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| To: | Mike Trojan, Minnesota Pollution Control Agency |
| From: | Aileen Molloy and Jennifer Olson |
| Date: | May 21, 2019 |
| Subject: | *Final* Street Sweeping: Survey of Crediting Approaches |

This document addresses Task B Subtask 1 of the project work plan: to prepare a report summarizing a literature review of existing street sweeping credit methods. Research revealed these categories and considerations to be integral in developing a crediting method: scheduling, equipment, debris measurement, and nutrient quantification.

Crediting methods vary by governing agency. Over 70% of state MS4 permitting agencies do not require or provide a nutrient or sediment reduction credit for street sweeping, regardless of whether there is an applicable TMDL. Generally, street sweeping is regarded as a good housekeeping measure and annual miles swept are tracked. Most street sweeping programs set schedules and prioritize streets based on traffic volume. Some programs attempt to measure the amount of debris removed by street sweeping. However, relatively few entities establish documented quantifiable crediting methods using research-based estimates of pollutant load removal. Of the roughly 30% of states and the District of Columbia that do have a street sweeping crediting program, half adhere to the Chesapeake Bay TMDL crediting method. While California does not have consistent crediting programs throughout the state, individual permitted entities do have street sweeping crediting programs.

While MS4 permits require varying degrees of quantitative and qualitative documentation on street sweeping activities, this literature review focuses on documenting permitting entities that have an established pollutant reduction crediting methodology. These programs typically require documentation, at a minimum, of the length or area of street swept or a measurement of the materials collected with reductions calculated from established pollutant concentrations or reduction efficiencies or individual load reductions based on permittee-specific data.

# Approach

In addition to resources provided by the University of Minnesota, researchers reviewed state and local stormwater/MS4 websites, EPA’s regional MS4 websites and performed general Google searches to identify street sweeping crediting programs. Federal, state and local websites were reviewed to identify the requirements of the relevant MS4 permits, with particular attention paid to TMDL-specific permit requirements. If specific street sweeping requirements were not evident in the state permitting pages, local MS4 permits and annual reports were identified and reviewed to determine the types of street sweeping information reported. The general Google review was conducted using the following search terms or a combination of terms coupled with specific state names: street sweeping, street cleaning, nutrient management, credit, reduction credit, TSS, phosphorus, nutrient removal, nutrient load, stormwater, quantification, qualifying lane miles, mass loading, TMDL and MS4. Once results were located using search terms, researchers reviewed document references to locate additional sources.

When a street sweeping crediting program was identified, researchers attempted to locate the following information: description of each crediting method, location and scale of applicability, factors considered, inputs, key assumptions, quantification approach (if applicable), and conditions under which credit cannot be received or is reduced. All street sweeping crediting programs that were identified are included in the following section.

# Existing Crediting Methods

Crediting methods vary widely across programs. Some rely on weight conversions of wet or dry material to an estimated reduction of total nitrogen, total phosphorus, or total suspended sediment. Other programs credit based on lane miles swept. Some programs use advanced modeling and provide a wide array of options based on equipment used, number of times swept, and seasonal breaks. Table 1 provides a summary of the crediting methods identified, followed by a more in-depth discussion of each method.

For Minnesota, the goal is to provide a mass-based approach, backed by research-based empirical relationships, for the crediting program. This approach is the most defensible as it involves direct measurement. Examples from Table 1 that use a similar approach include: Chesapeake Bay, Florida, Washington Ecology, and potentially North Carolina (in progress). This overall approach is yet to be discussed with stakeholders and may be modified.

Table 1. Crediting Methods Summary

|  |  |  |
| --- | --- | --- |
| Location | Crediting Method | Pollutants |
| Chesapeake Bay Watershed (entities subject to Bay TMDL requirements) | -Reduction efficiency - % reduction from existing load  -Qualifying lane miles -lb/acre reduction  -Mass load reduction | TN, TP, TSS |
| Florida | Mass load reduction | TN, TP |
| EPA Region 1 (New Hampshire and Massachusetts MS4 permittees) | Mass load reduction with efficiency factors | TN (NH only), TP |
| Massachusetts – stormwater requirements (not linked to MS4 permit) | Reduction efficiency - % | TSS |
| Wisconsin | -Reduction efficiency - progress towards % reduction target  -Reduction efficiency - % | TSS, with conversion to TP  TP |
| Washington Ecology – MS4 permittees with TMDL | Mass load reduction, effective developed acres reduction | TP, sediment |
| County and City of San Diego and MS4 Co-permittees | Performance-based compliance | Cu, Zn, Pb, TKN, TP |
| Orange County and MS4 Co-permittees | Reduction efficiency - % | Bacteria, sediment |
| City of Santa Cruz, California | Modeled load reduction | Sediment |
| Vermont (Under development) | Interim – modeled load reduction  Permanent – under development | TP |
| North Carolina (Under development | Mass load reduction | TN, TP |

## Chesapeake Bay Watershed (Chesapeake Bay Program, U.S. EPA)

**Crediting Method:** Reduction efficiency based on acres swept

**Applicability:** Chesapeake Bay watershed (NY, PA, DE, DC, MD, VA, WV) jurisdictions seeking Chesapeake Bay TMDL nutrient reduction credits.

**Details:** The Chesapeake Bay Program Expert Panel on Street Sweeping developed a crediting method for jurisdictions subject to the Chesapeake Bay TMDL (Schueler et al. 2016). WinSLAMM was used to simulate sediment reduction from nearly 1,000 street cleaning scenarios that varied by the length of winter shutdown, types of streets, sweeper technologies, cleaning frequencies and street parking conditions and controls. WinSLAMM does not explicitly simulate nutrients. Nutrient percent reductions are based on empirical nutrient enrichment ratios of street solids (Schueler et al. 2016).

To simplify the crediting, the modeled scenarios were reduced to 11 different practices, based on the type of street sweeper, and the number of times a street is swept per year. Mechanical broom technology was assigned 0% efficiency for all sweeping regimes and only a negligible TSS reduction efficiency. The TSS percent reduction is applied to the unit area sediment load for impervious cover in the Chesapeake Bay Watershed Model (CBWM) to determine the mass reduced. The nutrient reductions are applied to the unit area nitrogen and phosphorus loads for impervious cover in the CBWM. Table 2 summarizes the crediting for the Chesapeake Bay Program.

The credit is only available for curb and gutter roadways and is reported as curb-lane miles swept. Each mile of curb-lane is equivalent to one impervious acre.

**Tracking and Reporting:** To receive credit for the Chesapeake Bay TMDL, annual street cleaning information is reported by practice, as shown in Table 2, and must include the curb-miles or acres-equivalent swept, as well as the type of land use where sweeping occurred (roads, tree canopy over impervious, or roads and tree canopy over impervious). The efficiency is applied to the selected land use. The Expert Panel recommended that MS4 communities report annual street sweeping in annual MS4 reports that are submitted to the state agency. The state agencies are responsible for providing the information on an annual basis to the Chesapeake Bay Program, where it is entered into the Chesapeake Bay watershed model. For verification purposes, localities are required to maintain records that include length of routes swept, frequency, sweeper technology, and parking conditions and controls. In addition, localities are required to collect a single sample from a single route by a single sweeper once a year to characterize the mass and quality of sweeper material collected. The MS4 should measure or estimate the volume of sweeper waste collected, total wet mass, number of curb miles swept on the route and sweeper conditions (date, weather, days since antecedent rainfall, street type, and parking conditions). A sub-sample should also be sent to a laboratory to measure dry weight of sweeper material, particle size distribution, and average carbon, nitrogen and phosphorus content.

Although the reporting mechanism allows the user to indicate that tree canopy over impervious was swept, WinSLAMM did not explicitly account for leaf drop impacts on sediment.

**Additional Information:** The Expert Panel also developed a storm drain cleaning credit based on the mass of solids collected. The sediment credit is based on the dry weight of the mass of solids removed and the nutrient reduction is the mass of solids times a nutrient enrichment factor. Enrichment factors for BMP and catch basin sediments and organic matter/leaf litter are based on midpoint data from several referenced studies.

Table 2. Current CBP Street Sweeping Crediting

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Pollutant Reductions Associated with Different Street Cleaning Practices (SCP)** | | | | | |
| **Practice**  **#** | **Description** | **Approx  Passes/Yr\*** | **TSS Removal**  **(%)\*\*** | **TN Removal**  **(%)\*\*** | **TP Removal**  **(%)\*\*** |
| SCP-1 | AST- 2 PW | 100 | 21 | 4 | 10 |
| SCP-2 | AST- 1 PW | 50 | 16 | 3 | 8 |
| SCP-3 | AST- 1 P2W | 25 | 11 | 2 | 5 |
| SCP-4 | AST- 1 P4W | 10 | 6 | 1 | 3 |
| SCP-5 | AST- 1 P8W | 6 | 4 | 0.7 | 2 |
| SCP-6 | AST- 1 P12W | 4 | 2 | 0 | 1 |
| SCP-7 | AST- S1 or S2 | 15 | 7 | 1 | 4 |
| SCP-8 | AST- S3 or S4 | 20 | 10 | 2 | 5 |
| SCP-9 | MBT- 2PW | 100 | 0.7 | 0 | 0 |
| SCP-10 | MBT- 1 PW | 50 | 0.5 | 0 | 0 |
| SCP-11 | MBT- 1 P4W | 10 | 0.1 | 0 | 0 |

\* Depending on the length of the winter shutdown, the number of passes/yr may be 10 to 15% lower than shown.

\*\* % removal represents the proportion of the impervious surface unit area load removed

Table abbreviations:

AST: Advanced Sweeping Technology

MBT: Mechanical Broom Technology

2PW: 2 passes per week

1PW: 1 pass every week

1P2W: 1 pass every 2 weeks

1P4W: 1 pass every 4 weeks

1P8W: 1 pass every 8 weeks

1P12W: 1 pass every 12 weeks

In 2011, an earlier Chesapeake Bay Program expert panel developed two street sweeping crediting methods – mass loading and qualifying lane miles. In 2016, the Chesapeake Bay Program expert panel suggested immediately phasing out both methods of calculating street sweeping credits; however, they are briefly summarized here for completeness.

**Crediting Method:** Qualifying lane miles

**Details:** This method required entities to record the number of lane miles swept annually and convert them to total impervious acres. To receive credit for this practice, an enhanced street sweeping program was required. The eligibility requirements included:

* Urban streets with high average daily traffic volume,
* Streets swept 26 times/year, biweekly or concentrated in the spring and fall.

The impervious calculation was 5,280 ft times 10 ft per lane in width divided by 43,560 acre/ft2. Impervious acres were multiplied by pre-sweeping annual nutrient load using the Simple Method unit loads: 2.0 lbs/impervious acre/year TP and 15.4 lbs/impervious acre/year TN. The pre-sweep baseline loads were multiplied by pickup factors based on sweeper technology, as shown in Table 3. The pickup factors represent percent reductions from the baseline loads.

Table 3. Efficiency multipliers for street sweeping under qualifying lane miles approach

|  |  |  |  |
| --- | --- | --- | --- |
| Technology | TSS (% reduced) | TP (% reduced) | TN (% reduced) |
| Mechanical | 10% | 4% | 4% |
| Regenerative/Vacuum | 25% | 6% | 5% |

**Tracking and Reporting:** Reporting required either the impervious acres swept or annual dry solids mass collected. Practice verification was not required during the time this credit was used (Schueler 2016).

**Crediting Method:** Mass loading method

**Details:** This method credited nutrient and sediment reductions based on the annual wet mass of debris in pounds and required determining the hopper capacity of the sweeper, weighing the street solids collected and developing a relationship between street solid mass in tons and hopper capacity. Records were to be kept by each MS4 on the annual mass of street solids collected from qualifying streets (those swept at least 26 times/year). This mass was multiplied by 0.7 to convert to dry mass, then multiplied by 0.0025 pounds of dry weight to calculate total nitrogen, 0.001 pounds of dry weight to calculate total phosphorus, and 0.3 pounds of dry weight to calculate total suspended solids. This correction factor between dry mass solids and TSS is to remove particles larger than 250 microns, which are too large to be considered TSS. The TSS factor is based on particle size data from SPU 2009 and Law et al. 2008 (in Schueler et al 2016) showing that only 20-30% for street sweeping solids are less than 250 microns.

**Tracking and Reporting:** Pounds collected were reported to the Chesapeake Bay Program through the states’ annual submissions; however, the Chesapeake Bay Program did not provide verification procedures.

## Florida Department of Environmental Protection (DEP)

**Crediting Method:** Mass loading method

**Applicability:** Florida MS4s

**Details:** The Florida DEP MS4 Permit Resource Manual indicates that street sweeping tracking needs to occur to evaluate the effectiveness of the stormwater management program, especially if the MS4 discharges to a waterbody with a TMDL or Basin Management Action Plan (DEP 2013). The sweeping program only applies to streets with curb and gutter. The Florida Stormwater Association developed an MS4 Load Reduction Assessment Tool (Assessment Tool) to estimate the nutrient loads removed from street sweeping, catch basin cleaning and BMP cleanout (FSA 2012). The tool requires the weight or volume of solids removed, so street sweeping material must be measured or weighed. The methodology recommends direct measurement of the weight of a full truck for a year to develop reliable average values for the weight or volume of solids collected, and then allows the use of these data to develop an accurate estimate that will allow the jurisdiction to move to “counting trucks” as a way of tracking the amount of solids collected (Bateman 2012).

Solids are converted to dry solids using default moisture content and dry bulk density values. However, the default values are only to be used for the first year of permitting. Each permit group (e.g., Palm Beach County) is required to take monthly samples for moisture content and bulk density for at least one year. At least 24 samples, including replicates, per permit group are needed to develop final statistically valid values for bulk density and moisture content. Monthly sampling results are reported in MS4 annual reports. These values then replace the default moisture content and dry bulk density for each permit group.

Once the mass of dry solids is calculated, the Assessment Tool automatically applies the nutrient enrichment values for TN (563 mg/kg) and TP (361 mg/kg) and determines the pounds of TN and TP that were removed for the collection period. The enrichment values are based on sampling conducted at 14 MS4s throughout Florida on highway, commercial and residential land uses.

**Tracking and Reporting:** The FDEP Phase I MS4 Annual Report Form requires the frequency of sweeping, total miles swept, an estimate of the quantity of sweepings collected, and the TN and TP loadings in pounds that were removed as a result of sweeping activities. Each permittee can choose to report in volume or mass (DEP 2004). This is part of the Stormwater Management Program Roadways element of the MS4 annual report.

**Additional Information:** Catch basin (679 mg/kg TN, 417 mg/kg TP) and BMP cleanout (899 mg/kg TN and 364 mg/kg TP) nutrient reduction credits are also available with Florida-based TN and TP enrichment factors.

## EPA Region 1 - New Hampshire and Massachusetts

**Crediting Method:** Mass load reduction based on efficiency factors

**Applicability:** New Hampshire and Massachusetts MS4s subject to TMDLs

**Details:** EPA Region 1 is the MS4 permitting authority for both New Hampshire and Massachusetts. Enhanced street sweeping crediting applies to MS4 jurisdictions subject to nutrient-related TMDLs or discharging to water quality limited waterbodies and their tributaries where nitrogen or phosphorus is the cause of impairment. Other MS4 permittees are only required to sweep once a year in the spring and report the miles cleaned and volume or mass removed. MS4 permittees that discharge to waterbodies subject to a lake or pond phosphorus TMDL are required to develop a Lake Phosphorus Control Plan that includes planned non-structural controls to contribute to meeting the waste load allocation; an enhanced street/pavement cleaning program is a non-structural control practice eligible for TN and TP reductions (USEPA 2017a). As part of Good House Keeping and Pollution Prevention, MS4 permittees discharging to a nutrient impaired waterbody must increase street sweeping frequency on municipally owned streets and parking lots to a minimum of two times a year, once in the spring and once in the fall following leaf fall (USEPA 2017b).

In New Hampshire both TN and TP crediting is available. Massachusetts is limited to TP crediting for TMDLs, but the formula is the same for both states (USEPA 2017a):

**P credit (lbs/yr)** = Impervious area (acres) x P load export rate for impervious cover and specified land use (lb/ac/yr) x P reduction factor based on type and frequency x annual frequency

**N Credit (lbs/yr)** = Impervious area (acres) x N load export rate for impervious cover and specified land use (lb/ac/yr) x N reduction factor based on type and frequency x annual frequency

EPA provides a table of 13 land use categories including the distinction between directly connected impervious and pervious land cover, with individual phosphorus and nitrogen load export rates for each land use category and land cover combination. The P and N reduction factors are based on the frequency of sweeping and the sweeper technology and are unitless reduction multipliers. Credit is available for sweeping between 2 times a year and up to weekly. Credit is provided to mechanical broom, vacuum assisted and high-efficiency regenerative air-vacuum technology at variable rates, as shown in Table 4. The annual frequency is a reduction factor that is applied to represent the portion of the year when sweeping is conducted (e.g., if sweeping only occurs for 9 months of the year) the annual frequency factor is 0.75 (9 months/12 months = 0.75).

Table 4. Region 1 nutrient reduction efficiency factors for sweeping impervious areas (USEPA 2017a)

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency | Sweeper Technology | PRF\* | NRF\* |
| 2/year (spring and fall) | Mechanical Broom | 0.01 | 0.01 |
| 2/year (spring and fall) | Vacuum Assisted | 0.02 | 0.02 |
| 2/year (spring and fall) | High-efficiency Regenerative Air-Vacuum | 0.02 | 0.02 |
| Monthly | Mechanical Broom | 0.03 | 0.03 |
| Monthly | Vacuum Assisted | 0.04 | 0.04 |
| Monthly | High-efficiency Regenerative Air-Vacuum | 0.08 | 0.08 |
| Weekly | Mechanical Broom | 0.05 | 0.06 |
| Weekly | Vacuum Assisted | 0.08 | 0.07 |
| Weekly | High-efficiency Regenerative Air-Vacuum | 0.10 | 0.10 |

\*PRF – phosphorus reduction factor; NRF – nitrogen reduction factor

To receive credit, semi-annual sweeping must be conducted following the spring snowmelt and road sand applications and in the fall after leaf-fall and prior to the onset of snow regardless of timing or frequency of other sweeping activities.

As an alternative to the crediting described above, a credible model of the watershed that can reflect street sweeping with continuous simulations reflecting buildup and washoff of P and/or N using long-term rainfall data can be used to determine TN and TP removal credits. This alternative is only applicable to New Hampshire (USEPA 2017a).

**Tracking and Reporting:** Beginning 6 years after the permit effective date, permittees subject to phosphorus TMDL WLAs must include non-structural control measures implemented during the year, along with the associated phosphorus reduction in their annual reports (USEPA 2017a).More generally, annual reports must include the number of miles cleaned and the volume or mass of material removed (USEPA 2017c). EPA Region 1 developed the BMP Accounting & Tracking Tool (BATT) for New Hampshire and Massachusetts permittees, which provides watershed based nutrient accounting, tracking and reporting requirements in the MS4 permit (USEPA 2016). BATT is a spreadsheet tool that calculates the load reductions from BMPs implemented by the permittees, including street sweeping, catch basin cleaning and organic waste/leaf litter collection. It also generates reports of implementation activities and the associated nutrient load reductions to assist in annual reporting requirements and demonstrate compliance with the permit and/or TMDL requirements (USEPA 2016).

**Additional Information:** Catch basin cleaning credit is available based multiplying the impervious drainage area times the same nutrient load export rates for impervious land uses used for street sweeping times the catch basin cleaning reduction factors of 0.02 for phosphorus and 0.06 for nitrogen. Like the street sweeping reduction factors, these are unitless factors applied to the impervious area loading rates to yield a reduction in pounds per year. There is also an enhanced organic waste and leaf litter collection program credit. This credit is based on gathering and removing all landscaping wastes, organic debris, and leaf litter from impervious roadways and parking lots at least once a week from September 1 to December 1. The credit is based on the impervious acres times the nutrient load export rate for the impervious land use times 0.05. This credit may be achieved through street sweeping and both credits may be counted if the sweeping meets the requirements of both the enhanced street sweeping program and the collection program (USEPA 2017a). This may effectively result in double counting of credits; however, it is explicitly allowed under the MS4 permit.

## Massachusetts Department of Environmental Protection (MassDEP)

**Crediting Method:** Reduction efficiency

**Applicability:** Massachusetts New Development and Redevelopment

**Details:** Separate from the MS4 program discussed above, MassDEP maintains stormwater management standards for new development and redevelopment under the state’s Wetlands Protection Act Regulations and Water Quality Certification Regulations that require 80% removal of the average annual post-construction load of TSS (MassDEP 2008a). Nutrients are not addressed. Street sweeping is assigned a 0-10% TSS reduction credit depending on the sweeper technology and frequency of sweeping, as shown in Table 5. If sweeping activities are not conducted in March/April, prior to spring rains, the amount of credit is reduced by 50%.

Table 5. TSS removal credit for street sweeping in new/redevelopment (MassDEP 2008b)

|  |  |  |  |
| --- | --- | --- | --- |
| TSS Removal Rate | High Efficiency Vacuum Sweeper – Frequency of Sweeping | Regenerative Air Sweeper – Frequency of Sweeping | Mechanical Sweeper (Rotary Broom) |
| 10% | Monthly Average, with sweeping scheduled primarily in spring and fall. | Every 2 Weeks Average, with sweeping scheduled primarily in spring and fall. | Weekly Average, with sweeping scheduled primarily in spring and fall. |
| 5% | Quarterly Average, with sweeping scheduled primarily in spring and fall. | Quarterly Average, with sweeping scheduled primarily in spring and fall. | Monthly Average, with sweeping scheduled primarily in spring and fall. |
| 0% | Less than above | Less than above | Less than above |

Mass DEP provides a TSS Removal Calculation Sheet, a spreadsheet tool that calculates the percent removal for BMPs applied to a project area. There is no initial load calculated, but rather percentage reductions applied to the entire project area, with the starting TSS load assumed to be 100% of the post-construction load, and BMPs reducing the load according to their efficiency values (MassDEP 2008c).

**Tracking and Reporting:** If street sweeping is used as a compliance strategy, it is documented in the Stormwater Report that is required to be submitted to comply with the Stormwater Management Standards to receive a permit under the Wetlands Protection Act Regulations and/or the 401 Water Quality Certification Regulations (MassDEP 2008d).

## Wisconsin Department of Natural Resources

**Crediting Method:** Modeled reduction efficiency -street sweeping

**Applicability:** Wisconsin MS4 permittees (all)

**Details:** The Wisconsin Bureau of Watershed Management issued guidance to MS4 permittees on compliance with required TSS reductions of 20% by March 2008 and 40% by March 2013 to comply with the developed urban area performance standard.Crediting is only applicable to areas not subject to the new development post-construction performance standards (WI Bureau of Watershed Management 2010).MS4 permittees can report street sweeping as part of their credits towards meeting required TSS reductions. Two modeling options can be used to calculate the TSS reductions – WinSLAMM and P8. Crediting is based on percent reductions achieved in the model when compared to the “no controls” scenario (WI Bureau of Watershed Management 2010).

In addition to compliance with the developed urban area performance standard, MS4 permittees subject to TSS or TP TMDLs are also required to meet WLAs. The baseline loading condition, prior to TMDL reductions, should assume the MS4 20% or 40% TSS control requirement before applying TMDL allocations. Total phosphorus baseline loading is calculated by converting from the TSS baseline using a fixed formula (WI Bureau of Watershed Management 2014).

Under the modeling requirements, street cleaning credit can only be claimed if there is a curb and gutter or equivalent barrier. If both mechanical broom and vacuum cleaning occur within two weeks of each other, only the removal efficiency from vacuum cleaning can be claimed. If broom sweeping occurs in the spring and fall, but vacuum sweeping occurs the remainder of the year, a combined efficiency can be calculated as:

Model entire street cleaning program with mechanical broom + model just the period of vacuum cleaning – model the vacuum cleaning time period with a mechanical broom = overall combined sweeping efficiency (WI Bureau of Watershed Management 2014).

WinSLAMM runoff calculations are based on normal rainfall events and associated pollutant loading. Calculating TP and TSS loading requires entry of rain, runoff coefficients, pollutant probability distribution, particulate solids concentration (i.e., TSS concentration), land use and particle size distribution, etc. BMP efficiency determination for street sweeping requires input of frequency, sweeper technology, street cleaner productivity (street texture, parking density, parking controls), parking density and parking controls.

P8 inputs are precipitation, land use, hydrologic conditions, soil type, impervious connected fraction by land use. P8 uses SLAMM hydrology calculations. To determine street sweeping efficiency impervious area is entered as either swept or not swept; and sweeper efficiency is based on particle inputs and adjusted based on parking controls. Credit only applies to vacuum sweeping and efficiencies are revised down to 5-15% depending on particle size.

**Tracking and Reporting:** Stormwater Management Planning (SWMP) is required for MS4s subject to a TMDL and should include the estimated pollutant reductions from various practices, including street sweeping. TMDL implementation planning is incorporated into the MS4 permit and requires a compliance schedule and benchmark tracking. TMDL compliance reporting includes the practice type, areas affected, date of implementation, treatment performance efficiency and percent reduction towards the TMDL target reduction (WI Bureau of Watershed Management 2014). General MS4 annual reporting for street sweeping includes the roadway swept, frequency of sweeping, and volume of material collected (Milwaukee County 2017). For water quality management reporting requirements in the MS4 annual report, a pollutant loading analysis is required, but load reductions are reported as a cumulative percent TSS reduction for all relevant practices.

**Crediting Method:** Reduction efficiency - leaf management

**Applicability:** Wisconsin MS4 permittees subject to an approved TMDL

**Details:** WDNR has approved a 17% total phosphorus annual load reduction from leaf collection efforts. The reduction can be taking from the “no controls” phosphorus load in the selected model. This credit only applies to the medium density residential no alleys (MDRNA) land use; credit cannot be used for other land uses; and credit can only be taken for the portion of the land area that is MDRNA because there is insufficient data to quantify credit on other land uses at this time. Medium density residential is 2-6 units/acre consisting of single-family homes. Medium density with alleys can received credit if the alleys are receiving the same level of leaf collection and street cleaning as streets. The credit assumes light parking density and a curb and gutter system. It is unclear if the alleys must also have a curb and gutter system to qualify for credit. To be eligible for credit the area must have an average of 1 or more mature trees between the sidewalk and curb for every 80 linear feet of curb, or when sidewalk is not present, trees within 15 feet of curb. WDNR has determined that this equates to tree canopy over street pavement of 17% or greater. In addition, the municipality must have an ordinance prohibiting placement of leaves in the street and a policy that residents may place leaves on the terrace in bags or piles for collection. Leaf collection must occur at least 4 times in Oct and Nov. into a fully enclosed vehicle. Within 24 hours of collection, mechanical broom or vacuum street cleaner must remove remaining litter from street (WDNR 2018).

The phosphorus reduction credit for the leaf management program may not be taken in addition to phosphorus reductions from other BMPs in the same drainage area because additional evaluation is needed to determine the impact of leaf collection on loading to structural BMPs (WDNR 2018).

**Tracking and Reporting:** Tracking and reporting is not specifically addressed; however, this is a credit related to the development of SWMPs for MS4s subject to TMDLs. As such, it will likely be reported through the same mechanisms described under the Wisconsin street sweeping crediting.

## Washington Ecology

**Crediting Method:** Mass load reduction and effective developed acres reduction

**Applicability:** Washington MS4 permittees subject to an approved TMDL

**Details:** Washington Ecology’s new Phase I permit, set to take effect August 1, 2019 requires MS4s subject to a phosphorus TMDL to evaluate and track pollutant reductions. The requirements vary by TMDL and the different requirements are outlined for the various jurisdictions. For example, City of Bellingham is required to conduct enhanced street sweeping and the reductions are to be expressed as a reduction in Effective Developed Acres and may also be expressed as mass per unit time (Ecology 2019). Pierce County and the City of Puyallup are required to draft QAPPs outlining the information gathered to calibrate their regenerative air street sweeper annual calculation of sediment reduction credits. They must include a sampling program that measures particle size distribution, organic carbon fraction, and dry mass weight of recovered material. Sediment load reduction credit can only be claimed after developing a state-approved QAPP (Ecology 2019). There is no overarching street sweeping credit for MS4 permittees that are not subject to a relevant TMDL in either the current permit or the 2019-2024 permits. The current Phase I permit also does not include street sweeping credit for jurisdictions subject to a relevant TMDL.

**Tracking and Reporting:** For the City of Bellingham, enhanced street sweeping is required to be reported in each MS4 annual report as the estimate of the mass of total phosphorus removed and the estimate of the equivalent reduced effective developed acres (Ecology 2019). However, no specific methodology for determining the total phosphorus removed was identified.

**Additional Information:** The City of Seattle’s Stormwater Management Program includes street sweeping as a water quality practice, using regenerative air sweepers on a weekly basis (SPU 2017). Pollutants captured in the street sweeping are measured as TSS equivalent (City of Seattle 2018). The estimated TSS load reduction is provided and is intended to represent the target pollutant for basic stormwater treatment because it is often related to other particle-bound pollutants, like total metals, total phosphorus and other pollutants. The method for determining the TSS load reduction was not readily identifiable. Over the course of 2 years Seattle Public Utilities conducted a study of stormwater runoff samples to evaluate the effectiveness of street sweeping at reducing pollution in urban stormwater runoff, while initial results were presented, the analysis to determine removal values had not yet been conducted (SPU 2017).

## County and City of San Diego and Co-Permittees

**Crediting Method:** Performance-based compliance with optimized enhanced street sweeping program

**Applicability:** County and City of San Diego and MS4 co-permittees in the Los Peñasquitos Watershed Management Area

**Details:** San Diego and its MS4 co-permittees are subject to numerous TMDLs. Compliance with the WLAs is based on load reductions from modeled structural and non-structural practices. Since the water quality numeric goals exceed the timeframe of the current MS4 permit, performance-based goals were established to measure short term progress, with longer-term numeric goals acknowledged. In the case of street sweeping, Load Simulation Program C++ (LSPC) was used to model existing street sweeping practices and identify an optimized scenario (enhanced street sweeping) (AMEC 2015). Compliance with the regime that was determined to be the optimal strategy results in credit for the practice. The optimized scenario was based on reducing a suite of pollutants, not just nutrients and sediment. The enhanced street sweeping program for the Los Peñasquitos Watershed Management Area was determined to be bi-weekly sweeping of all routes and exclusive use of regenerative air sweepers (AMEC 2015). Specific credit values by pollutant are not identified.

Factors that were included in the LSPC optimization for street sweeping included start and end months for sweeping (year-round), typical days between high, medium and low frequency of route sweeping, fraction of land surface available for sweeping, total solids removal efficiency of different sweeper technologies, fraction of sand, silt/clay and gravel in solids, and the concentration of copper, zinc, lead, TKN, total phosphorus and bacteria in collected sediment, as determined by a pilot sweeping monitoring study (AMEC 2015).

**Tracking and Reporting:** Specific load reductions are not tracked or reported in association with street sweeping, but the annual report identifies whether and how the optimized strategy is being implemented (performance measures) (Wood 2019).

## Orange County, California and MS4 Co-Permittees

**Crediting Method:** Aggregate efficiency for suite of non-structural practices

**Applicability:** Orange County and MS4 co-permittees in the South Orange County Watershed Management Area

**Details:** The non-structural (programmatic) strategies in the South Orange County Water Quality Improvement Plan (WQIP) are based on Jurisdictional Runoff Management Plan (JRMP) requirements in the MS4 permit (The County of Orange et al. 2017). The JRMPs are required to detail jurisdictional programs to prohibit non-stormwater discharges to the MS4, reduce pollutants in stormwater, and protect beneficial uses of receiving waters. Non-structural practices include street sweeping, trash cleanup, good landscaping practices, commercial and industrial good housekeeping, pet waste control, etc. None of these practices are modeled for the WQIP. To account for the associated load reduction from these practices, a 10% load reduction from the baseline loads of each pollutant of concern is included in the quantification of reductions based on best professional judgement and earlier studies (The County of Orange et al. 2017). The 10% reduction applies to all programmatic practices in aggregate. There is not a specific load reduction associated with street sweeping as a stand alone practice. The reduction efficiencies apply to bacteria.

Part of the WQIP Monitoring and Assessment Program is to move to a modeling framework that includes non-structural practices, including street sweeping, to allow for the optimization of BMP opportunities (The County of Orange et al. 2017). A report of findings is expected in 2019 but is not yet available.

**Tracking and Reporting:** The most recent annual report, from 2017-2018, did not address programmatic measures.

## City of Santa Cruz, California

**Crediting Method:** Modeled load reductions

**Applicability:** City of Santa Cruz

**Details:** As part of the City of Santa Cruz’s Phase II MS4 permit, the city developed a stormwater management plan to address the primary pollutants of concern, which included sediment and silt, due to the presence of sediment impaired waterbodies and TMDLs (City of Santa Cruz 2010). Street sweeping was included as a management measure. Subsequently, the City prepared a Program Effectiveness Assessment and Improvement Plan with the objective of tracking annual and long-term effectiveness of the Stormwater program and allow for adaptive management (City of Santa Cruz 2015). Street sweeping was included as a practice for pollutant load and load reduction modeling. Santa Cruz planned to use the Tool for Estimating Load Reductions (TELR), a proprietary land use loading catchment level model. Additional information on the inputs into TELR were not readily available.

**Tracking and Reporting:** As of the 2017-2018 Annual Report and the 2018 Annual Report for TMDL BMP Implementation, the City of Santa Cruz was not reporting on load reductions but instead on curb miles swept and tons of solids collected (City of Santa Cruz 2018). The annual reports indicated that TELR was being used; however, it was not clear what the resulting sediment load reduction was determined to be.

## Crediting Methods under Development

**Vermont** is in the process of developing a phosphorus street sweeping credit to address nutrient TMDLs for municipalities that will be regulated under the Vermont Clean Water Act. An interim credit will be developed based on the BATT model from EPA Region 1 and other crediting methods, including the New Hampshire MS4 permit and the Chesapeake Bay Program Expert Panel report (Vermont Agency of Natural Resources 2019). A permanent credit will be developed based on “phosphorus source area delineations of municipal streets using real time materials sampling of sediment and nutrients, forest cover measurements, forest tree species, seasonal deposition of organic materials from trees, street sweeping efficiencies and street cleaning frequencies” (Vermont Agency of Natural Resources 2019). Additional information on the program was not available.

**North Carolina** Department of Environmental Quality is also in the process of developing a street sweeping and catch basin cleaning credit. The credit is only intended to apply to existing development requiring nutrient reductions to meet applicable nutrient strategies (NCDEQ 2018). It will not be applicable as credit towards nutrient reduction requirements related to new development. The streets must have a curb and gutter system. The street sweeping and catch basin credit is determined by applying conversion factors to the weight of freshly collected material (wet), as determined by direct measurement of the average weight of the contents of a collection vehicle. The conversion factors are 0.023 lb TN/lb of debris and 0.002 lb TP/lb of debris, respectively. These are derived from gross solids measurements in catch basins throughout coastal and Piedmont North Carolina. Dry weight is not used in this method. Custom conversion factors based on laboratory analysis may also be used, but consultation with the NC Department of Environmental Quality, Division of Water Resources is required. The product of the weight of material collected and the conversion factors is the mass of nitrogen and phosphorus removed. To receive credit, the entity will submit to North Carolina Division of Water Resources an estimate of annual weight collected at baseline, weight of material collected in reporting year, difference between baseline and reporting year weights, nutrient credit calculation, type of collection vehicle and the average weigh of contents of a full truck. The credit specifically does not include credit for fall street-side leaf pickup.

A final crediting method was presented to the North Carolina Nutrient Scientific Advisory Board in 2018; however, the Board determined that more work needs to be done to determine whether it is feasible to determine a baseline for this practice (NSAB 2018).

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