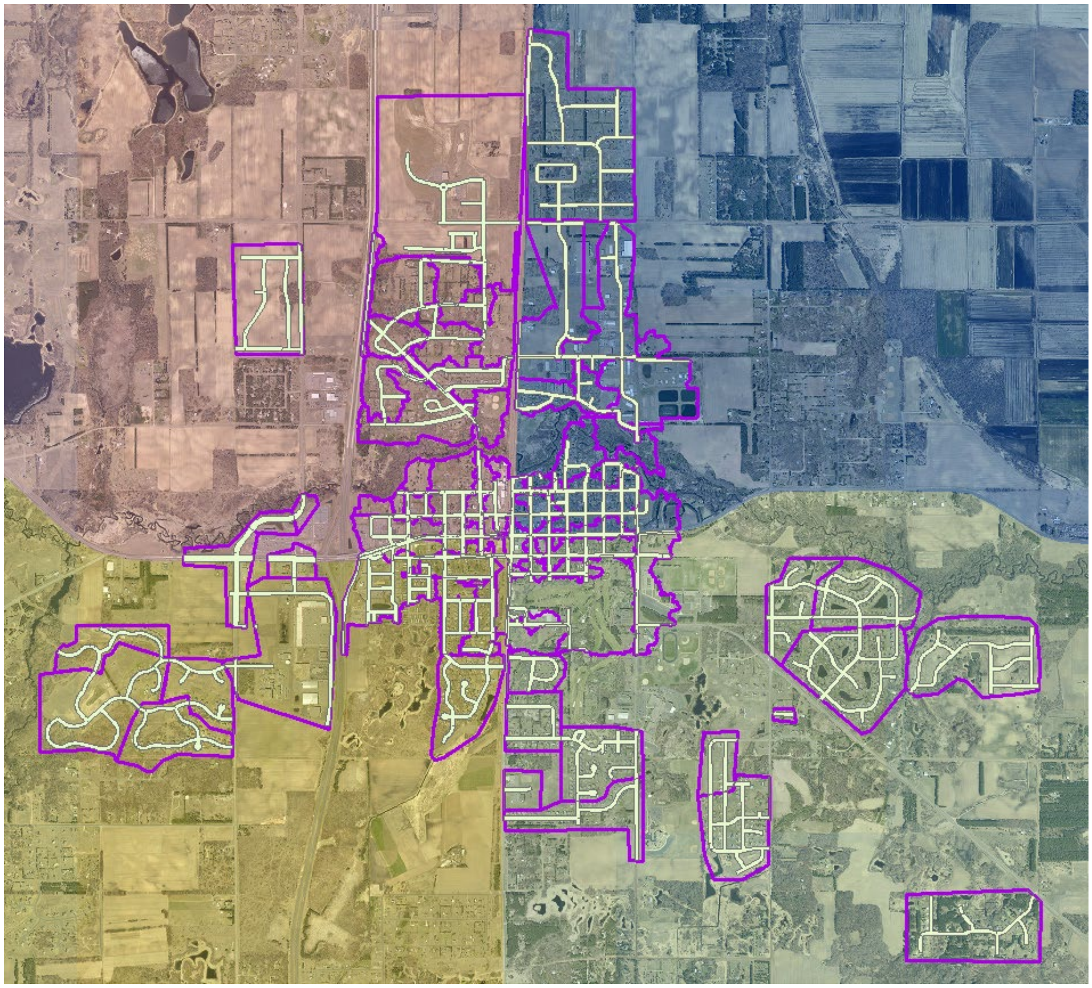
City of North Branch Enhanced Street Sweeping Analysis



Report Prepared for the City of North Branch by

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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.

An enhanced street sweeping analysis was completed for residential areas draining directly to the North Branch of the Sunrise River; this stream is on the State impaired waters list and a priority for improvement in local water plans. The City of North Branch currently sweeps most intersections as well as whole neighborhoods with storm sewers. However, the well-established neighborhoods contain high quantities of mature trees and 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 streets in the North Branch of the Sunrise River watershed.

Methods

Study Areas

All areas within the developed area of North Branch were evaluated. After reviewing aerial photos and storm drain data, areas were divided into groups to continue analysis. For the remainder of the study, areas that were included had the following attributes: curb and gutter conveyance, storm drain systems, pavement, and connection to surface water. Streets without these attributes were not included and are not suitable or recommended for enhanced street sweeping.

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 % coverage) was quantified by visual assessment. Altogether, these processes allowed for canopy cover comparisons within the study areas (see *Appendix B* for map), 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 (see *Appendix C* for stormwater infrastructure maps). These features were mapped and considered alongside tree canopy information to further gauge stormwater connectivity to the North Branch of the Sunrise River (NBSR).

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 the NBSR:

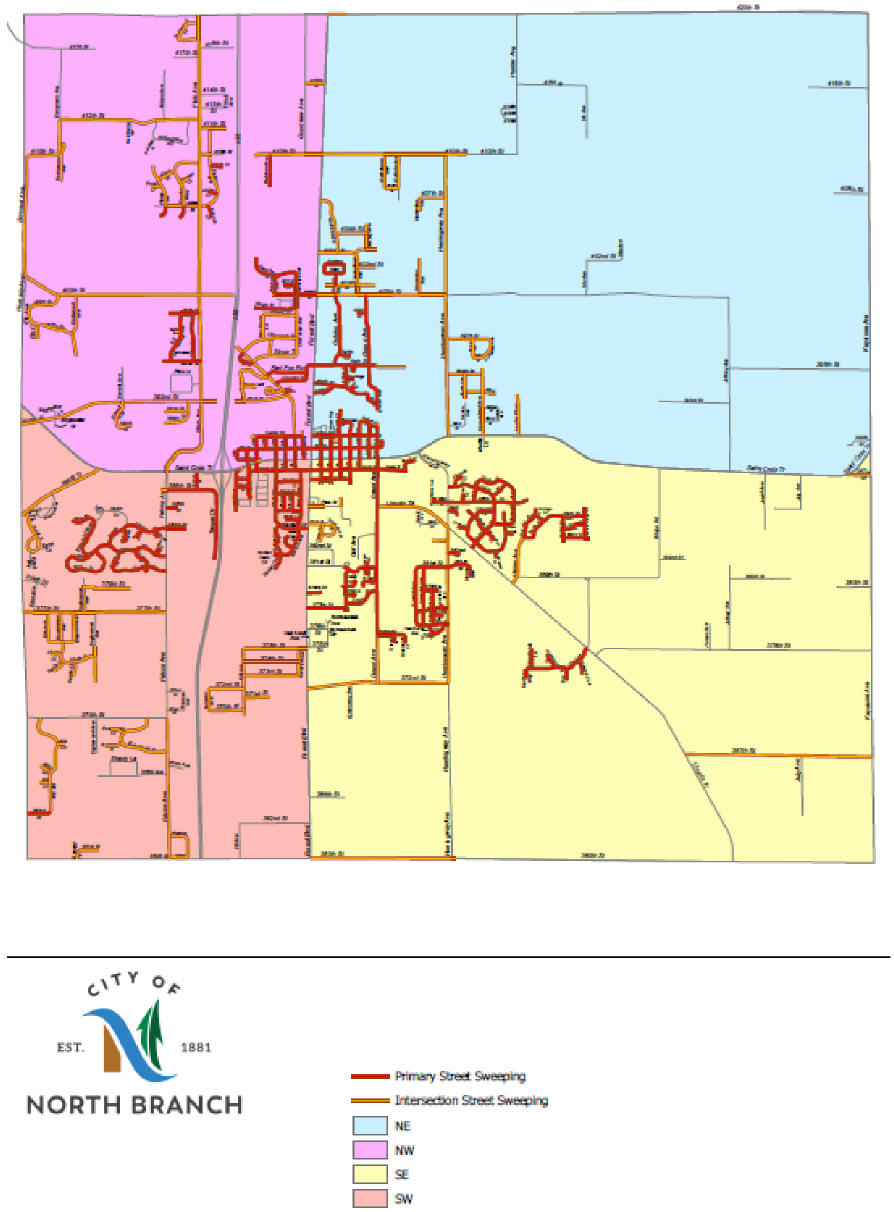
1. **Not Recommended:** Paved roadways/ segments of roadways confirmed to fall outside of the subwatershed boundaries with no connection to the NBSR through storm sewer networks. These were not included in subsequent load recovery and cost estimates.
2. **Low Priority:** Paved roadways/ segments of roadways lying within priority subwatershed boundaries, but not directly connected to a stormwater BMP and/or storm sewer outfall; often, these streets drain to and through upland or wetland areas adjacent to the river.
3. **Recommended:** Paved roadways/ segments of roadways located within priority subwatershed boundaries and draining directly to a BMP and/or storm sewer outfall into the NBSR.

Sweeping Schedules, Routes, and Scenarios

The City of North Branch has a robust sweeping program that they follow throughout the year. The Primary street sweeping roads (shown in red below) are swept monthly– these roads are swept entirely. The Intersection Street Sweeping Roads (shown in orange below) are swept at intersections once in the spring and then as needed – this helps reduce the amount of debris that reaches the storm drains as the largest concentrations of debris is found at these intersections for these road stretches.

Four street sweeping schedules were developed: one which reflects current practice (one sweeping per month), the others are described in the table below (*Table 1*). The two enhanced schedules were developed using data, recommendations, and a planning calculator tool described in the street sweeping guidance manual (Kalinosky et al., 2014).

Street Sweeping



Due to the many miles of paved streets within the City of North Branch, a few different scenarios are presented for the City to choose from.

Sweeping Schedule	Sweeping Frequency &Timing
Existing Practice for Curb and Gutter	1X Per Month March/April-November
Enhanced Sweeping: Option 1	High Priority Roads - 1X March, 1X May, 1X October, 1X November
Enhanced Sweeping: Option 2	High + Medium Priority Roads – 1X March/April, 1X October
Enhanced Sweeping: Option 3	All High + Medium Priority Roads 1X March/April. All high Priority Roads 1X October
Enhanced Sweeping: Option 4	All Roads - 1X March/April

Table 1: Street sweeping schedules compared in priority subwatersheds.

Cost and Pollutant Recovery Estimates

Pollutant load recovery, cost, and cost effectiveness estimates for the sweeping scenarios, routes, and schedules were compared using the planning calculator tool produced by Kalinosky and others (2014). 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 $100 per curb mile was then 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 routes and schedules. Planning calculators were not calibrated with data from water quality sampling or laboratory analyses of recovered street materials from the study areas.

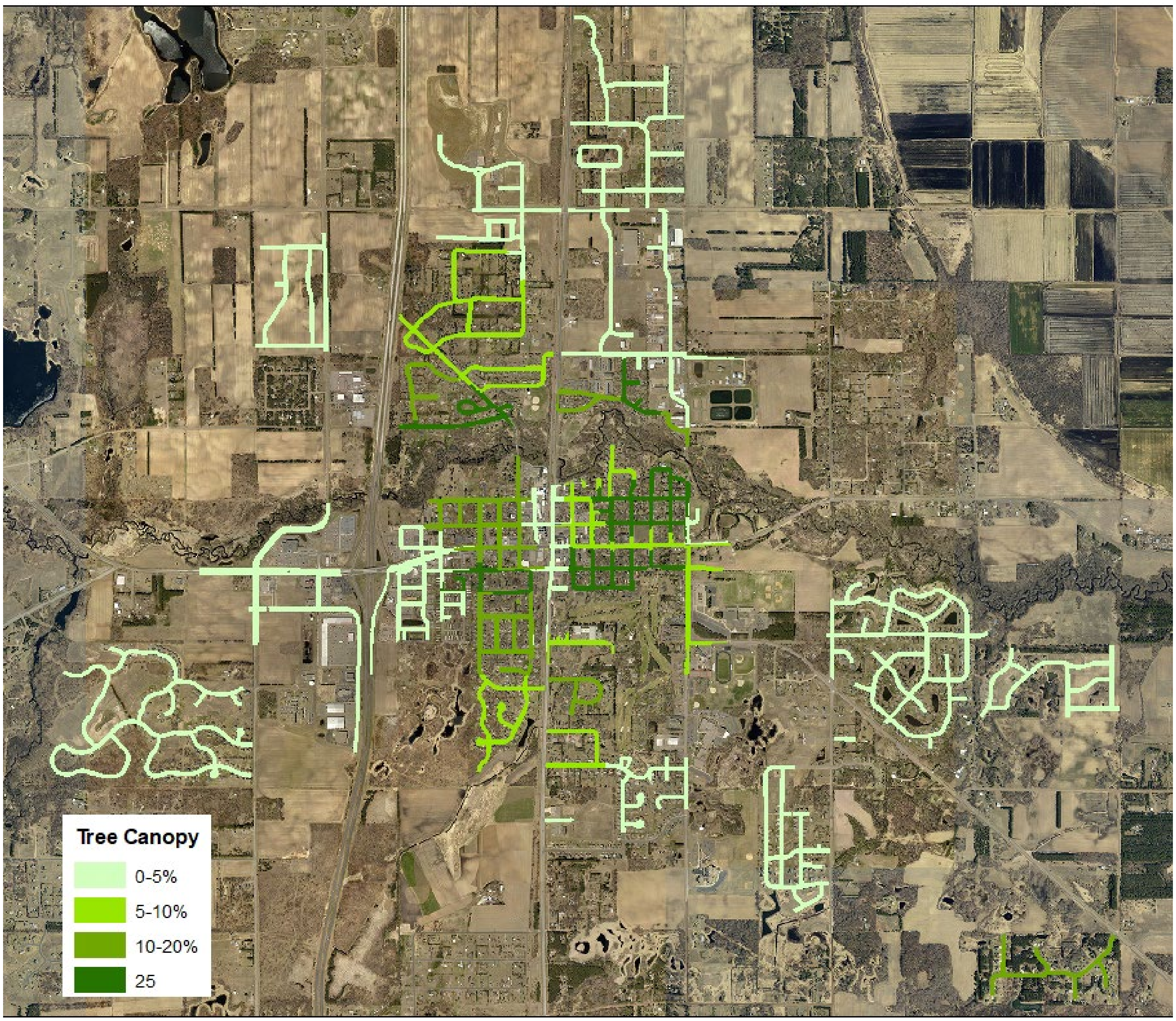
Findings and Recommendations

Streets Assessed and Classified

In total, 87.2 miles of candidate streets were evaluated. Of this, 10.2 curb miles are identified as high priority streets and are recommended for enhanced street sweeping, 24.3 curb miles are identified as medium priority options for enhanced sweeping, and 52.7 miles were determined to be low priority sweeping options and are therefore not recommended for enhanced sweeping.

Canopy Cover

Tree canopy cover for street segments ranged from 0% in newly developed areas to well over 25% in well-established/older neighborhoods. About 60% of the paved city streets have less than 5% canopy coverage.



Load Recovery and Cost Estimates

March and October are the most cost-effective times to complete street sweeping, followed by other months in the spring and fall (*Appendix D*). Current street sweeping practices (1X per month March/April through November, depending on weather), on all paved and curb & gutter roads in the City, yield a combined phosphorus recovery rate of approximately 122 lbs/year at an average cost of $574/ lb P (*Table 2*).

By completing sweeping on all High Priority streets 2 additional times per year (March and October) plus one additional time in March on all Medium Priority Streets, it is estimated that an additional 25 pounds of phosphorus will be kept out of the North Branch of the Sunrise River each year from these efforts.

Table 2. Load recovery and cost estimates for existing sweeping practices in the priority watersheds [1]

Existing Street Sweeping								
	Average Canopy Cover	Curb Miles	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Avg $/lb P
All Streets March-November	5%	785	225,511	175,210	597.5	121.5	$69,760	$ 574

Table 3. Load recovery and cost estimates for enhanced sweeping scenario ("Option 1") in the priority watersheds [1]

Enhanced Street Sweeping: Option 1								
	Average Canopy Cover	Curb Miles	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Avg $/lb P
High Priority Streets 4X per year	25%	40.8	41,761	28,087	193.7	23.4	$4,080	$174

Table 4. Load recovery and cost estimates for enhanced sweeping scenario ("Option 2") in the priority watersheds [1]

Enhanced Street Sweeping: Option 2								
	Average Canopy Cover	Curb Miles	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Avg $/lb P
High + Med Priority Streets 2X per year	15%	69.0	56,477	39,612	176.7	31.4	$6,900	$220

Table 5. Load recovery and cost estimates for enhanced sweeping scenario ("Option 3") in the priority watersheds [1]

Enhanced Street Sweeping: Option 3								
	Average Canopy Cover	Curb Miles	Wet solids, lb	Dry solids, lb	Nitrogen, lb	Phosphorus, lb	Cost, $	Avg $/lb P
High Priority Streets 2X + Med Priority 1X per year	15%	44.7	50,052	36.365	139.0	25.0	$4,470	$179

[1]Pollutant recovery values are derived from the street sweeping planning calculator and represent the total load that is predicted to be removed from the streets annually. Values do not represent load reductions to priority rivers.

Recommendations

To maximize cost effectiveness for phosphorus removal, street sweeping twice per year – once in the spring following snowmelt (March or April), and again in the fall (October) – is recommended for all High Priority streets with direct drainage to the North Branch of the Sunrise River should be swept 2 additional times per year (March/April and October) plus all Medium Priority streets should be swept 1 additional time in March/April. If more funding were to be available, the additional recommendation would be to add a second sweeping on the Medium Priority Streets in October. This would cost an additional $2,430 above the $4,470 for Option 3. The total cost of the recommended enhanced sweeping plan (Option 3) would be approximately $4,470.

The proposed street sweeping schedule(s) would benefit water quality in the North Branch of the Sunrise River by reducing pollutant loads in the stormwater that enters them. 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 blow/ fall onto roads following the initial autumnal leaf-drop.

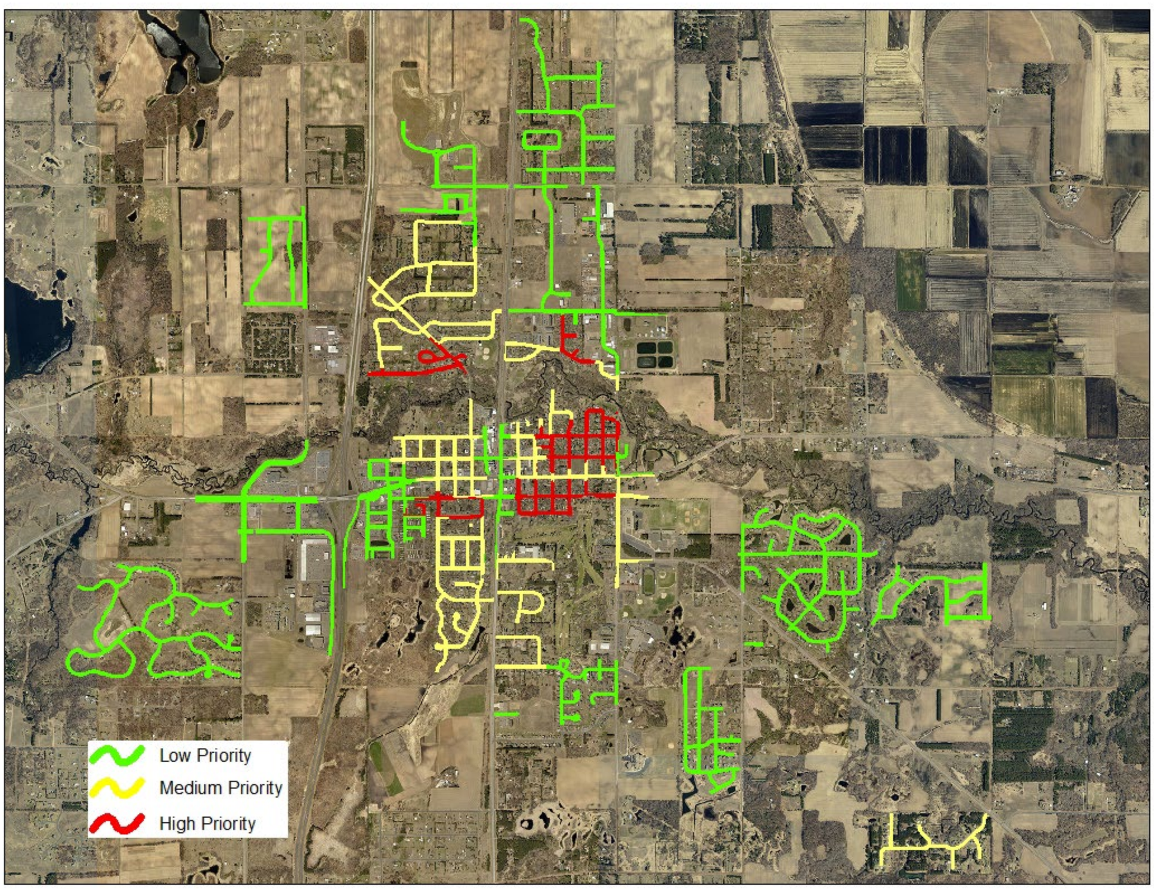


Figure 4. Proposed street sweeping routes for North Branch. A spring and fall sweeping is recommended for all High Priority streets plus an additional spring sweeping in the spring on Medium priority streets.

References

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

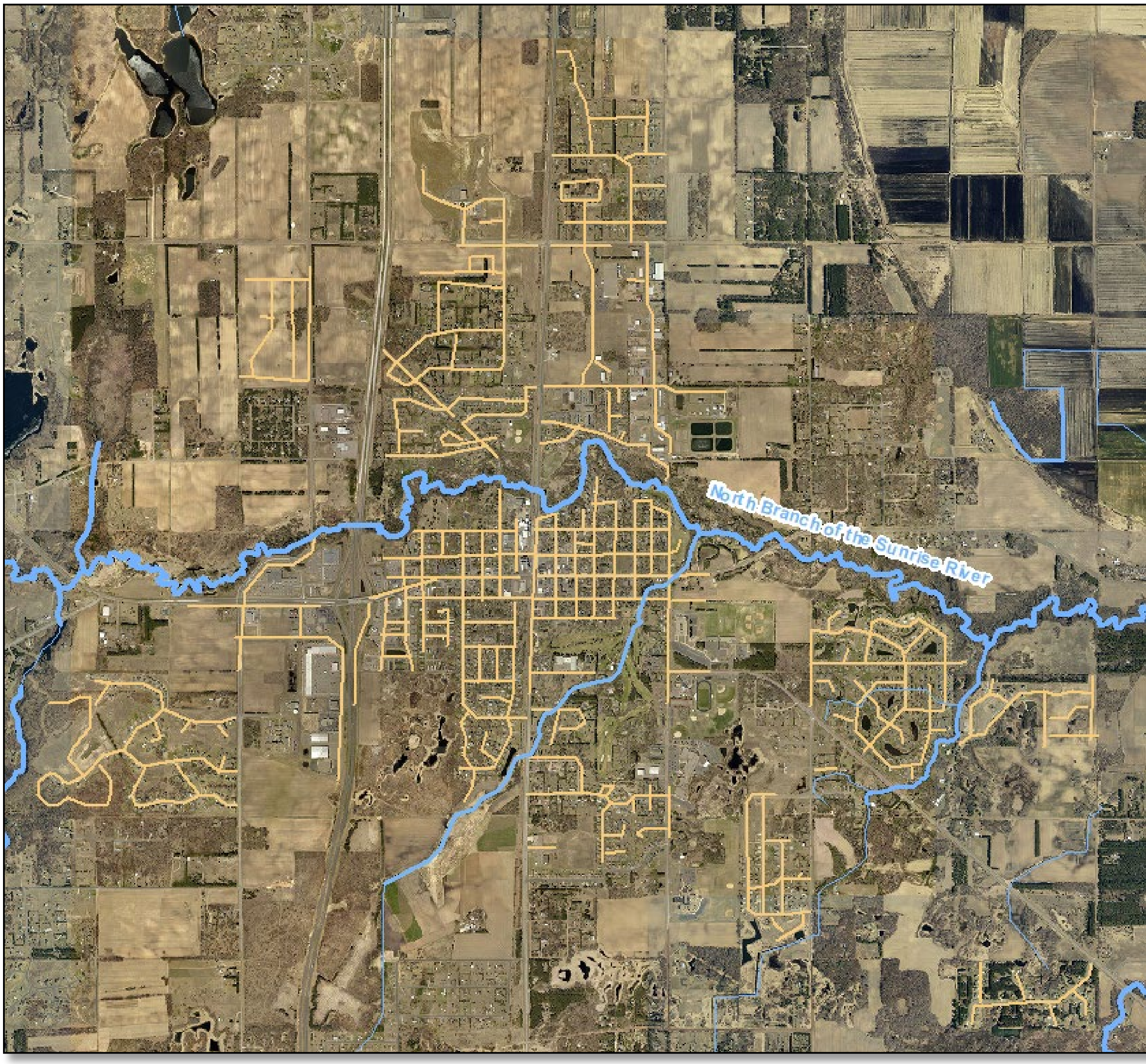
Janke, Benjamin D., Jacques C. Finlay, and Sarah E. Hobbie. 2017. Trees and Streets as Drivers of Urban Stormwater Nutrient Pollution. Sci. Technol. DOI: 10.1021/acs.est.7b02225 Environ.

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.

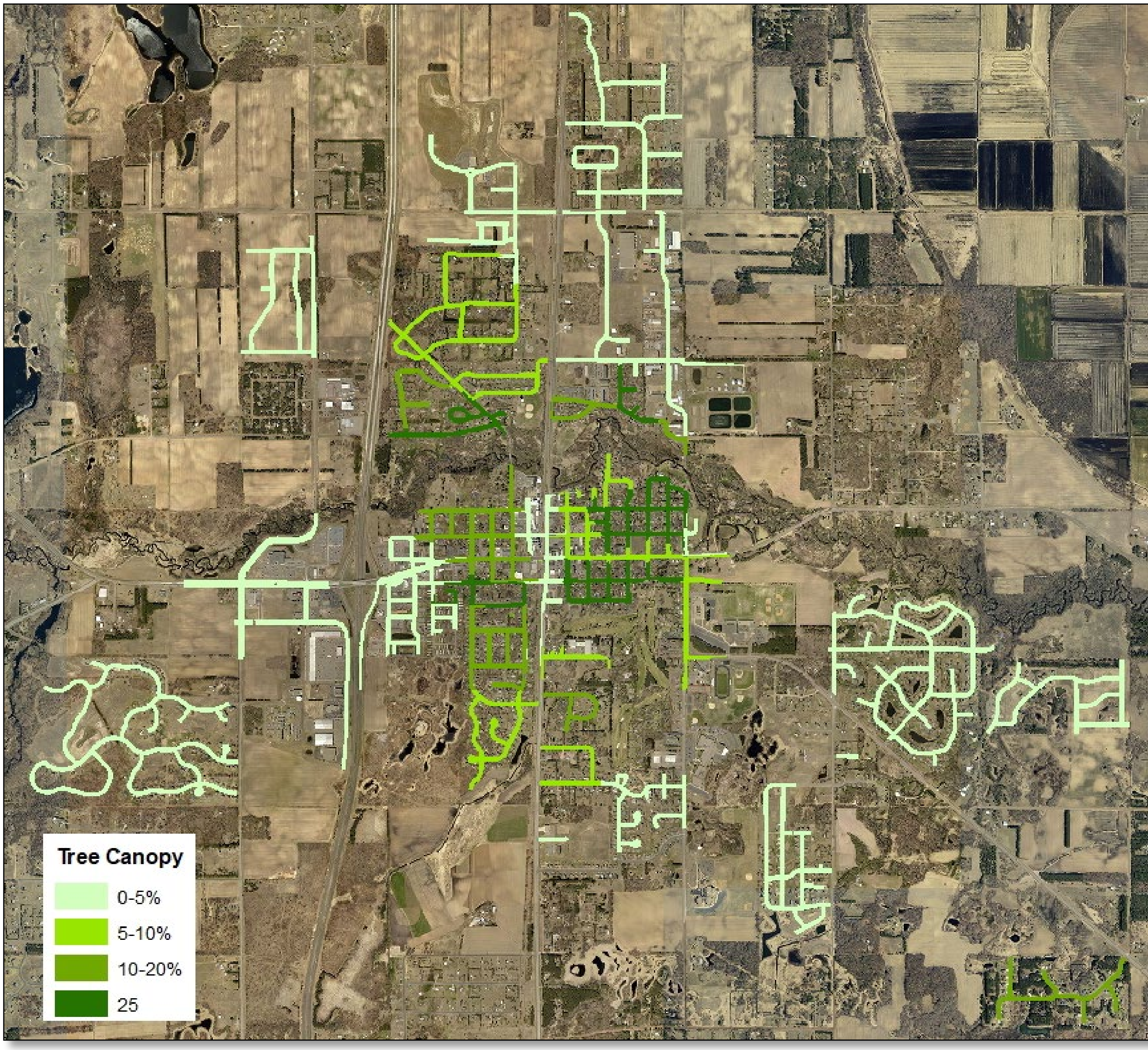
Kalinosky, P.M. 2015. Quantifying Solids and Nutrient Recovered Through Street Sweeping in a Suburban Watershed. A Thesis Submitted to the Faculty of University of Minnesota. Minneapolis, MN.

Appendices

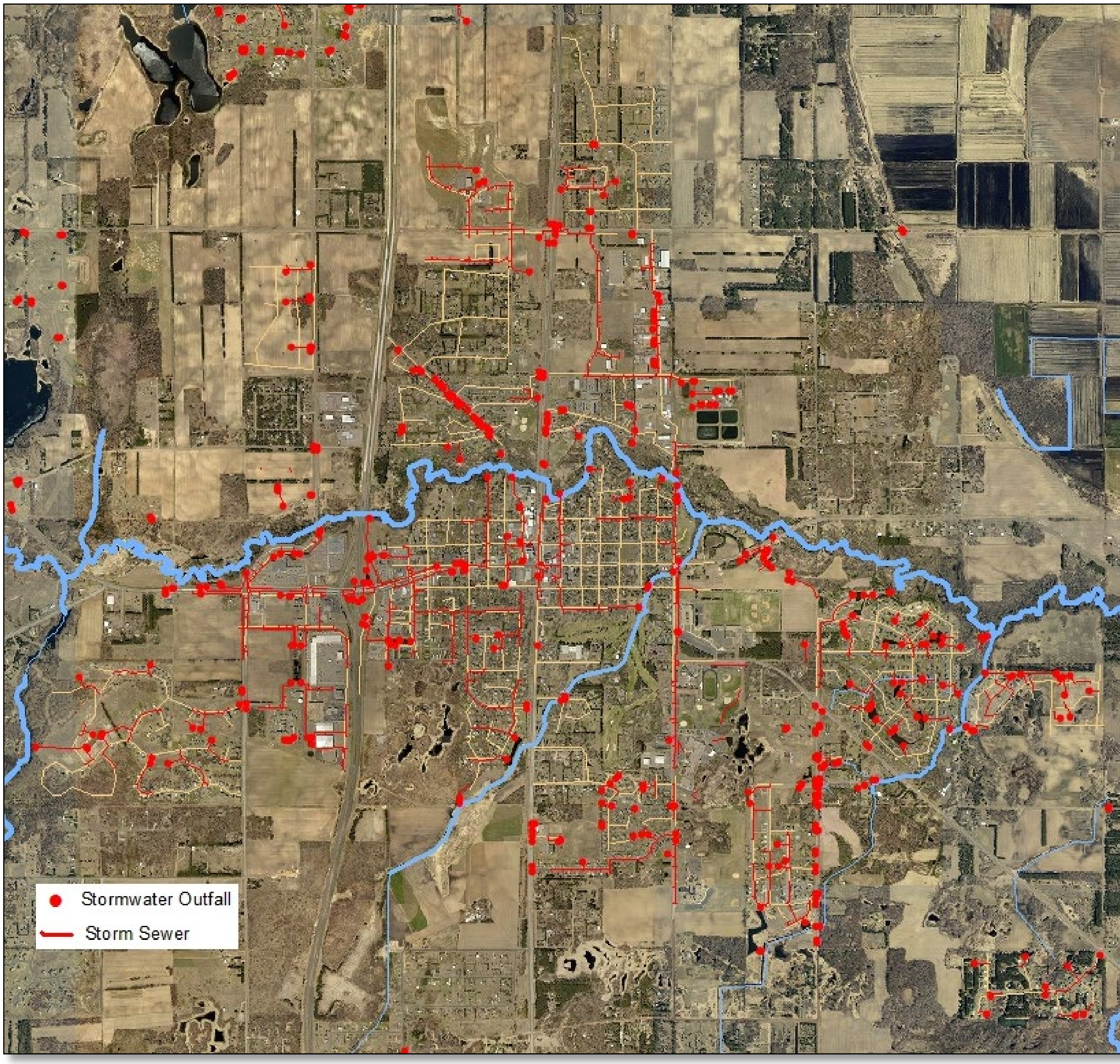
Appendix A: North Branch of the Sunrise River



Appendix B: Roadway Tree Canopy Cover



Appendix C: Stormwater Infrastructure



Appendix D: Planning Calculator Monthly Estimates – Example

Month	Frequency	Predicted (lb)				Predicted ($)	
		Wet Solids	Dry Solids	Nitrogen	Phosphorus	Cost $	$ Cost/lb P
January							
February							
March	1	681	552	0.5	0.3	$ 100.00	$ 346.38
April	1	422	340	0.8	0.2	$ 100.00	$ 508.85
May	1	267	215	0.9	0.2	$ 100.00	$ 633.11
June	1	225	190	0.8	0.1	$ 100.00	$ 742.23
July	1	195	155	0.5	0.1	$ 100.00	$ 1,099.44
August	1	216	172	0.7	0.1	$ 100.00	$ 895.17
September	1	175	144	0.8	0.1	$ 100.00	$ 871.28
October	1	406	241	1.9	0.3	$ 100.00	$ 336.05
November	1	296	181	0.9	0.2	$ 100.00	$ 581.46
December							
							Average $/lb
Predicted Annual		2882	2190	7.7	1.6	$ 900.00	$ 575.12