Selecting Monitoring Design

Fundamentals of Developing a Water Quality Monitoring Plan
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Mention of trade names or commercial products does not constitute their endorsement.

Topics to Cover

• Scale of Study (point to watershed)
• Sample Type (grab, composite, integrated)
• Variables Monitored
• Sampling Locations
• Sampling Frequency & Duration
• Station Types
• Sample Collection & Analysis

SCALE OF STUDY:

- Point
- Plot
- Field
- Watershed
- Combination

Point Scale

Smallest scale – point in space

Examples:
- Precipitation Gage
- Soil Sample

Often used in combination with other scales of monitoring
Plot Scale

Use
• Replicates
• Overland flow
Comments
• Good for BMP effectiveness
• Resource intensive

Field Scale

Larger than plot scale
Similar in use & purpose to plot
Resource intensive
Good for BMP effectiveness
Watershed Scale

Uses
• Long-term trends
• BMP system evaluation
• Generally not single BMP, except riparian buffers or streambank protection
• Biological & habitat monitoring
• CWA issues – assessment, protection, restoration

Scaling Issues

Edge of Field (acres)
100% Waste Application Fields
4.0 mg/L PO₄-P

Microwatershed (hundreds of acres)
45% Waste Application Fields
2.4 mg/L PO₄-P

Major Subwatershed (tens of thousands of acres)
7% Waste Application Fields
0.20 mg/L PO₄-P

Entire Watershed (hundred thousand acres)
3% Waste Application Fields
0.02 mg/L PO₄-P
SAMPLE TYPES

- Grab - discrete
- Composite – time-weighted; flow-weighted
- Integrated (specific type of grab)

Composite Samples

- Manual or automated sampler
- Holding time issues
Composite Samples

• Time-Weighted
  - Fixed volume collected at prescribed time intervals
  - Simplest; does not account for flow variability

• Flow-weighted
  - Fixed volume collected specified flow volume goes past station
  - Requires automated sampler and measurement of flow

Integrated Samples
VARIABLES MONITORED

- Categories of water quality variables
  - Physical
  - Chemical
  - Biological

- Selection of water quality variables

Categories of Variables

<table>
<thead>
<tr>
<th>Physical</th>
<th>Chemical</th>
<th>Biological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved oxygen</td>
<td>Nutrients (N&amp;P)</td>
<td>E. coli</td>
</tr>
<tr>
<td>Streamflow</td>
<td>pH</td>
<td>Enterococci</td>
</tr>
<tr>
<td>Water temp.</td>
<td>BOD&lt;sub&gt;5&lt;/sub&gt;</td>
<td>Plankton (algae)</td>
</tr>
<tr>
<td>Specific conduct.</td>
<td>Metals</td>
<td>Periphyton</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>Organics</td>
<td>Chlorophyll-a</td>
</tr>
<tr>
<td>Salinity</td>
<td>Ions (SO&lt;sub&gt;4&lt;/sub&gt;&lt;sup&gt;2-&lt;/sup&gt;)</td>
<td>Fish</td>
</tr>
<tr>
<td>TDS</td>
<td></td>
<td>Macrobenthos</td>
</tr>
<tr>
<td>Habitat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TCEQ Routine Parameters

- total Kjeldahl nitrogen (TKN)
- total phosphorus (TP)
- total ammonia (NH₃-N)
- total nitrite plus nitrate (NO₂⁺NO₃-N)
- soluble reactive phosphorus (dissolved PO₄³⁻P)
- total dissolved solids (TDS)
- total suspended solids (TSS)
- volatile suspended solids (VSS)
- chloride
- sulfate
- total alkalinity
- total organic carbon (TOC)
- chlorophyll-α

2010 §303(d) List
(Water bodies not meeting applicable standards)

- 610 impaired water bodies
- 51% due to elevated bacteria levels (non-support of recreational use, oyster waters, beaches)
- 15% due to depressed dissolved oxygen (aquatic life)
- 15% due to organics in fish tissue (fish consumption, aquatic life)
Variables Dictated by Water Quality Issues

- Bacteria (51%)
  - *E. coli* in freshwater
  - Enterococci in salt water
- Dissolved Oxygen (15%)
  - 24-hour DO, water temp, pH, specific conductance
  - Nutrients
  - Aquatic vegetation
- PCBs and Dioxin in edible fish tissue (15%)
SAMPLING LOCATIONS

• General site selection criteria
  ➢ Accessible all weather (e.g., bridge crossings)
  ➢ Cooperative landowner or road right-of-way
  ➢ Equipment protection from vandals
  ➢ Electricity and phone service

• Plot/Field Sites
  ➢ Homogenous land use
  ➢ Homogenous soil
  ➢ Definable drainage

SAMPLING LOCATIONS (Cont’d)

• Reconnaissance Trip – A Necessity

• Streams
  ➢ Stable streambed
  ➢ Straight uniform cross section
  ➢ Safety issues (bridge crossing sites)
Considering Special Conditions

Representative Sampling Locations

Source: TCEQ TMDL Program
Avoid Undesired Influences

Know your system before establishing sampling locations
Revisiting Assessment of Current Conditions (North Bosque River)

Subsample biweekly Soluble Reactive Phosphorus (SRP) (June 1993 –May 1998):

- Monthly (2 schemes)
- Quarterly (6 schemes)
Station Types

- Discharge Stations
- Concentration Sampling
- Precipitation Monitoring
- Biotic Sampling
- Sediment Sampling
Discharge Station

Edge-of-field & small stream –
• Flumes
• Weirs

Discharge Stations - Streams
Concentration Sampling – Manual & Automated Sampler Methods

Aquatic Life Surveys – Habitat, Fish, Macrobenthos
COLLECTION & ANALYSIS METHODS

Collection & Preservation - Follow TCEQ Surface Water Quality Monitoring procedures manuals:

- Surface Water Quality Monitoring Procedures, Volume 2: Methods for Collecting and Analyzing Biological Assemblage and Habitat Data (RG-416) (June 2007)
- Updates to procedures on TCEQ website

http://www.tceq.texas.gov/waterquality/monitoring/swqm_procedures.html

Examples of Collection & Preservation

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Vol. req (mL)</th>
<th>Container</th>
<th>Preservative</th>
<th>Maximum holding time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganics, nonmetals (continued)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>400</td>
<td>P,G</td>
<td>Cool, 4 °C</td>
<td>28 days</td>
</tr>
<tr>
<td>Kjeldahl, total</td>
<td>500</td>
<td>P,G</td>
<td>H₂SO₄ to pH &lt;2</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrate plus Nitrite</td>
<td>100</td>
<td>PG</td>
<td>Cool, 4 °C</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrate</td>
<td>100</td>
<td>P,G</td>
<td>H₂SO₄ to pH &lt;2</td>
<td>28 days</td>
</tr>
<tr>
<td>Nitrite</td>
<td>50</td>
<td>P,G</td>
<td>Cool, 4 °C</td>
<td>48 hrs</td>
</tr>
<tr>
<td>Dissolved oxygen Probe</td>
<td>300</td>
<td>G bottle &amp; top</td>
<td>None req.</td>
<td>Analyze immediately</td>
</tr>
<tr>
<td>Winkler</td>
<td>300</td>
<td>G bottle &amp; top</td>
<td>Pix on site and store in dark</td>
<td>8 hrs</td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ortho-phosphate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved</td>
<td>50</td>
<td>P,G</td>
<td>Filter on site and store in dark</td>
<td>48 hrs</td>
</tr>
</tbody>
</table>

Source: NRCS Handbook Part 614, Chapter 11 (from USEPA)
Quality Assurance & Quality Control

• “Quality Assurance (QA) is the total program for assuring the reliability of monitoring and measurement data.”
• “Quality Control (QC) refers to activities conducted to provide high quality data.”
• NELAP – National Environmental Laboratory Accreditation Program – accreditation administered by TCEQ

Example of Sampling Sites & Monitoring Frequencies

<table>
<thead>
<tr>
<th>Seg.</th>
<th>Reg.</th>
<th>Site Description</th>
<th>Station ID</th>
<th>24 Hr DO</th>
<th>Primary Station Conven. Analyses¹</th>
<th>Secondary Station Conven. Analyses²</th>
<th>TZI Habitat Assessment³</th>
<th>Inst Flow</th>
<th>Field¹</th>
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<tbody>
<tr>
<td>0836</td>
<td>4</td>
<td>Richland Arm</td>
<td>GR Control 1</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0836</td>
<td>4</td>
<td>Chambers Arm</td>
<td>GR Control 2</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0836</td>
<td>4</td>
<td>Cedar Creek</td>
<td>18717</td>
<td>8</td>
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<td>8</td>
<td>8</td>
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<td>0836B</td>
<td>4</td>
<td>Cedar Creek</td>
<td>CC01</td>
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<td>18719</td>
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<td>CC02</td>
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<tr>
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<td>CC03</td>
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<td>8</td>
</tr>
</tbody>
</table>
## Example of Laboratory Measurement Performance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Method</th>
<th>Parameter CODE</th>
<th>AWRB</th>
<th>Limit of Quantification (LOQ)</th>
<th>Precision (RPD of LCS/LQC)</th>
<th>Bias (% Rec. of LCS)</th>
<th>LOQ Check Standard %Rec.</th>
<th>Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll-a, spectrofluorometric method</td>
<td>mg/L</td>
<td>water</td>
<td>SM 10201H</td>
<td>32213</td>
<td>3</td>
<td>3</td>
<td>20</td>
<td>80-120</td>
<td>NA</td>
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<tr>
<td>Phosphorus, spectrophotometric method</td>
<td>mg/L</td>
<td>water</td>
<td>SM 10208H</td>
<td>32218</td>
<td>3</td>
<td>3</td>
<td>20</td>
<td>NA</td>
<td>TIARE</td>
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<tr>
<td>Nitrite-nitrate-N, low level</td>
<td>mg/L</td>
<td>water</td>
<td>SM 4806-NO₂-F</td>
<td>0.0610</td>
<td>0.06</td>
<td>0.04</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
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<tr>
<td>Nitrate-nitrite-N</td>
<td>mg/L</td>
<td>water</td>
<td>SM 4806-NO₃-F</td>
<td>0.0610</td>
<td>0.08</td>
<td>0.08</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
</tr>
<tr>
<td>Total Kjeldahl N</td>
<td>mg/L</td>
<td>water</td>
<td>SM 1010-5031G</td>
<td>0.0623</td>
<td>0.2</td>
<td>0.2</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
</tr>
<tr>
<td>Total phosphorous-P, low level</td>
<td>mg/L</td>
<td>water</td>
<td>EPA 365.4</td>
<td>0.0668</td>
<td>0.06</td>
<td>0.01</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
</tr>
<tr>
<td>TSS (total Soluble Solids)</td>
<td>mg/L</td>
<td>water</td>
<td>SM 2440 D</td>
<td>0.0510</td>
<td>4</td>
<td>4</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>TSS (Residue – volatile Solids)</td>
<td>mg/L</td>
<td>water</td>
<td>EPA 1664</td>
<td>0.0535</td>
<td>4</td>
<td>4</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Alkalinity, Total</td>
<td>mg/L</td>
<td>water</td>
<td>SM 2120 B</td>
<td>0.0410</td>
<td>20</td>
<td>20</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>water</td>
<td>EPA 200.0</td>
<td>0.0940</td>
<td>5</td>
<td>2</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
</tr>
<tr>
<td>Sulfide</td>
<td>mg/L</td>
<td>water</td>
<td>EPA 200.0</td>
<td>0.0945</td>
<td>5</td>
<td>2</td>
<td>20</td>
<td>80-120</td>
<td>70-130</td>
</tr>
<tr>
<td>TOC (responsible organic carbon)</td>
<td>mg/L</td>
<td>water</td>
<td>SM 5310-C</td>
<td>0.0680</td>
<td>2</td>
<td>0.5</td>
<td>10</td>
<td>90-110</td>
<td>NA</td>
</tr>
</tbody>
</table>
Connecting Topics Covered

- Scale of Study (point to watershed)
- Sample Type (grab, composite, integrated)
- Variables Monitored
- Sampling Locations
- Sampling Frequency & Duration
- Station Types
- Sample Collection & Analysis


Thank You

Questions?