Federal Water R&D: Current Landscape, Future Goals and Emerging Technologies

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Energy-Water Nexus
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Water was a major factor in the early development of the U.S. 

...and is still a major factor in U.S. health and growth.
Water Supplies Are Vulnerable

Population Growth is 20% to 50% in Most Water-Stressed Areas

Water Resources and Population Growth, 2000-2020

US population will increase significantly (double over 100 years)

Less Water

More Water

Source: DOE/NETL (M. Chan, July 2002)
U.S. WATER CHALLENGES ARE GROWING:

We do not have an adequate picture of water availability at national, regional, and local levels. “National water availability and use has not been comprehensively assessed in 25 years” – U.S. General Accounting Office report, July 2003.

“Water, which used to be considered a ubiquitous resource, is now scarce in some parts of the country, and not just in the West as one might assume. The water wars have spread to the Midwest, East and South as well. ” Water “…conflicts are occurring within states, among states, between states and the federal government and among environmentalists and state and federal agencies.” Tribal governments “…are pursuing several legal battles to reclaim their water rights.” – Council of State Governments report “Water Wars”, 2003.

We have a general idea of how much water is used for public water supply, industry, commerce, irrigated agriculture, livestock, and domestic purposes. Yet, “The accuracy and confidence limits of these water use estimates are not quantified.” – National Research Council report, 2002.

“The policies we adopt for the development of our water resources will have a profound effect in the years to come upon our domestic, agricultural, and industrial economy” – President Dwight D. Eisenhower.
Executive Office of the President

National Science & Technology Council:

- Subcommittee on Water Availability and Quality (SWAQ)
- 20+ Federal agencies
- USGS-EPA Co-chairs
- S&T Coordination
- Not operational

November 2004
The ability to measure, monitor and forecast U.S. and global supplies of fresh water is important because agencies are developing a coordinated, multi-year plan through the NSTC to improve research to understand the processes that control water availability and quality, and to collect and make available the data needed to ensure an adequate water supply for the future. Significant progress on this plan, including stakeholder input, is expected during the next two years.
MAJOR U.S. WATER CHALLENGES:

Know our Water Resources and Uses
1. Assess U.S. Water Resources
2. Assess How Water Resources are Changing
3. Assess U.S. Water Use
4. Assess U.S. Engineered Water Infrastructure
5. Assess Ecosystems Services

Science and Technology to Expand our Water Supply
1. Improve Use of Existing Water Resources and Infrastructure
2. Increase Supply through Treatment and Expanded Use of Lower Quality Water
3. Develop New Approaches to Water Storage

Develop Improved Models and Management Tools
1. Predict Outcomes of Water Management Decision
2. Predict Outcomes of Planning and Policy Decisions
3. Predict Water Needs and Services of Ecosystems
Challenge: Water quantity:

How much water do we have?
How much do we need?
How do we use it?
Will we run out?
Estimated U.S. Freshwater Flow* in 1995: ~341,000 Mgal/day

Source: Lawrence Livermore National Laboratory using data from ESTIMATED USE OF WATER IN THE UNITED STATES IN 1995, USGS (1998)
Figure 14. Trends in total water withdrawals by water-use category, 1950–2000. (Total withdrawals for rural domestic and livestock and for “other industrial use” are not available for 2000.)

Why did U.S. water withdrawals level off?

**Agriculture:** The average irrigation application rate declined about 30 percent, from 3.55 acre-feet per acre during 1950 to 2.48 acre-feet per acre during 2000. The largest declines in application rates occurred after 1980.

**Electrical generation:** Since the 1970s, power plants increasingly were built with or converted to closed-loop cooling systems or air-cooled systems instead of using once-through cooling systems. The average gallons of water used to produce one kilowatt-hour (gal/kWh) decreased from 63 gal/kWh during 1950 to 21 gal/kWh during 2000.

**Industrial use:** Passage of the Amendments to the Federal Pollution Control Act of 1972 and 1977 required stricter water-quality standards for water discharges, which in turn, encouraged conservation, greater efficiency, and lower water-using technologies. Decline in the number of manufacturing facilities during more recent years also has reduced industrial withdrawals.
Challenge: Water quality:

What is the quality of the U.S. fresh water supply?
## Water Quality Conditions in the United States
### A Profile from the 2000 National Water Quality Inventory

<table>
<thead>
<tr>
<th>Waterbody Type</th>
<th>Total Size</th>
<th>Amount Assessed* (% of Total)</th>
<th>Good (% of Assessed)</th>
<th>Good but Threatened (% of Assessed)</th>
<th>Polluted (% of Assessed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rivers (miles)</td>
<td>3,692,830</td>
<td>699,946 (19%)</td>
<td>367,129 (53%)</td>
<td>59,504 (8%)</td>
<td>269,258 (39%)</td>
</tr>
<tr>
<td>Lakes (acres)</td>
<td>40,603,893</td>
<td>17,339,080 (43%)</td>
<td>8,026,988 (47%)</td>
<td>1,348,903 (8%)</td>
<td>7,702,370 (45%)</td>
</tr>
<tr>
<td>Estuaries (sq. miles)</td>
<td>87,369</td>
<td>31,072 (36%)</td>
<td>13,850 (45%)</td>
<td>1,023 (&lt;4%)</td>
<td>15,676 (51%)</td>
</tr>
</tbody>
</table>

* Amount Assessed includes all waterbodies assessed during the 2000 Inventory, regardless of whether they met the criteria for being listed in the Inventory.
### Table 3. Top Sources of Impairment in Assessed Rivers and Streams

<table>
<thead>
<tr>
<th>Source</th>
<th>Percent of Impaired Stream Miles Affected</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td></td>
<td>113,663</td>
</tr>
<tr>
<td>Source Unspecified</td>
<td></td>
<td>91,824</td>
</tr>
<tr>
<td>Hydromodification</td>
<td></td>
<td>79,400</td>
</tr>
<tr>
<td>Habitat Alterations</td>
<td></td>
<td>51,298</td>
</tr>
<tr>
<td>Natural</td>
<td></td>
<td>41,764</td>
</tr>
</tbody>
</table>

Percent of Impaired Stream Miles Affected

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Challenge:

How can we affordably monitor water quantity (surface and ground water), water quality, and how they vary geographically and temporally?
Develop new monitoring technologies:

- reduce cost
- improve real-time data recovery
- different tools for different scales
- new tools needed for both ground water and surface water

GRACE data measured the weight of up to 10 centimeters (4 inches) of ground-water accumulations from heavy tropical rains, particularly in the Amazon basin and Southeast Asia.
Challenge:

How do ecosystem needs factor into the supply-demand equation?
The Demand for Ecosystem Services is a Major Driver of the Changes in Water Allocations

Old paradigm:
• How much water can we reliably remove from the river?

New paradigm:
• How much water do we need to leave in the river?

What are the positive effects of healthy ecosystems on water availability and quality?
Challenge:
What effect does climate variability and change have on water supply?
Decreasing daily streamflow in May: Narraguagus River, Maine

All trends highly significant (p < 0.01)
Increasing daily streamflow in February: Narraguagus River, Maine

All trends highly significant (p < 0.01)
Annual Mean Flow
Narraguagus River, Maine

No Trend.
Trends in Center of Mass of Runoff

Source: USGS
Challenge: Can we expand water supply through innovative management and technologies?

- water reuse
- aquifer storage and recovery
- phreatophyte control
- desalination

Cost of Desalinated and Fresh Water Supplies, 1970 to 2010

![Graph showing cost per 1,000 gallons of water from 1970 to 2010 for seawater, brackish water, and fresh water (Southern California).]
Challenge:

How can we improve accurate forecasts of water availability and use?
Water models must be developed and improved:

- Existing hydrologic models must be strengthened, integrated, and transformed into tools that can be used by water managers for making decisions on a watershed, or sub-watershed scale.

- Hydrologic models should, to the extent possible, be linked to climate models that model the water cycle over broad geographic areas and long time periods.

- Hydrologic models must be coupled with institutional models to provide a full suite of physical, economic, and technological decision tools for water managers.

- Advanced hydrologic models must be transitioned to operational services through the establishment of a “community hydrologic prediction system.”
Examples of Federal Water R&D

Energy-Water Nexus

Energy-Water Nexus Team: 11 national laboratories and EPRI, working together to develop support for a national energy/water security program.

Estimated Freshwater Withdrawals by Sector, 2000

- PUBLIC SUPPLY: 14%
- THERMOELECTRIC: 39%
- IRRIGATION: 39%
- Industrial: 6%
- Livestock: 2%

Source: USGS Climater 1268, March, 2004
Examples of Federal Water R&D

National Water Quality Monitoring System

CHAPTER 15
Creating a National Monitoring Network

Ongoing monitoring is essential to assess the health of ocean and coastal ecosystems and detect changes over time. More than any other measure, monitoring provides accountability for management actions. The nation needs a coordinated, comprehensive monitoring network that can provide the information necessary for managers to make informed decisions, adapt their actions as needed, and assure effective stewardship of ocean and coastal resources. In developing such a network, the National Oceanic and Atmospheric Administration, the U.S. Environmental Protection Agency, the U.S. Geological Survey, and other agencies as appropriate, should coordinate and expand their efforts to ensure adequate monitoring in coastal areas and the inland regions that affect them.
Examples of Federal Water R&D

- Integrated Earth Observation System (IEOS)

Near-term Opportunities:

- Data Management
- Improved Observations for Disaster Warnings
- Global Land Observation System
- Sea level observation system
- National Integrated Drought Information System (NIDIS)
- Air Quality Assessment and Forecast

STRATEGIC PLAN FOR THE U.S. INTEGRATED EARTH OBSERVATION SYSTEM
Examples of Federal Water R&D

U.S. Climate Change Science Program (CCSP)

Nine key priority areas:

- Aerosols-clouds-climate
- Development of an integrated Earth system analysis capability
- **Integration of water cycle observations, research and modeling**
- Global Landsat data for answering critical climate questions
- North American carbon program integration
- Impacts of climate variability and change on ecosystem productivity and biodiversity
- **Coping with drought through research and regional partnerships**
- International Polar Year
- Integrated Ocean Observing System
Homeland Security

Protecting Water Infrastructure and Improving Decontamination:

The FY07 budget requests a total of $94 million to fund new and ongoing research in water security and post-incident decontamination at the Environmental Protection Agency. This includes research and development for monitoring and surveillance of terrorist threat agents in drinking water and the strengthening of decontamination capabilities.
KAZAKHSTAN, CHINA AGREE ON JOINT USE OF TRANSBORDER RIVERS

Algeria Objects to Libyan Move To Drain Off Water From Shared Border

Uganda: President Museveni pledges to build additional Nile dams

China's State Council approves water rise in Three Gorges Reservoir

Cyprus faces water shortage

Without water, Indian farmers can't find a bride

Severe, Prolonged Drought Threatens Food Security in Western China

Problems Plague Ambitious Irrigation Plan in Africa

Egyptian Minister Praises EU Cooperation in Water Resources, Irrigation

Journal Relooks at Indus Waters Treaty from Kashmir's Perspective
International water issues:
United Nations (and many other international organizations)