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RWMWD Street Sweeping Prioritization Study: Technical Memorandum

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Project: RWMWD Street Sweeping Prioritization Study
Date: November 16th, 2022
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Street sweeping is a critical non-structural best management practice (BMP) employed by cities throughout Minnesota for the purposes of maintaining road surfaces, improving public safety through clearing of walking lanes and trash removal, and improving water quality through the removal of accumulated sediment (e.g., sand application from winter road maintenance) and vegetation detritus (e.g., leaf litter). The water quality impact of street sweeping is a topic of emerging research in the state on Minnesota, with recent studies promoting the practice as a highly cost-effective BMP for phosphorus reduction (Hobbie et al, 2020; EOR, 2022). In consideration of recent research and focus on street sweeping program development, Ramsey-Washington Metro Watershed District (RWWMD) is considering supporting street sweeping program enhancement requests through their existing Stewardship Grant Program.

The Ramsey-Washington Metro Watershed District (RWWMD) Stewardship Grant Program (2022) offers financial, educational, and technical assistance to protect and improve water resources throughout the District. To provide a basis for consideration of street sweeping program enhancement requests, a study was performed to (a) evaluate existing street sweeping programs throughout the District, (b) develop a methodology to rank and prioritize street sweeping areas / zones, and (c) summarize findings and outline recommendations for updates to the Stewardship Grant Program. The following technical memorandum summarizes methodology used to evaluate street sweeping throughout the District and provides recommendations for related programmatic updates to support street sweeping through the Stewardship Grant Program.

1 Street Sweeping Survey: District Partners

Before development of a street sweeping strategy could begin, it was first critical to understand existing municipal street sweeping operations throughout the District. In the summer of 2022, Barr Engineering Co. (Barr) and District staff developed a list of programmatic street sweeping survey questions and provided them to all member Cities within the District. A total of nine cities (out of 10) responded to the street sweeping survey. A complete record of all survey responses is included in **Appendix A**. Key questions from the survey and a summary of general responses to each are provided below:

a) How often and in what seasons is street sweeping being performed? What types of sweepers are being used?
  - Table 1-1 provides a summary of street sweeping operations conducted per season. According to the Minnesota Stormwater Manual MS4 Street & Parking Lot Sweeping Fact Sheet, the typical Minnesota municipality performs two sweepings per year. Table 1-1 indicates that that a majority of cities within the District are performing more sweepings per year than the state average.

b) What are the goals of your street sweeping program? What are the annual expenses?
  - Reponses varied, but nearly all surveyed noted water quality as a key goal of street sweeping. Other responses included public safety, trash removal, aesthetics, improving drainage through catch basins and inlets, and fulfilling MS4 requirements.
  - Annual expenses varied based primarily on city size ($47K to $4.5M). Some cities contract out street sweeping while others perform operations in-house.

c) What are the barriers to implementing or expanding street sweeping operations?
  - Responses were highly varied (see **Appendix A**). Barriers included:
    - Lack of staffing / funding / vehicle acquisition / vehicle maintenance
    - Finding disposal sites / cost of disposal / cost of screening of material
    - Weather and optimal timing of street sweeping related to leaf drop
    - Logistics and on-street parking

d) What type of support would be most helpful to maintain or improve street sweeping operations?
  - Responses were highly varied (see **Appendix A**). Cost share requests included:
    - Assistance with staffing costs / costs to acquire and maintain equipment
    - Assistance with contracting street sweeping in high priority areas
    - Assistance with disposal costs / screening costs
    - Study of material reuse requirements / advanced screening to allow for more material reuse (offset disposal costs)

Information obtained from the street sweeping of District partners was critical to elements of the study described in the following sections. Survey results are directly referenced in the evaluation of existing operations (Section 2), development of prioritization strategies (Section 3), and development of Stewardship Grant Recommendations (Section 4).

Table 1-1 RWMWD member City street sweeping survey response

Municipality	Response: street sweeping program summary	Response: sweeper type	Sweepings per Season Assumptions for Modeling (#/season) [1]		
			Spring	Summer	Fall
Little Canada	3 times/year. Spring, summer, and fall	Johnston VT651 sweeper: combination mechanical/vacuum sweeper	1	1	1
Maplewood	Goal of 5 times/year. 2 in spring, 3 in fall.	2 Elgin Mechanical	2	0	3
North St. Paul	6-7 times per year. 2 in spring, 2 in summer, 3 in fall.	1 Elgin Pelican mechanical street sweeper	2	2	3
Oakdale	At least 3 times per year (one in each season)	1 Elgin Pelican mechanical sweeper, 1 Tymco 500X regenerative air sweeper	1	1	1
Roseville	4-6 full city sweeps per year. 1 in spring, 2-4 in summer, 1 in fall.	2 Pelican sweepers, 1 regenerative sweeper/vacuum	1	3	1
Shoreview	4-6 citywide sweeps per year. Sweeping starts after snow melt in spring and continues until snow starts in fall.	1 mechanical sweeper, 1 regenerative air sweeper.	2	1	2
St. Paul	Most swept in spring and fall. Arterial streets swept 4-8 times per year	15 Elgin Pelican and 1 Elgin Crosswind	1	0	1
White Bear Lake	We do a complete sweep of the entire city twice a year Spring & Fall. During that time, we are able to sweep all the city streets at least once sometimes twice. Also, throughout the summer we sweep high volume areas every Friday and touch up problems as they occur.	One sweeper it is a Tymco 500X regenerative air truck mount on a Freightliner chassis.	1	1	1
Woodbury	In spring after the snow melt, in fall before leaves drop from the trees.	1 mechanical, 1 regenerative air sweeper. 8 contractual sweepers in the spring and 6 contractual sweepers in the fall.	1	0	1

[1] Note: an assumption of one sweeping in the Spring, one sweeping in the Fall was assumed for all member Cities with no survey response.

2 District-Wide Street Sweeping: Evaluation of Existing Conditions

Prior to development of street sweeping prioritization strategies, it was first critical to develop a methodology to evaluate existing conditions throughout the District. The following subsections outline methodology used to evaluate (a) pollutant loading, (b) street sweeping pollutant recovery, and (c) street sweeping pollutant reduction based on existing street sweeping operations. An overview of the models and calculations used to evaluate existing street sweeping performance is included, below:

1) The GIS-based water quality model (GIS WQM) was used to evaluate (a) pollutant loading throughout the District and (b) street sweeping removal based on existing seasonal street sweeping operations (Table 1-1) (Section 2.2).
2) Existing P8 models were used to estimate the cumulative pollutant reduction from existing water quality BMPs in all modeled subwatersheds (Section 0).
3) Results from the GIS WQM and P8 models were combined to estimate the pollutant load recovery and pollutant load reduction to all District waterbodies (Section 2.4).

2.1 Street sweeping: pollutant recovery vs reduction

Recent studies have made an effort to differentiate street sweeping pollutant "recovery" versus pollutant "reduction" (EOR, 2022). Within this study, the terms are defined as follows:

- **Pollutant recovery**: the mass of pollutants collected during street sweeping operations.
- **Pollutant reduction**: the mass of pollutants prevented from reaching downstream waterbodies.

Many recent studies have been have been utilized to develop street sweeping reduction "calculators" to estimate pollutant load recovery associated with street sweeping operations (Kalinosky et al., 2014; Hobbie et al, 2020), including the recently published MPCA Street Sweeping Calculator. While the estimation of pollutant mass recovery is critical to evaluating the performance of street sweeping operations, it is important to acknowledge that not every pound of pollutant "recovered" via street sweeping equates to a pound of pollutant "reduced" to downstream waterbodies. Examples of processes impacting the relationship between recovery and reduction include:

- **Downstream water quality treatment**: if BMPs exist downstream of street sweeping operations, material removed via street sweeping may have instead been removed by the downstream BMP.
- **Bioavailability**: total phosphorus (TP) held in leaf litter and other sources may not decompose and become biologically available in receiving waterbodies.
- **Pollutant delivery**: some fraction of pollutant residing in a street may not be conveyed to downstream waterbodies. E.g., wind action my move leaf material from the street into a park where it degrades over the winter and following spring, never traveling to downstream waterbodies

The purpose of this section and definitions are to highlight that (a) a majority of modern studies have focused on pollutant recovery and that (b) pollutant reduction is equal to or less than pollutant recovery.

While this study attempts to account for the impact of downstream water quality treatment, it does not account for processes related to bioavailability or pollutant delivery, which have not been well studied and are outside of the focus of this study. For this reason, pollutant reduction cited in the study should only be used for relative comparison and prioritization of street sweeping efforts.

2.2 GIS WQM: pollutant loading and street sweeping recovery

The Barr developed GIS WQM is a GIS-based water quality model used to estimate pollutant loading and BMP performance on an annualized basis using methodology developed for the MIDS calculator and pollutant loading areal empirical equations developed from the P8 water quality model. For this study, only the pollutant loading and street sweeping modules were utilized. A complete description of methodology utilized in the GIS WQM can be found in the City of Richfield Street Sweeping Prioritization Study technical memorandum (Barr, 2021).

To analyze pollutant loading and street sweeping recovery using the GIS WQM, the following datasets were required:

- **Watershed imperviousness**: Directly connected imperviousness was estimated using land use based assumptions and impervious surface data from Ramsey County 2021 land use data.
- **Canopy cover**: Barr developed canopy cover estimates using 2022 aerial imagery processing techniques.
- **Road surfaces**: Barr developed road surface polylines (GIS delineations that identify the locations of road surfaces) using best available road surface datasets, including those requested from and provided by member cities.
- **Street sweeping frequency**: The seasonal street sweeping frequency assumed for member cities was developed using survey responses and assumptions outlined in Table 1-1.

The following provides a high-level overview of processing used to develop areal pollutant loading values and estimates of street sweeping recovery:

- **Pollutant loading**: Areal total phosphorus (TP) and total suspended sediment (TSS) loadings were estimated using empirical equations developed from P8 simulations relating pollutant loading to watershed directly connected imperviousness (Barr, 2020).
- **Street sweeping recovery**: street sweeping pollutant recovery is estimated using empirical relationships for TSS and TP developed by Sutherland and Jelen, 1997 and Kalinosky et alcaono., 2015. Empirical relationships are a function of canopy cover, average sweeping interval, and regression coefficients which vary by month to reflect seasonal phosphorus loading conditions.

Figure 2-1 provides an example of the District-wide road surface and tree canopy spatial datasets generated during this project. Figure 2-2 and Figure 2-3 show percent canopy cover and areal TP loading rate for all areas within the District legal boundary, respectively.

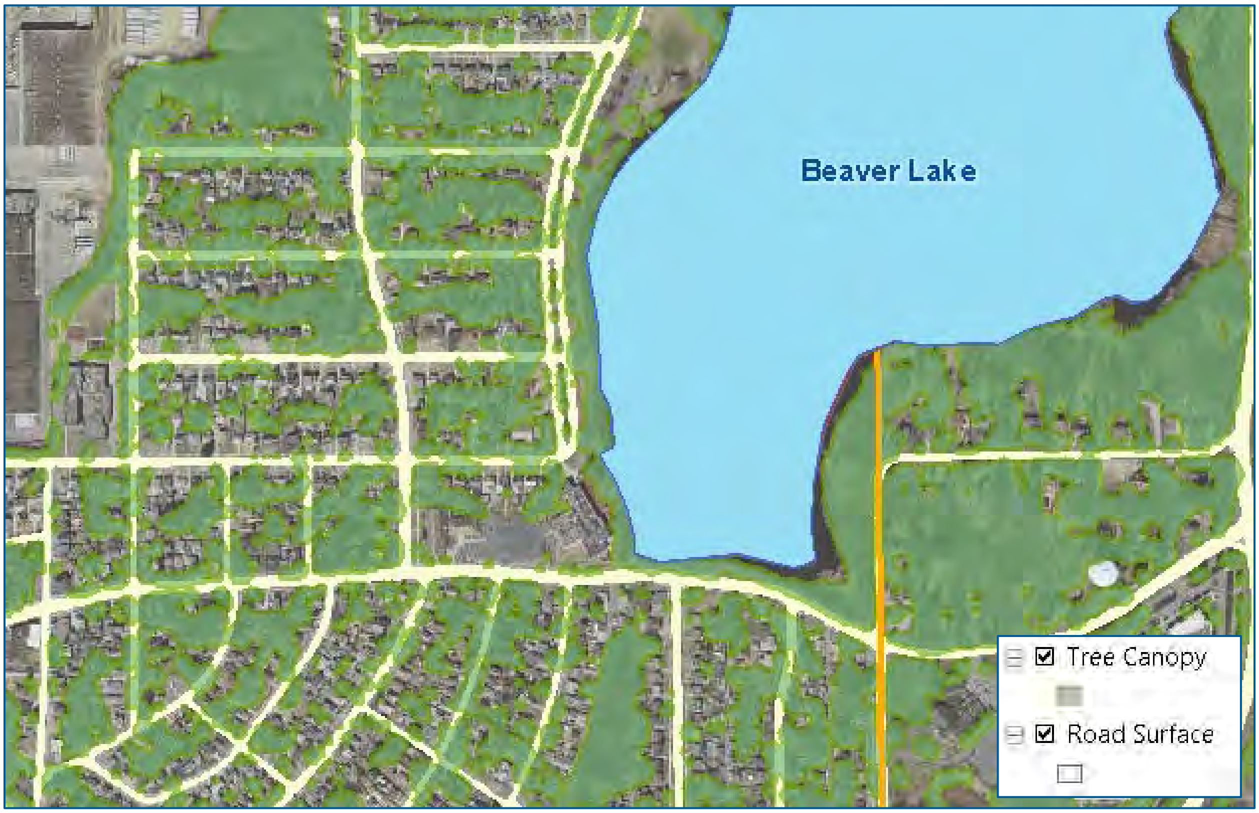


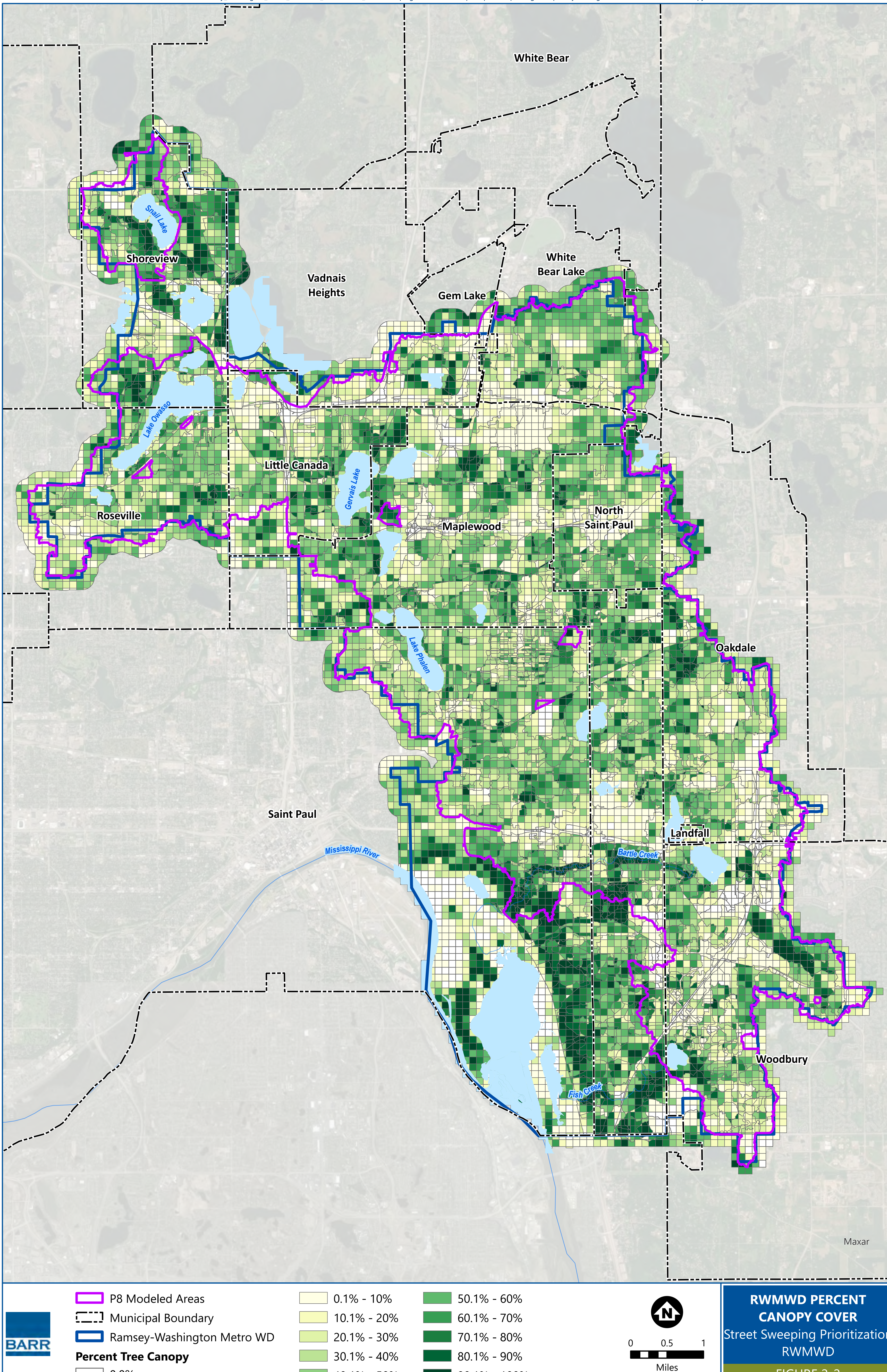
Figure 2-1 Example of District-wide road surface and canopy cover datasets

2.3 P8: downstream treatment from existing BMPs

Existing, best-available P8 water quality models that have been developed for the RWMWD in recent years were used to evaluate the pollutant reduction achieved by water quality BMPs throughout the District. Results from these models were used to estimate the cumulative pollutant reduction (%) occurring downstream from all modeled P8 catchments. This information was then used to calculate street sweeping pollutant reduction to downstream waterbodies as follows:

$$Pollutant\ Reduction\ (lbs/yr)\ = Pollutant\ Recovery\ (lbs/yr) \times Cumulative\ Polluant\ Reduction\ (\%)$$

Calculation of pollutant reduction is critical to prioritization steps, as this value more closely approximates the actual pounds of pollutant reduction to a downstream waterbody achieved via street sweeping. Figure 2-4 shows the cumulative TP pollutant reduction calculated in all modeled catchments throughout the District. Note that not all areas of the District have been modeled in P8. In these areas, pollutant reduction is not calculated and these areas are not considered in prioritization strategies based on pollutant reduction. Additionally, as noted above, all P8 modeling was completed using best-available P8 models. These P8 models may not account for all recent development and BMP implementation throughout the District.

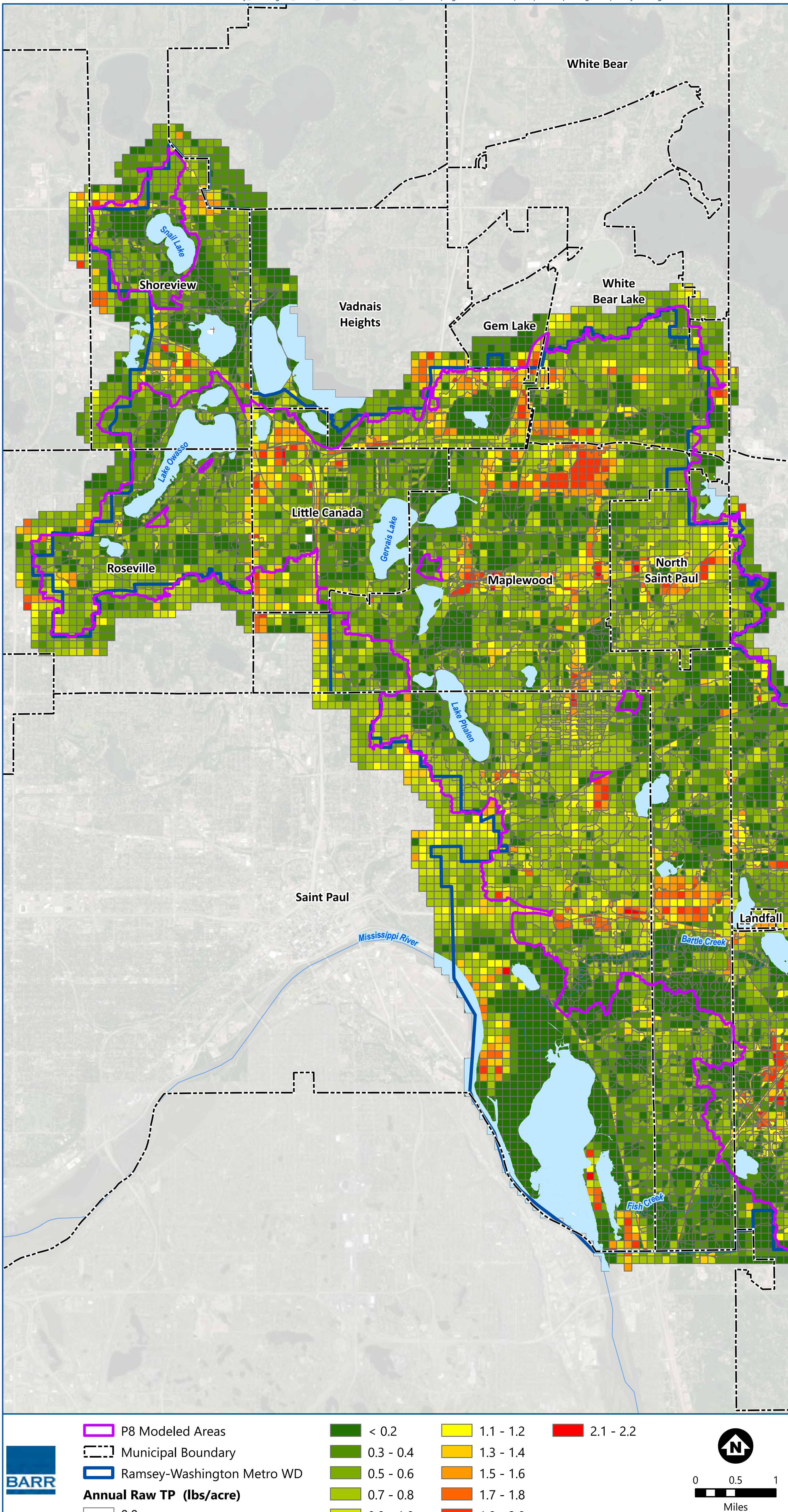


RWMWD PERCENT CANOPY COVER

Street Sweeping Prioritization
RWMWD

FIGURE 2-2

Barr footer: 11/06/22 1:54 PM 11/08/22 7:40 AM File: I:\Client\Ramsey_Washington_Metro_WD\Work_Orders\2022_StreetSweepingPrioritization\Maps\Reports\Report Figures.aprx Layout: Figure 2-3 RWMWD Areal Pollutant Loading TP1 User: EMA

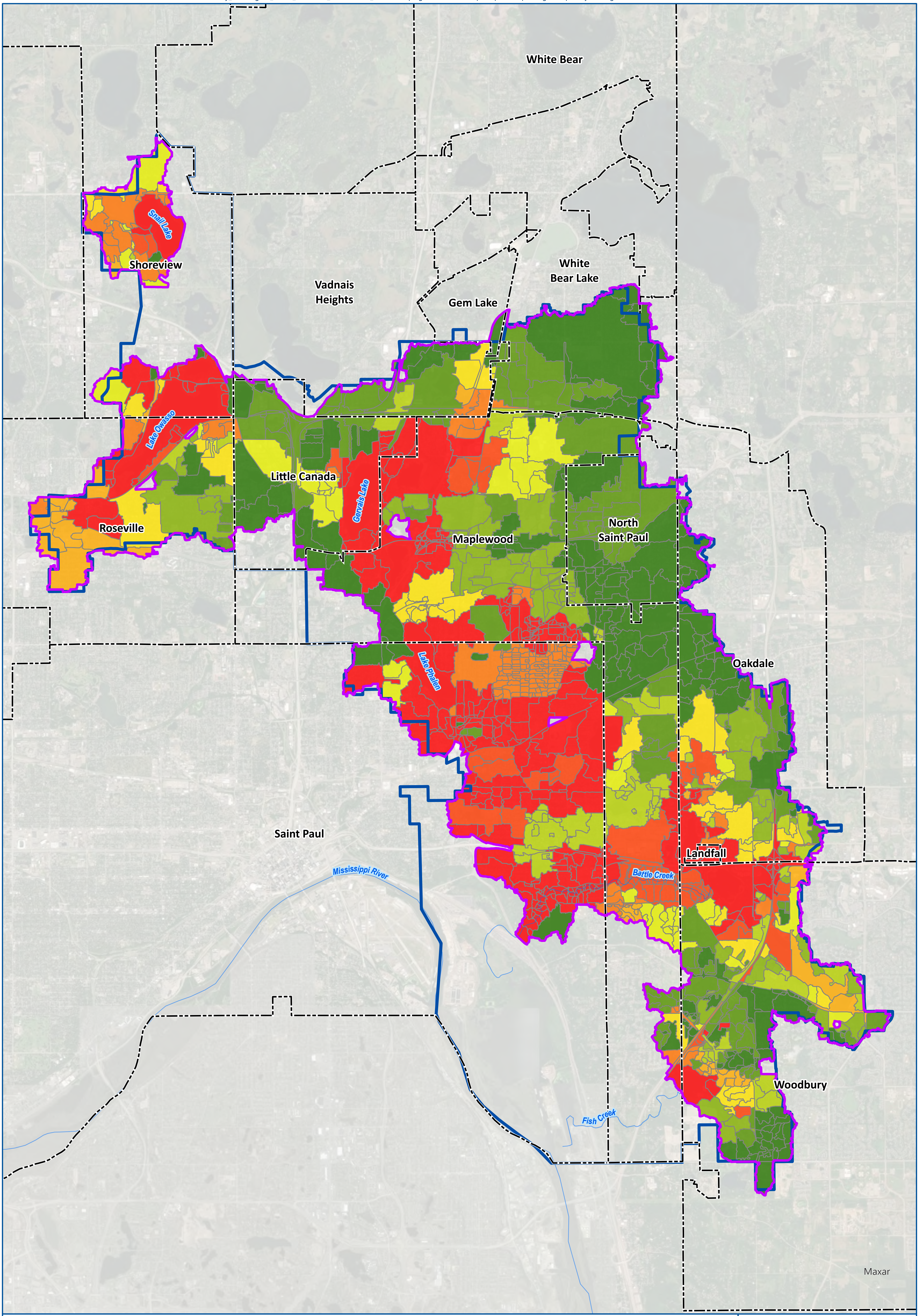


RWMWD AREAL POLLUTANT LOADING: TP

Street Sweeping Prioritization

RWMWD

FIGURE 2-3



P8 Modeled Areas
Municipal Boundary
Ramsey-Washington Metro WD

Cumulative Reduction (%)

- 0% - 10%
- 11% - 20%
- 21% - 30%
- 31% - 40%
- 41% - 50%
- 51% - 60%
- 61% - 70%
- 71% - 80%
- 81% - 90%
- 91% - 100%

0 0.5 1
Miles

BARR

RWMWD CUMULATIVE POLLUTANT REDUCTION: TP
Street Sweeping Prioritization
RWMWD

FIGURE 2-4

2.4 District-wide street sweeping summary: existing conditions

Using methodology described in Section 2.2 and 2.3, street sweeping pollutant recovery and reduction was evaluated for all areas within the RWMWD legal boundary. Table 2-1 through Table 2-3 provides a summary of (a) street sweeping TSS and TP recovery, (b) reduction, and (c) reduction specifically in "impaired" or "at risk" waterbodies (impairment status as determined by the 2017 RWMWD WRAPS report and the MPCA's 2022 impaired waterbodies list). As shown, model results estimate that existing street sweeping operations recover over 4% of TSS and nearly 11% of total phosphorus loading annually.

Table 2-1 RWMWD existing street sweeping performance: pollutant recovery

Pollutant	Street Sweeping: Recovery		
	Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)
TSS	6,827,556	286,886	4.2%
TP	22,759	2,491	10.9%

Table 2-2 RWMWD existing street sweeping performance: pollutant reduction

Pollutant	Street Sweeping: Reduction [1]		
	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)
TSS	5,541,974	59,474	1.1%
TP	18,433	1,017	5.5%

[1] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8.

Table 2-3 RWMWD existing street sweeping performance: pollutant reduction in Impaired or At Risk watersheds

Pollutant	Street Sweeping: Reduction [1] [impaired / at risk watersheds]		
	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
TSS	2,773,367	37,302	1.3%
TP	9,231	655	7.1%

[1] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8. Table 2-3 accounts for pollutant reduction only within impaired or at risk watersheds.

Results shown in Table 2-1 through Table 2-3 are shown by (a) municipality and (b) major watershed in **Appendix B**. Existing conditions model results inform the baseline sweeping recommendations and street sweeping prioritization discussed in Section 3.

3 District-Wide Street Sweeping: Prioritization

To inform potential future street sweeping grant funding via the Stewardship Grant Program, Barr performed an analysis to evaluate the cost-effectiveness of street sweeping throughout the District. Specifically, the following steps were complete:

1) Seasonal street sweeping and cost-benefit analyses were performed to determine the optimal number of sweeping operations per season.
2) Results from the seasonal street sweeping analysis and survey responses were used to develop a "baseline" street sweeping recommendation for the District.
3) The baseline street sweeping recommendation was modeled District-wide and results were used to develop prioritization ranking strategies.

The following subsections outline process used to develop a baseline street sweeping recommendation and the methodology used to develop street sweeping prioritization strategies.

3.1 Development of baseline street sweeping recommendation

Development of a "baseline" street sweeping recommendation for the District was considered for the following reasons: (1) to create a "baseline" recommendation to member cities on how often street sweeping should be performed seasonally, and (2) to develop a street sweeping approach that could be modeled to inform prioritization (i.e., have a consistent street sweeping modeling scenario to allow for equivalent comparison of relative street sweeping priority throughout the District). The process used to evaluate the optimal number of sweepings per season is described, below:

- **Seasonal sweeping modeling**: Iterations of the District-wide GIS WQM were performed to evaluate pollutant recovery per sweeping, per season (e.g., one spring sweeping, two spring sweepings, etc.). Based on the methodology used to estimate TP and TSS recovery (Kalinosky et al., 2014; Sutherland and Jelen, 1997), the cumulative recovery of TSS and TP always goes up with successive sweepings, but the recovery per sweeping degrades (based on the assumption there is less recoverable material following each sweeping event). The cost-benefit of each sweeping was then evaluated to determine the optimal number of sweepings each season (see below).
- **Cost-benefit analysis:** Because a detailed, municipality-specific cost evaluation of street sweeping operations was outside the scope of this analysis, cost-efficiency information for the recently completed City of Woodbury: Enhanced Street Sweeping Plan (EOR, 2022) were used to estimate the cumulative cost of successive sweepings per season per lane-mile swept. Note: cost estimation information from the EOR study is highly specific to the City of Woodbury and should not be used to estimate actual cost per sweeping for other municipalities. However, because the goal of analysis was to have an equivalent basis of cost comparison of cost across all RWMWD municipalities, this methodology was deemed sufficient for development of this cost-benefit analysis.

Figure 3-1 shows the cost-benefit analysis of fall street sweeping operations for the District. As can be seen the optimal number of sweepings (i.e., sweepings resulting in the lowest cost per pound to TP removed) is 2 sweepings per fall season.

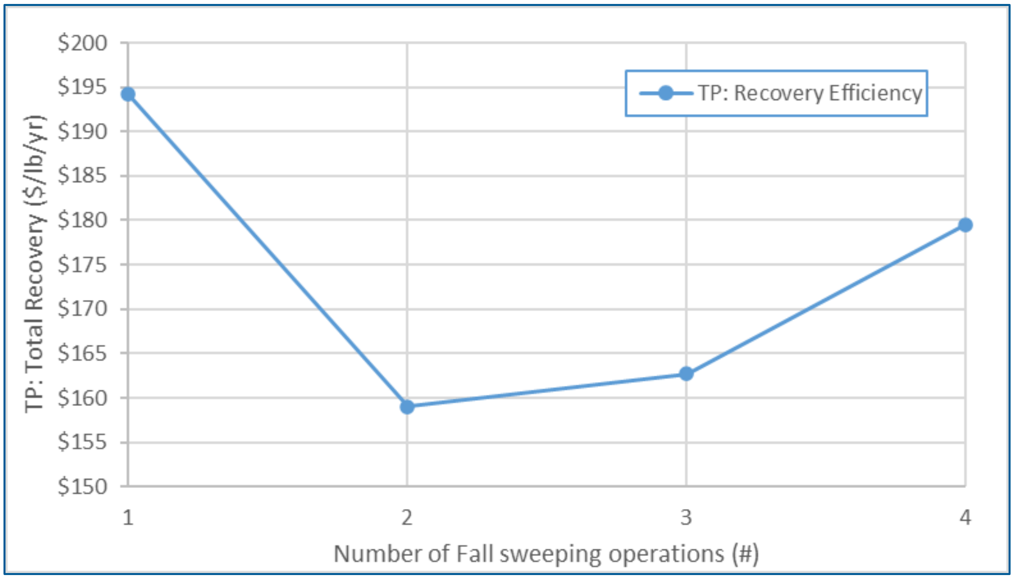


Figure 3-1 TP removal cost efficiency for the RWMWD: Fall Season

Using this methodology, the average cost efficiency was calculated for each season for one through four sweepings per season. District-wide results of this analysis are shown in Table 3-1. As shown in Figure 3-1, assuming sweeping equipment is owned (i.e., assuming street sweeping is not contracted out), the optimal number of sweeping each season is two. This finding as well as the following considerations were used to develop a District-wide, baseline street sweeping recommendation:

- **Seasonal cost efficiency**: the optimal number of sweepings to perform based on cost-efficiency values evaluated within a season is two sweepings per season. This frequency results in the lowest combined cost per pound per year of TP recovered for all three seasons evaluated (spring, summer, and fall).
- **Overall cost efficiency**: Fall pollutant recovery values produces the highest cost efficiency per season, followed by spring, then summer.
- **Existing street sweeping operations**: based on results of the District street sweeping survey, a majority of municipalities sweep four to five times per year.

Table 3-1 TP recovery cost efficiency by season and number of sweepings.

Season	No. Sweeps (#)	Recovery Efficiency ($/lb TP/yr)	
		Sweeping Equipment: Owned	Sweeping Equipment: Contracted
SPRING	1	$324.88	$230.34
	2	$261.50	$306.28
	3	$265.15	$396.78
	4	$291.78	$507.01
SUMMER	1	$448.39	$317.91
	2	$356.23	$417.22
	3	$360.02	$538.75
	4	$395.75	$687.68
FALL	1	$194.15	$137.65
	2	$159.03	$186.26
	3	$162.70	$243.47
	4	$179.55	$312.00

In consideration of the cost benefit analysis, results of the street sweeping survey, and coordination with District staff, the following baseline street sweeping recommendation was developed:

- **District-wide baseline recommendation: 1** spring sweeping, **1** summer sweeping, and **2 to 3** fall sweepings.

The baseline recommendation serves as a minimum sweeping recommendation to member cities. The baseline recommendation can be considered within the Stewardship Grant Program (e.g., does the proposed enhanced sweeping program meet District baseline sweeping recommendations?). Additionally, the baseline recommendation is used as the default modeling assumption the sweeping prioritization analysis, discussed in the following section.

Street sweeping pollutant recovery and reduction results calculated using the District-wide baseline assumption are compared to existing condition recovery and reduction results in Table 3-2 through Table 3-4. As can be seen, the baseline recommendation results in higher removal and recovery values than existing street sweeping operations. Results in **Appendix C** (see related discussion in Section 3.2) indicate that only two municipalities have existing street sweeping operations which meet or exceed the baseline recommendation (North Saint Paul and Shoreview, see Table 1-1).

Table 3-2 RWMWD baseline street sweeping recommendation compared to existing conditions: TP Recovery

Pollutant	Loading (lbs/yr)	Street Sweeping: Recovery			
		Existing Conditions		Baseline Recommendation	
		Recovery (lbs/yr)	Recovery (%)	Recovery (lbs/yr)	Recovery (%)
TSS	6,827,556	286,886	4.2%	537,056	7.9%
TP	22,759	2,491	10.9%	2,988	13.1%

Table 3-3 RWMWD baseline street sweeping recommendation compared to existing conditions: TP Reduction

Pollutant	Loading (lbs/yr)	Street Sweeping: Reduction [1]			
		Existing Conditions		Baseline Recommendation	
		Reduction (lbs/yr)	Reduction (%)	Reduction (lbs/yr)	Reduction (%)
TSS	5,541,974	59,474	1.1%	141,997	2.6%
TP	18,433	1,017	5.5%	1,296	7.0%

[1] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8.

Table 3-4 RWMWD baseline street sweeping recommendation compared to existing conditions: TP Reduction in impaired or at risk watersheds

Pollutant	Loading (lbs/yr)	Street Sweeping: Reduction [impaired / at risk watersheds] [1]			
		Existing Conditions		Baseline Recommendation	
		Reduction (lbs/yr)	Reduction (%)	Reduction (lbs/yr)	Reduction (%)
TSS	2,773,367	37,302	1.3%	94,773	3.4%
TP	9,231	655	7.1%	875	9.5%

[1] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8. Table 3-3 accounts for pollutant reduction only within impaired or at risk watersheds.

3.2 District-wide street sweeping prioritization

During development of this study, Barr and District staff coordinated to discuss many different prioritization strategies (e.g., prioritize by total pollutant recovery? Prioritize by pollutant loading reduction to nutrient impaired water bodies? Etc.). Eventually, the following three strategies were developed. Pros and cons of each strategy are described, below:

1) **Total recovery**: prioritize street sweeping by evaluating total TSS and TP pollutant recovery across the District.
   - **Pros**: Priority areas can be identified District-wide (not reliant on P8 results).
   - **Cons**: does not account for pollutant reduction to downstream waterbodies (i.e., does not account for treatment opportunities in BMPs downstream of street sweeping areas).
2) **Total reduction**: prioritize street sweeping by evaluating total TSS and TP pollutant reduction to District managed waterbodies.
   - **Pros**: accounts for downstream treatment / attempts to approximate actual pollutant load reduction to District managed waterbodies.
   - **Cons**: Priority areas can only be identified in P8-modeled areas (i.e., areas where cumulative downstream reduction can be evaluated).
3) **Total reduction to impaired / at risk waterbodies**: prioritize street sweeping by evaluating total TSS and TP pollutant reduction to impaired or at-risk District managed waterbodies (as defined by the 2017 WRAPS report and review of MPCA's 2022 draft list of impaired waterbodies).
   - **Pros**: accounts for downstream treatment / attempts to approximate actual pollutant load reduction to impaired and at-risk District managed waterbodies.
   - **Cons**: Priority areas can only be performed in P8-modeled areas (i.e., areas where cumulative downstream reduction can be evaluated) and only applies to watersheds classified as impaired or at risk.

Using GIS WQM and P8 results, total recovery and reduction values were calculated at the scale of subwatershed segments (average size: 2.5-acres) for all areas throughout the District. Specifically, recovery and reduction values were calculated for all modeled GIS WQM subwatersheds segments, normalized, and ranked to produce a final ranking value (1 = highest priority ranked area, 0 = lowest ranked priority area).

Because prioritization calculations were conducted at a small resolution, prioritization values can be evaluated at a very small scale (e.g., street-by-street analysis). However, results at this fine of a scale are not useful for street sweeping prioritization, as it is inefficient for cities to vary sweeping operations street-by-street. Based on coordination with the District, prioritization calculations were rasterized and recalculated at the scale of Public Land Survey System (PLSS) **quarter sections** (160 acres). Quarter sections were chosen as they match more-closely to the size of typical street sweeping "zones" used by Cities to implement street sweeping operations. Note: because prioritization calculations have been calculated at the scale of subwatershed segments, it requires minimal effort to recalculate prioritization ranking based on actual street sweeping zones used by Cities (street sweeping zones were requested as part of this study but were not provided by enough municipalities to use within this study). Figure 3-2below shows and example of the TP total recovery ranking calculated and displayed specifically for the City of Woodbury.

Figure 3-3 though Figure 3-5 display results based on the three prioritization methodologies listed above at the quarter section scale. Prioritization ranking for total recovery is a function of canopy cover and street density, while prioritization ranking for total reduction is additionally a function of cumulative reduction (%) (see Figure 2-2). Because ranking results are rasterized, relative street sweeping ranking can be evaluated at any scale (e.g., municipal scale, major watershed scale, etc.). **Appendix C** provides a summary of removal, reduction, and ranking values at the municipal and major watershed scale. Results summarized in Appendix C are discussed in respect the Stewardship Grant program and funding consideration in the following section.

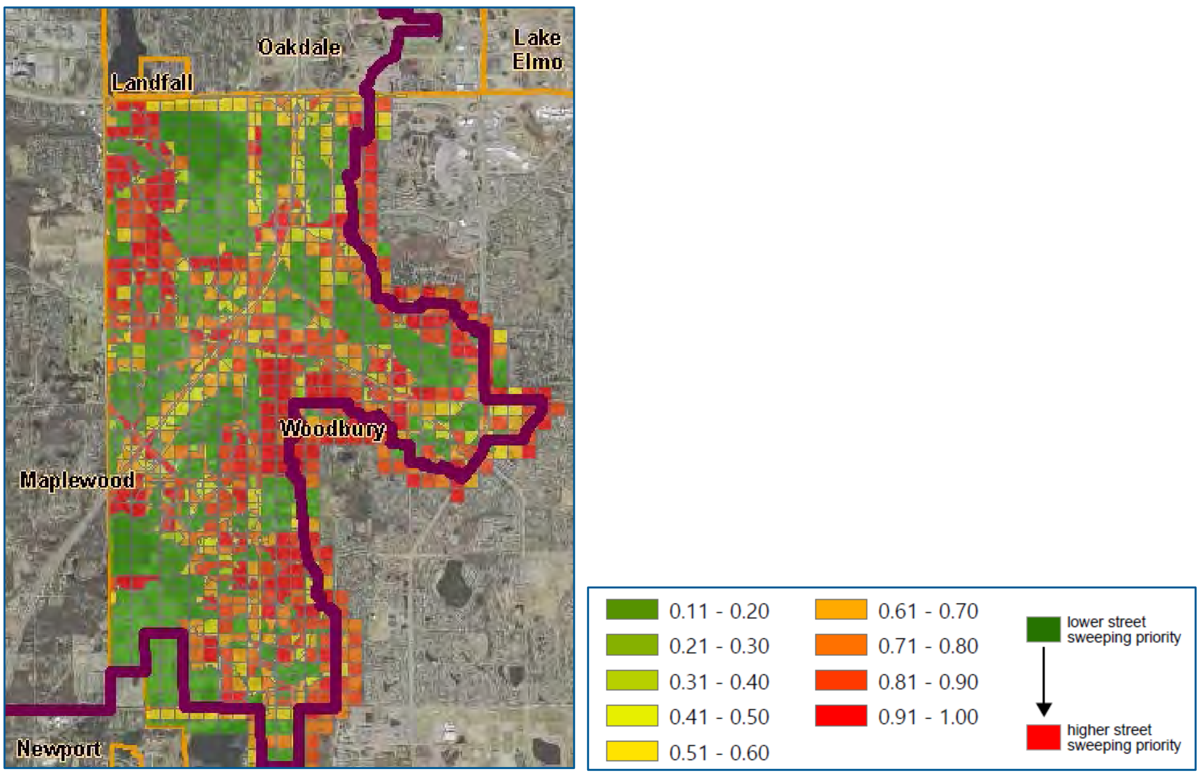
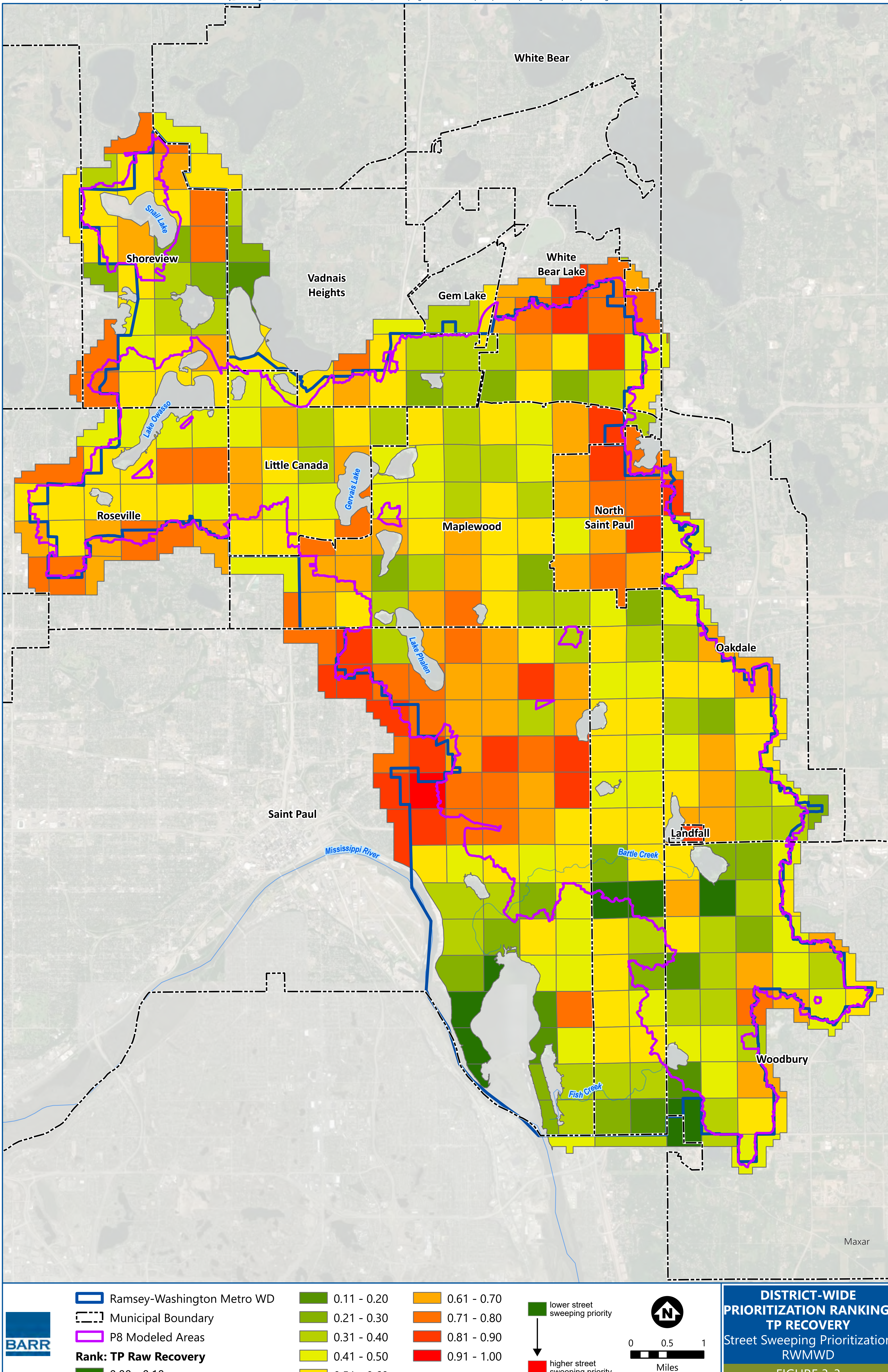


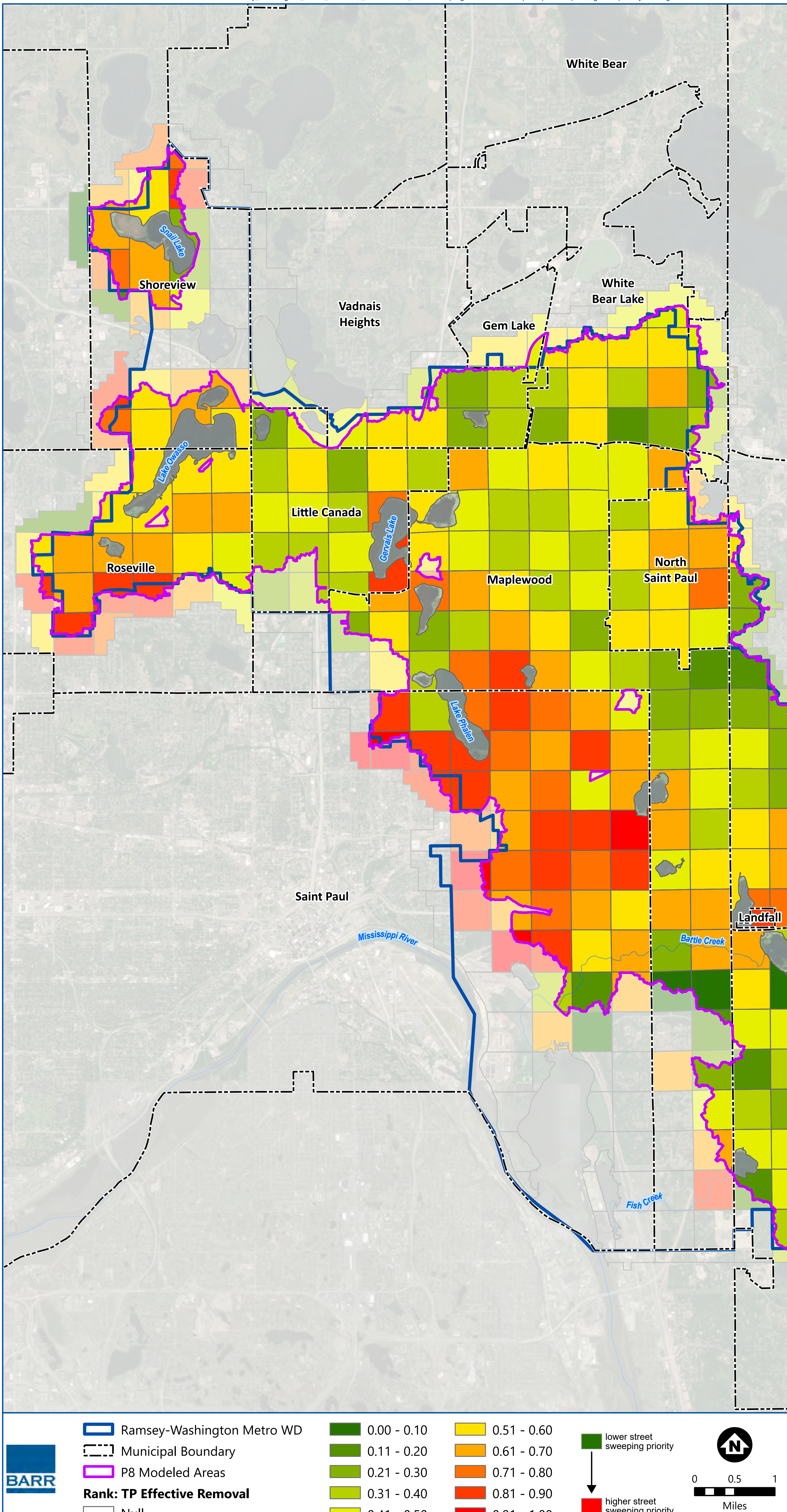
Figure 3-2 TP recovery ranking values: City of Woodbury



DISTRICT-WIDE PRIORITIZATION RANKING: TP RECOVERY

Street Sweeping Prioritization
RWMWD

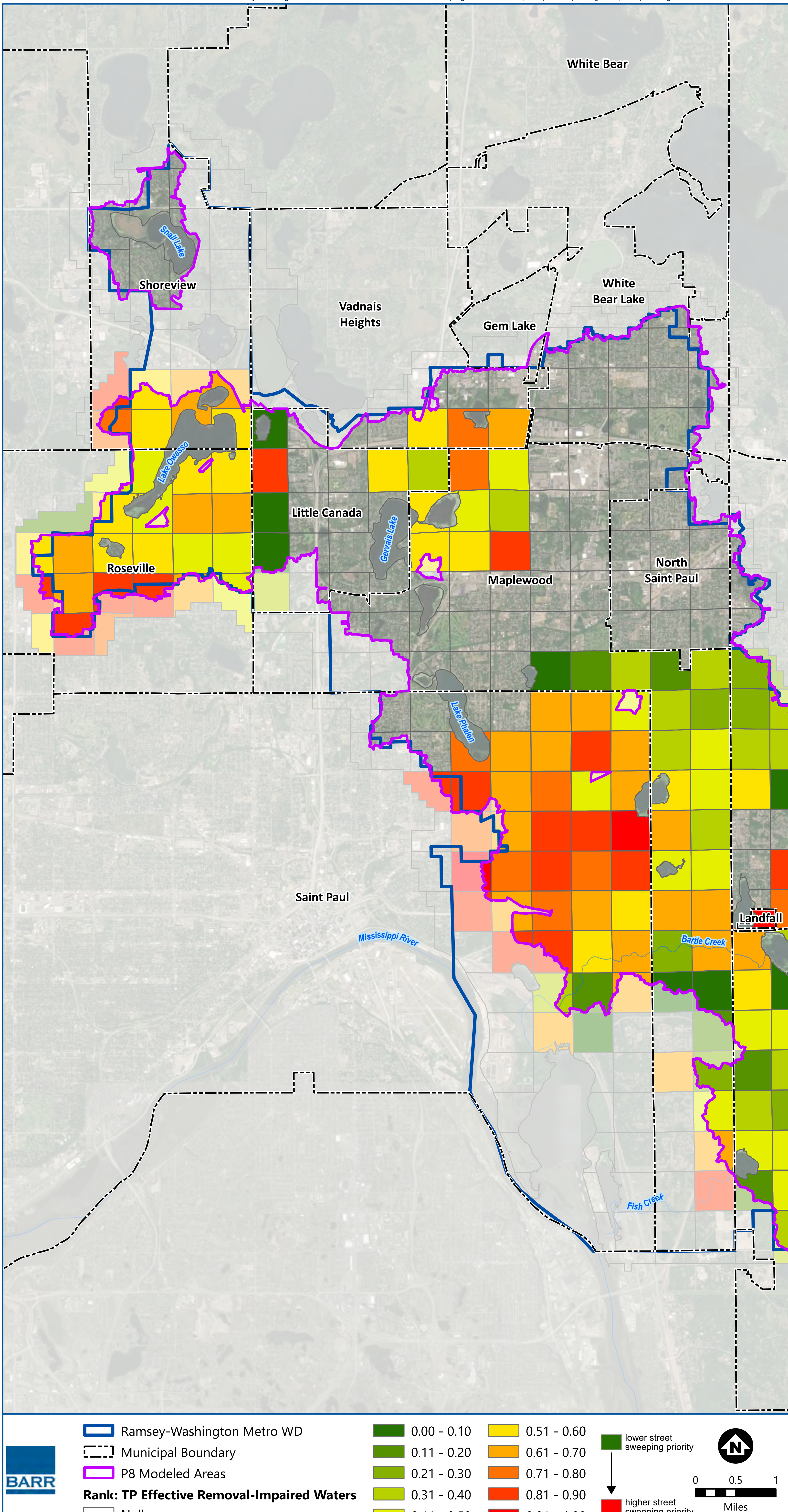
FIGURE 3-3



DISTRICT-WIDE PRIORITIZATION RANKING: TP REDUCTION

Street Sweeping Prioritization
RWMWD

FIGURE 3-4



DISTRICT-WIDE PRIORITIZATION RANKING: TP REDUCTION FOR IMPAIRED & AT RISK WATERSHEDS
Street Sweeping Prioritization
RWMWD
FIGURE 3-5

4 Stewardship Grant Recommendations

As outlined in Section 1, the District is considering supporting street sweeping operations and street sweeping program enhancement requests in priority areas through their existing Stewardship Grant Program. The following subsections outline how street sweeping performance review (Section 2) and prioritization (Section 3) may be used by the District to help inform the Stewardship Grant Program and evaluation of grant requests related to street sweeping.

4.1 Strategies for awarding Stewardship Grant Funding

Throughout development of this Study, Barr and District staff discussed several strategies to incorporate street sweeping program enhancement into the Stewardship Grant program. Strategies discussed are briefly described, below:

- **Targeted**: This strategy involves evaluating street sweeping prioritization results and actively selecting geographic areas to approach with grant opportunities (e.g., cities, major watershed, priority areas, etc.). This strategy is based on the grant funding approach utilized for the RWMWD Targeted Retrofit Program. Prioritization results and mapping presented in this study could be used to determine which partners to actively approach with grant opportunities.
- **Application Based**: This strategy involves advertising street sweeping grant opportunities to member cities and allowing cities to apply for grant funding. If grant funding is not sufficient to support all grant requests within a given funding year, a list of pre-developed criteria could be used to evaluate and prioritize funding support. Criteria could include the prioritization analysis presented in this technical memorandum and programmatic questions including the following:
  - Does the applicant's proposed street sweeping plan meet or exceed baseline street sweeping recommendations (Section 3.1)?
  - Does the applicant demonstrate the ability to execute the proposed street sweeping plan? E.g., do they have sufficient sweeping equipment and staff in place?
  - Is the applicant planning enhanced sweeping in high priority areas?

Based on discussion from an internal RWMWD meeting to discuss 2023 implementation of the Stewardship Grant Program, District staff propose to initially incorporate street sweeping grant opportunities utilizing the "Targeted" approach, outlined above. To support active evaluation of street sweeping partners within the District, Table 4-1 and Table 4-2 provide a summary of prioritization ranking by municipality and major watershed, respectively. Note: these tables summarize the complete prioritization analysis results summarized in **Appendix C**. In addition to prioritization ranking values, the tables also include a comparison of pollutant reduction and recovery values (pounds of pollutant per year) from the suggested baseline sweeping condition (Section 3.1) to existing conditions sweeping operations (Section 2.4). A combined ranking values which considers both the (a) prioritization results from the GIS WQM and (b) the difference in pollutant recovery and reduction from existing to baseline conditions is also included in the tables. Combined ranking values may be used to determine municipalities and/or watersheds to target via the "Targeted" grant funding approach.

Table 4-1 Street sweeping prioritization values for total phosphorus: by municipality.

Municipality	Area (acres)	TP Prioritization Ranking Strategies								
		Street Sweeping Recovery & Reduction Comparison [Baseline - Existing Conditions] (lbs/yr)			Recovery / Reduction Ranking Number (#) [1]			Combined Ranking Number [Rank based on Baseline Change & Recovery / Reduction Ranking] (#) [2]		
		Recovery	Reduction [3]	Reduction [imp. / at risk] [4]	Recovery	Reduction [3]	Reduction [imp. / at risk] [4]	Recovery	Reduction [3]	Reduction [imp. / at risk] [4]
Gem Lake	45.6	+0.8	+0.1	0.0	6	8	--	4	7	--
Landfall	53.0	+2.5	+2.5	+2.1	5	2	1	2	1	1
Little Canada	2,882.3	+34.0	+9.2	+0.9	7	6	7	6	4	5
Maplewood	10,840.4	+12.2	+8.6	+4.9	11	7	9	13	10	9
North Saint Paul	1,774.7	-47.4	-3.6	0.0	1	5	--	6	10	--
Oakdale	3,328.8	+37.9	+12.8	+4.6	9	9	6	8	5	7
Roseville	2,603.2	+20.6	+10.8	+10.8	3	3	3	5	3	4
Saint Paul	10,431.9	+323.7	+214.6	+176.7	4	1	5	3	1	3
Shoreview	3,409.1	-4.8	-3.1	-1.2	8	4	4	11	7	8
Vadnais Heights	1,320.3	+17.2	+2.7	+0.4	12	10	2	10	9	2
White Bear	6.5	+0.0	+0.0	0.0	10	13	10	11	13	10
White Bear Lake	1,956.2	+35.6	+2.5	0.0	2	11	--	1	12	--
Woodbury	4,670.2	+63.1	+21.2	+21.2	13	12	8	9	6	6

[1] Ranking value based on TP recovery or reduction values calculated from GIS WQM results.
[2] Combined ranking value considering both (a) ranking of TP recovery or reduction values calculated in from GIS WQM results and (b) recovery / reduction ranking values.
[3] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8.
[4] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8. Table 2-3 accounts for pollutant reduction only within impaired or at risk watersheds.

Table 4-2 Street sweeping prioritization values for total phosphorus: by major watershed.

Major Watershed	RWMWD Impairment Status [3]	TP Prioritization Ranking Strategies								
		Street Sweeping Reduction & Removal Comparison [Baseline - Existing Conditions] (lbs/yr)			Recovery / Reduction Ranking Number (#) [1]			Combined Ranking Number [Rank based on Baseline Change & Recovery / Reduction Ranking] (#) [2]		
		Recovery	Reduction [4]	Reduction [imp. / at risk] [5]	Recovery	Reduction [4]	Reduction [imp. / at risk] [5]	Recovery	Reduction [4]	Reduction [imp. / at risk] [5]
Battle Creek	Impaired	+46.0	+32.3	+32.3	17	13	5	6	6	1
Battle Creek Lake	At Risk	+28.3	+15.1	+15.1	19	15	4	12	5	2
Beaver Lake	At Risk	+13.0	+5.6	+5.6	15	18	6	11	10	6
Blufflands	Impaired	+30.5	0.0	0.0	11	--	--	3	--	--
Carver Lake	At Risk	+28.3	+7.7	+7.7	18	17	7	8	7	4
Fish Creek	At Risk	+2.2	0.0	0.0	21	--	--	15	--	--
Gervais Creek	Stable	+22.1	+3.7	0.0	7	14	--	9	12	--
Gervais Lake	Stable	+9.9	+5.3	0.0	3	4	--	5	2	--
Grass Lake	Stable*	+0.3	0.0	0.0	14	--	--	19	--	--
Keller Lake	Stable	+3.3	+2.8	0.0	10	9	--	17	13	--
Kohlman Creek	Stable	-43.4	-2.7	0.0	2	10	--	14	16	--
Kohlman Lake	Impaired	+5.0	+4.3	+4.3	16	8	3	13	4	3
Lake Owasso	At Risk	+17.4	+9.8	+9.8	6	5	2	16	9	5
Lake Phalen	Stable	+47.2	+36.6	0.0	8	6	--	4	3	--
Lake Wabasso	Stable	+0.0	+0.2	0.0	4	2	--	20	15	--
Snail Lake	Stable	-3.3	-2.0	0.0	12	7	--	21	17	--
Snake Creek	Stable*	+0.1	0.0	0.0	22	--	--	18	--	--
St. Paul Beltline	Impaired	+153.1	+145.6	+145.6	1	1	1	22	18	7
Tanners Lake (North)	Stable	+12.9	+4.6	0.0	13	12	--	10	8	--
Tanners Lake (South)	Stable	+6.0	+5.1	0.0	5	3	--	1	1	--
West Vadnais Lake	Stable*	+1.9	+0.0	0.0	20	11	--	2	11	--
Willow Creek	Stable*	+41.9	+4.5	0.0	9	16	--	7	14	--

[1] Ranking value based on TP recovery or reduction values calculated from GIS WQM results.
[2] Combined ranking value considering both (a) ranking of TP recovery or reduction values calculated in from GIS WQM results and (b) recovery / reduction ranking values.
[3] Impairment status as determined by the 2017 RWMWD WRAPS report and the MPCA's 2022 draft impaired waterbodies list. (*) indicates that waterbody status is not listed in the 2017 RWMWD WRAPS report and impairment status was determined via review of the MPCA's 2022 draft impaired waterbodies list
[4] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8.
[5] Pollutant reduction (accounting for downstream treatment) can only be calculated for portions of the District modeled in P8. Table 2-3 accounts for pollutant reduction only within impaired or at risk watersheds.

4.2 Street sweeping activities to support via Stewardship Grant Funding

Based on results from the street sweeping survey (Section 1), District partners experience unique barriers to conducting street sweeping operations. For this reason, it is anticipated partners will request funding to support a variety of program improvements to help overcome challenges unique to each City. The following list outlines a variety of activities which the District may decide to support via Stewardship Grant funding. When considering support, it is recommended the District assign higher priority to activities that improve street sweeping operations or assist in meeting or maintaining baseline standards:

- Purchasing additional street sweeping equipment / support of funding for additional street sweeping personnel.
- Contracting of additional street sweeping operations.
- Funding to support enhanced sweeping in priority areas.
- Assistance with vehicle maintenance costs / labor costs.
- Assistance with material disposal / screening costs to support sweeping efforts.
- Assistance with public education and outreach (e.g., pre-sweeping operation signage).
- Assistance with research and analysis related to material testing and disposal / reuse.

This list above is intended to outline types of activities that the District may choose to support via the Stewardship grant program. This is not a complete list, and funding consideration should remain flexible to allow for consideration of unique requests to enhance or maintain street sweeping operations.

4.3 Stewardship Grant Funding: Progress Tracking

Tracking progress related to application of grant funds is critical to the success of any grant program. Below is a list of strategies that may be used to track enhanced sweeping efforts associated with Steward grant funding:

- **Street sweeping logs and reporting**: request that the grantee submit existing street sweeping tracking documentation and outline a strategy for tracking enhanced street sweeping efforts. This may include operator logs of streets swept including dates and number of passes.
- **GPS tracking**: some Cities have implemented GPS tracking units on street sweeping equipment to help track streets swept, log timing of sweepings, and track operator progress during sweeping operations. GPS tracking could be utilized to demonstrate enhanced street sweeping efforts.
- **Material weight tracking**: many Cities weigh material as part of screening and disposal processes. Requesting applicants to collect swept material may be utilized to demonstrate the effectiveness of enhanced street sweeping efforts. As discussed in Section 5, weight may also be used to estimate pollutant reduction utilizing the MPCA Street Sweeping Calculator.

5 General Street Sweeping Guidance and Recommendations

During research and development related to this study, Barr reviewed many references, fact sheets, and studies related to the development, implementation, and improvement of street sweeping programs. The following table provides a summary of key recommendations from reviewed references (see Section 7) as well as the following sources:

- MPCA MS4 Fact Sheet: Street and Parking Lot Sweeping
- North American Sweeper Magazine: Top Tips for Street Sweeping
- Adopt a Storm Drain
- MCPA Managing Street Sweepings

Table 5-1 General street sweeping program recommendations

Category	Street Sweeping Recommendation
Sweeping Frequency and Timing	• Street sweeping operations should be targeted at the following critical times each year: o Early spring: immediately following snowmelt to capture sand, leaf litter from the previous season, and other deicing materials. o Mid-June: following release of summer flowering material and seeds (e.g., maple seeds) o Fall: timed with leaf drop to the extent practicable.
Regenerative Air versus Mechanical Sweepers	• Regenerative air sweepers are more effective for capturing small particulate but less effective than mechanical sweepers during wet conditions. • Tandem sweeping (one sweeper followed by another, e.g., mechanical sweeper followed by regenerative air) can greatly increase sweeping efficiency. • A recent Minnesota Stormwater Research Council study did not find a statistically significant difference in total nutrient recovery between mechanical broom and regenerative air sweepers (Hobbie et al, 2020)
Operations	• Coordinate with street sweeping operators to determine what are the most significant barriers to effective curb sweeping (for example): o Interruptions caused by on-street parking o Distance to storage/disposal facility o Asset management/route tracking o Timing of street sweeping operations, etc.
Policy	• Enact policies to discourage tree placement along boulevards (i.e., enact policies to reduce street canopy overhang and encourage a buffer between street surfaces and trees). Note: this policy recommendation does not account for other benefits of canopy cover, including rainfall interception and heat island reduction. • Use off-street signage to inform residents when streets are being swept and remind residents to move vehicles.
Public Outreach	• Consider incorporating the following public outreach objectives into a comprehensive street sweeping program: o Encourage residents to rake/bag June and fall leaf litter. o Include a link to MN adopt a drain (i.e., encourage residents to "adopt" and clean debris/clear ice from a nearby catch basin). o Consider adding functionality for residents to request street sweeping/report issues (e.g., sediment loading from a nearby construction site, etc.). Information gathered in aggregate can be used to evaluate high sediment/pollutant loading areas.
MPCA Street Sweeping Calculator	• Consider recording collected material weights (wet or dry) for pollutant removal evaluation using the recently developed MPCA Street Sweeping Calculator. o The calculator utilizes empirical relationships developed from the 2020 Minnesota Stormwater Research Council study (Hobbie et al., 2020) to estimate phosphorus recovery associated with wet or dry weight sweeping mass totals.

6 Conclusions and Recommendations

A modeling analysis was performed to evaluate the performance of existing street sweeping operations throughout the District. Results of this analysis were used to (a) evaluate existing street sweeping programs throughout the District, (b) develop a methodology to rank and prioritize street sweeping areas / zones, and (c) develop recommendations to RWMWD Stewardship Grant program to support funding of enhanced street sweeping operations. A summary of key conclusions and recommendations presented in this technical memorandum is included, below:

- A survey of RWMWD municipal partners was conducted to evaluate existing street sweeping programs. Survey results were summarized and used to (a) develop modeling of existing street sweeping operations and (b) identify challenges to implementing street sweeping operations and potential requests for funding support to enhance operations.
- Existing street sweeping modeling and a seasonal modeling cost-benefit analysis was used to develop a baseline street sweeping recommendation for member cities (i.e., 1 summer sweeping, 1 spring sweeping, and 2-3 fall sweepings). Baseline modeling results were used to develop strategies to identify and rank high priority street sweeping areas throughout the District.
- Street sweeping prioritization strategies were reviewed with District staff and used to develop programmatic recommendations for updates to the RWMWD Stewardship Grant Program. It is recommended that prioritization strategies outlined in Section 4 and street sweeping prioritization rankings and results (Table 4-1, Appendix C) be used to inform support of enhanced street sweeping operations through the Stewardship Grant Program.
- Consider summarizing and sharing general street sweeping guidance and recommendations summarized in Section 5 with partner cities.
- Prioritization results developed during this study can be re-evaluated at any scale. If member Cities have operational street sweeping areas (street sweeping “zones”), prioritization values could be used to develop a unique ranking analysis for each City based on existing street sweeping zones.

List of Appendices

Appendix A – RWMWD street sweeping survey responses.
Appendix B – Existing condition street sweeping recovery and reduction results.
Appendix C – Baseline condition recovery, reduction, and ranking results.

7 References

Barr Engineering Co. (Barr). 2020. Development and Validation of GIS WQM and P8 Water Quality Models. Prepared for the City of Richfield. December 11, 2020.

Barr Engineering Co. (Barr). 2021. Street Sweeping Prioritization Study. Prepared for the City of Richfield. September 8, 2021.

Emmons and Olivier Resources (EOR). 2022. City of Woodbury: Enhances Street Sweeping Plan. Prepared for the South Washington Watershed District. June 2022.

Hobbie, S.M., King, R., Belo, T., Baker, L.A., and Finlay, J.C. 2020. Developing a Street Sweeping Credit for Stormwater Phosphorus Source Reduction. A Project of the Minnesota Stormwater Research Council. September, 2020.

Kalinosky, P. 2015. Quantifying Solids and Nutrient Recovered Through Street Sweeping in Suburban Watershed (Master's Thesis). University of Minnesota.

Sutherland, R.C. and Jelen, S.L. 1997. Contrary to Conventional Wisdom, Street Sweeping Can be a Effective BMP. Advances in Modeling the Management of Stormwater Impacts. Vol. 5 (1997) 179-190.

Appendix A – RWMWD street sweeping survey responses.

Municipality	RWMWD street sweeping survey question to municipal partners										
	1. Curb Miles Maintained	2. Sweepings per year	3. Certain areas more frequent	4. Annual expenses	5. Type and number of sweepers	6. Annual staff hours	7. Barriers	8. Data collected	9. Reasons for sweeping	10. Cost share options	11. Additional comments
Little Canada	58	3 times/year. Spring, summer, and fall	Some areaswith excessive leaves and tree seeds are hit twice during each sweeping event	Not available	Johnston VT651 sweeper: combination mechanical/vacuum sweeper	250	1) Staff availability. 2) Timing sweepings to be the most efficient in collecting leaves. 3) Cost of disposal	Not at this time.	Aesthetics and water quality	Further study of the material that is collected and help offset disposal costs	
Maplewood	275	Goal of 5 times/year. 2 in spring, 3 in fall.	Isolated sweeping in summer for maintenance operations or storm cleanup.	2022 budget: $318,000	2 Elgin Mechanical	1734. Includes haul truck	Weather	No, material is screened and disposed of	Public safety, water quality, maintenance	Disposal and screening cost	
North St. Paul	91	6-7 times per year. 2 in spring, 2 in summer, 3 in fall.	Sweep by lakes and ponds more frequently because of the immediate drainage into them. Possible additional clean ups after storms.	Approximately $150,000	1 Elgin Pelican mechanical street sweeper	1,100	1) Finding places to dispose of material and cost of disposal. 2) staff because they juggle multiple duties and can't always get the sweeper out when they would like.	2021: collected approximately 400 yards of leaves and 350-400 tons of street sweepings (sand, road debris)	To remove trash, sand, leaves, and debris from our roadways to help prevent these things from entering storm drains, lakes, and ponds	1) Assist with staffing costs to increase sweeping in priority areas. 2) Disposal costs.	
Oakdale	200	At least 3 times per year. Spring sweeping is done in late March and April, Summer sweeping is more random but done from late May into July, Fall sweeping is done in mid to late October into November or as long as weather allows.	some areas are swept 4-6 times per year due to leaves and other organic debris. They are swept more frequently for appearance as well as water quality.	Approximately $75,000	1 Elgin Pelican mechanical sweeper, 1 Tymco 500X regenerative air sweeper	1,000	1) lack of staffing. 2) lack of funding.	We tend to track miles swept more than amount of material collected, but we have a good idea of amount collected as we are charged per yard to dump.	Water quality and appearance/cleanliness, also safety for bike riders and motorcyclists	Assist with staffing costs to increase sweeping	
Roseville	250	4-6 full city sweeps per year. 1 in spring, 2-4 in summer, 1 in fall.	Sensitive areas (adjacent to lakes, wetlands, etc.) & critical areas (areas adjacent to known drainage/flooding issues). potential for smaller clean up areas throughout the year due to do construction, weather, accidents, etc.	Approximately $250,000	2 Pelican sweepers, 1 regenerative sweeper/vacuum	1,850	1) On street parking. 2) disposal of materials. 3) staff time. 4) budget.	Roseville currently collects the material, tests it, and then hires a contractor to haul the material to be reused and/or landfilled depending on the type.	Improve and protect water quality, reduce drainage/flooding issues, and helps keep the city looking clean.	1) Upgrade equipment. 2) purchase another sweeper. 3) pay staff. 4) purchase a screen so we can reuse more material (priority for the city), etc.	**Roseville**: 350 lane miles are swept each full sweep. Roseville has a 126 centerline miles of road, but we sweep all lanes (turn lanes, center/left turn lanes, etc.) 1,400 – 2,100 lane miles annually. Expanding the street sweeping program may be difficult, but we could likely look at efficiencies and capturing more materials off the road with newer equipment. Any funding the city saves in street sweeping, could be used to add sumped catch basins with hoods/baffles to help capture what we don't pick up from the streets before it gets to our surface waters. Roseville also operates a leaf drop off site that residents use, and the city also puts leaves that are collected in the fall there. Currently we are looking to purchase a new compost turner (~$250,000) that we use to help speed up the break down of leaves and turn it into compost of residents to pick up at no charge. Educating the public on why we are sweeping as frequently as we do, and why we are sweeping more often if we add additional sweepings.
Shoreview	110	4-6 citywide sweeps per year. Sweeping starts after snow melt in spring and continues until snow starts in fall.	Yes, permeable pavement areas, typically once per month. Require additional sweeping to maintain permeability.	$60,000	1 mechanical sweeper, 1 regenerative air sweeper. Both sweepers are used throughout the city, but the mechanical sweeper will be used in areas where there is larger material or many leaves and the regenerative air is used for the permeable pavement.	600	1) Maintenance of equipment. 2)available staff time. 3) distance to dispose of material during the fall when collecting mainly leaves. Typically take swept up leaves directly to the compost site.	Yes, we screen the swept up material and the screened material is sent to the landfill and used as daily cover. The material that is removed by the screen is landfilled. The weight for both types of material is determined when taken to the landfill. Material is also tested annually to determine if a special disposal of the material is required.	Water quality and reduce maintenance required for city BMPs.	Potentially use to hire company to complete additional sweeping in high priority areas.	**Shoreview**: We charge developers $75/hour if we need to use city equipment to clean a street. Typical citywide sweeper requires two staff for two weeks, total of 160-hours. Assuming 5 citywide sweeps a total of 600-hours annually.
St Paul	2,000 curb miles, 2000 alleys	Most swept in spring and fall. Arterial streets swept 4-8 timesper year	Higher volume traffic areas	$4.5 million	15 Elgin Pelican and 1 Elgin Crosswind	30 FTEs	parking and staffing	track loads per shift	Clean streets of debris and trash, Fulfill the City's MS4 permit requirements	open to discuss opportunities.	**STP**: spring/summer has more trash, silt, and dirt. Fall is heavy on leaves.
White Bear Lake	183	We do a complete sweep of the entire city twice a year Spring & Fall. During that time we are able to sweep all the city streets at least once sometimes twice. Also throughout the summer we sweep high volume areas every Friday, and touch up problems as they occur.	Yes, our downtown area is swept more frequently because of the activities that are a constant in that area. A lot of trees and foliage in this area and runoff from much of the area flows to White Bear Lake.	47000	one sweeper it is a Tymco 500X regenerative air truck mount on a Freightliner chassis.	720	1) Finding places to dispose of material and cost of disposa. 2) weather 3) the man hours to get the job done; it's a very slow time-consuming process, the sweeper doesn't pick up sticks so the operator has to get out and move them or it jams the equipment. We do have a follow truck to collect the sweepings and that helps; they try and pave the way for the operator. 4) Residents are always parked on the street so we can't do a thorough job also. 5) Barriers that prevent sweeping from happening more often include the cost to purchase a second sweeper. 6) cost of additional driver and maintenance staff, and finding qualified staff to operate the sweeper. 7) More research would need to be done to determine the need for additional sweeping, optimal timing for additional sweeping, and specific target areas. There is limited staff time to complete this analysis.	Not at this time.	Pollution control and preventative maintenance to help maintain street integrity.	1) disposal costs 2) staffing for additional sweeping in priority areas 3)additional sweeper 4) staff for operation and maintenance 5) hire someone to complete an initial analysis to determine the need for additional sweeping, targeted areas, and timing.	**White Bear Lake**: Maintenance and fuel costs run approximately $16,949.47, labor costs to run the machine is approximately $29,851.20. There are also costs associated with street sweeper training for the driver and mechanic. Providing a location to dump the street sweepings would be very helpful. It's good that we collect the pollution off of the street but now we need a way to dispose of the pollution. Public Works staff have talked about other options for sweeping streets. For example, is there a sweeping attachment for a 1 ton truck that can be used in smaller priority areas for the entire season? This may reduce the need for specialized training for the driver and mechanic and may allow for a seasonal person to operate. Environmental impacts from running an additional sweeper should be considered and mitigated if possible. The City looks for ways to reduce our environmental impact, which includes lowering emissions from our vehicles. City staff toured Zeus Electric Chassis in WB Township this spring and they may be offering an electric street sweeper in the future. We asked them to
Woodbury	722	In spring after the snow melt, in fall before leaves drop from the trees.	Some roads are swept during months after any type of road maintenance has been performed.	2021 expenses: $117,250- equipment, labor and contractual services that are brought in to complete the spring and fall sweep.	1 mechanical, 1 regenerative air sweeper. 8 contractual sweepers in the spring and 6 contractual sweepers in the fall.	450 for spring and fall staff sweepings.	Finding places to dispose of material.	We currently only track how many tons of material are collected not the type of material collected.	To keep material from the roadways from entering our ponds and to meet the requirements of our MS4 permit.	Assist with staff time to sweep more often during the summer months and to possibly do a leaf sweep after the leaves have fallen off of the trees.	

Complete list of survey questions:

1) How many curb miles are maintained annually?
2) How many times per year are streets swept and when does sweeping usually occur (e.g., how many street sweeping operations are conducted in the Spring / Summer / Fall)?
3) Are certain areas swept more frequently than others? How are those areas determined?
4) What are approximate street sweeping expenses annually, including equipment and labor costs?
5) What type(s) of sweepers (e.g., mechanical sweeper, regenerative air, vacuum, etc.) and how many pieces of street sweeping equipment are used?
6) How many full time staff hours are used each year to operate the sweepers?
7) What are the biggest barriers encountered while street sweeping especially those that may prevent sweeping from happening more often (e.g., interruptions caused by on-street parking, distance to storage/disposal facility, time / staff / budget, etc.)?
8) Is any data currently collected to assess the type and amount of material collected?
9) What are the main reasons for street sweeping in this city?
10) If RWMWD could offer cost share dollars to help increase street sweeping in priority areas to help improve water quality, how can you imagine using that money?
11) Any additional comments to share?

Appendix B – Existing condition street sweeping recovery and reduction results.

Table B-1 Existing condition street sweeping results by municipality: TSS recovery and reduction

Municipality	Area (acres)	Total Suspended Sediment (TSS) Loading and Removal								
		Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
		Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Gem Lake	45.6	8,730	125	1.4%	20,990	5	0.0%	0	0	0.0%
Landfall	53.0	13,604	414	3.0%	13,604	414	3.0%	11,019	332	3.0%
Little Canada	2,882.3	485,332	21,847	4.5%	405,678	3,782	0.9%	16,165	556	3.4%
Maplewood	10,840.4	1,675,210	54,129	3.2%	1,438,099	14,805	1.0%	513,231	5,018	1.0%
North Saint Paul	1,774.7	364,669	17,113	4.7%	364,361	234	0.1%	0	0	0.0%
Oakdale	3,328.8	537,506	31,363	5.8%	495,495	4,643	0.9%	233,385	2,256	1.0%
Roseville	2,603.2	357,145	31,785	8.9%	338,452	6,357	1.9%	338,260	6,357	1.9%
Saint Paul	10,431.9	1,507,700	35,068	2.3%	970,903	19,177	2.0%	811,745	15,903	2.0%
Shoreview	3,409.1	396,296	33,705	8.5%	167,255	4,848	2.9%	46,216	2,160	4.7%
Vadnais Heights	1,320.3	275,828	4,399	1.6%	228,571	320	0.1%	16,270	45	0.3%
White Bear	6.5	327	22	6.6%	515	3	0.6%	1	0	0.0%
White Bear Lake	1,956.2	311,926	19,507	6.3%	310,549	198	0.1%	0	0	0.0%
Woodbury	4,670.2	867,449	36,747	4.2%	787,496	4,688	0.6%	787,077	4,676	0.6%

Table B-2 Existing condition street sweeping results by municipality: TP recovery and reduction

Municipality	Area (acres)	Total Phosphorus (TP) Loading and Removal								
		Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
		Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Gem Lake	45.6	8,730	125	1.4%	20,990	5	0.0%	0	0	0.0%
Landfall	53.0	13,604	414	3.0%	13,604	414	3.0%	11,019	332	3.0%
Little Canada	2,882.3	485,332	21,847	4.5%	405,678	3,782	0.9%	16,165	556	3.4%
Maplewood	10,840.4	1,675,210	54,129	3.2%	1,438,099	14,805	1.0%	513,231	5,018	1.0%
North Saint Paul	1,774.7	364,669	17,113	4.7%	364,361	234	0.1%	0	0	0.0%
Oakdale	3,328.8	537,506	31,363	5.8%	495,495	4,643	0.9%	233,385	2,256	1.0%
Roseville	2,603.2	357,145	31,785	8.9%	338,452	6,357	1.9%	338,260	6,357	1.9%
Saint Paul	10,431.9	1,507,700	35,068	2.3%	970,903	19,177	2.0%	811,745	15,903	2.0%
Shoreview	3,409.1	396,296	33,705	8.5%	167,255	4,848	2.9%	46,216	2,160	4.7%
Vadnais Heights	1,320.3	275,828	4,399	1.6%	228,571	320	0.1%	16,270	45	0.3%
White Bear	6.5	327	22	6.6%	515	3	0.6%	1	0	0.0%
White Bear Lake	1,956.2	311,926	19,507	6.3%	310,549	198	0.1%	0	0	0.0%
Woodbury	4,670.2	867,449	36,747	4.2%	787,496	4,688	0.6%	787,077	4,676	0.6%

Table B-3 Existing condition street sweeping results by major watershed: TSS recovery and reduction

Major Watershed	RWMWD Impairment Status	Area (acres)	Total Suspended Sediment (TSS) Loading and Removal								
			Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
			Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Battle Creek	Impaired	2,978.0	516,624	15,876	3.1%	490,052	5,371	1.1%	490,052	5,371	1.1%
Battle Creek Lake	At Risk	2,622.5	549,789	20,127	3.7%	555,059	5,056	0.9%	555,059	5,056	0.9%
Beaver Lake	At Risk	1,942.8	231,880	10,049	4.3%	231,882	1,404	0.6%	231,882	1,404	0.6%
Blufflands	Impaired	1,844.5	209,305	7,893	3.8%	0	0	0.0%	0	0	0.0%
Carver Lake	At Risk	2,273.3	394,478	19,047	4.8%	390,603	1,876	0.5%	390,603	1,876	0.5%
Fish Creek	At Risk	708.3	52,130	1,395	2.7%	0	0	0.0%	0	0	0.0%
Gervais Creek	Stable	1,815.7	382,707	15,026	3.9%	382,882	1,156	0.3%	0	0	0.0%
Gervais Lake	Stable	893.1	82,956	5,118	6.2%	82,956	2,416	2.9%	0	0	0.0%
Grass Lake	Stable*	1,384.1	194,084	12,303	6.3%	0	0	0.0%	0	0	0.0%
Keller Lake	Stable	1,698.4	271,645	8,973	3.3%	269,049	3,274	1.2%	0	0	0.0%
Kohlman Creek	Stable	3,526.2	723,903	26,978	3.7%	730,046	1,115	0.2%	0	0	0.0%
Kohlman Lake	Impaired	1,011.4	138,205	3,772	2.7%	138,205	2,552	1.8%	138,205	2,552	1.8%
Lake Owasso	At Risk	3,016.4	371,173	33,836	9.1%	389,754	8,555	2.2%	389,754	8,555	2.2%
Lake Phalen	Stable	2,814.2	422,079	14,560	3.4%	377,014	7,699	2.0%	0	0	0.0%
Lake Wabasso	Stable	146.7	13,080	1,563	11.9%	13,080	1,353	10.3%	0	0	0.0%
Snail Lake	Stable	922.6	91,814	10,531	11.5%	102,504	1,335	1.3%	0	0	0.0%
Snake Creek	Stable*	149.7	9,143	241	2.6%	0	0	0.0%	0	0	0.0%
St. Paul Beltline	Impaired	2,875.6	573,083	14,897	2.6%	577,812	12,488	2.2%	577,812	12,488	2.2%
Tanners Lake (North)	Stable	1,352.2	217,733	11,979	5.5%	218,839	1,365	0.6%	0	0	0.0%
Tanners Lake (South)	Stable	349.4	52,311	3,389	6.5%	52,311	1,990	3.8%	0	0	0.0%
West Vadnais Lake	Stable*	134.1	20,230	1,009	5.0%	2,449	2	0.1%	0	0	0.0%
Willow Creek	Stable*	2,796.1	510,226	21,302	4.2%	537,476	465	0.1%	0	0	0.0%

Table B-4 Existing condition street sweeping results by major watershed: TP recovery and reduction

Major Watershed	RWMWD Impairment Status	Area (acres)	Total Phosphorus (TP) Loading and Removal								
			Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
			Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Battle Creek	Impaired	2,978.0	1,720.0	164.5	9.6%	1,628.5	105.3	6.5%	1,628.5	105.3	6.5%
Battle Creek Lake	At Risk	2,622.5	1,816.1	58.1	3.2%	1,833.3	32.7	1.8%	1,833.3	32.7	1.8%
Beaver Lake	At Risk	1,942.8	784.0	101.4	12.9%	784.0	31.4	4.0%	784.0	31.4	4.0%
Blufflands	Impaired	1,844.5	712.3	121.7	17.1%	0.0	0.0	0.0%	0.0	0.0	0.0%
Carver Lake	At Risk	2,273.3	1,312.4	63.8	4.9%	1,299.3	18.6	1.4%	1,299.3	18.6	1.4%
Fish Creek	At Risk	708.3	183.2	16.4	9.0%	0.0	0.0	0.0%	0.0	0.0	0.0%
Gervais Creek	Stable	1,815.7	1,263.9	65.1	5.1%	1,264.6	11.2	0.9%	0.0	0.0	0.0%
Gervais Lake	Stable	893.1	280.3	47.1	16.8%	280.3	25.5	9.1%	0.0	0.0	0.0%
Grass Lake	Stable*	1,384.1	649.2	74.3	11.4%	0.0	0.0	0.0%	0.0	0.0	0.0%
Keller Lake	Stable	1,698.4	905.3	94.3	10.4%	896.1	44.3	4.9%	0.0	0.0	0.0%
Kohlman Creek	Stable	3,526.2	2,395.5	406.1	17.0%	2,416.2	42.6	1.8%	0.0	0.0	0.0%
Kohlman Lake	Impaired	1,011.4	463.1	28.3	6.1%	463.1	22.2	4.8%	463.1	22.2	4.8%
Lake Owasso	At Risk	3,016.4	1,246.4	178.9	14.4%	1,308.1	106.0	8.1%	1,308.1	106.0	8.1%
Lake Phalen	Stable	2,814.2	1,409.5	204.6	14.5%	1,257.1	127.9	10.2%	0.0	0.0	0.0%
Lake Wabasso	Stable	146.7	44.2	9.8	22.2%	44.2	8.7	19.7%	0.0	0.0	0.0%
Snail Lake	Stable	922.6	311.5	74.9	24.0%	346.6	51.5	14.9%	0.0	0.0	0.0%
Snake Creek	Stable*	149.7	32.8	4.4	13.4%	0.0	0.0	0.0%	0.0	0.0	0.0%
St. Paul Beltline	Impaired	2,875.6	1,899.9	357.8	18.8%	1,914.7	338.6	17.7%	1,914.7	338.6	17.7%
Tanners Lake (North)	Stable	1,352.2	727.1	41.3	5.7%	730.8	17.2	2.4%	0.0	0.0	0.0%
Tanners Lake (South)	Stable	349.4	173.7	24.3	14.0%	173.7	20.4	11.8%	0.0	0.0	0.0%
West Vadnais Lake	Stable*	134.1	67.5	16.8	24.8%	8.1	0.1	0.7%	0.0	0.0	0.0%
Willow Creek	Stable*	2,796.1	1,694.5	143.4	8.5%	1,784.2	12.6	0.7%	0.0	0.0	0.0%

Appendix C – Baseline condition recovery, reduction, and ranking results.

Table C-1 RWMWD baseline condition street sweeping results by municipality: TSS recovery and reduction

Municipality	Area (acres)	Total Suspended Sediment (TSS) Loading and Removal								
		Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
		Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Gem Lake	45.6	8,730	465	5.3%	20,990	19	0.1%	0	0	0.0%
Landfall	53.0	13,604	1,532	11.3%	13,604	1,532	11.3%	11,019	1,226	11.1%
Little Canada	2,882.3	485,332	32,443	6.7%	405,678	5,154	1.3%	16,165	668	4.1%
Maplewood	10,840.4	1,675,210	123,678	7.4%	1,438,099	34,986	2.4%	513,231	12,076	2.4%
North Saint Paul	1,774.7	364,669	33,109	9.1%	364,361	455	0.1%	0	0	0.0%
Oakdale	3,328.8	537,506	40,466	7.5%	495,495	6,265	1.3%	233,385	3,325	1.4%
Roseville	2,603.2	357,145	33,535	9.4%	338,452	6,791	2.0%	338,260	6,790	2.0%
Saint Paul	10,431.9	1,507,700	129,759	8.6%	970,903	70,932	7.3%	811,745	58,824	7.2%
Shoreview	3,409.1	396,296	35,508	9.0%	167,255	4,708	2.8%	46,216	2,088	4.5%
Vadnais Heights	1,320.3	275,828	16,328	5.9%	228,571	1,190	0.5%	16,270	168	1.0%
White Bear	6.5	327	36	11.1%	515	6	1.2%	1	0	0.0%
White Bear Lake	1,956.2	311,926	25,819	8.3%	310,549	306	0.1%	0	0	0.0%
Woodbury	4,670.2	867,449	62,791	7.2%	787,496	9,653	1.2%	787,077	9,608	1.2%

Table C-2 RWMWD baseline condition street sweeping results by municipality: TP recovery and reduction

Municipality	Area (acres)	Total Phosphorus (TP) Loading and Removal								
		Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
		Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Gem Lake	45.6	29.0	2.0	6.9%	68.2	0.3	0.4%	0.0	0.0	0.0%
Landfall	53.0	44.5	6.6	14.7%	44.5	6.6	14.7%	35.9	5.6	15.6%
Little Canada	2,882.3	1,610.6	149.6	9.3%	1,347.0	46.7	3.5%	55.8	3.9	7.1%
Maplewood	10,840.4	5,597.3	551.8	9.9%	4,787.5	214.6	4.5%	1,716.3	86.9	5.1%
North Saint Paul	1,774.7	1,207.0	261.0	21.6%	1,206.1	20.5	1.7%	0.0	0.0	0.0%
Oakdale	3,328.8	1,793.2	172.6	9.6%	1,651.6	58.5	3.5%	775.5	20.1	2.6%
Roseville	2,603.2	1,197.2	165.5	13.8%	1,134.7	80.6	7.1%	1,134.1	80.6	7.1%
Saint Paul	10,431.9	5,028.4	1,045.7	20.8%	3,223.2	697.1	21.6%	2,693.3	583.0	21.6%
Shoreview	3,409.1	1,332.8	240.5	18.0%	565.5	92.7	16.4%	156.8	34.3	21.9%
Vadnais Heights	1,320.3	911.1	45.1	4.9%	754.1	7.2	0.9%	53.3	1.0	1.8%
White Bear	6.5	1.2	0.1	7.1%	1.8	0.0	2.5%	0.0	0.0	0.0%
White Bear Lake	1,956.2	1,042.2	171.0	16.4%	1,037.2	10.9	1.1%	0.0	0.0	0.0%
Woodbury	4,670.2	2,878.2	172.1	6.0%	2,611.4	60.0	2.3%	2,610.0	59.8	2.3%

Table C-3 RWMWD baseline condition street sweeping results by watershed: TSS recovery and reduction

Major Watershed	RWMWD Impairment Status	Area (acres)	Total Suspended Sediment (TSS) Loading and Removal								
			Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
			Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Battle Creek	Impaired	2,978.0	516,624	40,464	7.8%	490,052	15,952	3.3%	490,052	15,952	3.3%
Battle Creek Lake	At Risk	2,622.5	549,789	34,559	6.3%	555,059	10,425	1.9%	555,059	10,425	1.9%
Beaver Lake	At Risk	1,942.8	231,880	19,492	8.4%	231,882	4,111	1.8%	231,882	4,111	1.8%
Blufflands	Impaired	1,844.5	209,305	21,546	10.3%	0	0	0.0%	0	0	0.0%
Carver Lake	At Risk	2,273.3	394,478	32,012	8.1%	390,603	3,481	0.9%	390,603	3,481	0.9%
Fish Creek	At Risk	708.3	52,130	3,482	6.7%	0	0	0.0%	0	0	0.0%
Gervais Creek	Stable	1,815.7	382,707	25,231	6.6%	382,882	1,818	0.5%	0	0	0.0%
Gervais Lake	Stable	893.1	82,956	8,674	10.5%	82,956	3,847	4.6%	0	0	0.0%
Grass Lake	Stable*	1,384.1	194,084	14,152	7.3%	0	0	0.0%	0	0	0.0%
Keller Lake	Stable	1,698.4	271,645	20,530	7.6%	269,049	7,755	2.9%	0	0	0.0%
Kohlman Creek	Stable	3,526.2	723,903	53,124	7.3%	730,046	2,512	0.3%	0	0	0.0%
Kohlman Lake	Impaired	1,011.4	138,205	8,415	6.1%	138,205	5,794	4.2%	138,205	5,794	4.2%
Lake Owasso	At Risk	3,016.4	371,173	35,010	9.4%	389,754	8,939	2.3%	389,754	8,939	2.3%
Lake Phalen	Stable	2,814.2	422,079	39,026	9.2%	377,014	21,874	5.8%	0	0	0.0%
Lake Wabasso	Stable	146.7	13,080	1,526	11.7%	13,080	1,337	10.2%	0	0	0.0%
Snail Lake	Stable	922.6	91,814	10,331	11.3%	102,504	1,284	1.3%	0	0	0.0%
Snake Creek	Stable*	149.7	9,143	571	6.3%	0	0	0.0%	0	0	0.0%
St. Paul Beltline	Impaired	2,875.6	573,083	54,977	9.6%	577,812	46,071	8.0%	577,812	46,071	8.0%
Tanners Lake (North)	Stable	1,352.2	217,733	16,187	7.4%	218,839	2,186	1.0%	0	0	0.0%
Tanners Lake (South)	Stable	349.4	52,311	5,010	9.6%	52,311	3,380	6.5%	0	0	0.0%
West Vadnais Lake	Stable*	134.1	20,230	1,677	8.3%	2,449	7	0.3%	0	0	0.0%
Willow Creek	Stable*	2,796.1	510,226	33,320	6.5%	537,476	1,226	0.2%	0	0	0.0%

Table C-4 RWMWD baseline condition street sweeping results by watershed: TP recovery and reduction

Major Watershed	RWMWD Impairment Status	Area (acres)	Total Phosphorus (TP) Loading and Removal								
			Street Sweeping: Recovery			Street Sweeping: Reduction			Street Sweeping: Reduction [impaired / at risk watersheds]		
			Loading (lbs/yr)	Recovery (lbs/yr)	Recovery (%)	Loading in P8 Modeled Areas (lbs/yr)	Reduction (lbs/yr)	Reduction (%)	Loading in P8 Modeled Areas [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (lbs/yr)	Reduction [imp. / at risk] (%)
Battle Creek	Impaired	2,978.0	1,720.0	210.6	12.2%	1,628.5	137.6	8.5%	1,628.5	137.6	8.5%
Battle Creek Lake	At Risk	2,622.5	1,816.1	86.3	4.8%	1,833.3	47.9	2.6%	1,833.3	47.9	2.6%
Beaver Lake	At Risk	1,942.8	784.0	114.5	14.6%	784.0	37.0	4.7%	784.0	37.0	4.7%
Blufflands	Impaired	1,844.5	712.3	152.3	21.4%	0.0	0.0	0.0%	0.0	0.0	0.0%
Carver Lake	At Risk	2,273.3	1,312.4	92.1	7.0%	1,299.3	26.3	2.0%	1,299.3	26.3	2.0%
Fish Creek	At Risk	708.3	183.2	18.7	10.2%	0.0	0.0	0.0%	0.0	0.0	0.0%
Gervais Creek	Stable	1,815.7	1,263.9	87.2	6.9%	1,264.6	14.9	1.2%	0.0	0.0	0.0%
Gervais Lake	Stable	893.1	280.3	57.0	20.3%	280.3	30.9	11.0%	0.0	0.0	0.0%
Grass Lake	Stable*	1,384.1	649.2	74.6	11.5%	0.0	0.0	0.0%	0.0	0.0	0.0%
Keller Lake	Stable	1,698.4	905.3	97.6	10.8%	896.1	47.1	5.3%	0.0	0.0	0.0%
Kohlman Creek	Stable	3,526.2	2,395.5	362.7	15.1%	2,416.2	39.9	1.7%	0.0	0.0	0.0%
Kohlman Lake	Impaired	1,011.4	463.1	33.4	7.2%	463.1	26.5	5.7%	463.1	26.5	5.7%
Lake Owasso	At Risk	3,016.4	1,246.4	196.3	15.8%	1,308.1	115.9	8.9%	1,308.1	115.9	8.9%
Lake Phalen	Stable	2,814.2	1,409.5	251.8	17.9%	1,257.1	164.6	13.1%	0.0	0.0	0.0%
Lake Wabasso	Stable	146.7	44.2	9.8	22.2%	44.2	8.9	20.1%	0.0	0.0	0.0%
Snail Lake	Stable	922.6	311.5	71.6	23.0%	346.6	49.5	14.3%	0.0	0.0	0.0%
Snake Creek	Stable*	149.7	32.8	4.5	13.8%	0.0	0.0	0.0%	0.0	0.0	0.0%
St. Paul Beltline	Impaired	2,875.6	1,899.9	510.9	26.9%	1,914.7	484.2	25.3%	1,914.7	484.2	25.3%
Tanners Lake (North)	Stable	1,352.2	727.1	54.1	7.4%	730.8	21.8	3.0%	0.0	0.0	0.0%
Tanners Lake (South)	Stable	349.4	173.7	30.3	17.4%	173.7	25.5	14.7%	0.0	0.0	0.0%
West Vadnais Lake	Stable*	134.1	67.5	18.7	27.7%	8.1	0.1	1.1%	0.0	0.0	0.0%
Willow Creek	Stable*	2,796.1	1,694.5	185.3	10.9%	1,784.2	17.1	1.0%	0.0	0.0	0.0%

Table C-5 RWMWD baseline condition street sweeping prioritization ranking by municipality: TSS recovery and reduction

Municipality	Area (acres)	TSS Prioritization Ranking Strategies								
		Street Sweeping Reduction & Removal Comparison [Baseline - Existing Conditions] (lbs/yr)			Reduction / Recovery Ranking Value [1 = high priortiy, 0 = low priority]			Reduction / Recovery Ranking Number (#)		
		Recovery	Reduction	Reduction [imp. / at risk]	Recovery	Reduction	Reduction [imp. / at risk]	Recovery	Reduction	Reduction [imp. / at risk]
Gem Lake	45.6	+340	+14	0	0.37	0.39	--	8	4	--
Landfall	53.0	+1117	+1117	+895	0.44	0.50	0.78	4	2	1
Little Canada	2,882.3	+10596	+1372	+112	0.40	0.38	0.36	5	5	6
Maplewood	10,840.4	+69549	+20181	+7058	0.33	0.36	0.22	13	6	9
North Saint Paul	1,774.7	+15996	+221	0	0.51	0.36	--	1	7	--
Oakdale	3,328.8	+9103	+1622	+1069	0.38	0.30	0.33	7	11	7
Roseville	2,603.2	+1750	+434	+433	0.46	0.39	0.39	2	3	4
Saint Paul	10,431.9	+94691	+51755	+42921	0.39	0.52	0.41	6	1	3
Shoreview	3,409.1	+1802	-139	-72	0.37	0.36	0.38	9	8	5
Vadnais Heights	1,320.3	+11929	+870	+123	0.34	0.35	0.47	12	9	2
White Bear	6.5	+15	+3	0	0.34	0.18	0.00	10	13	10
White Bear Lake	1,956.2	+6312	+108	0	0.44	0.27	--	3	12	--
Woodbury	4,670.2	+26044	+4965	+4933	0.34	0.31	0.30	11	10	8

Table C-6 RWMWD baseline condition street sweeping prioritization ranking by municipality: TP recovery and reduction

Municipality	Area (acres)	TP Prioritization Ranking Strategies								
		Street Sweeping Reduction & Removal Comparison [Baseline - Existing Conditions] (lbs/yr)			Reduction / Recovery Ranking Value [1 = high priortiy, 0 = low priority]			Reduction / Recovery Ranking Number (#)		
		Recovery	Reduction	Reduction [imp. / at risk]	Recovery	Reduction	Reduction [imp. / at risk]	Recovery	Reduction	Reduction [imp. / at risk]
Gem Lake	45.6	+1	+0	0	0.39	0.33	--	6	8	--
Landfall	53.0	+3	+3	+2	0.40	0.45	0.72	5	2	1
Little Canada	2,882.3	+34	+9	+1	0.39	0.35	0.29	7	6	7
Maplewood	10,840.4	+12	+9	+5	0.32	0.34	0.21	11	7	9
North Saint Paul	1,774.7	-47	-4	0	0.53	0.40	--	1	5	--
Oakdale	3,328.8	+38	+13	+5	0.36	0.32	0.31	9	9	6
Roseville	2,603.2	+21	+11	+11	0.44	0.43	0.43	3	3	3
Saint Paul	10,431.9	+324	+215	+177	0.42	0.51	0.40	4	1	5
Shoreview	3,409.1	-5	-3	-1	0.37	0.41	0.42	8	4	4
Vadnais Heights	1,320.3	+17	+3	+0	0.32	0.31	0.43	12	10	2
White Bear	6.5	+0	+0	0	0.34	0.16	0.00	10	13	10
White Bear Lake	1,956.2	+36	+2	0	0.44	0.30	--	2	11	--
Woodbury	4,670.2	+63	+21	+21	0.29	0.28	0.28	13	12	8