

# Wireless Sensor Networks

## Exploring New Technology in Surface Water Monitoring

Surface Water Monitoring and Standards Meeting  
Feb. 10, 2009

### In the Beginning, Data Transducers had Limited Applications

- ◆ Used in small centralized applications
- ◆ Measured physical data (e.g. temp, moisture, tilt angle, acceleration, magnetic field, sound, light)
- ◆ Wires connected each sensor to power and data supply
- ◆ Cost of computing equipment
- ◆ Required technical know-how

## Past/Current Examples of Ground Based Sensors and Sampling Networks

- ◆ Air quality sensors
- ◆ Water flow gauges
- ◆ Well monitoring
- ◆ Weather conditions

## Typical Water Quality Sampling Trip

### Project Staff

- Work plan preparation
- Prepare field crew
- Gather field equipment
- Maintenance check before deployment



### Field Crew

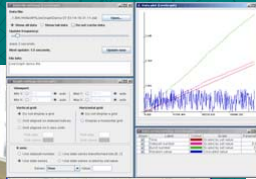
- Transportation to site or sites
- Field data collection/management (temperature, EC, turbidity, etc.)
- Sample collection
- Sample handling (CoC, prep & shipment)
- Data entry



## Typical Water Quality Sampling Trip

### Analytical Laboratory Staff

- Laboratory preparation
- Analysis
- Produce data
- QA/QC check of data
- Data reduction



### Project Staff

- Data interpretation
- Report generation
- Deliver data to customer



SP16-0207	0.00	AM	22.6176244	C
SP16-0207	0.04	AM	22.6481929	C
SP16-0207	0.08	AM	22.6841929	C
SP16-0207	0.12	AM	22.6841929	C
SP16-0207	0.16	AM	22.6841929	C
SP16-0207	0.20	AM	22.6841929	C
SP16-0207	0.24	AM	22.6841929	C
SP16-0207	0.28	AM	22.6841929	C
SP16-0207	0.32	AM	22.6841929	C
SP16-0207	0.36	AM	22.6841929	C
SP16-0207	0.40	AM	22.6841929	C
SP16-0207	0.44	AM	22.6841929	C
SP16-0207	0.48	AM	22.6841929	C
SP16-0207	0.52	AM	22.6841929	C
SP16-0207	0.56	AM	22.6841929	C
SP16-0207	0.60	AM	22.6841929	C
SP16-0207	0.64	AM	22.6841929	C
SP16-0207	0.68	AM	22.6841929	C
SP16-0207	0.72	AM	22.6841929	C
SP16-0207	0.76	AM	22.6841929	C
SP16-0207	0.80	AM	22.6841929	C
SP16-0207	0.84	AM	22.6841929	C
SP16-0207	0.88	AM	22.6841929	C
SP16-0207	0.92	AM	22.6841929	C
SP16-0207	0.96	AM	22.6841929	C
SP16-0207	1.00	AM	22.6841929	C

## Costs Incurred in Traditional Sampling

- ◆ Manual collection of samples, time intensive – largest single expense
- ◆ Travel
- ◆ Field equipment and materials
- ◆ Shipping & storing samples
- ◆ Sample analysis, lab waste & data reporting
- ◆ Timeliness
  - “Early warning” isn’t in our vocabulary

## Agency Grant Budgets Surface Water Monitoring

- ◆ Example A (\$300,000)
  - Personnel/Fringe 21%
  - Travel 11%
  - Supplies 1%
  - Contractual 62%
  - Indirect 5%
  
- ◆ Example B (\$170,000)
  - Personnel/Fringe 79%
  - Travel 1%
  - Supplies 7%
  - Indirect 13%

## Positive Benefits of Applying Wireless Technology

- ◆ Cost Savings
  - Reduces labor expenses
  - Reduces travel expenses
  - Reduces field equipment needs
  - Reduces lab analysis cost & lab wastes
  - Reduces energy consumption from less transportation, lodging, shipping, and storing of samples
- ◆ Timeliness
  - “Early warning” would be in our vocabulary

## Sensor Networks Provide Measurable Environmental Management Improvement

- ◆ Sensor networks deployed over wide areas could improve State/Federal/Tribal responsiveness to environmental issues
- ◆ Sensor networks could provide improvement in performance measurement, program management, & environmental monitoring
- ◆ Sensor networks could collect actual "beans" used in bean counting

## If Sensor Networks Could Provide Surface Water Monitoring in "Real" Time?

- ◆ Where would we go?
- ◆ What would we do?
- ◆ What would we look at? ✓

## Examples of Surface Water Measurements

- ◆ Temperature, pH, dissolved oxygen (DO), & turbidity
- ◆ Total phosphorus, total nitrogen, NH<sub>4</sub>, NO<sub>3</sub>, basic anions and cations, & alkalinity
- ◆ Total suspended solids, & conductivity

## Examples of Surface Water Measurements

- ◆ Dissolved organic carbon & total organic carbon
- ◆ Sediment Enzymes
- ◆ Chlorophyll-a
- ◆ Fecal Indicator (Enterococci)
- ◆ Metals
- ◆ And more. . . . .

## How Do We Attract Industry's Attention?

- ◆ Need application ideas to drive industry & technology
- ◆ EPA's role in the Forum on Environmental Measurement (FEM)

## Forum on Environmental Measurement (FEM)

- ◆ FEM is a committee of senior EPA managers which develop & guide the EPA measurement community in validating & exploring new methods for environmental monitoring.
- ◆ FEM is looking for opportunities to develop new applications and technologies, including providing resources to support implementation.
- ◆ FEM has a resource connection with the Small Business Administration for technological development.

## Forum on Environmental Measurement (FEM)

- ◆ Technically oriented
- ◆ Cross Agency perspective
  - Multi media
  - Regulatory and field implementation
  - Practiced at working together
- ◆ Responsive to customers
  - Addressed outside concerns

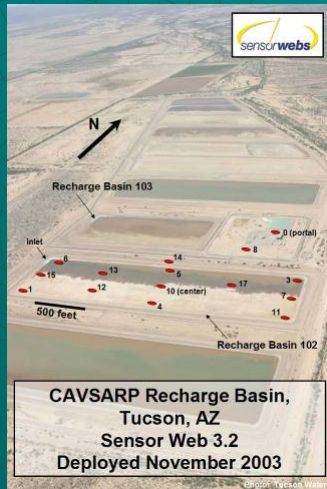
## Successful Sensor Network Deployment

### Necessary Ingredients:

- Computation
  - ◆ On-board each sensor node
  - ◆ At data use location
- Communication
  - ◆ Between and among sensors
- Sensing
  - ◆ Chemical, biological, radiological
  - ◆ Physical characteristics (pH, temperature, etc.)



## Existing Sensor Network Applications



## Challenges to Sensor Network Development

- ◆ Sensors
  - Chemical specific, accuracy, sensitivity
  - Rugged, waterproof ✓
  - Low power consumption ✓
  - Low maintenance ✓
  - Long enough life cycle to make practical ✓
  - Cost
  - Exposure to environment, bio-fouling
  - Data quality
  - Security

## Potential Water Applications of Distributed Wireless Networks

- ◆ Early warning system for septic systems – preserve groundwater quality
- ◆ Monitoring beach water quality – real time data to protect swimmers from pathogens/chemicals
- ◆ Nutrient trading credits for point and non-point source trading - measuring Ag runoff & pollution reduction credits
- ◆ Combined sewer overflow management – monitor storm water flow, divert overflows to holding areas

## Overview

- ◆ Sensor networks have the potential to provide enhanced environmental stewardship.
  - Resource management
  - Protecting human health & the environment
- ◆ There is no “silver bullet” sensor or set of sensors out there now.
- ◆ A corporate investment is needed to push the state of the art.
- ◆ Sensor networks merit additional deliberation by the FEM.
  - **Recruit potential surface water applications**

## Potential Surface Water Application Brainstorming, Suggestions, & Ideas

- Audience Participation -

- ◆ What surface water applications could benefit from real-time, continuous monitoring?
- ◆ Which routine sampling events could be replaced by wireless sensors?
- ◆ What are your specific needs for real-time surface water monitoring ?
- ◆ Have you already explored or used this technology? What was your experience?

## Contact Information:

Andrew Tschampa  
Water Quality Deputy Branch Chief  
Water Division  
U.S. EPA Region 5  
77 W. Jackson Blvd  
Chicago, IL 60604  
(312) 886-6136  
[tschampa.andrew@epa.gov](mailto:tschampa.andrew@epa.gov)

## Web References

- ◆ [http://www.xbow.com/Industry\\_solutions/CustomerReference.aspx](http://www.xbow.com/Industry_solutions/CustomerReference.aspx)
- ◆ <http://www.ci.tucson.az.us/water/cavsarp.htm>
- ◆ [www.mdpi.com/1424-8220/5/1/103/pdf](http://www.mdpi.com/1424-8220/5/1/103/pdf)

## Key Articles

1. J. K. Hart and K. Martinez, 2006, Environmental Sensor Networks: Revolution in the earth system science?, Earth-Science Reviews 78 (2006) 177-191
2. J. Goldman et al., 2007, White Paper: Distributed Sensing Systems for Water Quality Assessment and Management, Woodrow Wilson International Center for Scholars, [http://www.wilsoncenter.org/topics/docs/Sensor\\_whitepaper\\_lr.pdf](http://www.wilsoncenter.org/topics/docs/Sensor_whitepaper_lr.pdf)
3. M. McInnis and M. Brody, 2007, New Sensor Network Technologies: Improving Performance Measurement at EPA, USEPA Internal Report
4. C. Chong and S. Kumar, 2003, Sensor Networks: Evolution, Opportunities, and Challenges, Proceedings Of the IEEE, Vol. 91, No. 8.
5. K. Delin, 2006, The Sensor Web: Distributed Sensing for Collective Action, Sensors Online <http://www.sensorsmag.com/sensors/>