Water quality monitoring: Sensors Basics

An Introduction to the Aquatic Sensor Workgroup

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Comparability Board

National Water Quality Monitoring Council

Outline

- Introduction to the Aquatic Sensor Workgroup (ASW)
- Tools developed by the ASW: laying the groundwork for sensors QA

- Data Management
- Specifications

Aquatic Sensor Workgroup (ASW)

- The ASW is a subcommittee of the *Methods and Data Comparability Board*, a workgroup of the National Council
- Objective: to convene a workgroup of experts to consider efforts to address challenges:
  - SOPs have not kept pace with technology
  - No central repository for information about SOPs, sensor performance, etc.

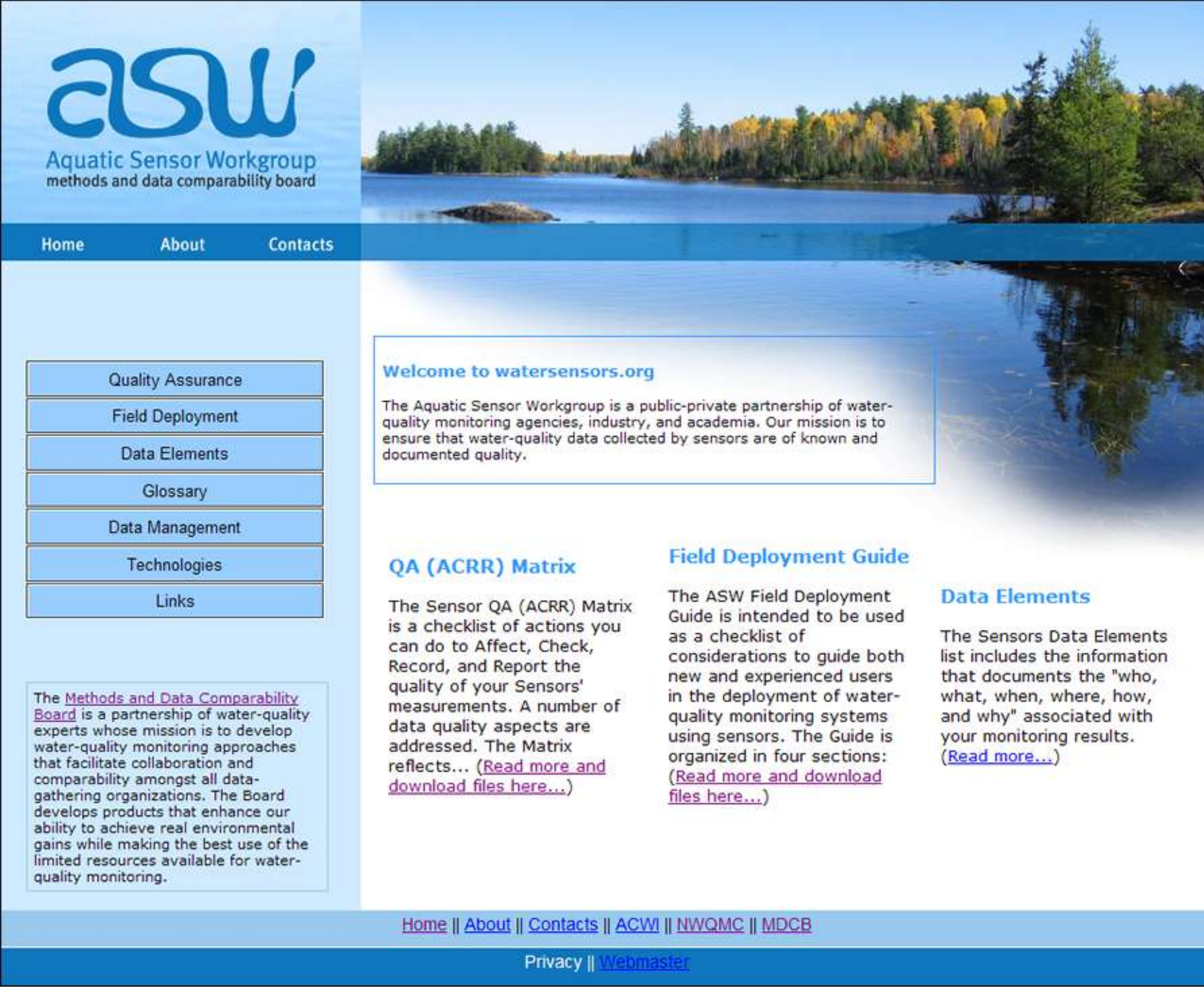
ASW milestones and members

- Formed after 2008 NMC in response to overwhelming interest in aquatic sensors
- Members from all sectors including manufacturers
- “Sensors QA Initiative” products were introduced at the Nat’l. Monitoring Conference in Denver in April, 2010

Sensors QA Initiative Products

- Website
- Deployment Guide
- QA (ACRR) Matrix
- Data Elements
- Glossary

Generate data of known and Documented quality



http://watersensors.org

Field Deployment Guide

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Field Deployment Guide

Checklist for Sensor Selection, Deployment, and Maintenance: **Rivers & Streams**

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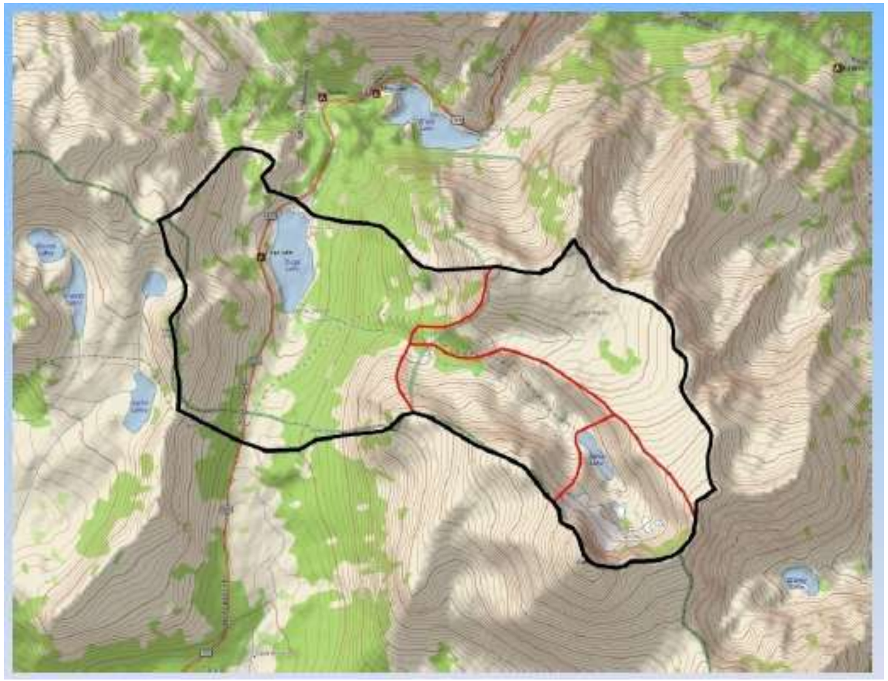
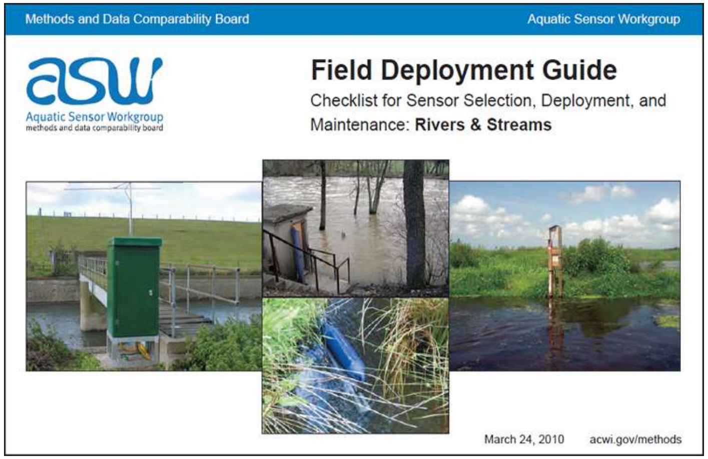
Assumptions/Overview of the Guide

- Your site has been selected (e.g., "Black Earth Creek at Cross Plains, WI")
- The guide will help ensure that measurements you take at that "point" are representative of conditions in that stream while measuring the inherent variability



Field Deployment Guide

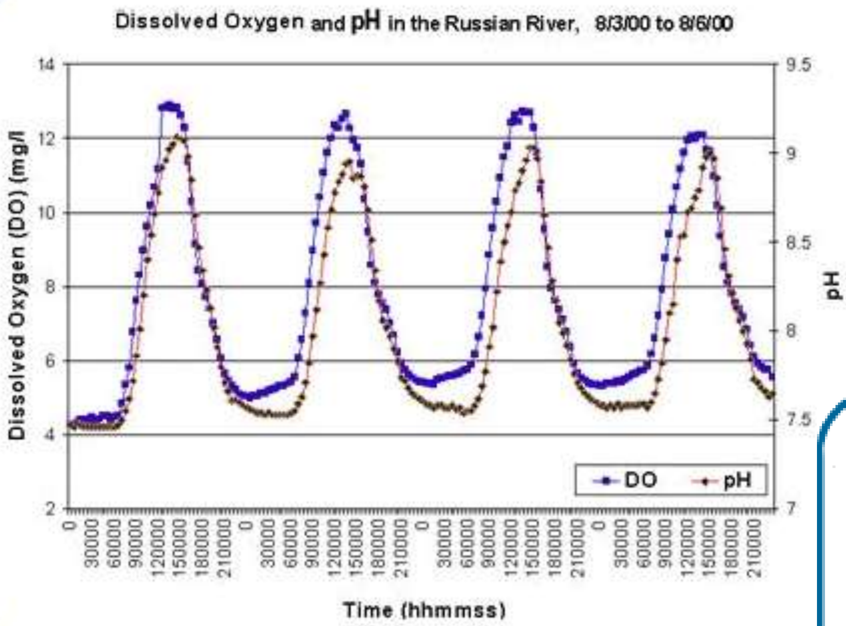
- Data quality considerations
  - Representative of conditions
  - Capture natural variability
  - Ensure data of known quality – useful for decision-making, sharing
- Informative tool
  - New users
  - Experienced users
- Aid to system and site selection
  - Checklist to evaluate site conditions



Representativeness

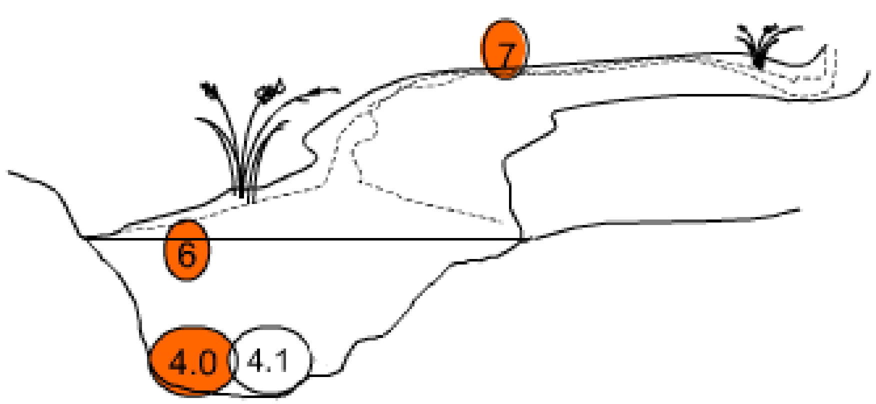
- A measurement is taken at one point in a stream: one point in time & space
- What does that measurement represent?
- Water quality varies in time & space
- Where you put the sensor is very important!

Variability



Source: SWAMP Field Modules (2005)

Dissolved Oxygen during very low flow



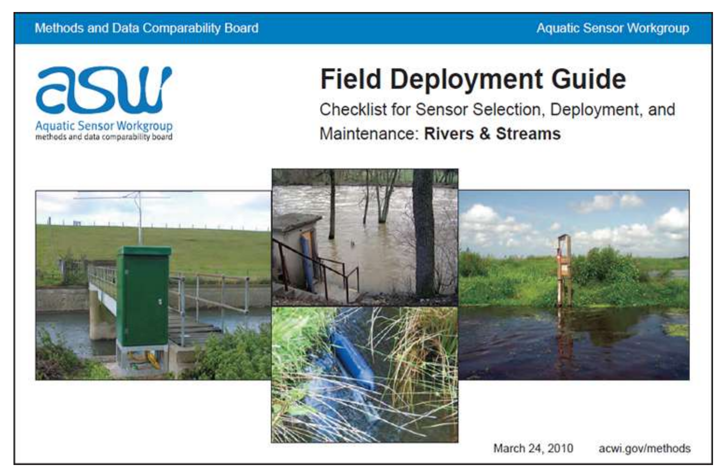
Deployment Guide Outline

1) System Selection
- Attended Monitoring
- Unattended Monitoring
- Flow-through systems

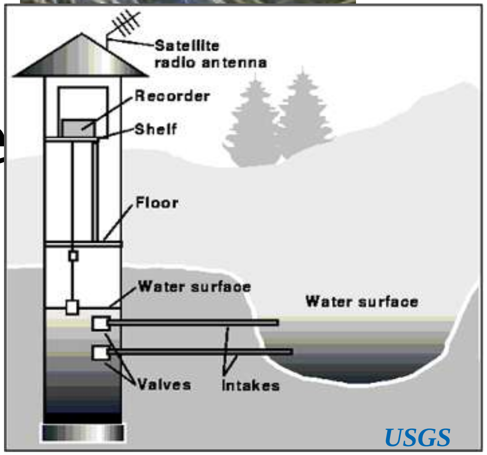
2) Site Selection
- Location within the channel
- Flow and Stage

3) Installation and Maintenance
- Access and safety
- Equipment location
- Infrastructure
- Extreme conditions
- Service intervals

4) Documentation
- Installation
- On-going site visits



1. System Selection



Attended monitoring
- Infrequent discrete samples
- Multiple points in the cross section

Unattended monitoring
- Continuous data from a fixed point
- Low power requirements - internal-logging syst

Flow-through monitoring syste
- High power requirements
- Typically tied to telemetry

2. Site Selection

- Location within channel/reach

Photo: Jerrod Wheeler, USGS

Faith Fitzpatrick, USGS

2. Site Selection

- Flow and stage

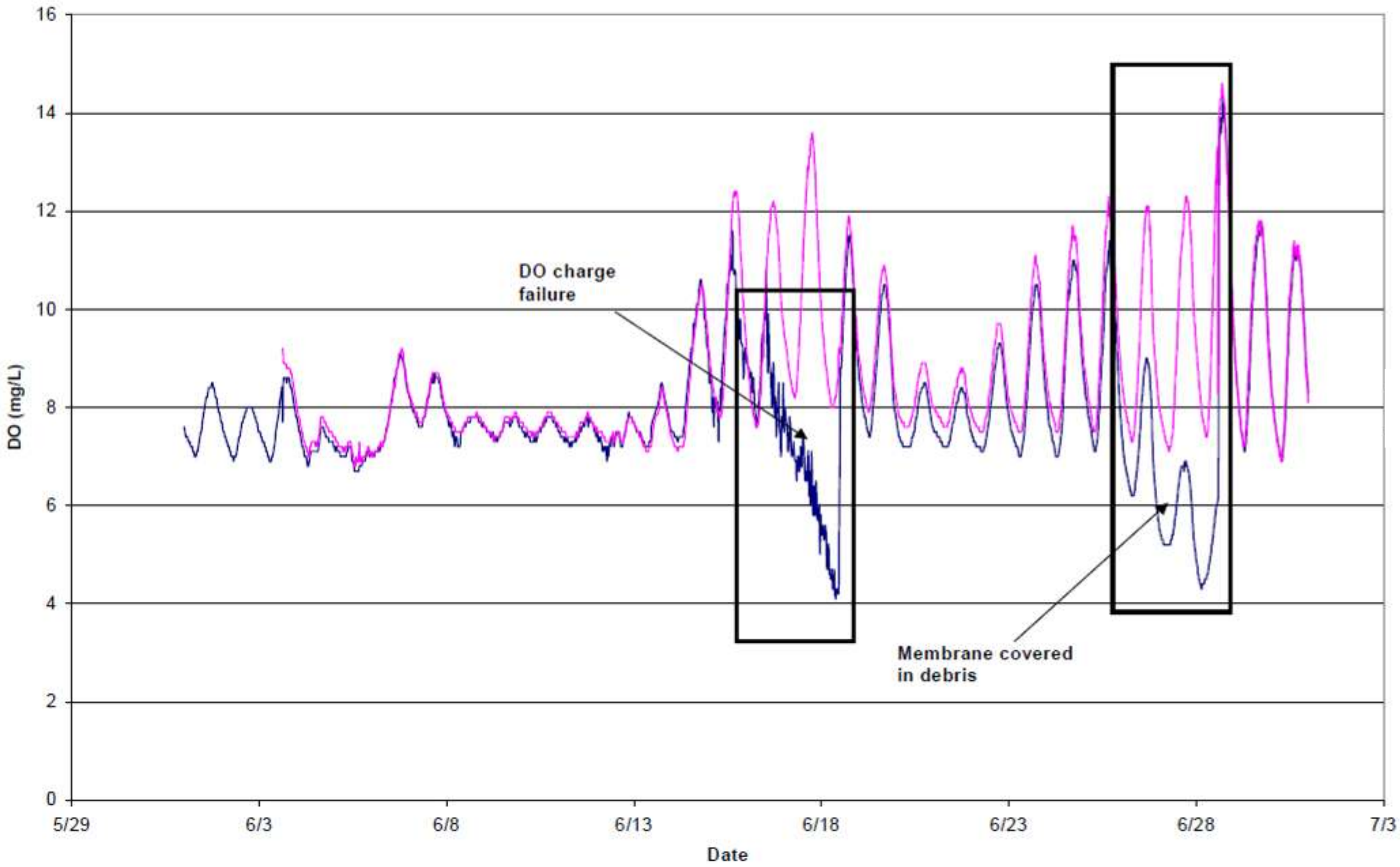
3. Installations

Laura Flight, USGS

Shelters, sondes, intakes

Flood & debris damage

3. Installations
Service Intervals



Rasmussen, USGS

4. Documentation

- Written documentation
  - USGS National Field Manual Chapter 6 (online)
  - Record every field visit
  - Log books/electronic files for every instrument
- Photo documentation
  - A picture says a thousand words
  - Pictures provide perspective

QA (ACRR) Matrix

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Quality Assurance (ACRR) Matrix

QA Checklist for Calibration, Quality Checks, and Record Keeping to Ensure that Data Are of Known and Documented Quality

April 19, 2010 acwi.gov/methods

What's in the Matrix?

- The basic sensors that are in wide use for monitoring (NPS "Vital Signs"):

- Temp.
- SC
- D.O.
- pH
- Turbidity
- Depth
- ORP (Oxidation Reduction Potential)

QA (ACRR) Matrix

- List of actions you can do to:
  - **Affect** (act to influence the outcome)
  - **Check** (test to evaluate or verify)
  - **Record** (documentation)
  - **Report** (communicate the data quality indicator)
- Used in conjunction with users manual, result will be <u>data of known and documented quality</u>

Aspects of Data Quality

- Accuracy/Bias
- Precision
- Lack of interference or contamination

QA Matrix – Accuracy/Bias example

3. Specific Conductance Sensors: Conductivity Cell

Data Quality Aspect	Mode (See Notes)	Quality Assurance Actions		Documentation Actions	
		Affect (Control, act to influence the outcome)	**Check** (Test to evaluate or verify)	**Record** (Keep everything documented)	**Report** (Communicate the data quality indicator)
Accuracy/ Bias		Conduct one-point calibration in the lab, at a value in the middle of anticipated environmental range, at room temperature [Tips SP1-SP3], before each trip. Conduct two point calibration in the field, at values that bracket expected range, at stream temperature, before first use of the day. Make sure the probe is properly hydrated before calibration and before each use; assure sufficient voltage.	Conduct a one-point accuracy check in the lab, at a mid-range value, at room temperature [Tip SP2], within 24 hours of trip's end.	Temperature of standard, instrument conductivity reading, temperature compensation factor (if needed), and "true" value of standard	Report bias: Instrument drift, i.e., difference from known ("true") value of Standard, expressed either in measurement units or as percent of Standard's "true" value, whichever is higher.
		Conduct two-point calibration in the lab, at zero and at value higher than expected range, at room temperature, before deployment and at every maintenance event (if needed)	Conduct three-point accuracy check, with Standards at min/mid/max values of expected range, plus a zero check in air, at room or field temperature, within 24 hrs of retrieval and at every maintenance event, before and after cleaning.	Temperature of standard, instrument conductivity reading, temperature compensation factor (if needed), and "true" value of standard.	Report bias: Instrument drift, i.e., difference from known ("true") value of Standard, expressed either in measurement units or as percent of Standard's "true" value, whichever is higher.

Specific Conductance Sensors: Tips & Comments

[Tip SP1] It may be beneficial to conduct calibrations and accuracy checks at 25 C, even if the sensor has automatic temperature compensation.
[Tip SP2] Always rinse sensors twice with standard prior to performing checks and calibrations.
[Tip SP3] Calibrating linear conductivity sensors is best done with a strong conductivity signal (i.e., 1,000 uS/cm or higher); above this value choose a standard that is close to your expected values.
[Tip SP4] Precision can be reported as (1) standard deviation (SD), or as (2) relative percent difference (RPD), or as (3) relative standard deviation (RSD) a.k.a. coefficient of variations (%CV), depending on the number of repeated measurements and the requirements of the data management system or the Program.

Summary

- Guides are designed as checklists
- Important to know site details/specific sensor requirements
- Maintenance intervals – data quality
- Document everything

The Future of Sensors?

- “Water Quality – Anytime, Anywhere” (B. Hirsch)
- Capabilities, reliability, and deployment of sensors will continue to increase
- Several networks in planning stages
  - Mississippi River Basin sediment pilot
  - Great Lakes Restoration Initiative
  - NAWQA
- Areas of need:
  - Data management
  - Specifications
  - Data analysis

ASW Initiatives FY11-

- NEMI-ACT web portal
- Data Management
- Specifications
- Data Quality Objectives

NEMI-ACT web portal

- Access traditional analytical and sampling methods from NEMI along with sensors information from ACT
- Over 4,000 sensors in ACT database
- Side-by-side comparisons
- Format for standardizing performance criteria for sensors
  - w/in single manufacturers, reported performance for a given analyte can be different for different models

DJSULLIV Logout

Reset Search

Analyte All

Method All

ACT data linked with NEMI methods

Name	Analyte Name	Method No
AMT Deep Water pH Sensor	pH	150.1
AMT Deep Water pH Sensor	pH	8156
AMT ORP-Combined Shallow Water Sensor	Electromotive force	NFM 6.5
AMT Shallow Water DO Micro-sensor	Dissolved Oxygen	360.1
AMT Shallow Water DO Micro-sensor	Dissolved Oxygen	D888 B
AMT Shallow Water pH Sensor	pH	150.1
AMT Shallow Water pH Sensor	pH	8156
Aanderaa Data Instruments Oxygen Optodes 3835/4130/4175	Dissolved Oxygen	360.1
Aanderaa Data Instruments Temperature Sensor 4060	Temperature	170.1
Aanderaa Data Instruments Turbidity/Temperature Sensor 3712	Turbidity	180.1
Aanderaa Data Instruments Water Level /Temperature Sensor	Water level	D5413B
Aanderaa Data Instruments pH Sensor	pH	150.1
Aanderaa Data Instruments pH Sensor	pH	8156
Aquamatic Oxygen Sensor	Dissolved Oxygen	360.1
Aquamatic pH Sensor	pH	150.1

row(s) 1 - 15 of 176 Next

NEMI Methods

NEMI Method	Name
100.1	Asbestos in Water by TEM
100.2	Asbestos in Water by TEM
10029	E. coli by m-ColiBlue24 Broth Procedure for Membrane Filtration
110.1	Color by Spectrophotometry
110.2	Color by Spectrophotometry
110.3	Color by Spectrophotometry
1103.1 (modified)	Membrane filtration plating of E. coli on modified mTEC agar
1106.1	Enterococci in water by MF using mE-EI Agar
120.1	Conductance by Conductivity Meter
130.00	Capillary gas chromatography analysis for organic contaminates in marine sediments.
130.01	Organic contaminates in marine animal tissues by GC-FPD
130.1	Total Hardness by Spectrophotometer
130.10	Organic contaminants in marine sediments by GC-ECD
130.11	Organic contaminants in marine animal tissues by GC-ECD
130.2	Total Hardness of Water by Titrimetry

row(s) 1 - 15 of more than 500 Next

Sensors Table - no join to NEMI methods or analytes

Name	Keywords	Analyte Name
AMT CTD/O2 Fast Profiling Probe	CTD, DO	Dissolved Oxygen
AMT Dissolved Oxygen Sensor for Deep Sea	DO	Dissolved Oxygen
AMT Dissolved Oxygen Sensor for Deep Sea	DO	Dissolved Oxygen
AMT Shallow Water DO Micro-sensor	DO, dissolvedoxygen	Dissolved Oxygen
Aanderaa Data Instruments Oxygen Optode 3830/3930/3975	DO, dissolved oxygen	Dissolved Oxygen
Aanderaa Data Instruments Oxygen Optode 4330/4330F	DO	Dissolved Oxygen
Aanderaa Data Instruments Oxygen Optodes 3835/4130/4175	DO, dissolved oxygen	Dissolved Oxygen
Aquamatic Oxygen Sensor	DO	Dissolved Oxygen
Campbell Scientific CS511-L Dissolved Oxygen Probe	DO, dissolvedoxygen	Dissolved Oxygen
Centre for Microcomputer Applications Dissolved Oxygen Sensor	DO	Dissolved Oxygen
Coastal-USA MacroQual	DO	Dissolved Oxygen
Common Sensing Model TBO-F	dissolvedgases, DO	Dissolved Oxygen
Common Sensing Wireless Probe WDGL-3	dissolvedgases, DO	Dissolved Oxygen

Data Management

- The water quality monitoring community needs better data management procedures to deal with the large amount of data generated by remotely-deployed sensors.
- Sensors provide unique challenges in almost every phase of data management, from what data should be collected and stored (the content of the data) to data transfer.

Data Management

- SOP for basic data verification, validation, and error calculation to connect the outcome of quality checks with the data, plus a standardized set of data qualifiers
- List of data elements/data fields that need to be recorded (*DRAFT long list is complete)
- Recommendations for a streamlined process of sensors' data correction, i.e., alteration to correct for drift and fouling, using consistent procedures/algorithms and consistent categories for the extent of corrections

Specifications

- Technology performance standards and test criteria designed specifically for field sensors and natural environmental conditions are required to allow inter-comparison of sensor specifications and the data generated by field sensors
- Need for EPA-accepted criteria for sensors for ambient monitoring

Specifications

- ASTM D-19 workgroup – standard reference samples
  - ASW will provide input and comments
  - First meeting Jan. 19
- Working with EPA's Forum on Environmental Measurements to move forward on ambient monitoring standards for sensors

Questions and Comments

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Acknowledgements

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