WATERS Network:
An MREFC initiative in NSF’s Engineering and Geosciences Directorates

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The Principal Actors
Why WATERS Network?

Critical importance of water to society and ecosystems, and increasing demands for water.

Growing recognition that old-style, piecemeal, small-scale research efforts simply are not adequate.

Four critical deficiencies in current abilities:

1. Basic data about water-related processes at needed spatial and temporal resolution.

2. The means to integrate data from different media and sources (observations, experiments, simulations).

3. Sufficiently accurate modeling and decision-support tools to predict underlying processes and forecast effects of different engineering management strategies.

4. The understanding of fundamental processes needed to transfer knowledge and predictions across spatial and temporal scales—from the scale of measurements to the scale of a desired management action.
WATer and Environmental Research Systems Network: WATERS Network

Vision: WATERS Network will transform our understanding of the Earth’s water and related biogeochemical cycles across multiple spatial and temporal scales to enable forecasting and management of critical water processes affected by human activities.
The Idea:

The WATERS Network will:

1. Consist of:
   (a) a national network of *interacting field sites*, across a range of spatial scales, climate and land-use/cover conditions
   (b) teams of *investigators* studying human-stressed landscapes, with an emphasis on water problems;
   (c) *specialized support* personnel, facilities, and technology; and
   (d) *integrative cyberinfrastructure* to provide a shared-use network as the framework for collaborative analysis

2. Transform environmental engineering and hydrologic science research and education

3. Enable more effective management of water resources in human-dominated environments based on *observation, experimentation, modeling, engineering analysis, and design*
WATERS Network Grand Challenge

**Grand Challenge:** To develop a knowledge base that ensures adequate clean water for future generations and which overcomes degradation of the nation’s water resources from burgeoning population growth and development

**Drivers:** 1) Increases in popn. and shifts in land use; 2) changes in energy, materials and water use; 3) changes in climate

*Transforming our science →*

River gauging station of the future. WATERS is the proposal for the water research network of future.
High-Level Science Questions

1. What biogeochemical pathways are most important for water, sediment, and contaminant transport at all scales?

2. How do we scale knowledge of water processes from point to plot to basin scale?

3. Which policy designs provide appropriate incentives for reducing water resource impacts?

4. Which treatment and management practices will reduce water resource impacts?

5. How can human uses of water be made sustainable in light of population, development and climate trends?
Science of WATERS Network

- **Nonlinearities** – knowledge base to discern mechanisms and basic kinetics of nonlinear water processes
- **Scalability** – the knowledge to scale-up from point to basin to the entire country
- **Prediction and Forecasting** – the capacity to predict events and provide warnings (or operational control) of water quantity and quality
- **Discovery Science** – unknown and unreported processes from high resolution data
Network Design Principles:

Enable multi-scale, dynamic predictive modeling for water, sediment, and water quality (flux, flow paths, rates), including:
- Near-real-time assimilation of data
- High frequency measurements
- Point- to national-scale prediction

Observatory provides data sets/framework to test:
- Sufficient data to test science hypotheses
- Alternative model conceptualizations across entire range of attributes (popn., hydrology)

Master Design Variables:
- Scale
- Climate
- Hydrologic setting
- Land form and geology
- Land use & population

Nested Observatories over Range of Scales:
- Point to Plot (100 m²)
- Subcatchment (2 km²)
- Catchment (10 km²) – single land use
- Watershed (100–10,000 km²) – mixed use
- Basin (10,000–100,000 km²)
- Continental scale-up by HIS, models & remote sensing (MODIS, Landsat, flyovers)
Simplified schema of a potential national **WATERS Network** based on three hydrologic regions: (I) coastal, (II) humid-continental, and (III) arid-continental; large blue circles: regional, watershed-based observatories; smaller circles: nested watershed and intensively instrumented field sites. **NOTE:** All locations shown are hypothetical examples.
Including human impacts on the “water cycle”…

Humid Continental Watershed: Hypothetical WATERS Observatory
Arid Continental Watershed: Hypothetical WATERS Observatory

Water supply, wastewater discharge, Aquifer Storage/Recovery
WATERS Network Concept

Observatories/Experimental & Field Facilities

Sensors & Measurement Facility

Informatics/Cyberinfrastructure

Synthesis/Modeling

User Community

Q(x) = \int_{CA} r(x)dx
WATERS Network cyberinfrastructure

OBSERVATORY

Clear Creek Watershed

sensor

data node

sensor

sensor

sensor

sensor

sensor

sensor

access node

satellite

modem

phone

access node

Digital Watershed

- Relational database
- Eco-hydrological simulators
- Quality control, calibration, validation
- Observation-model fusion
- Process analysis and visualization
- Dissemination

application server

database server

Internet

- Open access for:
  - Investigators
  - University partners
  - Management agencies
  - K12, K16, K20
  - Watershed communities
  - Museums

USERS
Environmental CI Architecture: Research Services

Integrated CI

ECID Project Focus: Cyberenvironments
Supporting Technology

Knowledge Services
Data Services
Workflows & Model Services
Meta-Workflows
Collaboration Services
Digital Library

HIS Project Focus

Create Hypothesis
Obtain Data
Analyze Data &/or Assimilate into Model(s)
Link &/or Run Analyses &/or Model(s)
Discuss Results
Publish

Research Process
Environmental Engineering and Hydrologic Sciences jointly are funding 11 two-year “test-bed” projects to gain field experience with EO development and operation (FY2006-2008); total investment: ~$3.3M.

- San Joaquin Valley and Sierra Nevada
- Susquehanna River Basin
- Santa Fe Basin
- Minnehaha Creek
- Clear Creek
- Corpus Christi Bay
- Flathead River
- FerryMon – Pamlico Sound
- Susquehanna River Basin
- Little Bear River
- Baltimore