Minnesota Pollution Control Agency

Large Watershed Total Maximum Daily Load Studies

Guidance Document

Introduction

Total Maximum Daily Load (TMDL) studies occur at a variety of scales. Many of these studies are for large watersheds. Examples include the Lake Pepin nutrient TMDL study, the Mississippi River turbidity TMDL study; the Minnesota River dissolved oxygen and turbidity TMDL studies, the Lake St. Croix nutrient TMDL study, the West Fork Des Moines River TMDL study, and the Lower Cannon River turbidity TMDL study.

This guidance provides approaches for addressing large watershed TMDL studies that have a regulated Municipal Separate Storm Sewer System (MS4) stormwater component. The guidance provides an equitable strategy for addressing regulated stormwater.

What is a large watershed TMDL study?

Large-watershed TMDLs have the following characteristics.

1. The study area is several hundred or thousands of square miles in extent and includes a variety of land uses. Consequently, pollutant loading occurs from many sectors, including urban stormwater, urban wastewater, agriculture, feedlots, septic systems, and so on.
2. The model(s) used in calculating the TMDLs was not developed specifically for urban stormwater. Examples include the following.
   a. **Load Duration Curve (LDC):** LDCs do not explicitly address loads from urban stormwater. Consequently, allocations for regulated stormwater are often based on the proportional regulated MS4 area within the watershed. Examples of LDCs include the Cannon River and West Fork of the Des Moines River TMDLs. LDCs provide an allocation based on 100 percent delivery of the pollutant. This is not likely to be true and it therefore becomes difficult for an MS4 to translate the Wasteload Allocation (WLA) into an allowable load, since the MS4 would need to incorporate some sort of attenuation factor. LDCs often include large Margins of Safety (MOS), which in turn reduces the allowable load for other sectors. Also, allocations are often set for five flow regimes across the LDC, even when pollutant reductions are not needed in a particular flow regime or the entire load is taken up by wastewater (low flows).
   b. **Hydrological Simulation Program Fortran (HSPF):** HSPF simulates a wide variety of processes from the source of pollutant loading to the final receiving water. It therefore can be used to estimate a pollutant export from urban areas that meets the WLA in the receiving water. However, HSPF addresses pervious and impervious runoff separately. A typical approach for modeling urban loads is to aggregate all impervious surfaces within a watershed into a single connected impervious block. A loading rate (export coefficient) is applied to the impervious surface. This was the approach used for the Minnesota River TMDLs. Best Management Practices (BMPs) can be addressed implicitly by adjusting various coefficients in the model. Although HSPF can generate estimates of export from urban areas, the simplified method of addressing urban stormwater limits the ability of the model to provide meaningful loading estimates for a wide variety of geographically separate MS4s.
   c. **Soil and Water Assessment Tool (SWAT):** Like HSPF, SWAT can simulate the fate of pollutants along a flow path. However, SWAT was developed to assess pollutant loadings from agricultural settings. Although model inputs and coefficients can be adjusted to simulate loading from urban areas, these modifications are fairly rudimentary and do not adequately address specific characteristics of pollutant loading from urban areas. SWAT has been used for calculating TMDLs in Carver County.

   With these modeling approaches, loading from regulated stormwater can at best be approximated for large watershed TMDL studies. WLAs are therefore not particularly informative. The models also provide almost no insight into Best Management Practices (BMPs) needed to reduce loadings from urban areas. The TMDL report and subsequent implementation plan will therefore contain little useful information on implementation.
3. Pollutant loading from urban areas is usually ten percent or less of the total loading.
4. Required reductions in loading for many of these TMDLs are 50 percent or more from current loading.

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5. Pollutant loading from urban areas is usually ten percent or less of the total loading.
6. Required reductions in loading for many of these TMDLs are 50 percent or more from current loading.
7. These TMDL studies often include multiple MS4s that are geographically separated (i.e. storm sewer systems are not hydraulically connected to each other). In addition, management practices likely differ between the MS4s in the study area, with some MS4s practicing more aggressive stormwater management than others. As discussed above, the models used for large watershed TMDL studies do not allow consideration of this variability in management.
8. Large watershed TMDL studies may include multiple impairments on multiple reaches.

Table 1 illustrates examples of large watershed TMDL studies, as well as several small watershed studies for comparison. Note in Table 1 that all large watershed studies have a small percent of MS4 area and employ models not specifically developed for urban stormwater. The small watershed studies have very small areas and either employ a model developed for urban stormwater or have monitoring data that can be used to specifically conduct source evaluations. Figure 1 illustrates the location of several large watershed TMDL studies.

Why is this guidance needed?

Large watershed TMDL studies pose concerns about equity. MS4s comprise a small percent of total loading to the impaired water and meeting the WLA would have a small impact on the receiving water. Nevertheless, regulated MS4s must comply with the permit, which requires them to meet the TMDL WLA. The same is not true for sectors included in the Load Allocation (LA). For a TMDL with a very large required reduction, regulated MS4s may be required to meet the reduction while other sectors are not required to make progress. The solution to this dilemma is a phased approach for the TMDL.

Table 2: Summary of some large- and small-watershed TMDL studies.

TMDL study	Number of impairments	Number of MS4s	Total area of study (mi^2)	MS4 area (% of total area)	Model(s)[1]
Large watershed TMDL studies					
Lake Pepin/Mississippi River	2	203	48600	5	UMR-LP
Lower Cannon River	2	5	1470	3	LDC
Lower Vermillion River	1	9	356	9	CE-QUAL-W2
West Fork Des Moines River	32	1	1333	0.3	LDC
Minnesota River Dissolved Oxygen	4	10	17000	3.5	HSPF
Minnesota River Turbidity	18	10	17000	3.5	HSPF
Lower Mississippi River Bacteria	39	23	7266	3	LDC
Crow River					
Zumbro River					
Lake St. Croix					
Small watershed TMDL studies					
Long-Farquar lakes	1	3	3.3	100	P8
Shingle Creek Chloride	4	10	44.5	100	LDC
Twin-Ryan lakes	4	8	8.7	100	SWMM, P8
Burandt Lake	1	1	12.2	15.4[2]	In-lake[3]
Lake Independence	1	5	11.9	100[4]	In-lake

[1] LDC = Load Duration Curve; UMR-LP = Upper Mississippi River-Lake Pepin
[2] Using local land use plans, the projected MS4 area is more than 50 percent of the watershed
[3] Watershed modeling was not conducted. In-lake model(s) was calibrated to monitoring data
[4] The entire watershed is regulated MS4, but only about 10 percent of the watershed is currently developed

The diversity of MS4s in most large watersheds and the lack of information needed to guide implementation make it nearly impossible to identify specific implementation activities. One way to overcome this is to select generic BMPs that apply to all MS4s in a study area.

This guidance provides conditions for a phased TMDL and the BMPs needed to meet the WLA.

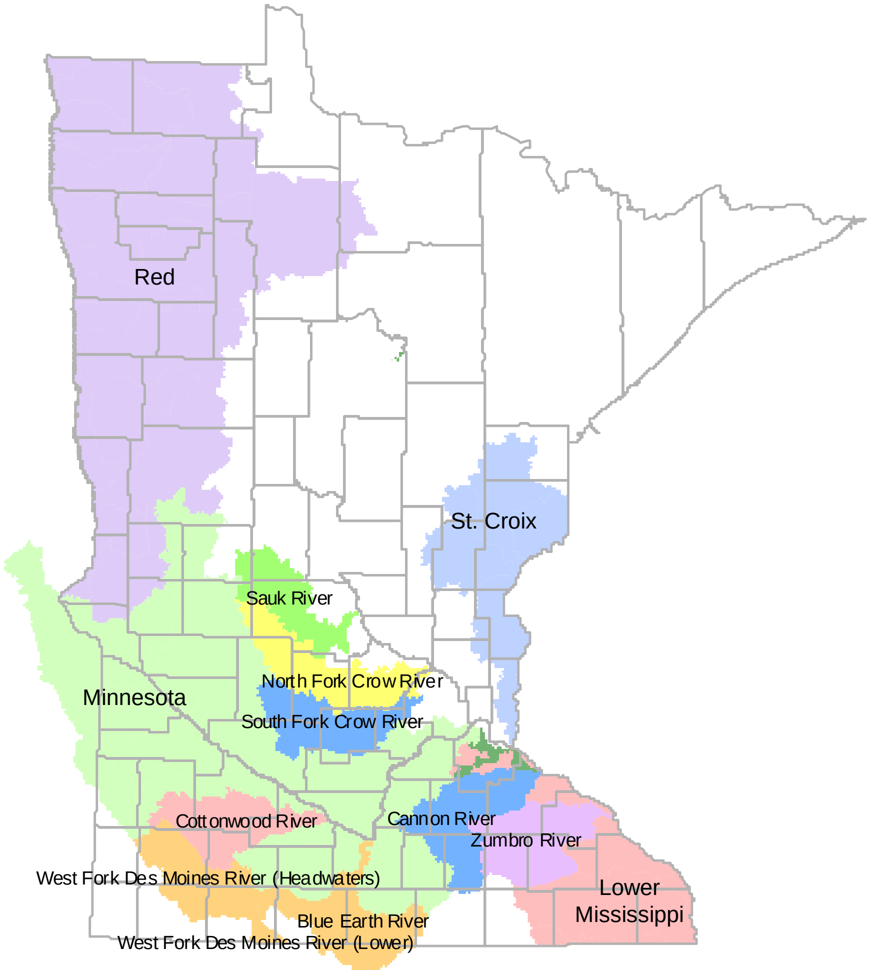

Figure 1: Location of some large watershed TMDL studies.

Guidance for Large Watershed TMDL Studies

This section provides the basis for estimating the MS4 WLA, defining the TMDL implementation phases, selecting appropriate BMPs, and linking the BMPs to the MS4 permit.

Estimating the Wasteload Allocation

WLAs for large-watershed studies should be categorical (include all MS4s into a single WLA). All MS4s should be treated equally in the calculation. This means loads for all MS4s are calculated using the same method with the same assumptions and model inputs. Some examples are provided below.

1. For the Minnesota River TMDLs, HSPF was used to calculate the WLA for MS4 stormwater. The model combined all impervious surface and assumed the impervious surface was connected, even though the study included ten geographically isolated regulated MS4s. No BMPs were assumed in the initial model design. If a BMP was applied through the model, it was applied to the impervious block, thus treating all MS4s equally.
2. For the Lower Mississippi River TMDL, WLAs were based on the percent of land area encompassed by regulated MS4s. For example, if regulated MS4s comprised five percent of the watershed, they received five percent of the overall allocation.
3. For the Lake Pepin TMDLs, WLAs were estimated by multiplying the regulated area in the watershed by pollutant export coefficients, then reducing this number by 25 percent. The calculation assumed no BMPs were in place. The export coefficients were based on literature and monitoring data.

There are two primary difficulties for estimating the MS4 contribution. The first is selecting the areas that represent urban. Below is a recommended procedure.

- Using the Geographic Information System (GIS) coverage of regulated MS4s, clip the regulated MS4 areas that occur within the watershed.
- For methods utilizing impervious cover, using the most recent GIS impervious cover layer and clip impervious cover within the regulated MS4s. Combine this into a single impervious cover for the study area. This area will typically then be used in conjunction with an export coefficient and precipitation data to estimate a load. Example models include the Simple Method and HSPF.
- For methods utilizing area estimates, use the most recent National Land Cover Data (NLCD) GIS layer. Clip the NLCD coverage using the MS4 clipped layer. NLCD includes several land covers, four of which are classified as developed. Combine the four developed land use areas for all MS4s. This gives a total area of developed land which can then be used to estimate the contribution from urban areas. Other land use coverages may be available but the NLCD is recommended unless another land use coverage can be applied across the entire study area. For example, in the Lower Mississippi River bacteria TMDL, it would not be appropriate to use Met Council's land use coverage for portions of the study area within the Metro Area and the NLCD data outside the Metro Area.[1]

A second concern is addressing future growth. There are several ways to address future growth in large watershed TMDLs.

- Use comprehensive land use plans to estimate growth and include this in the WLA. This approach is appropriate if there are a small number of MS4s and each MS4 has a land use plan.
- Multiply the WLA by a growth factor for the study area. For example, if historic growth in a study area has been two percent for every ten years, then multiply the WLA by 1.04 to account for likely growth in the next 20 years. This approach was used in the Minnesota River turbidity TMDL.
- Include all the remaining land areas within regulated MS4s into the WLA. This method will over-estimate the WLA, so the TMDL report will have to define a mechanism by which the growth portion of the WLA can be accessed. This approach was used in the Lake Pepin TMDL study.
- Have a targeted load for land use as it converts to urban area. Targets may range from no net increase (nondegradation) to meeting a watershed goal, such as a 20 percent reduction in loading for all land use changes. A watershed-based target can be complicated because the reductions may vary with land use. The Lower Vermillion River turbidity TMDL study utilized a nondegradation approach.

The allocation section of the TMDL report should express the WLA as a required reduction, typically as a percent. The baseline for the reduction must be specified. The baseline is the year from which an MS4 will judge progress toward the WLA. The baseline may reflect other conditions, such as the BMPs that can or cannot be applied toward the WLA. An example is a baseline of 1988 and no BMPs in place for the Minnesota River Dissolved Oxygen TMDL.

Phased approach for regulated stormwater

When the magnitude of required reductions exceeds 50 percent, implementation for large-watershed TMDL studies should be phased. Three tiers or phases are recommended.

1. The first phase is primary municipal stormwater system treatment. This is discussed in the next section (Performance-based approach). At this level, MS4s should achieve pollutant load reductions of 25 percent from a non-BMP level for built-out areas. This is done with a variety of information and education as well as other common foundational practices that MS4 likely are already implementing to some extent. For newly developing areas, the target may be set equivalent to Phase 2 (discussed below).
2. The second phase is secondary municipal stormwater system treatment and achieves an additional 25 percent pollutant and/or runoff volume reduction from built-out areas. This phase can be applied to all newly developing areas. This is achieved by employing primary treatment measures along with a combination of volume control practices and more typical structural practices such as sedimentation related practices (wet detention basins) along the stormwater treatment flow network.
3. The final phase, called tertiary municipal stormwater system treatment, achieves additional pollutant load and/or runoff volume reduction. This is achieved by operation and maintenance of a stormwater flow network including multiple areal

[1] We have done some simple comparisons of the NLCD data with what we know to be areas where urban areas discharge stormwater. NLCD's developed land use appears to include some areas that are not likely part of an MS4s conveyance, such as private driveways and parking lots in rural portions of an MS4. However, some areas that are part of an MS4 conveyance, such as parkland, are often not included in the developed category. Our estimates suggest these over- and under-estimates of loading from an MS4 conveyance approximately cancel each other.

practices (education, residential lawn recycling programs, street sweeping) and serial treatment practices (sedimentation, filtration and infiltration practices). This level of treatment requires stormwater treatment system operation by qualified personnel with dedicated MS4 budgets. Achieving phase III or tertiary level requires dedicated MS4 commitment to their daily operation and maintenance.

The three phases described above correspond with TMDL evaluation points. All sectors are expected to achieve their target reductions within reasonable time frames (e.g. at the end of each phase) and assume both voluntary and permit compliance. If one sector is not meeting its target, then the Minnesota Pollution Control Agency (MPCA) retains authorities and options to achieve compliance. Regulated MS4 communities should be able to achieve Phase 1 over the first two permit cycles. Planning for Phase 2 should be completed within the first permit cycle. Phase 2 and 3 compliance is proposed to occur over subsequent permit cycles. Tertiary treatments require additional operator training and funding of new development, redevelopment and retrofitting opportunities. Table 2 provides a summary of the phased approach.

Table 2: Summary of three phases in implementation plan for regulated stormwater.

Phase	Reduction	Example BMPs	Comment
1	25% from a no-BMP baseline	street sweeping, properly designed and maintained ponds, education/outreach, certification, prevention	Include BMPs and associated reductions in the SWPPP; in the SWPPP, discuss general BMP strategies and schedules beyond the next permit cycle
2	25% from Phase 1	infiltration BMPs, targeted prevention and education programs, enhanced structural BMPs	Begins when all sectors complete Phase 1; SWPPP contains specific BMPs and associated reductions; discuss general BMP strategies and schedules beyond the next permit cycle
3	remainder of required reduction	treatment trains, extensive infiltration or treatment	Likely to be very expensive; possible trading opportunities

Performance-based approach

Because the WLA for large watershed TMDL studies is difficult to interpret in the permit, another approach is recommended. The United States Environmental Protection Agency (EPA) has determined that "because stormwater discharges are due to storm events that are highly variable in frequency and duration and are not easily characterized, only in rare cases will it be feasible or appropriate to establish numeric limits for municipal and small construction stormwater discharges. The variability in the system and minimal data generally available make it difficult to determine with precision or certainty actual and projected loadings for individual dischargers or groups of dischargers. Therefore, EPA believes that in these situations, permit limits typically can be expressed as BMPs, and that numeric limits will be used only in rare instances." It is therefore appropriate for specific BMPs to be identified as satisfying the WLA. This is a performance-based approach in which BMPs are selected and a load reduction is associated with appropriate implementation of that BMP.

The MPCA recommends an approach that is flexible for BMP selection but prescriptive for the load reduction associated with each BMP. MPCA has not developed specific lists of BMPs for Phases 1, 2 and 3 respectively. Example BMPs for Phase 1 are shown in Appendix A.

Summary

This guidance summarizes approaches for addressing regulated MS4 stormwater in large watershed TMDL studies. The guidance provides information on the following:

1. How to set WLAs, including how to address future growth in the allocations.
2. Developing a phased approach to meeting TMDL requirements.
3. Developing a performance-based approach for MS4s that have been given WLAs for large watershed studies.

Appendix A — Phase 1 BMPS

PHOSPHORUS (for nutrient eutrophication impairments)

1. Leaf and grass recycling
2. Fertilizer restriction
3. Public information and education
    a. Instruction on how to apply fertilizers in accordance with fertilizer P limitation (MN Rule ….) including relevant soil testing
    b. Pet waste ordinance and demonstration of enforcement
    c. Education on residential and non-profit car washing
    d. Storm drain marking
    e. Municipal water body duck/geese management programs
    f. Short and long term reinforcing education/information programs for home owner composting, rain harvesting, lawn maintenance including grass seed
    g. Disconnecting impervious, rain barrels, rain gardens sprinkler system adjustments, pervious pavement options for home owners and commercial entities
    h. For MS4s using polyphosphates in their water supply, a public education program and possible ordinance regarding irrigation practices
    i. Street sweeping
    j. Lawn management

TSS (for turbidity, possibly biota impairments)

1. Street sweeping

BACTERIA

1. Identify illicit discharges and develop a plan to eliminate them.
2. Identify discharges to MS4 conveyance system from permitted industrial and commercial stormwater.
3. Identify Combined Sewer Overflows and wastewater bypasses.
4. Identify cross-connections between the sanitary and storm sewer systems (e.g., inspect foundation drains to locate and disconnect clear water sources to sanitary sewers to avoid overflow).
5. Implement an inflow/infiltration assessment and correction program (e.g., slip line old inflow and infiltration prone sections of sanitary sewers).
6. Develop and implement a response plan for reports of sanitary sewer overflows.
7. Provide dump stations for RV waste.
8. Develop mitigation plans for all illicit discharges.
9. Identify wildlife population centers and evaluate source control BMPs (e.g., wildlife feeding bans, permits to oil and shake eggs, goose harassment programs, special hunts, etc,) or treatment BMPs (e.g., riparian buffers) in these areas.
10. Identify effective structural BMPs (e.g., wet detention basins, infiltration/filtration basins, constructed wetlands, bioretention systems, sand filters, riparian buffers, etc.) and develop a strategy for implementing them (MPCA can provide additional guidance on structural BMPs that are effective for fecal coliform bacteria).
11. Consider the development of a modeling program or monitoring plan to evaluate fecal coliform bacteria load reductions (monitoring could include BMP effectiveness monitoring, source identification, and BMP maintenance monitoring).
12. Evaluate existing ordinances or develop ordinances regarding the management of pet waste.
13. Develop and distribute educational materials specifically about pet waste management.
14. Install pet waste bag dispensers at key locations for public use.

15. Street sweeping
16. Evaluate the potential for implementing Low Impact Design BMPs and evaluate existing or draft new ordinances related to implementation of LID BMPs in newly developed areas.

CHLORIDE

1. Certification and education
2. Winter street sweeping
3. Stockpile protection
4. Minimize impacts from snow dumps
5. Increase use of winter tires
6. Conduct salt inventories
7. Conduct research into new products and techniques, lab and field demonstrations

DISSOLVED OXYGEN – see phosphorus

BIOTA – see appropriate stressor