Effective Water Quality BMP Monitoring Tools

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Overview

BMP Monitoring Guidance Document for Stream Systems

- Lessons learned
  - CEAP
    Conservation Effects Assessment Project
- The Guidance Document & Tools
  Water Quality Monitoring Training Resources
  - Components and key links...
Examples from the Little Bear River CEAP Project
Little Bear Watershed

- 74,000 ha (182,000 acres)
  - 70% range / wild lands
  - 20% irrigated land
  - 5% cropland
  - 5% urban and other

- High Elevation Watershed: 4,400 to 9,000 ft
  - Precipitation: winter snow, summer storms
  - 32% pop growth between 90-2000

- Two main drainages....2 impoundments.
  - 122 miles of perennial stream
  - 228 miles of intermittent streams
Pre-treatment problems:
Bank erosion, manure management, flood irrigation
Treatments:
bank stabilization, river reach restoration, off-stream watering, improved manure and water management
Common problems in BMP monitoring programs:

- Failure to design monitoring plan around BMP objectives
- A failure to understand pollutant pathways and transformations and sources of variability in these dynamic system.
- Tend to draw on a limited set or inappropriate approaches
Failure to design monitoring plan around BMP objectives

A failure to understand pollutant pathways and transformations and sources of variability in these dynamic system.

Tend to draw on a limited set or inappropriate approaches
## Total Observations at Watershed Outlet

<table>
<thead>
<tr>
<th></th>
<th>Discharge</th>
<th>Total phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976 - 2004:</td>
<td>162</td>
<td>241</td>
</tr>
<tr>
<td>1994</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>1995</td>
<td>10</td>
<td>13</td>
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<td>1996</td>
<td>10</td>
<td>13</td>
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<td>1997</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>1998</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>1999</td>
<td>7</td>
<td>10</td>
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<tr>
<td>2000</td>
<td>6</td>
<td>5</td>
</tr>
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<td>2001</td>
<td>4</td>
<td>7</td>
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<td>2002</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>2003</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>2004</td>
<td>1</td>
<td>8</td>
</tr>
</tbody>
</table>
Failure to design monitoring plan around BMP objectives

A failure to understand pollutant pathways and transformations and sources of variability in these dynamic system.

Tend to draw on a limited set or inappropriate approaches
Understanding natural variability – annual variation
Since 2005, measure flow and turbidity at 30 minute intervals

Stage recording devices to estimate discharge

Turbidity sensors

Dataloggers and telemetry equipment

http://www.campbellsci.com
http://www.ftsinc.com/
http://www.campbellsci.com
Capturing pollutant movement from source to waterbody.

Little Bear River Near Paradise

Date

Streamflow (cfs)  Turbidity (NTU)
- Failure to design monitoring plan around BMP objectives

- A failure to understand pollutant pathways and transformations and sources of variability in these dynamic system.

- Tend to draw on a limited set or inappropriate approaches
Problem: excess sediment

Average flow = 20 cfs

BMP = series of in-stream sediment basins

Above and Below monitoring design...

Rees Creek TSS load

Weeks

kg/day

0 5000 10000 15000 20000 25000 30000 35000 40000 45000 50000

1 2 3 4 5 6 7 8 9

Above

Below
Problems with “one-size-fits-all” monitoring design
Problem: excess phosphorus

Average flow = 1000 cfs

BMP = fence cattle OUT of riparian area and revegetate

Bear River phosphorus load

0
50
100
150
200
250
300
350
0 1 2 3 4 5 6 7 8 9

weeks

load (kg/day)
Considerations and decisions necessary as a project is first being considered.

NOT a “how-to” manual of protocols

Website:
http://www.uwyo.edu/bmp-water/
Target Audience

- State Environmental Agencies
- Conservation Groups
- Land Management Agencies
- Volunteer Monitoring Groups
What is your monitoring objective?

✓ Long term trends?
✓ PDES compliance?
✓ Educational?
✓ Assessment for impairment?
✓ Track response from an implementation?
How do pollutants “behave” within the watershed?

✓ How does the pollutant move from the source to the waterbody?
How do pollutants “behave” within the watershed?

- How does the pollutant move from the source to the waterbody?
  
- How is the pollutant processed or transformed within a waterbody?
  
- What is the natural variability of the pollutant? Will concentrations change throughout a season or day?
  
- What long term changes within the watershed may also affect this pollutant?
  
- What else must be monitored to help interpret the data?
What to monitor?

- Monitor the pollutant(s) of concern?
- Monitor a “surrogate” variable?
- Monitor a response variables?
- Monitor the impacted beneficial use?
- Monitor the BMP itself?
- Monitor human behavior?
- Model the response to a BMP implementation.
- Collect other data necessary to interpret monitoring results OR calibrate and validate the model?
Where and when to monitor?
How to monitor?

- Points in time versus continuous?
- Integrated versus grab samples?
- Consider:
  - Cost
  - Skill and training required
  - Accessibility of sites
Appropriate monitoring or modeling methods

BACI Design

Control

Treatment “A”

Sampling points

Above and below treatment design

Above-treatment monitoring stations

Below-treatment monitoring stations
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Direct Monitoring</th>
<th>Surrogate Monitoring</th>
<th>Other important variables *</th>
<th>Response variables</th>
<th>Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Probes, launched monitors (e.g. hobo), and direct measurements</td>
<td>Light / shading, ground water signal (stable isotope variables)</td>
<td>Air temperature, flow, time of day, depth, turbidity, cloud cover</td>
<td>Algae, macros, and fish</td>
<td>CEQual WASP(7) SNTEMP (USGS)</td>
</tr>
<tr>
<td>Dissolved Oxygen (DO)</td>
<td>Probes and direct measurements</td>
<td>Temperature, redox, and Flow/temperature/algal biomass</td>
<td>Temperature will affect percent saturation, depth, flow, velocity</td>
<td>Macros and fish</td>
<td>Streeter Phelps</td>
</tr>
<tr>
<td>Nutrients (phosphorus and nitrogen)</td>
<td>Grab samples and integrated samples In some cases use probes, or streamside auto-analyzers to collect surrogates</td>
<td>Turbidity or sediment</td>
<td>pH, temperature, and DO might affect the solubility of phosphorus, flow, sediment transport</td>
<td>Algae, macros, and fish</td>
<td>UAFRI SWAT QUAL2K</td>
</tr>
<tr>
<td>Sediment</td>
<td>Grab samples and integrated samples</td>
<td>Turbidity</td>
<td>Flow</td>
<td>Physical characteristics, embeddedness, macros, and algae</td>
<td>PSIAC /AgNPS SWAT KINEROS2 SELOAD</td>
</tr>
<tr>
<td>Salts / TDS</td>
<td>Probes and grab samples</td>
<td>Riparian vegetation</td>
<td>Flow</td>
<td>Macros and fish</td>
<td>QUAL2K</td>
</tr>
<tr>
<td>Pathogens</td>
<td>Grab samples and integrated samples</td>
<td>Fecal Coliform Bacteria, E.coli</td>
<td>Turbidity, nutrients</td>
<td>Human health, livestock health</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>Grab samples</td>
<td>Bioaccumulation in living organisms</td>
<td>DO might affect total hardness</td>
<td>Bacteria in the sediments</td>
<td>MINTEQAQ</td>
</tr>
<tr>
<td>Organic pesticides</td>
<td>Grab samples</td>
<td>Bioaccumulation in living organisms</td>
<td></td>
<td>Bacteria in the sediments</td>
<td>WINPST</td>
</tr>
</tbody>
</table>
Links to modeling resources

US EPA Water Quality Models and Tools: This site includes information and guidance on several simulation models and tools for watershed and water quality monitoring (http://www.epa.gov/waterscience/models/).

AGricultural Non-Point Source Pollution Model (AGNPS): continuous simulation surface runoff model designed to assist with determining BMPs, the setting of TMDLs, and for risk & cost/benefit analyses (http://www.ars.usda.gov/Research/docs.htm?docid=5199).

Soil Water Assessment Tool (SWAT): a river basin scale model developed to quantify the impact of land management practices in large and complex watersheds. SWAT is a public domain model supported by the USDA Agricultural Research Service (http://www.brc.tamus.edu/swat/).

Kinematic runoff and erosion model (KINEROS2): is an event oriented, physically based model describing the processes of interception, infiltration, surface runoff and erosion from small agricultural and urban watersheds (http://www.tucson.ars.ag.gov/kineros/).

River and Stream Water Quality Model (QUAL2K): a one dimensional river and stream water quality model for a well mixed, vertically and laterally channel with steady state hydraulics (http://www.epa.gov/athens/wwqtsc/html/qual2k.html).
Links to monitoring resources

NRCS products and tools from the National Waters and Climate Center: http://www.wcc.nrcs.usda.gov/products.html

Monitoring protocols: National Water Quality Monitoring Handbook, specifically Section 614
http://policy.nrcs.usda.gov/media/pdf/H_450_600_a.pdf

http://www.epa.gov/owow/monitoring/volunteer/qapp/vol_qapp.pdf


<http://www.epa.gov/QUALITY/gs-docs/g6-final.pdf>
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Additional Resources - Tools

• Check list
  • identify KEY components of a monitoring program

• Decision Tree
  • non- linear process - very interactive

• Web Version of the Guidance Document:
  • active links to the information and references in the Guidance Document
Introduction

These monitoring guidance tools are designed to help identify appropriate and effective monitoring strategies for water quality implementation projects. In particular, this site focuses on the effectiveness of Best Management Practices (BMPs) implemented to address water quality impairments in a watershed. These practices may range from site-specific installations, such as a manure bunker, to large-scale efforts such as improved grazing management over thousands of acres of rangeland. In all cases, however, we need to understand and quantify the effectiveness of these practices. This website provides agencies, watershed managers and field practitioners with tools and techniques to develop and implement a monitoring program that will meet this critical need.

The most common mistakes in developing a monitoring program
Decision Tree

- Identifies KEY components
- Shows links between components
- Links to information in the Guidance doc
- Non-linear!!
Check List

- Method to help identify KEY components that need to be considered
- Takes one through the thought process.
The road to more effective monitoring....

- Monitoring plans require careful thought before anything is implemented.
- Consider how the data will be used to demonstrate change.
- Use your understanding of the watershed and how the pollutants of concern behave to target monitoring most effectively.
- Use different approaches for different BMPs.
- Keep project goals in mind when monitoring BMPs
- Monitor at an appropriate scale
- Keep time lags in mind
- Be selective, consider individual situations
- Monitor surrogates when appropriate
- Control or measure human behaviors / other watershed changes.