Guidance on Stormwater Quality Monitoring Program Development for Existing BMPs

TO: Katie Hunter
Environment and Development Planner
North Central Texas Council of Governments

DATE: April 29th, 2025

FROM: Saumya (Sam) Sarkar, PE
Project Manager
Halff Associates, Inc.

Randy Peterman, PE, CFM, ENV SP
Lead Professional
Halff Associates, Inc.

AVO: 45347.001

EMAIL: ssarkar@halff.com
rpeterman@halff.com

SUBJECT: Guidance on Stormwater Quality Monitoring Program Development for Existing BMPs

---

1.0 Introduction

Best Management Practices (BMPs) improve water quality by capturing and treating stormwater runoff. The guidance manual, "Urban Stormwater BMP Performance Monitoring" (2002), produced by the Environmental Protection Agency (EPA) and American Society of Civil Engineers (ASCE), contains a detailed, 248-page explanation of how to analyze the ongoing performance of BMPs. This memo summarizes key points from the guidance manual and identifies questions that city or county officials should consider prior to developing a BMP performance monitoring program. These questions should not only be answered before the program is developed, but also routinely during the program's lifecycle.

2.0 Set Overall Objectives

2.1 Summary

The first step to developing a BMP performance monitoring program is to define water quality goals. The methods of data analysis should be tailored to these goals. Stricter adherence to the guidance in the 2002 EPA Manual is recommended for water quality goals like testing the performance of BMPs for compliance with regulatory standards or qualification for submission into the National Stormwater Best Management Practices Database.

The 2002 EPA manual suggests that monitoring sites should be selected to ensure representative sampling and accurate flow measurement. The following list summarizes characteristics of a good choice for a monitoring site

- Flow at the monitoring site is well-mixed and hydraulically stable
- The site is safely accessible
- The site has clear catchment boundaries
- The site meets requirements for reliable equipment operation and data collection

Placement of monitoring stations is also an important variable. Monitoring stations should be placed immediately downstream of a BMP (before mixing with receiving waters) and immediately upstream of a BMP (but far enough away to avoid backwater influence on water quality data). Stations can also be placed intermediately, whether within BMPs or at individual BMPs in a treatment train. It is typically difficult to meet all of these criteria perfectly, so compromises usually need to be made.

The choice of contaminants to test should address site specific concerns and be consistent with land use in the drainage area of the BMP. Proxy parameters can also be used if a high degree of correlation exists between two parameters to reduce cost of analysis. For example, turbidity can be used as a proxy for suspended solids concentration.

2.2 Questions

- **What is the goal of the BMP performance monitoring program? Is it to study one of the topics listed below, or something else?**
    - BMP effectiveness (usually characterized as the difference between influent and effluent concentrations of pollutants) under design conditions
    - BMP effectiveness variance between pollutants
    - BMP effectiveness variance between different types of storm events
    - BMP effectiveness with different levels of maintenance
    - BMP effectiveness over time (improvement or decay?)
    - BMP effectiveness in comparison to “acceptable” water quality standards
    - BMP effectiveness variance between different types of BMPs

- **Will the City/ County be able to routinely access the BMP site to conduct water quality monitoring?**

- **Which BMPs will be monitored? Consider the following criteria.**
    - The upstream contributing drainage area and storm system should be clearly delineated and well understood.
    - BMPs should be monitored in locations that are safe for field personnel to access and where vandalism of equipment is unlikely.
    - BMPs can be monitored as a part of a treatment train or individually.

- **Where will BMP monitoring stations be placed?**
    - Open channel flow measurement stations should be located where reliably accurate rating curves can be developed.

- Stations located in relatively uniform flow conditions will provide representative results.

- **Which parameters will be monitored?**
  - Conventional (PH, Turbidity, Total Suspended Solids, Total Hardness, Chloride, Dissolved Oxygen)
  - Bacteria (Fecal Coliform, Total Coliform, Enterococci)
  - Nutrients (Total Phosphorus, Total Kjeldahl Nitrogen, Nitrate, Orthophosphate)
  - Heavy Metals (Zinc, Lead, Copper, Cadmium, Chromium)
  - Oil and Grease
  - Flow Rate
  - Others not listed here

3.0 Statistical Analysis

3.1 Summary

Estimating the required number of storm events to sample is an important step in ensuring a monitoring study can detect meaningful changes in pollutant concentrations or loads. This can be done with a statistical power analysis.

A common place to start is a confidence level of 95% and a statistical power of 80%. A confidence level of 95% means the specified method will contain the true value of the parameter within a specified confidence interval 95% of the time. Statistical power of 80% means that if there is a significant change in the concentration of a pollutant due to the BMP, there is an 80% chance that the results of the analysis will capture this improvement and show the positive effect that the BMP has on water quality. Higher power percentages will require exponentially larger amounts of data.

The 2002 EPA Manual encourages users to ask themselves how accurate results need to be and whether sufficient staff and finances are available to obtain results at that level of accuracy when preparing a scope for a BMP performance analysis. The requirements and limitations of data accuracy should be assessed. Cost may be a limiting factor in the number of samples that are able to be collected, but collecting too few samples can result in inconclusive or incorrect analysis. Modeling software can also be used to supplement an analysis like this, particularly for estimating parameter concentrations.

3.2 Questions

- **How accurate do results need to be to accomplish goals?**
  - The level of accuracy could be determined by the preference of staff or by following national guidance.

- **What are the values of the statistical parameters needed for this study?**
  - Minimum detectable change possible in data to be gathered

- Number of samples needed to achieve defined goals
- Desired confidence level
- Probability of detecting a difference in data for a given number of samples and confidence level
- Standard deviation of data to be collected (typically determined from existing published datasets)

- **Would modelling software be useful in tandem with BMP monitoring program?**
  - Data collected could be used to supplement analysis in a potentially more cost-effective manner.
    - For example, data could be used to fill gaps in results, predict long term performance, calibrate models, or compare design alternatives.

- **Are sufficient staff available and financial needs covered to effectively meet the defined goals?**
  - Staff could be available in-house or from consultants
  - The number of samples collected is a critical variable affecting the level of accuracy and confidence in conclusions but will require significant investment in resources.

4.0 Methods and Equipment

4.1 Summary

First, the method of BMP monitoring analysis should be considered. The Effluent Probability Method is recommended, which involves collecting pollutant concentration data at both the inflow and outflow of the BMP for multiple storms. The values are sorted from lowest to highest, plotted as cumulative probability curves, and compared.

Next, storm selection criteria should be considered. Ideally data from every storm over a long period would be collected, but concessions will need to be made to align with available resources. "Qualifying storms" should be defined – for instance, a minimum of 0.1 inches of rainfall is a recommended parameter.

Finally, water quality sampling techniques should be considered. Automated samplers offer the advantage of capturing multiple flow-weighted composite samples throughout an event; multiple flow-weighted composite samples are often necessary to accurately characterize pollutant loads and meet the recommended Effluent Probability Method guidelines. Manual grab sampling can be less costly and easier to implement but is more prone to human error and may miss critical parts of the hydrograph. Additionally, collecting a flow rate alongside water quality data is essential. This can either be done with modeling software, direct measurement using weirs and flumes, or with automated sensors.

Other steps to consider include developing a Quality Assurance/Quality Control (QA/QC) plan for laboratory analysis and a plan for how to store data collected in an organized way. For more detailed information on any of these topics, please see the 2002 EPA manual listed in the **References** section.

4.2 Questions

- **If modelling software is to be used in tandem with BMP monitoring program, which is best suited for project needs?**
    - Modelling software could be chosen based on staff familiarity and applicability to specific use case:
        - QUAL2E (Enhanced Stream Water Quality Model)
        - AQAUTOX (Simulation Model for Aquatic Ecosystems)
        - EPASWMM (EPA Storm Water Management Model)
        - HSPF (Hydrologic Simulation Program)
        - WASP5 (Water Quality Analysis Simulation Program)
        - SLAMM (Source Loading and Management Model)

- **Which method of BMP water quality monitoring analysis should be used?**
    - Effluent Probability Method (generally recommended)
    - Other methods in Table 2.3 of 2002 EPA Manual

- **What are the parameters by which a "qualifying storm" is defined?**
    - Rainfall volume minimums and maximums
    - Rainfall duration
    - Antecedent dry period
    - Dry period between storms

- **Will flow data be collected alongside water quality data?**

- **Will automated or manual sampling be used?**

- **If manual sampling is selected, how will sampling be triggered and managed during storm? Will staff on call be used?**

- **What equipment will be needed for data collection?**
    - Rain gauges
    - Common flow data measurement and collection equipment
        - Flumes
        - Weirs
        - Data Loggers
        - Stage-Based Variable Gate Meters
        - Float Gauges
        - Bubbler Tubes
        - Pressure Transducers
        - Ultrasonic Depth Sensors
        - Rotating-Element Current Meters
        - Pressure Sensors
        - Tracers
    - Common water quality data measurement and collection equipment

- Automated Samplers
- Overland Flow Samplers
- Bottles for manual grab sampling
- Bailers
- Mixing bucket (if composite sampling is taken)

- **What is the maintenance plan for equipment used for data collection?**

- **What QA/QC procedures should be used for data collection and analysis?**

- **How will data be stored and managed?**

References

U.S. Environmental Protection Agency. (2002, April). *Urban stormwater BMP performance monitoring: A guidance manual for meeting the national stormwater BMP database requirements* (EPA-821-B-02-001). Retrieved from https://www3.epa.gov/npdes/pubs/montcomplete.pdf