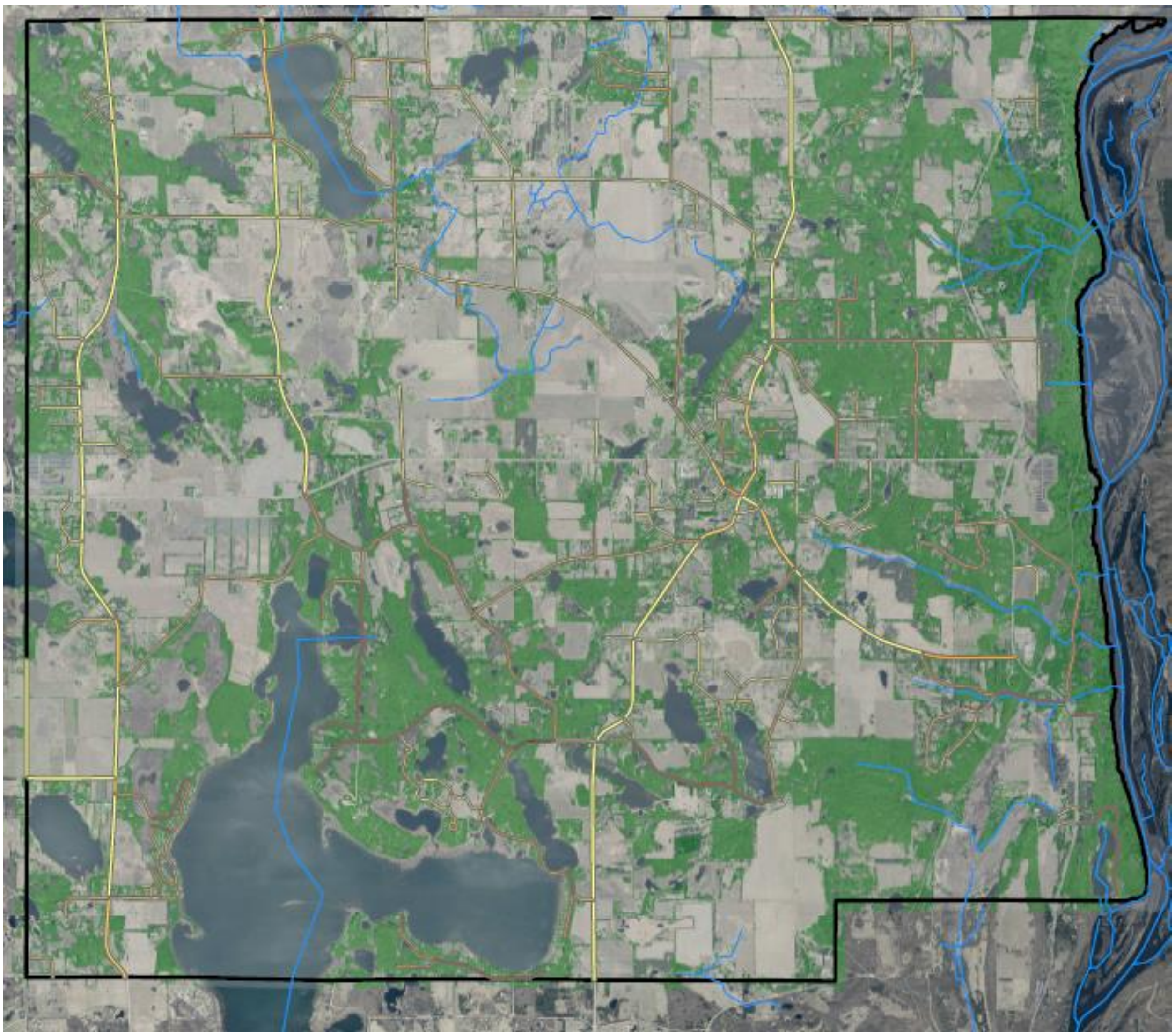
Enhanced Street Sweeping Analysis

City of Scandia



Report Prepared for the City by

Washington Conservation District

Funded by

Lower St. Croix Watershed Partnership

In partnership with

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Background

Street sweeping is a cost-effective way to reduce nutrient and sediment loads entering lakes, streams and wetlands from storm sewers. Sweeping is typically completed in the spring to remove accumulated sediment from winter road treatment, and again in the fall to reduce leaf litter. However, trees adjacent to roadways can be a significant contributor of nutrient loading throughout the year as they drop seeds, pollen, leaves, and other organic debris. Similarly, large gaps in traditional fall and spring sweeping schedules give these materials time to re-accumulate and flush into storm drains before they can be removed.

Figure 1. Leaves, seeds, and other tree debris accumulating in road gutters will eventually wash into storm drains and downstream waterbodies unless they are removed.

Enhanced street sweeping is the incorporation of additional sweeping protocols, the timing and location of which are targeted to maximize water quality protection. One way to prioritize locations for enhanced sweeping is to quantify tree canopy cover overhanging and immediately adjacent to roadways; this is because tree canopy cover is highly correlated with the amount of recoverable organic materials on roadways (Kalinosky, 2015) and average total phosphorus concentrations in stormwater runoff (Janke et al. 2017). Tree canopy data can then be combined with stormwater infrastructure information to identify roadways likely contributing most to nutrient inputs derived from fallen tree materials.

The Washington Conservation District received funding from the Lower St. Croix Partnership to map and rank city streets for enhanced sweeping practices in multiple communities. The maps developed as part of this analysis include: road canopy cover percentages, roads vs subwatersheds, and prioritized sweeping zones (See Appendix).

The enhanced street sweeping analysis for the **City of Scandia** includes roads draining directly to priority lakes as well as land that ultimately drains to the St. Croix River. This report presumes the majority of paved streets in these drainage areas are currently swept once or twice per year in the late spring and/or fall. However, these well-established neighborhoods contain high quantities of mature trees and some stormwater infrastructure, resulting in several roadways that are excellent candidates for enhanced street sweeping protocols. This report describes enhanced street sweeping scenarios that would maximize the cost efficiency of pollutant removal from these roadways.

Methods

Study Areas

All areas within or immediately adjacent to the direct drainage area of priority lakes and the St. Croix River were included in enhanced street sweeping considerations. Streets that drain to landlocked areas or have low canopy cover were not considered because they are not suitable or recommended for enhanced street sweeping. Subwatershed boundaries were obtained from subwatershed data maintained by the Carnelian Marine St. Croix Watershed District.

Tree Canopy Assessment

Tree canopy cover within the study areas was analyzed following methodology in the *Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization*, produced by Emmons and Oliver Resources Inc. (EOR) for the Lower St. Croix Watershed Partnership (LSCWP).

Figure 2 Roadway buffers, derived from MNDOT right-of-way widths, within which tree canopy coverage was calculated

First, centerline data was compiled for all paved roadways within or immediately adjacent to the targeted subwatershed boundaries. Longer roads were split into smaller sections to increase the resolution of canopy cover estimates along them. Next, each roadway was assigned a right-of-way width corresponding with its MNDOT functional classification. Right-of-way values were then referenced to generate a buffer around each roadway, and deciduous tree canopy abundance within these buffers (total percentage areal coverage) was quantified by intersecting them with the *Twin Cities Metro Area (TCMA) Urban Tree Canopy Classification* dataset (*Figure 2*). Altogether, these processes allowed for canopy cover comparisons within the study areas, and correspondingly the prioritization of roadways most likely to contribute nutrient-rich stormwater derived from tree materials.

Stormwater Infrastructure Considerations

The subwatersheds selected for enhanced sweeping considerations contain stormwater infrastructure such as catch basins, subsurface storm sewers, stormwater ponds, and biofiltration/bioinfiltration areas. Where the data were available, local stormwater infrastructure was also considered for priority sweeping zones.

Street Sweeping Priority Ratings

Once subwatersheds were delineated and stormwater infrastructure was assessed, all candidate roadways were classified into one of three categories based on connectivity to priority lakes:

- **High Priority:** Paved roadways/segments of roadways located within priority subwatershed boundaries, high canopy coverage, and draining directly to a BMP and/or stormwater outfall at the lake's edge.
- **Medium Priority:** Paved roadways/segments of roadways lying within priority subwatershed boundaries and moderate canopy coverage, but not directly connected to a stormwater BMP and/or storm sewer outfall or are separated by a large distance from the priority drainage areas.
- **Low Priority:** Paved roadways/segments of roadways confirmed to fall outside of the subwatershed boundaries with negligible or no connection to priority lakes through storm sewer networks. These areas are not recommended for enhanced or additional street sweeping.

Sweeping Zones and Frequency

This enhanced sweeping plan was developed for maximum load reduction and recommended sweeping frequencies are shown in Table 1. High priority zones will be swept a total of 6 or 7 times per year, medium priority 4 or 5 times, and low priority once or twice per year. Current sweeping frequency is referred to as "Baseline." In optimal conditions, the Baseline would be 2 times per year. Accordingly, for low priority areas essentially receive no prioritization for extra sweeping. Under optimal conditions (where Baseline is 2 sweepings per year), high priority zones are recommended to be swept three times in the spring (Biweekly after snow has melted, once during the summer, and three times in autumn (Biweekly once leaves have started falling). Under optimal conditions (where Baseline is 2 sweepings per year), medium priority zones should be swept twice in the spring after snowmelt and twice in the autumn after leaves have started falling.

Table 1: Street sweeping zones and recommended frequencies.

Sweeping Zones	Recommended Sweeping Frequency for Optimal Load Reduction
Baseline (Current) Sweeping	Typically 1 or 2X Annually
Medium Priority	3 Additional Sweepings Annually
High Priority	6 Additional Sweepings Annually

Given the street sweeping schedules and priorities described above, three enhanced sweeping scenarios were generated and compared: one for existing sweeping practices and three for enhanced street sweeping options (Optimal, Option 1, and Option 2) – See Appendix B.

Cost and Pollutant Recovery Estimates

Pollutant load recovery, cost, and cost effectiveness estimates for the aforementioned sweeping scenarios, routes, and schedules were compared using the planning calculator tool produced by Kalinosky and others (2014), available in the Minnesota Stormwater Manual. This calculator uses statistical models informed by tree canopy cover and MN-based street sweeping studies to predict the amount of solids and nutrients that can be recovered through street sweeping. A cost of $172 per curb mile, based on current estimated rates experienced by the City of Afton to contract street sweeping services, was applied to each candidate sweeping plan to compare costs and cost effectiveness.

NOTE: Pollutant load reductions achieved through street sweeping are dependent on several factors, such as when and how often streets are swept and the type of machinery that is used. For example, sweeping immediately prior to a major storm event and using a regenerative-air sweeper rather than a mechanical sweeper are both actions that will yield higher nutrient recovery rates. All load recovery, cost, and cost effectiveness values described herein are only estimates used for relative comparisons between candidate sweeping scenarios. The load recovery planning calculator was not calibrated with data from water quality sampling or laboratory analyses of recovered street materials from the study areas.

Findings and Recommendations

Streets Assessed and Classified

A total of 134.30 curb miles (street miles x 2) of candidate streets were evaluated. Of this, **41.05** curb miles are in High, **34.37** curb miles in Medium, and **58.88** in Low Priority Zones. See Table below and *Appendix B* for a breakdown of curb miles within each subwatershed. Only city roads were calculated for curb miles, cost, and nutrient removal estimates.

Canopy Cover

Average tree canopy cover for candidate streets/street segments ranged from 0% - 81%. Canopy cover was ranked into five categories: 0-20%, 20-40%, 40-60%, 60-80%, and 80-100%. Table 2 shows the percent canopy within each of the **28** subwatersheds/zones.

Table 2: Canopy coverage by zone for city roads.

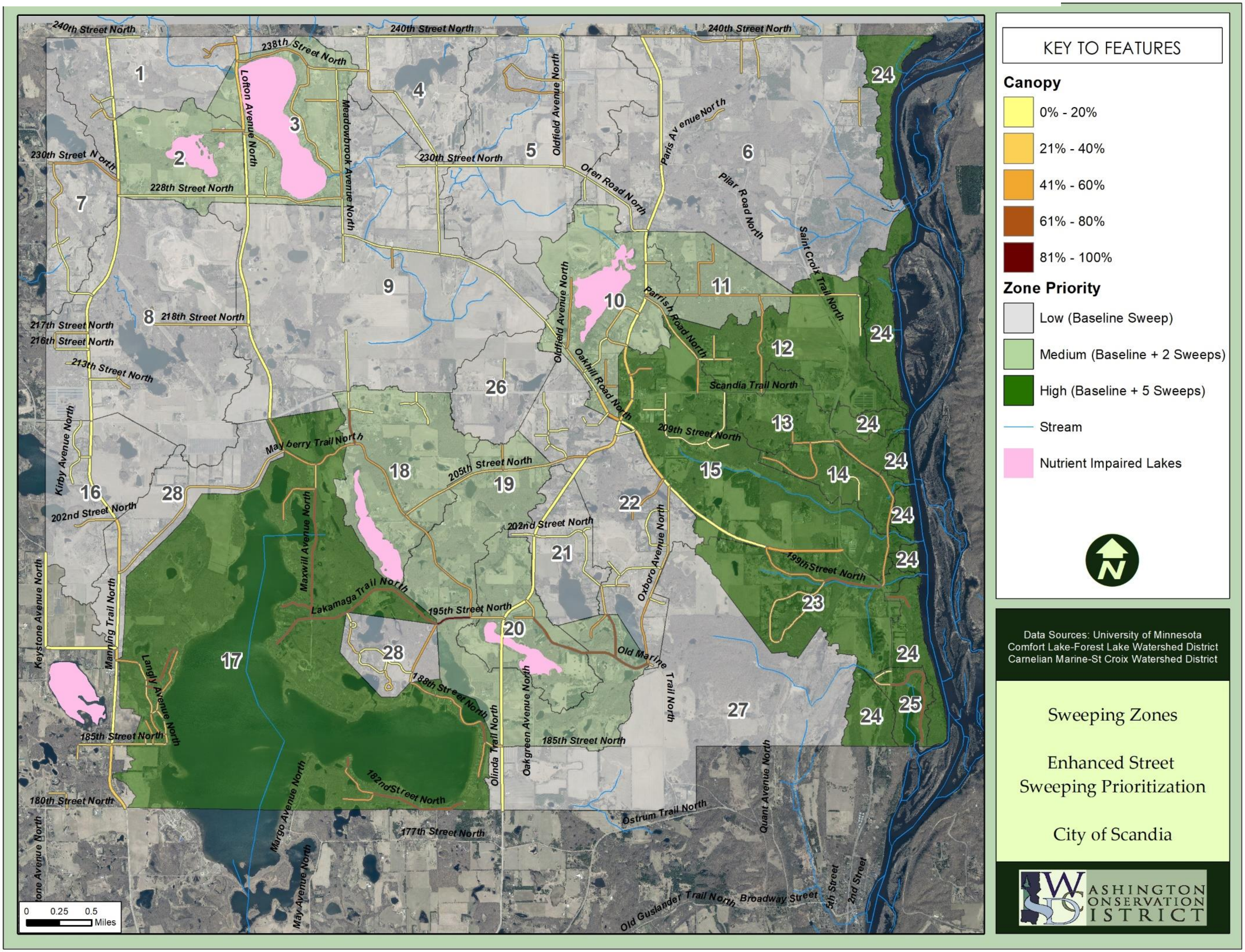
Zones Summary						
Zone #	Major Watershed	Canopy % of Zone	Zone Curb-Miles	Priority	Canopy Coverage Range	Target Waterbody Drainage
1	Birch Lake	30.3%	2.18	Low	Low-Med	Upstream
2	Neilsen Lake	21.2%	2.44	Medium	Low-Med	Landlocked/Impaired
3	Bone Lake	28.7%	9.36	Medium	Medium	Impaired
4	Sea Lake	26.5%	4.45	Low	Low	Landlocked
5	First Lake	22.2%	7.12	Low	Low-Med	Landlocked
6	Falls Creek (Low)	21.7%	5.81	Low	Low-Med	Landlocked/Direct
7	CLFLWD	25.3%	3.70	Low	Low-Med	Landlocked
8	German Lake	18.2%	4.14	Low	Low-Med	Direct
9	Bone Lake (Low)	12.0%	8.03	Low	Low	Upstream
10	Goose Lake	32.1%	6.19	Medium	Low-Med	Impaired
11	Falls Creek	50.6%	3.05	Medium	Medium	Direct/Upstream
12	Zavorals Creek	30.3%	3.78	High	Low-Med	Direct/Upstream
13	South Creek	46.0%	1.71	High	Medium	Direct/Upstream
14	Gilbertsons	33.4%	3.03	High	Low-Med	Direct/Upstream
15	Clapps Stream	36.4%	5.42	High	Low-Med	Direct/Upstream
16	Sylvan Lake	24.8%	1.91	Low	Low	Landlocked
17	Big Marine Lake (High)	52.0%	19.09	High	Low-High	Impaired
18	Fish Lake	38.7%	4.76	Medium	Low-High	Impaired
19	Jellums Lake	56.9%	6.53	Medium	Med-High	Landlocked
20	Long Lake (Scandia)	37.4%	2.05	Medium	Low-High	Impaired
21	Hay Lake	9.9%	2.23	Low	Low	Upstream
22	Sand Lake	16.3%	10.12	Low	Low-Med	Upstream
23	Swedish Flag	40.2%	4.75	High	Med-High	Direct/Upstream
24	St. Croix River	62.2%	0.43	High	High	Direct
25	Lake Alice	52.5%	2.84	High	Med-High	Direct
26	Closed basin - New Scandia	15.8%	0.52	Low	Low	Landlocked
27	Mill Stream	0.7%	0.97	Low	Low	Upstream
28	Big Marine Lake (Low)	12.7%	7.71	Low	Low	Upstream
	Total		134.30			

See *Appendix* for more details on canopy coverage and additional maps.

Load Recovery and Cost Estimates

March (or immediately following snow melt) and October are the most cost-effective times to complete street sweeping, followed by other months in the spring and fall (*Appendix A*). Current Baseline street sweeping practices yield an estimated phosphorus (P) recovery rate of 158 lbs/year at an average cost around $146/lb P recovered. In comparison, all enhanced street sweeping scenarios explored in this analysis yielded higher phosphorus recovery rates and improved the cost effectiveness of phosphorus removal. Targeting only high priority streets further improved load recovery and cost effectiveness. See *Table 3* for a summary of candidate street sweeping scenarios, and *Appendix B* for all planning calculator outputs.

Figure 3: Street Sweeping Zones. Note: County roads are shown for reference only, and are not included in cost and nutrient removal calculations.



Recommendations

To maximize cost effectiveness for phosphorus removal and water quality benefits to the City, two Options are recommended. Option 1 would reduce annual TP loads by 471 lbs/yr with a total cost of approximately $70,224/year. Option 2 would reduce annual TP loads by 222 lbs/yr with a total cost of approximately $30,160/year. Many factors may change these costs, such as necessity to hire multiple contractors. Further, if additional funds are identified higher sweeping frequencies may become the preferred alternative.

Table 3: Load reductions and cost estimates for existing and candidate sweeping practices in the priority watersheds for city streets.

Load Reductions and Cost Estimates

Month Swept	Existing	Optimal Load Reduction Plan			Option #1			Option #2		
Street Priority:	(All Streets) Frequency	High	Medium	Low	High	Medium	Low	High	Medium	Low
		Frequency			Frequency			Frequency		
March	-	1	1	-	1	-	-	-	-	-
April	-	1	1	1	1	1	-	1	-	-
May	-	1	-	-	1	-	-	-	-	-
June	-	1	-	-	-	-	-	-	-	-
October	1	2	1	1	2	1	1	1	1	1
November	-	1	1	-	1	1	-	-	-	-
Total Curb-miles/Year	134.30	542.58			408.28			175.35		
Est. Sweeping	$ 23,100.13	$ 93,324.45			$ 70,224.32			$ 30,160.08		
Est. Phosphorus	158.00	571.90			471.10			221.60		
Average Cost lb/P	$ 146.20	$ 163.18			$ 149.06			$ 136.10		

In summary, the recommended street sweeping schedule(s) would benefit water quality in the City and for downstream water bodies. Sweeping immediately following snowmelt removes accumulated winter pollutants before they can be flushed into sewers by heavy spring rains. Sweeping in the fall removes leaf litter and other organic debris identified as major contributors to nutrient loads in stormwater. An additional sweeping on priority roads during these seasons will further reduce accumulated pollutants in street gutters, such as pollen and seeds in the late spring and leaves that continue blowing/ falling onto roads following the initial autumnal leaf-drop and sweeping.

Lower St. Croix Partnership Funding Available!

The Lower St. Croix Watershed Partnership (LSCWP) has allocated funds to enhance street sweeping operations for interested communities, including increased sweeping in late spring, early summer, and fall in areas with medium to high tree canopy that direct connect and flow to priority water bodies. In this analysis, Option 2 is designed to provide the highest water quality benefit and cost efficiency if the only additional funding used for sweeping, in addition to baseline practices, is the reimbursement funds provided by the LSCWP.

Reimbursement rates will be as follows:

- Tier 1: $100/curb-mile/year (complete the MPCA credit calculator based on curb miles swept and provide the report)
- Tier 2: $125/curb-mile/year (complete the MPCA credit calculator based on the tracking of weights, dates, and provide the report)

To apply for a grant, interested communities can work with their local LSCWP contact. Participating communities will be responsible for implementing their customized enhanced sweeping plan over three years that will include annual incentive payments adding up to (but not to exceeding) $5,000 per year.

References

Anoka Conservation District (ACD). Enhanced Street Sweeping Analysis: Martin and Linwood Lakes. 2023.

Lower St. Croix Watershed Partnership (LSCWP) and Emmons and Oliver Resources Inc. (EOR). Tree Canopy Assessment Protocol for Enhanced Street Sweeping Prioritization. 2022.

Janke, Benjamin D., Jacques C. Finlay, and Sarah E. Hobbie. 2017. Trees and Streets as Drivers of Urban Stormwater Nutrient Pollution. Sci. Technol. DOI: 10.1021/acs.est.7b02225 Environ.

Kalinosky, P., L.A. Baker, S.E. Hobbie, R. Binter, and C. Buyarski. 2014. User Support Manual: Estimating Nutrient Removal by Enhanced Street Sweeping. Minneapolis, MN.

Kalinosky, P.M. 2015. Quantifying Solids and Nutrient Recovered Through Street Sweeping in a Suburban Watershed. A Thesis Submitted to the Faculty of University of Minnesota. Minneapolis, MN.

Appendices

Appendix A: Planning Calculator Monthly Estimates – Example

Monthly Phosphorus Recovery and Cost Estimates for Martin Lake				
Month	Sweeping Events	Phosphorus, lb	Cost, $	$ Cost, lb/P
January	0	0	$ -	$ -
February	0	0	$ -	$ -
March	1	6	$1,011.00	$163.18
April	1	4	$1,011.00	$239.72
May	1	3	$1,011.00	$298.26
June	1	3	$1,011.00	$349.66
July	1	2	$1,011.00	$517.95
August	1	2	$1,011.00	$421.71
September	1	2	$1,011.00	$410.46
October	1	6	$1,011.00	$158.31
November	1	4	$1,011.00	$273.93
December	0	0	$ -	$ -

Appendix B: Planning Calculator Outputs for all Street Sweeping Scenarios (City Streets Only)

Optimal Load Reduction Plan

Zone #	Major Watershed	Zone Curb-Miles	Priority	Baseline Frequency	Cost per Curb-Mile	Baseline sweeping, Curb-Miles	Enhanced Sweeping (Over Baseline)	Enhanced Curb-Miles (Over Baseline)	Total Curb-Miles (Baseline +Enhanced)	Baseline Predicted Solids Removed (lb)	Baseline Predicted Phosporus Removal (lb)	Enhanced Predicted Solids Removed (lb)	Enhanced Predicted Phosporus Removal (lb)	Total Predicted Solids Removed (Baseline + Enhanced, lbs)	Total Predicted Phosporus Removal (Baseline + Enhanced, lbs)	Baseline Cost (2x per year)	Enhanced Cost (Over Baseline)	Total Cost for Enahnced Sweeping + Baseline	Average Cost($)/lb P removed
1	Birch Lake	2.18	Low	2	$ 172.00	4.36	-	-	4.36	5,089	3.3	-	-	5,089	3.3	$ 749.92	$ -	$ 749.92	$ 227.25
2	Neilsen Lake	2.44	Medium	2	$ 172.00	4.88	2	4.88	9.76	4,376	2.7	4,174	2.0	8,550	4.7	$ 839.36	$ 839.36	$ 1,678.72	$ 357.17
3	Bone Lake	9.36	Medium	2	$ 172.00	18.72	2	18.72	37.44	22,822	14.5	21,768	10.8	44,590	25.3	$ 3,219.84	$ 3,219.84	$ 6,439.68	$ 254.53
4	Sea Lake	4.45	Low	2	$ 172.00	8.90	-	-	8.90	9,915	6.2	-	-	9,915	6.2	$ 1,530.80	$ -	$ 1,530.80	$ 246.90
5	First Lake	7.12	Low	2	$ 172.00	14.24	-	-	14.24	13,304	8.3	-	-	13,304	8.3	$ 2,449.47	$ -	$ 2,449.47	$ 295.12
6	Falls Creek (Low)	5.81	Low	2	$ 172.00	11.62	-	-	11.62	10,636	6.6	-	-	10,636	6.6	$ 1,998.64	$ -	$ 1,998.64	$ 302.82
7	FLCLWD	3.70	Low	2	$ 172.00	7.40	-	-	7.40	7,849	4.9	-	-	7,849	4.9	$ 1,272.18	$ -	$ 1,272.18	$ 259.63
8	German Lake	4.14	Low	2	$ 172.00	8.28	-	-	8.28	6,567	4.0	-	-	6,567	4.0	$ 1,424.16	$ -	$ 1,424.16	$ 356.04
9	Bone Lake (Low)	8.03	Low	2	$ 172.00	16.06	-	-	16.06	9,882	6.0	-	-	9,882	6.0	$ 2,762.32	$ -	$ 2,762.32	$ 460.39
10	Goose Lake	6.19	Medium	2	$ 172.00	12.38	2	12.38	24.76	17,347	11.1	16,546	8.3	33,893	19.4	$ 2,129.36	$ 2,129.36	$ 4,258.72	$ 219.52
11	Falls Creek	3.05	Medium	2	$ 172.00	6.09	2	6.09	12.19	18,230	12.3	17,390	9.3	35,620	21.6	$ 1,047.98	$ 1,047.98	$ 2,095.96	$ 97.04
12	Zavorals Creek	3.78	High	2	$ 172.00	7.55	5	18.88	26.44	9,840	6.3	16,776	9.6	26,616	15.9	$ 1,299.14	$ 3,247.86	$ 4,547.00	$ 285.97
13	South Creek	1.71	High	2	$ 172.00	3.43	5	8.56	11.99	8,466	2.6	14,433	11.7	22,899	14.3	$ 589.16	$ 1,472.89	$ 2,062.04	$ 144.20
14	Gilbertsons	3.03	High	2	$ 172.00	6.06	5	15.14	21.20	8,955	5.8	15,267	8.8	24,222	14.6	$ 1,041.60	$ 2,604.01	$ 3,645.62	$ 249.70
15	Clapps Stream	5.42	High	2	$ 172.00	10.84	5	27.10	37.94	18,113	11.8	30,878	18.0	48,991	29.8	$ 1,864.48	$ 4,661.20	$ 6,525.68	$ 218.98
16	Sylvan Lake	1.91	Low	2	$ 172.00	3.82	-	-	3.82	3,970	2.5	-	-	3,970	2.5	$ 657.04	$ -	$ 657.04	$ 262.82
17	Big Marine Lake	19.09	High	2	$ 172.00	38.18	5	95.45	133.63	120,836	82.2	205,997	126.0	326,833	208.2	$ 6,566.96	$ 16,417.40	$ 22,984.36	$ 110.40
18	Fish Lake	4.76	Medium	2	$ 172.00	9.51	2	9.51	19.03	17,478	11.4	16,672	8.6	34,150	20.0	$ 1,636.39	$ 1,636.39	$ 3,272.79	$ 163.64
19	Jellums Lake	6.53	Medium	2	$ 172.00	13.06	2	13.06	26.12	50,517	34.8	48,186	26.1	98,703	60.9	$ 2,246.32	$ 2,246.32	$ 4,492.64	$ 73.77
20	Long Lake (Scandia)	2.05	Medium	2	$ 172.00	4.10	2	4.10	8.20	7,137	4.6	6,808	3.5	13,945	8.1	$ 705.20	$ 705.20	$ 1,410.40	$ 174.12
21	Hay Lake	2.23	Low	2	$ 172.00	4.46	-	-	4.46	2,518	1.5	-	-	2,518	1.5	$ 767.12	$ -	$ 767.12	$ 511.41
22	Sand Lake	10.12	Low	2	$ 172.00	20.24	-	-	20.24	14,851	9.1	-	-	14,851	9.1	$ 3,481.28	$ -	$ 3,481.28	$ 382.56
23	Swedish Flag	4.75	High	2	$ 172.00	9.50	5	23.75	33.25	18,546	12.2	31,617	18.7	50,163	30.9	$ 1,633.81	$ 4,084.54	$ 5,718.35	$ 185.06
24	St. Croix River	0.43	High	2	$ 172.00	0.87	5	2.16	3.03	4,133	2.9	7,045	4.4	11,178	7.3	$ 148.90	$ 372.26	$ 521.16	$ 71.39
25	Lake Alice	2.84	High	2	$ 172.00	5.67	5	14.18	19.86	18,349	12.5	31,279	19.2	49,628	31.7	$ 975.83	$ 2,439.58	$ 3,415.41	$ 107.74
26	closed basin - New Scandia	0.52	Low	2	$ 172.00	1.03	-	-	1.03	748	0.5	-	-	748	0.5	$ 177.51	$ -	$ 177.51	$ 355.02
27	Mill Stream	0.97	Low	2	$ 172.00	1.94	-	-	1.94	752	0.4	-	-	752	0.4	$ 333.23	$ -	$ 333.23	$ 833.06
28	Big Marine Lake (Low)	7.71	Low	2	$ 172.00	15.42	-	-	15.42	9,764	5.9	-	-	9,764	5.9	$ 2,652.24	$ -	$ 2,652.24	$ 449.53
		134.30				268.61		273.98	542.58	440,990	286.9	484,836	285.0	925,826	571.9	$ 46,200.26	$ 47,124.19	$ 93,324.45	$ 163.18

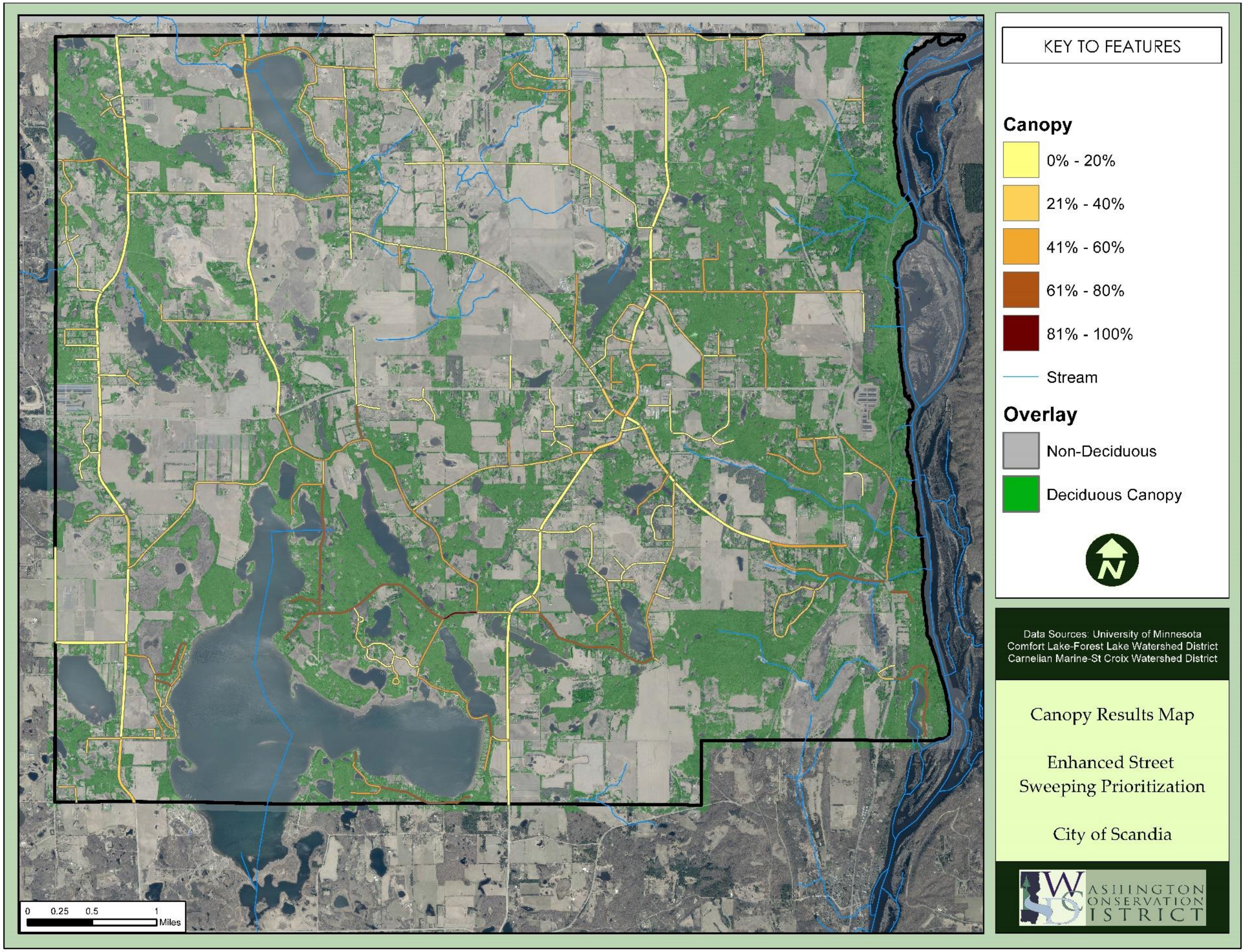
Option #1

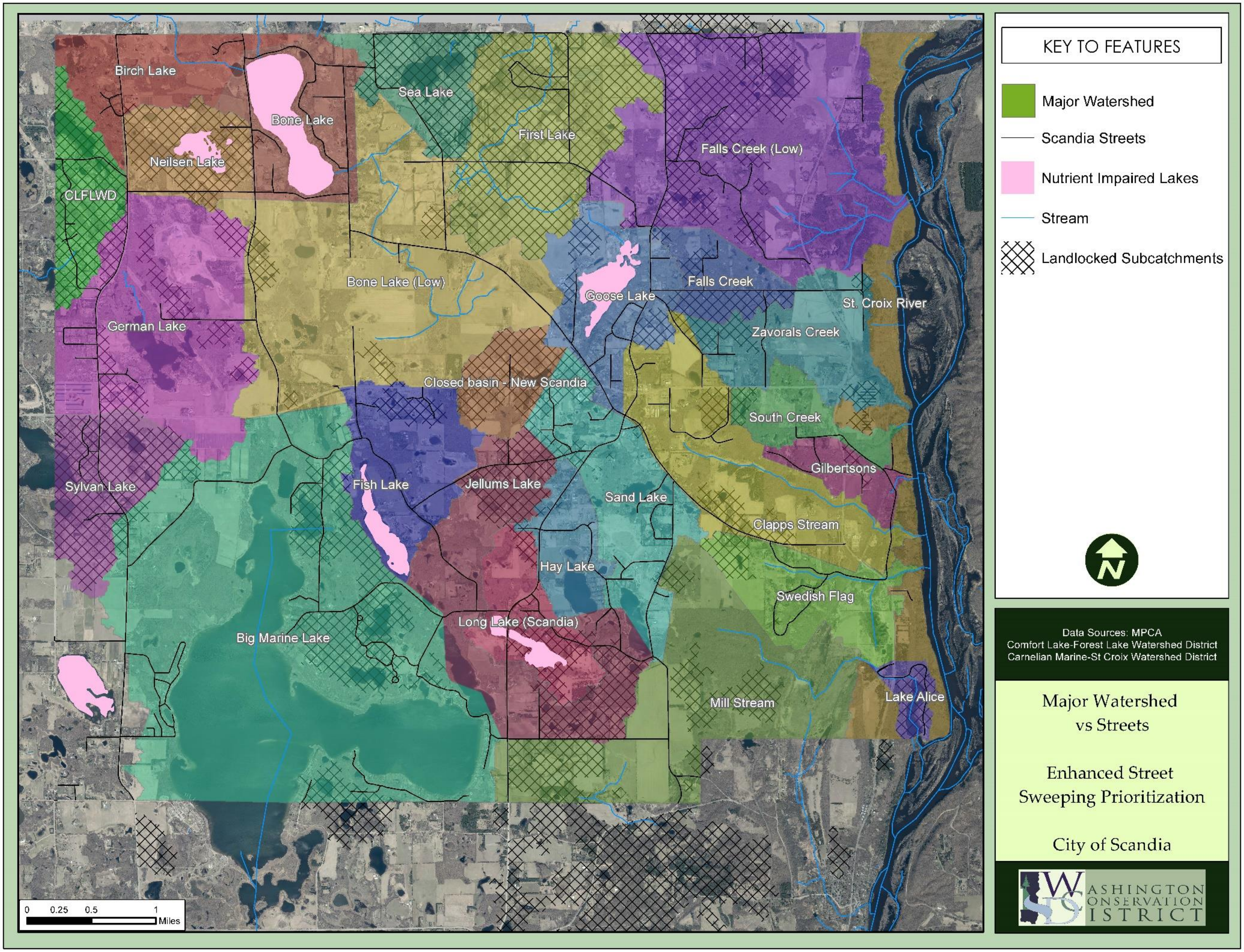
Zone #:	Major Watershed	Zone Curb-Miles	Priority	Baseline Frequency	Cost per Curb-Mile	Baseline sweeping, Curb-Miles	Enhanced Sweeping (Over Baseline)	Enhanced Curb-Miles (Over Baseline)	Total Curb-Miles (Baseline +Enhanced)	Baseline Predicted Solids Removed (lb)	Baseline Predicted Phosporus Removal (lb)	Enhanced Predicted Solids Removed (lb)	Enhanced Predicted Phosporus Removal (lb)	Total Predicted Solids Removed (Baseline + Enhanced, lbs)	Total Predicted Phosporus Removal (Baseline + Enhanced, lbs)	Baseline Cost (2x per year)	Enhanced Cost (Over Baseline)	Total Cost for Enahnced Sweeping + Baseline	Average Cost($)/lb P removed
1	Birch Lake	2.18	Low	1	$ 172.00	2.18	-	-	2.18	2,497	2.0	-	-	2,497	2.0	$ 374.96	$ -	$ 374.96	$ 187.48
2	Neilsen Lake	2.44	Medium	1	$ 172.00	2.44	2	4.88	7.32	1,925	1.5	3,854	2.1	5,779	3.6	$ 419.68	$ 839.36	$ 1,259.04	$ 349.73
3	Bone Lake	9.36	Medium	1	$ 172.00	9.36	2	18.72	28.08	10,039	7.9	20,098	11.1	30,137	19.0	$ 1,609.92	$ 3,219.84	$ 4,829.76	$ 254.20
4	Sea Lake	4.45	Low	1	$ 172.00	4.45	-	-	4.45	4,362	3.4	-	-	4,362	3.4	$ 765.40	$ -	$ 765.40	$ 225.12
5	First Lake	7.12	Low	1	$ 172.00	7.12	-	-	7.12	5,852	4.5	-	-	5,852	4.5	$ 1,224.74	$ -	$ 1,224.74	$ 272.16
6	Falls Creek (Low)	5.81	Low	1	$ 172.00	5.81	-	-	5.81	4,679	3.6	-	-	4,679	3.6	$ 999.32	$ -	$ 999.32	$ 277.59
7	FLCLWD	3.70	Low	1	$ 172.00	3.70	-	-	3.70	3,453	2.7	-	-	3,453	2.7	$ 636.09	$ -	$ 636.09	$ 235.59
8	German Lake	4.14	Low	1	$ 172.00	4.14	-	-	4.14	2,889	2.2	-	-	2,889	2.2	$ 712.08	$ -	$ 712.08	$ 323.67
9	Bone Lake (Low)	8.03	Low	1	$ 172.00	8.03	-	-	8.03	4,347	3.2	-	-	4,347	3.2	$ 1,381.16	$ -	$ 1,381.16	$ 431.61
10	Goose Lake	6.19	Medium	1	$ 172.00	6.19	2	12.38	18.57	7,631	6.1	15,276	8.5	22,907	14.6	$ 1,064.68	$ 2,129.36	$ 3,194.04	$ 218.77
11	Falls Creek	3.05	Medium	1	$ 172.00	3.05	2	6.09	9.14	8,020	6.7	16,054	9.5	24,074	16.2	$ 523.99	$ 1,047.98	$ 1,571.97	$ 97.04
12	Zavorals Creek	3.78	High	1	$ 172.00	3.78	5	18.88	22.66	4,329	3.4	19,891	11.0	24,220	14.4	$ 649.57	$ 3,247.86	$ 3,897.43	$ 270.65
13	South Creek	1.71	High	1	$ 172.00	1.71	5	8.56	10.28	3,724	3.1	17,114	9.8	20,838	12.9	$ 294.58	$ 1,472.89	$ 1,767.47	$ 137.01
14	Gilbertsons	3.03	High	1	$ 172.00	3.03	5	15.14	18.17	3,940	3.1	18,102	10.1	22,042	13.2	$ 520.80	$ 2,604.01	$ 3,124.81	$ 236.73
15	Clapps Stream	5.42	High	1	$ 172.00	5.42	5	27.10	32.52	7,968	6.4	36,613	20.5	44,581	26.9	$ 932.24	$ 4,661.20	$ 5,593.44	$ 207.93
16	Sylvan Lake	1.91	Low	1	$ 172.00	1.91	-	-	1.91	1,746	1.4	-	-	1,746	1.4	$ 328.52	$ -	$ 328.52	$ 234.66
17	Big Marine Lake	19.09	High	1	$ 172.00	19.09	5	95.45	114.54	53,156	44.8	244,256	143.2	297,412	188.0	$ 3,283.48	$ 16,417.40	$ 19,700.88	$ 104.79
18	Fish Lake	4.76	Medium	1	$ 172.00	4.76	2	9.51	14.27	7,689	6.2	15,391	8.8	23,080	15.0	$ 818.20	$ 1,636.39	$ 2,454.59	$ 163.64
19	Jellums Lake	6.53	Medium	1	$ 172.00	6.53	2	13.06	19.59	22,222	19.0	44,487	26.8	66,709	45.8	$ 1,123.16	$ 2,246.32	$ 3,369.48	$ 73.57
20	Long Lake (Scandia)	2.05	Medium	1	$ 172.00	2.05	2	4.10	6.15	3,140	2.5	6,285	3.6	9,425	6.1	$ 352.60	$ 705.20	$ 1,057.80	$ 173.41
21	Hay Lake	2.23	Low	1	$ 172.00	2.23	-	-	2.23	1,108	0.8	-	-	1,108	0.8	$ 383.56	$ -	$ 383.56	$ 479.45
22	Sand Lake	10.12	Low	1	$ 172.00	10.12	-	-	10.12	6,533	4.9	-	-	6,533	4.9	$ 1,740.64	$ -	$ 1,740.64	$ 355.23
23	Swedish Flag	4.75	High	1	$ 172.00	4.75	5	23.75	28.50	8,159	6.6	37,489	21.3	45,648	27.9	$ 816.91	$ 4,084.54	$ 4,901.44	$ 175.68
24	St. Croix River	0.43	High	1	$ 172.00	0.43	5	2.16	2.60	1,818	1.6	8,354	5.0	10,172	6.6	$ 74.45	$ 372.26	$ 446.71	$ 67.68
25	Lake Alice	2.84	High	1	$ 172.00	2.84	5	14.18	17.02	8,072	6.8	37,089	21.8	45,161	28.6	$ 487.92	$ 2,439.58	$ 2,927.50	$ 102.36
26	closed basin - New Scandia	0.52	Low	1	$ 172.00	0.52	-	-	0.52	329	0.2	-	-	329	0.2	$ 88.76	$ -	$ 88.76	$ 443.78
27	Mill Stream	0.97	Low	1	$ 172.00	0.97	-	-	0.97	331	0.2	-	-	331	0.2	$ 166.61	$ -	$ 166.61	$ 833.06
28	Big Marine Lake (Low)	7.71	Low	1	$ 172.00	7.71	-	-	7.71	4,295	3.2	-	-	4,295	3.2	$ 1,326.12	$ -	$ 1,326.12	$ 414.41
		134.30				134.30		273.98	408.28	194,253	158.0	540,353	313.1	734,606	471.1	$ 23,100.13	$ 47,124.19	$ 70,224.32	$ 149.06

Option #2

Zone #:	Major Watershed	Zone Curb-Miles	Priority	Baseline Frequency	Cost per Curb-Mile	Baseline sweeping, Curb-Miles	Enhanced Sweeping (Over Baseline)	Enhanced Curb-Miles (Over Baseline)	Total Curb-Miles (Baseline +Enhanced)	Baseline Predicted Solids Removed (lb)	Baseline Predicted Phosporus Removal (lb)	Enhanced Predicted Solids Removed (lb)	Enhanced Predicted Phosporus Removal (lb)	Total Predicted Solids Removed (Baseline + Enhanced, lbs)	Total Predicted Phosporus Removal (Baseline + Enhanced, lbs)	Baseline Cost (2x per year)	Enhanced Cost (Over Baseline)	Total Cost for Enahnced Sweeping + Baseline	Average Cost($)/lb P removed
1	Birch Lake	2.18	Low	1	$ 172.00	2.18	-	-	2.18	2,497	2.0	-	-	2,497	2.0	$ 374.96	$ -	$ 374.96	$ 187.48
2	Neilsen Lake	2.44	Medium	1	$ 172.00	2.44	-	-	2.44	1,925	1.5	-	-	1,925	1.5	$ 419.68	$ -	$ 419.68	$ 279.79
3	Bone Lake	9.36	Medium	1	$ 172.00	9.36	-	-	9.36	10,039	7.9	-	-	10,039	7.9	$ 1,609.92	$ -	$ 1,609.92	$ 203.79
4	Sea Lake	4.45	Low	1	$ 172.00	4.45	-	-	4.45	4,362	3.4	-	-	4,362	3.4	$ 765.40	$ -	$ 765.40	$ 225.12
5	First Lake	7.12	Low	1	$ 172.00	7.12	-	-	7.12	5,852	4.5	-	-	5,852	4.5	$ 1,224.74	$ -	$ 1,224.74	$ 272.16
6	Falls Creek (Low)	5.81	Low	1	$ 172.00	5.81	-	-	5.81	4,679	3.6	-	-	4,679	3.6	$ 999.32	$ -	$ 999.32	$ 277.59
7	CLFLWD	3.70	Low	1	$ 172.00	3.70	-	-	3.70	3,453	2.7	-	-	3,453	2.7	$ 636.09	$ -	$ 636.09	$ 235.59
8	German Lake	4.14	Low	1	$ 172.00	4.14	-	-	4.14	2,889	2.2	-	-	2,889	2.2	$ 712.08	$ -	$ 712.08	$ 323.67
9	Bone Lake (Low)	8.03	Low	1	$ 172.00	8.03	-	-	8.03	4,347	3.2	-	-	4,347	3.2	$ 1,381.16	$ -	$ 1,381.16	$ 431.61
10	Goose Lake	6.19	Medium	1	$ 172.00	6.19	-	-	6.19	7,631	6.1	-	-	7,631	6.1	$ 1,064.68	$ -	$ 1,064.68	$ 174.54
11	Falls Creek	3.05	Medium	1	$ 172.00	3.05	-	-	3.05	8,020	6.7	-	-	8,020	6.7	$ 523.99	$ -	$ 523.99	$ 78.21
12	Zavorals Creek	3.78	High	1	$ 172.00	3.78	1	3.78	7.55	4,329	3.4	5,511	2.9	9,840	6.3	$ 649.57	$ 649.57	$ 1,299.14	$ 206.21
13	South Creek	1.71	High	1	$ 172.00	1.71	1	1.71	3.43	3,724	3.1	4,742	2.6	8,466	5.7	$ 294.58	$ 294.58	$ 589.16	$ 103.36
14	Gilbertsons	3.03	High	1	$ 172.00	3.03	1	3.03	6.06	3,940	3.1	5,015	2.7	8,955	5.8	$ 520.80	$ 520.80	$ 1,041.60	$ 179.59
15	Clapps Stream	5.42	High	1	$ 172.00	5.42	1	5.42	10.84	7,968	6.4	10,145	5.4	18,113	11.8	$ 932.24	$ 932.24	$ 1,864.48	$ 158.01
16	Sylvan Lake	1.91	Low	1	$ 172.00	1.91	-	-	1.91	1,746	1.4	-	-	1,746	1.4	$ 328.52	$ -	$ 328.52	$ 234.66
17	Big Marine Lake (High)	19.09	High	1	$ 172.00	19.09	1	19.09	38.18	53,156	44.8	67,680	37.4	120,836	82.2	$ 3,283.48	$ 3,283.48	$ 6,566.96	$ 79.89
18	Fish Lake	4.76	Medium	1	$ 172.00	4.76	-	-	4.76	7,689	6.2	-	-	7,689	6.2	$ 818.20	$ -	$ 818.20	$ 131.97
19	Jellums Lake	6.53	Medium	1	$ 172.00	6.53	-	-	6.53	22,222	19.0	-	-	22,222	19.0	$ 1,123.16	$ -	$ 1,123.16	$ 59.11
20	Long Lake (Scandia)	2.05	Medium	1	$ 172.00	2.05	-	-	2.05	3,140	2.5	-	-	3,140	2.5	$ 352.60	$ -	$ 352.60	$ 141.04
21	Hay Lake	2.23	Low	1	$ 172.00	2.23	-	-	2.23	1,108	0.8	-	-	1,108	0.8	$ 383.56	$ -	$ 383.56	$ 479.45
22	Sand Lake	10.12	Low	1	$ 172.00	10.12	-	-	10.12	6,533	4.9	-	-	6,533	4.9	$ 1,740.64	$ -	$ 1,740.64	$ 355.23
23	Swedish Flag	4.75	High	1	$ 172.00	4.75	1	4.75	9.50	8,159	6.6	10,387	5.6	18,546	12.2	$ 816.91	$ 816.91	$ 1,633.81	$ 133.92
24	St. Croix River	0.43	High	1	$ 172.00	0.43	1	0.43	0.87	1,818	1.6	2,315	1.3	4,133	2.9	$ 74.45	$ 74.45	$ 148.90	$ 51.35
25	Lake Alice	2.84	High	1	$ 172.00	2.84	1	2.84	5.67	8,072	6.8	10,277	5.7	18,349	12.5	$ 487.92	$ 487.92	$ 975.83	$ 78.07
26	closed basin - New Scandia	0.52	Low	1	$ 172.00	0.52	-	-	0.52	329	0.2	-	-	329	0.2	$ 88.76	$ -	$ 88.76	$ 443.78
27	Mill Stream	0.97	Low	1	$ 172.00	0.97	-	-	0.97	331	0.2	-	-	331	0.2	$ 166.61	$ -	$ 166.61	$ 833.06
28	Big Marine Lake (Low)	7.71	Low	1	$ 172.00	7.71	-	-	7.71	4,295	3.2	-	-	4,295	3.2	$ 1,326.12	$ -	$ 1,326.12	$ 414.41
		134.30				134.30		41.05	175.35	194,253	158.0	116,072	63.6	310,325	221.6	$ 23,100.13	$ 7,059.95	$ 30,160.08	$ 136.10

Appendix C: Additional Maps




KEY TO FEATURES
Major Watershed
Scandia Streets
Nutrient Impaired Lakes
Stream
Landlocked Subcatchments
Data Sources: MPCA
Comfort Lake-Forest Lake Watershed District
Carnelian Marine-St Croix Watershed District
Major Watershed
vs Streets
Enhanced Street
Sweeping Prioritization
City of Scandia
Washington Conservation District
Birch Lake
Bone Lake
Sea Lake
First Lake
Falls Creek (Low)
Neilsen Lake
CLFLWD
Bone Lake (Low)
Goose Lake
Falls Creek
St. Croix River
German Lake
Zavorals Creek
Closed basin - New Scandia
South Creek
Gilbertsons
Sylvan Lake
Fish Lake
Jellums Lake
Sand Lake
Clapps Stream
Hay Lake
Swedish Flag
Long Lake (Scandia)
Big Marine Lake
Mill Stream
Lake Alice
0 0.25 0.5 1
Miles