Lane and Recycling Center stormwater BMPs	.445	.851
Combined Cromwell School stormwater BMPs	.807	.900