South Carolina Surface Water Monitoring: Different Designs for Different Objectives

Presented by David Chestnut
Reporting Requirements

- §305(b) Report
  - Comprehensive statewide summary report on water quality to Congress every two years

- §303(d) List
  - Listing of impaired waters
  - Submitted to EPA every two years
Other Data Needs

• Capability for targeted monitoring for specific needs:
  – Special studies
  – Tracking of implementation of control strategies
  – Respond to emerging issues
Purpose of the Ambient Water Quality Monitoring Program

• The collection and analysis of data needed to make water quality management decisions:
  – Determine water quality status & identify waters not supporting classified uses (§305(b), §303(d), WWQA)
  – Determine long-term trends in concentrations of various constituents at individual sites (WWQA)
  – Collect data for Wasteload Allocation Models
  – Support specific NPDES permit limits
  – Evaluate effectiveness of SCDHEC programs
Basic Designs of Ambient Surface Water Monitoring are:

• **Big Picture:**
  – Make statements about representative WQ at varying scales (§305(b), WWQA)

• **Site Specific**
  – Examine long-term trends in concentration of specific WQ parameters
  – Identify waterbodies not meeting classified uses (§303(d))
  – Track specific targeted activities
Main Ambient Monitoring Activities

- Physical & Chemical Monitoring
  - Water Column
  - Sediment
- Biological Community Monitoring
  - Macroinvertebrate
- Fish Tissue Monitoring
Components of the Ambient Monitoring Network Design

• Fixed Monitoring Network
  – Long-term trends
  – Consistent statewide coverage

• Cyclical Basin Monitoring
  – More spatially dense coverage
  – Watershed focus

• Probability-Based Monitoring
  – Statistical survey of statewide resources
  – Sample new locations
Types of Fixed Statewide Surface Water Chemistry Monitoring Sites

- **Integrator & Special Purpose Sites**
  - Sampled monthly year-round, every year
  - Target outflow of 11-digit WSU or specific data needs
  - Tend to be larger streams with smaller order streams under-represented

- **Special Summer-Only Sites**
  - Sampled monthly May-October, every year
  - Target specific data needs
Cyclic Basin Sites

- More-or-less fixed, on a 5 year cycle
- Sampled monthly for 1 year when active
- Historical sites – old primaries & secondaries
  - Individual sites were selected for a variety of reasons, e.g. below point source, urban area, background conditions, locations with strong public use or interest, district requests, citizen concerns, other special interests
Probability-Based Component

- Probability Sites
  - Sampled monthly for 1 year

- Make comprehensive statements about *statewide* WQ conditions (§305(b) use support)
  - Unbiased random sample (survey) of water resources
  - Represents entire resource
  - Known confidence of condition estimates

- Sample previously unsampled locations
  - Identify new §303(d) candidates
Resource Types Assessed Using Probability-Based Approach

- Streams
- Lakes
- Estuaries
Targeted Categories for Probability-Based Sites

- Streams (30 sites per year)
  - Sampled monthly
  - First order streams
  - Second order streams
  - Third order & greater streams
  - Unequal weights
Targeted Categories for Probability-Based Sites

• Significant Lakes with Public Access (30 sites per year)
  – Sampled monthly
  – Major lakes ($\geq$ 850 acres)
  – Minor lakes (40 to 850 acres)
  – Unequal weights
Targeted Categories for Probability-Based Sites

- Estuaries (30 sites per year with cooperators)
  - 30 visited monthly
  - Two distinct strata
  - Open water (> 100 m wide)
  - Creeks (< 100 m wide)
Habitat Designation Criteria

Less than 100 m wide
Primary Uses to be Assessed with Probability Data

- **Statewide**
  - Aquatic Life Use Support
  - Recreational Use Support
Use of Generated Data

- §303(d)
  - Integrator Sites
  - Special Purpose Sites
  - Summer Only Sites
  - Basin Sites
  - Probability Sites
  - Other QA’d data

- §305(b)
  - Probability Sites
In order to do that, **sufficient data** must be collected at **each** Probability Site to apply SCDHEC’s Assessment Methodology

- This is a different approach than that employed by most other states with Probability-Based designs
Annual Ambient Surface Water Chemistry Monitoring Numbers

- 313 Integrators (statewide)
- 31 Special Purpose (statewide)
- 5 Summer Only (statewide)
- 8 Sediment Only (statewide)
- 83-104 Basin Sites (depending on target basins)
- 90 Probability Sites (statewide)
Don’t Put All of Your Eggs in One Basket!
You Need to Have a Little of Everything

- Probability based for big picture statements
- Fixed sites to examine long-term trends in individual parameters
- Capability for targeted monitoring for specific needs:
  - Emerging issues/special studies
  - Tracking of implementation of control strategies
Benefits of Entire Package

• Consistent & comparable data statewide
• Known confidence in §305(b) statements
• Sample previously unsampled locations
• Identify new §303(d) candidates
So what do the results show?

Site-Based §303(d) List

vs.

Statewide Probability-Based §305(b) Results
§303(d) List

- 2006 list approved by Region IV EPA
- Basis for TMDLs, projects, etc.
- Directly impacts permit limits
- Based on assessment results at individual monitoring sites
  - Number of sites not meeting standards
  - Number of parameters not meeting standards at an individual site
### 2006 §303(d) List

- **Sites Assessed**: 1405
- **Sites Listed**: 585
- **Total # Impairments**: 757
- **Fecal Coliform**: 21%*
- **Low DO**: 17%
- **Impaired Bio. Comm.**: 19%
- **pH**: 10%
- **Copper**: 12%
- **Zinc**: 2%
- **Turbidity**: 7%
- **Other impairment**: 11%
- **Impaired Bio. Comm.**: 12%
- **Low DO**: 11%
- **Fecal Coliform**: 28%
- **pH**: 4%
- **Copper**: 9%
- **Zinc**: 4%
- **Turbidity**: 15%
- **Other impairment**: 15%

### Of Random Sites Listed
- 28 Lake Sites
- 65 Stream Sites
- 28 Estuary Sites

\[
\text{%} = \frac{\# \text{ Sites Impaired for Parameter}}{\# \text{ Total # Impairments}}
\]
So what do the statewide probability-based results show?
SCDHEC Probability Based Network 2001 & 2002

- Monthly Coastal
- Lake Sites
- Stream Sites
- Mixed Class
- Rotating Basins Boundaries
Rivers & Streams

- Probability-Based Approach
  - Estimated 20,954 miles in stream design frame
  - 2004: 58 water quality monitoring sites 2001-02
  - 2006: 118 water quality monitoring sites 2001-04
  - 65 sites on §303(d)
  - Representing all stream miles
Rivers & Streams Aquatic Life Use Support (ALUS)

- Fully Supporting (Good): 79%
- Partially Supporting (Fair): 15%
- Not Supporting (Poor): 6%

2006: Probability 2001-2004
- Fully Supporting (Good): 65%
- Partially Supporting (Fair): 18%
- Not Supporting (Poor): 17%

Legend:
- Green: Fully Supporting (Good)
- Yellow: Partially Supporting (Fair)
- Red: Not Supporting (Poor)
Rivers & Streams Recreational Use Support

- Fully Supporting (Good): 49%
- Partially Supporting (Fair): 15%
- Not Supporting (Poor): 36%

2006: Probability 2001-2004
- Fully Supporting (Good): 22%
- Partially Supporting (Fair): 47%
- Not Supporting (Poor): 31%
### Percent of Rivers & Streams Impaired by Specific Causes

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2001-2004 Estimated %</th>
<th>2001-2004 Lower 95% CL</th>
<th>2001-2004 Upper 95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent of Rivers and Streams Miles Impaired by Various Cause Categories</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macroinvertebrate Community *</td>
<td>22.6%</td>
<td>13.7%</td>
<td>31.5%</td>
</tr>
<tr>
<td>Turbidity</td>
<td>1.9%</td>
<td>0.3%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>8.3%</td>
<td>3.7%</td>
<td>13.0%</td>
</tr>
<tr>
<td>pH</td>
<td>3.9%</td>
<td>0.1%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.5%</td>
<td>0.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Copper</td>
<td>6.6%</td>
<td>1.8%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.5%</td>
<td>0.0%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Zinc</td>
<td>3.9%</td>
<td>1.0%</td>
<td>6.8%</td>
</tr>
<tr>
<td>Fecal Coliform Bacteria</td>
<td>53.2%</td>
<td>43.8%</td>
<td>62.6%</td>
</tr>
</tbody>
</table>

* - Misleading because not every site had a macroinvertebrate assessment. The total resource size represented by macroinvertebrate results is 5,667 miles
Lakes & Reservoirs

- **Probability-Based Approach**
  - Estimated 308,765 acres of lake/reservoir in design frame
  - 2004: 61 water quality monitoring sites 2001-02
  - 2006: 91 water quality monitoring sites 2001-03
  - 28 sites on §303(d)
  - Representing all lake acres
Lakes & Reservoirs Aquatic Life Use Support (ALUS)

- Fully Supporting (Good): 75%
- Partially Supporting (Fair): 16%
- Not Supporting (Poor): 9%

- Fully Supporting (Good): 85%
- Partially Supporting (Fair): 11%
- Not Supporting (Poor): 4%
## Percent of Lakes & Reservoirs Impaired by Specific Causes

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Percent of Lake and Reservoir Acres Impaired by Various Cause Categories</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>0.2%</td>
<td>0.0%</td>
<td>0.3%</td>
</tr>
<tr>
<td>pH</td>
<td>10.7%</td>
<td>3.9%</td>
<td>17.5%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>6.8%</td>
<td>1.6%</td>
<td>12.0%</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Chlorophyll-a</td>
<td>2.3%</td>
<td>0.0%</td>
<td>5.8%</td>
</tr>
<tr>
<td>Copper</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Fecal Coliform Bacteria</td>
<td>0.1%</td>
<td>0.0%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
Estuaries

• Probability-Based Approach
  – 277 square miles in the estuarine sampling design frame
  – 2004: 60 water quality monitoring sites 2001-02
  – 2006: 120 water quality monitoring sites 2001-04
    • 28 sites on §303(d)
  – Representing all estuary square miles
Estuaries Aquatic Life Use Support (ALUS)

- Fully Supporting (Good): 75%
- Partially Supporting (Fair): 22%
- Not Supporting (Poor): 3%

2006: Probability 2001-2004
- Fully Supporting (Good): 78%
- Partially Supporting (Fair): 3%
- Not Supporting (Poor): 19%
Estuaries Recreational Use Support


- 100%

2006: Probability 2001-2004

- 99%
- 1%

Legend:
- Green: Fully Supporting (Good)
- Yellow: Partially Supporting (Fair)
- Red: Not Supporting (Poor)
### Percent of Estuaries Impaired by Specific Causes

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2001-2004 Probability Estimated %</th>
<th>2001-2004 Lower 95% CL</th>
<th>2001-2004 Upper 95% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of Estuary Square Miles Impaired by Various Cause Categories</td>
<td>Turbidity: 11.2%</td>
<td>6.0%</td>
<td>16.4%</td>
</tr>
<tr>
<td></td>
<td>Dissolved Oxygen: 7.6%</td>
<td>2.9%</td>
<td>12.3%</td>
</tr>
<tr>
<td></td>
<td>pH: 0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Ammonia: 1.4%</td>
<td>0.0%</td>
<td>3.8%</td>
</tr>
<tr>
<td></td>
<td>Copper: 5.2%</td>
<td>0.9%</td>
<td>9.6%</td>
</tr>
<tr>
<td></td>
<td>Nickel: 0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td></td>
<td>Zinc: 0.2%</td>
<td>0.0%</td>
<td>0.6%</td>
</tr>
<tr>
<td></td>
<td>Fecal Coliform Bacteria: 0.2%</td>
<td>0.0%</td>
<td>0.6%</td>
</tr>
</tbody>
</table>
That’s All Folks!
Any Questions?
Discussion?
Visit our Web Site!
www.scdhec.net/water/

- Laws and regulations
- Reports and publications
- Fish Consumption Advisories
- Watershed maps
- Program contacts
- Outreach information
Indicators
Core Parameters -
All Physical & Chemical Sites

Monthly

- Air & Water Temp
- Dissolved Oxygen
- pH
- BOD$_5$
- Fecal Coliform Bacteria
- Turbidity

- Total Phosphorus
- Kjeldahl Nitrogen
- Nitrate
- Ammonia
- Alkalinity
Core Parameters - All Physical & Chemical Sites

**Quarterly**
- Total Organic Carbon
- Cadmium
- Chromium
- Copper
- Iron
- Lead

**Annually**
- Manganese
- Mercury
- Nickel
- Zinc
- Hardness*

*Freshwater sites only
Core Parameters - Waterbody-Type Specific

Monthly
- Salinity
- Conductivity

Chlorophyll a (May-Oct. all lakes and select estuarine)
- Transparency (Secchi depth, all lakes)

Saltwater sites only
Sediment Sampling

Annually

- Probability-based sites
  - All 30 streams and 30 lakes sampled and analyzed by SCDHEC
  - All estuarine sites collected by SCDNR and analyzed by NOAA – NOS
- 86 Fixed-location sites
- Select basin sites each year