A Review of Monitoring Practices for Assessing BMP Performance – the Good and the Not so Good

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Outline

- Introduction
- Review of BMPs monitoring practice
- Examples
  - Observations from monitoring a bioretention cell (in a large city)
  - Monitoring multiple treatment practices simultaneously
  - Monitoring a wet pond in a park
- Summary of lessons learned
Review of BMP Monitoring Practices
Methods for BMP Monitoring and Assessment

- Hydraulic Monitoring (mass-in, mass-out)
- Paired watershed monitoring
  - Spatial
  - Temporal
- Randomized Sampling of outputs
- Modeling based upon physical understanding
- Expert opinions
Types of Hydraulic Monitoring

- Primary measurement devices
  - Weirs
  - Flumes
- Secondary measurement devices
  - Float Gage
  - Bubbler Tube
  - Ultrasonic Depth Sensor
  - Pressure Probe
  - Measurement Stick

- Velocity-Based Methods
  - Ultrasonic (Doppler) Sensors
  - Electromagnetic Sensors
  - Acoustic Path
  - Rotating-Element Current Meters
  - Pressure Sensors
  - Acoustical Sensors
Variability of Stormwater Runoff

- Stormwater inflow quality highly variable
- Address some variability by monitoring homogenous land uses
- P dynamics with sediment, particularly small particles

Calculating Mass Load (EMC)

\[
EMC = \frac{\sum_{i=1}^{n} C_i \Delta V_i}{\sum_{i=1}^{n} \Delta V_i} = \frac{\int_{0}^{t_D} C_i \, dV}{\int_{0}^{t_D} dV}
\]
Sample Compositing

Discharge, $L^3 t^{-1}$

$V_1 = V_2 = V_n$

Time

Source: Grizzard, T., personal communication.
Placement of Monitoring Devices

Natural Channel

Parabolic Channel

Trapezoidal Channel

Placement of Monitoring Devices

Pipe (partly full)

Triangular Channel/swale

Rectangular Channel

Monitoring-Calibration

- Flumes typically have rating curve
- However, installation is not always perfect
- Example w/ Palmer-Bowlus flume indicates field data are biased low

Source: Grizzard, T. (personal communication).
Observations

- Flow measurement is crucial to mass balance
- Flow splitters may impact flow measurements
- Primary flow measurement required (not uniform flow/Manning)
- Placement of probe critical
- For inflows with potential for solids and debris—flumes preferred
- Weirs can be used in outfall IF CLEAN
Potential Pitfalls

- Power system for sampling equipment
- Logging software failure
- Accidents (near roadways, parking)
- Laboratory unprepared for low detection limits for chosen constituents
- Clogging of weirs, flumes with debris
- Sediment resuspension
- Cross contamination
Observations from monitoring a bioretention cell (in a large city)
Haibo Zhang
Bioretention Area Monitoring Setup

- Inlet from street with flume, stilling well & flow diverter box
- Overflow to sewer with Thel-mar weir
- Full climate station & solar power station
- Groundwater well (10m)
- Slotted shallow well (1m)
- ISSO water sampler and Data logger with cell modem
- Weighing lysimeter with vertically distributed soil moisture and tensiometer arrays
- Soil moisture arrays (external to lysimeter)

(Courtesy of Kimberly DiGiovanni)
Flume and stilling pond

Inlet with flume

Flume and stilling pond
Flume and stilling pond

Observations:

• Accumulation of sediment at the inlet
• Blockage of inlet screen by leaves, papers and other debris
• Damage of screens by human activities
Equipment housing and lysimeter
Equipment Housing and lysimeter

Observations:

• Water pipe leakage
• Flooding of equipment housing
• Battery corrosion
  – lost of sensor data
• Water sampler errors
• Corrosion of level actuator
  – lost of water samples
• Unwanted animals in water container
Recommendations

• Dry run is necessary to ensure that every piece of equipment is working properly and identify problem areas which need high attention during the monitoring period.

• Maintenance work is intense, however, needs to be done regularly to ensure the site performance.

• For sites located in residential areas, involvement of neighborhood may help reduce damages made purposely by human activities.
Summary

- Monitoring sites is not easy
- Storm event prediction—many false alarms
- Equipment can malfunction, dry runs recommended
- Compromises can affect quality of estimates of flow
- Statistical methods can help
  - Censored data
  - EPM and SOL
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