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National Water-Quality Assessment Program — Cycle II

Regional Assessments of Aquifer Systems and Streams and Rivers

Regional assessments are planned by the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program to describe water-quality conditions and trends in 18 major aquifer systems and in streams and rivers draining 8 broad geographic areas (see maps inside). These assessments build on previous NAWQA studies in 51 individual river basins assessed from 1991 to 2001 that show how natural features, land use, and human activities affect ground- and surface-water quality and aquatic ecosystems. (Summary reports are available online; see back page.) Water-quality information in the regional context will be useful for regional monitoring councils, States, and localities in addressing priority water-quality and drinking-water issues across broad regions that have similar hydrogeology, land use, and landscapes.

Regional assessments of aquifer systems

A total of 71 aquifer systems underlie the United States; the 18 selected for regional assessment account for nearly 75 percent of estimated withdrawals for drinking-water supply. Water quality within the different aquifers will be compared, and factors that affect ground-water quality and vulnerability to contamination will be assessed. These factors include natural features related to physiography, geology, mineralogy of aquifer material, geochemical characteristics, and geohydrology, which affect the movement of water and associated chemicals into and through the aquifer material. For example, rapid influx and vertical mixing of water throughout the aquifer system occurs in sand and gravel aquifers, alluvial fans, and carbonate (karst) settings in which open conduits allow relatively rapid downward movement of water.

Human activities also affect the movement of water and chemicals through the aquifers. Such activities include pumping for irrigation and water supply, and upgradient land use where water that replenishes the major aquifers is derived from a variety of sources and is affected by fertilizers, pesticides, and other chemicals used on the land.

Each of the NAWQA regional assessments focuses on water-quality issues of concern within a particular aquifer system, and addresses one or more of the following general issues:

- Condition of the ambient resource
- Chemical quality of domestic and public ground-water supplies
- Chemical and hydrologic processes affecting ground-water quality and transport of contaminants
- Effects of agricultural and urban land use on water quality

NAWQA findings will be useful to water managers and scientists in assessing ground-water vulnerability across different regions. By identifying natural and human factors and key processes affecting contaminant

Regional analyses in Cycle II

In 2001, the National Water-Quality Assessment (NAWQA) Program began its second decade (or "Cycle II") of water-quality assessments. Forty-two of the 51 areas assessed from 1991 to 2001 (referred to as "Study Units") will be revisited, in which current conditions and trends in ground water and in nearly 85 streams will be assessed.

During Cycle II, interagency coordination, data collection, modeling, and reporting of results will be generally organized at broader regional scales, rather than at the basin or study-unit scale. This adjustment reflects declining budgets and results in more efficient coordination of an interdisciplinary USGS workforce needed to address program objectives over the long term.

Regional-scale analyses, models (such as SPARROW), and other scientific tools will provide a quantitative framework for understanding regional ground-water flow, analyzing ground- and surface-water quality conditions and trends, and extrapolating findings to unmonitored, comparable areas in other parts of the regions. By providing water-quality information in a regional context, the analyses will be useful for regional monitoring councils, States, and localities in addressing priority water-quality and drinking-water issues and in assessing water resources in their areas.

For more details about NAWQA's Cycle II studies and a map showing locations of Study Units, see Gilliom, Hamilton, and Miller, 2001.

occurrence and transport, managers and scientists can apply findings to broader classes of contaminants and to newly identified, emerging contaminants. NAWQA models and other decision-support tools, which integrate aquifer characteristics, land use, and water-quality monitoring data, will help water managers assess the sustainability of water resources for future supply and develop cost-effective ground-water monitoring programs.

Condition of the ambient resource

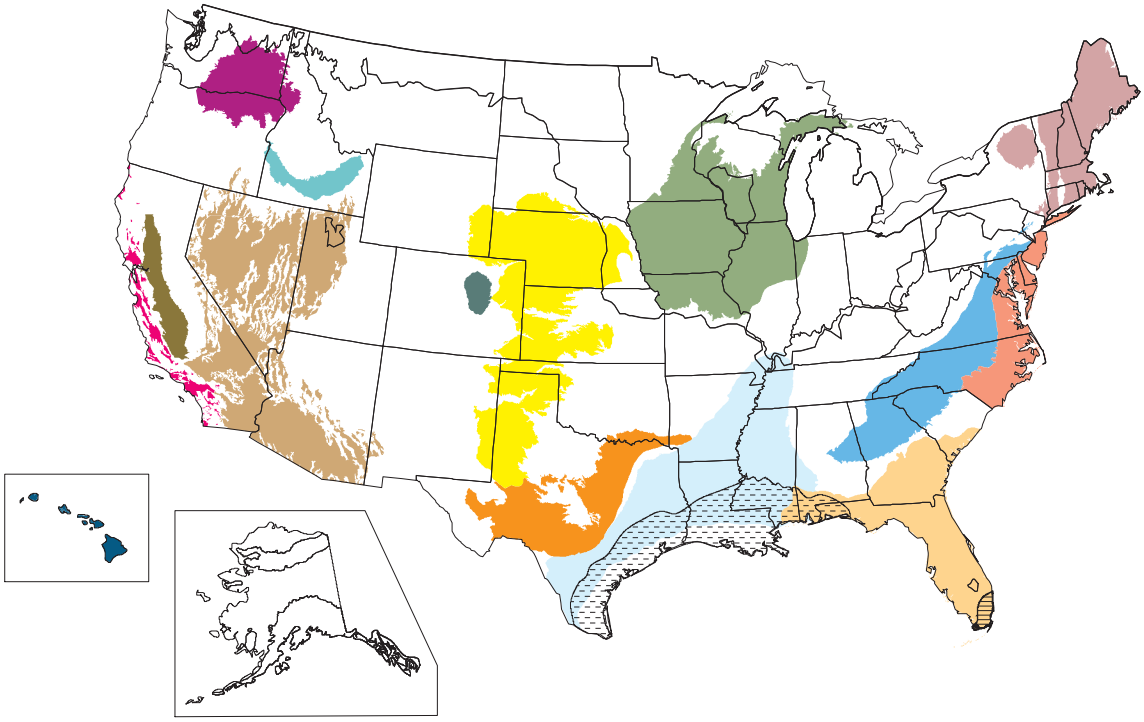
NAWQA studies from 1991 to 2001 indicated that contaminants in shallow ground water are widespread, often in mixtures but at low concentrations, in aquifer systems across a wide range of landscapes and land uses. Comprehensive assessments of a multitude of chemical constituents — nutrients, pesticides, volatile organic compounds (VOCs), trace elements, and radionuclides — are planned in the Program's regional assessments of many of the aquifer systems, including carbonate aquifers underlying Florida and the Basin and Range, and volcanic aquifers underlying much of the western United States and Hawaii.

Special studies also are planned of selected contaminants of concern within particular systems. For example, selected studies focus on arsenic, radon-222, uranium, and trace elements in glacial aquifer systems throughout the northeast and upper Midwest; salinity in aquifers underlying the Basin and Range, Central Valley, and California Coastal Basins; and nitrate and mixtures of urban-related pesticides in ground-water discharge to streams in the northeast and upper Midwest.

Chemical quality of domestic and public ground-water supplies

Several regional assessments are planned of anthropogenic chemicals,

Locations of Regional Assessments of Aquifer Systems



- Denver Basin aquifer system
- Edwards-Trinity aquifer system
- Basin and Range basin-fill and carbonate-rock aquifers
- Columbia Plateau basin-fill and basaltic-rock aquifers
- Central Valley aquifer system
- Snake River Plain basin-fill and basaltic-rock aquifers
- California Coastal Basin aquifers
- Glacial deposits aquifers
- Hawaiian volcanic-rock aquifers
- New York and New England crystalline-rock aquifers
- Northern Atlantic Coastal Plain aquifer system
- Piedmont and Blue Ridge crystalline and carbonate rock aquifers
- Floridan aquifer system and overlying Surficial aquifer system
- Biscayne aquifer
- Cambrian-Ordovician aquifer system
- Mississippi embayment-Texas coastal uplands aquifer system
- Coastal lowlands aquifer system
- High Plains aquifer

Source: USGS, 2003, Principal Aquifers of the United States.

such as fertilizers and pesticides, in domestic and public-supply wells. These assessments cover a large part of the Nation, including ground-water supplies tapping the Floridan aquifer system, Northern Atlantic Coastal Plain, Coastal Lowlands regional aquifer, and the glacial aquifer systems in the northern United States. A special assessment also is planned on the effects of long-term withdrawals (1950-2000) on ground-water quality in the Floridan aquifer system.

Chemical and hydrologic processes affecting ground-water quality and transport of contaminants

Previous NAWQA studies indicated that natural features affect the transport of chemicals, and often result in different contaminant concentrations in aquifer systems. Natural features include aquifer characteristics, such as geology, hydrology, lithochemistry, mineral composition, and redox conditions, and the properties of the chemicals themselves, such as their tendency to dissolve, attach to sediment, and persist in the environment.

Several regional aquifer assessments will focus on the transport and transformation (breakdown, dilution, or removal) of contaminants as ground water moves within aquifers, including those underlying the Midwest, southeastern and Northern Atlantic Coastal Plain, and New England. In addition, several studies are planned to assess the effects of flow-system alterations and controls — such as artificial recharge and pumping — on water quality in aquifers underlying the arid to semi-arid western United States and Hawaii.

Effects of agriculture and urban land use on water quality

Contaminants found in ground water underlying agricultural and urban land use are closely related to the chemicals that are used. In previous NAWQA studies, nitrate and selected herbicides were frequently detected in shallow ground water underlying agricultural land, and VOCs were frequently detected in shallow ground water underlying urban land. NAWQA regional assessments will establish relations between ground-water quality and land use in the Northern Atlantic Coastal Plain, the arid and semi-arid western aquifers, glacial aquifer systems, and the Piedmont aquifer. Special topics include: (1) effects of chemical use and agricultural practices in four agricultural settings in Florida and the southeastern Coastal Plain; (2) effects of urban development in the Mississippi Embayment-Texas Coastal Uplands and Piedmont physiographic province on ground-water quality used for drinking; and (3) possible use of chloride concentrations as an indicator of urban influence on glacial aquifer systems used for drinking.

Regional assessments of streams and rivers

Regional assessments of streams and rivers cover 8 areas, which were delineated on the basis of 21 water-resource regions described in Seaber and others (1987). Each of the NAWQA assessments focuses on chemicals of concern and water-quality issues specific to each geographic area, and addresses one or more of the following general issues:

- Sources and transport of nutrients to major rivers, lakes, estuaries, and coastal waters
- Effects of urban development and agricultural practices on aquatic communities
- Trends in the occurrence of nutrients and pesticides in relation to changes in chemical use and management practices

Installation of a shallow monitoring well for studying effects of land use on shallow ground water.

Sources and transport of nutrients to major rivers, lakes, estuaries, and coastal waters

Sources and transport of nitrogen and phosphorus to rivers and coastal waters will be assessed in 6 areas:

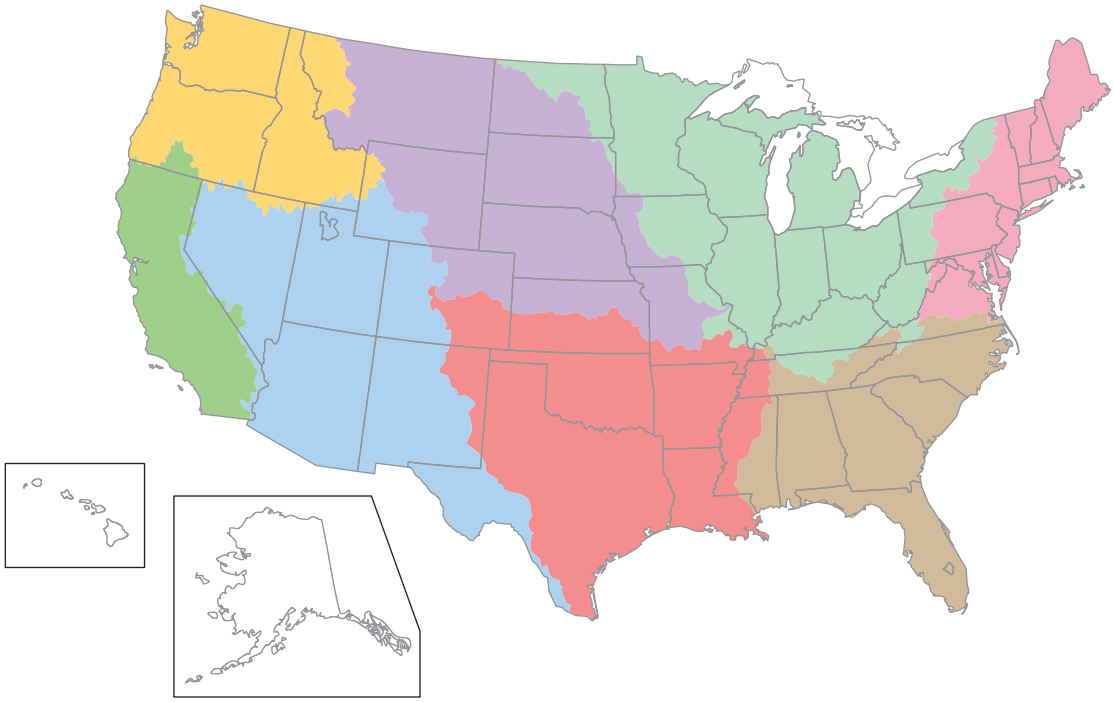
- New England and Mid-Atlantic
- South Atlantic-Gulf and Tennessee
- Gulf of Mexico, including the Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy
- Missouri
- Lower Mississippi, Arkansas-White-Red, and Texas-Gulf
- Pacific Northwest

Sediment will be assessed to the extent data are available.

Loads of nutrients and sediment carried by streams and rivers can vary because of basin characteristics, hydrologic events, seasonality, land use, and contaminant sources. NAWQA will therefore determine the relative significance of these factors and apply statistical tools, such as the USGS regression model SPARROW and load-estimation program S_LOADEST. The goal is to assess annual and seasonal trends in nutrient and sediment transport and to spatially extrapolate findings to unmeasured areas throughout the basins.

Findings will help water-resource managers, planners, and scientists better understand the causes and sources that may lead to impaired conditions and trends, such as annual or episodic algal blooms and hypoxia. Findings can also be used in developing nutrient criteria, managing nutrient enrichment in rivers, estuaries, and coastal waters, and in evaluating large-scale changes in nutrients and suspended sediment from farm-conservation and land-management programs.

Locations of Regional Assessments of Streams and Rivers



New England and Mid-Atlantic
South Atlantic-Gulf and Tennessee
Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy
Missouri
Lower Mississippi, Arkansas-White-Red, and Texas-Gulf
Rio Grande, Colorado, and Great Basin
Pacific Northwest
California

Source: Seaber and others, 1987, Hydrologic Unit Maps, USGS Water-Supply Paper 2294.

Effects of urban development and agricultural practices on aquatic communities

Previous NAWQA studies have shown that chemical, physical, and biological characteristics of streams are affected by urban development and agricultural practices. These activities can degrade water quality and physically alter streams, thus disturbing habitat and degrading fish, invertebrate, and algal communities. Degraded aquatic communities generally show reduced biological diversity and richness, and a dominance of species that are tolerant of disturbance, such as worms, midges, and omnivorous fish communities.

The most profound effects to biological, chemical, and physical conditions were observed in streams draining urbanizing areas. The studies generally showed elevated contaminant levels, increased stream flows and transport of sediment, and physical disturbances to streams, including, for example, deepened channels, reduced natural habitat, and altered substrates. Chemical and physical changes were therefore highlighted as possible factors in the degradation of aquatic communities in urbanizing streams.

The NAWQA studies also showed that the degree to which aquatic communities is affected, however, can vary among land-use settings because of natural features, such as substrates, soils, geology, climate, basin characteristics, and hydrology—all of which can control the transport of water and associated contaminants over land and through the subsurface. In addition, the aquatic response can vary because of different land-management practices in urban and agricultural settings, such as tile drains, grass buffer strips, and regulated flow controls.

NAWQA regional assessments in all 8 areas will describe effects of activities in urban and agricultural settings on stream health and aquatic communities. Each of the studies will emphasize a particular issue characteristic of the region, as indicated by selected studies below:

- New England and Mid-Atlantic—Variable streamflow conditions associated with increased impervious surfaces, storm drains, and other artificial controls draining residential and commercial development and dense road networks.
- Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy—(1) Role of agricultural land-management practices, such as grassed waterways and riparian buffer strips, hydrology, and environmental setting; (2) Conversion of large amounts of agricultural land to suburban and urban development, typical of much of the north-temperate United States (also will be studied in New England and Mid-Atlantic areas).
- Rio Grande, Colorado, and Great Basin, the Pacific Northwest, and California—Regulation and control of streamflow to meet agricultural and urban needs, which result in alterations in natural flow regimes, typical of many of the drier climates in the West.
- South Atlantic-Gulf and Tennessee, including streams—Role of natural features, such as related to substrate, soils, and basin characteristics affecting streams draining southeastern urban areas, including Birmingham, Alabama; Raleigh, North Carolina; and Atlanta, Georgia.

Findings and models developed in the regional assessments will provide managers and planners a better understanding of the effects of urbanization on aquatic ecosystems in a regional context, and will be useful in monitoring, protecting, and restoring urban streams. Relations drawn among chemical characteristics, hydrology, and basin characteristics to ecosystem health will be useful for identifying key stressors and mitigat-

Biological communities in streams in the relatively pristine Yellowstone River Basin, such as this Montana stream, will be compared to communities in urban streams across the Great Plains.

ing factors that can assist watershed managers in developing smart-growth strategies and reducing negative impacts to urban aquatic communities. The findings also will be helpful to the agricultural community and water-resource managers who implement conservation programs, such as through USDA and state agricultural agencies. Finally, the findings will be useful in the development of regional bio-assessment indicators of stream and landscape alterations and degradation, and lead to improved and more cost-effective application of regional bio-monitoring criteria.

Trends in nutrient and pesticide occurrence in relation to changes in chemical use and management practices

Changes in water quality over time frequently are controlled by changes in chemical use. A NAWQA regional assessment is, therefore, planned to determine the changing occurrence of pesticides in streams throughout the Corn Belt in relation to changes in pesticide use, such as the increasing use of glyphosate (trade name "Roundup"). Glyphosate is being used almost as much as atrazine as farmers switch to glyphosate-tolerant soybeans to simplify weed control and lower costs. The assessment covers streams in parts of four areas, including the Great Lakes, Ohio, Upper Mississippi, and Souris-Red-Rainy; New England and Mid-Atlantic; Missouri; and Lower Mississippi, Arkansas-White-Red, and Texas-Gulf. Findings will be of particular interest to the pesticide industry, as well as to managers and regulators involved with pesticide management and registration.

NAWQA regional assessments also are planned to describe trends in the pesticides diazinon, carbaryl, malathion, chlorpyrifos, and prometon in streams draining urban areas in the New England and Mid-Atlantic area. Changes in pesticide use and regulations, such as the phasing out of diazinon in 2001, may lead to changes in pesticide occurrence in urban streams. Findings will help regulators and managers evaluate the effectiveness of pesticide registration and manage chemical use in urban basins.

A regional assessment in California will determine long-term trends in concentrations of nitrate. Nitrate concentrations have decreased in some parts, such as in southern California, but have increased in others, such as in the San Joaquin River Basin. Agricultural practices related to artificial drainage and dairies may account for the increase since the 1960s. Findings on long-term trends will be useful for managers involved in the development of nutrient criteria, TMDLs, ecosystem restoration, and management of drinking water and wastewater.

References

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For online information, reports, and data:

Summary assessments conducted during the first decade in the 51 Study Units are available at: *http://water.usgs.gov/nawqa/nawqa_sumr.html*

All other reports, maps, and data are available at: *http://water.usgs.gov/nawqa*